Private versus Social Incentives for Backward Integration by Food Processors under Input Supply and Output Demand Uncertainty

by
Rimjhim M. Aggarwal

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Department of Agricultural and Resource Economics
The University of Maryland, College Park

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Rimjhim M. Aggarwal
Department of Agricultural and Resource Economics
University of Maryland, College Park MD 20742
Email: aggarwal@arec.umd.edu

Abstract:
Previous studies have attempted to explain the growing trend towards vertical integration in the food industry in terms of gains in private efficiency. These studies typically assume a bilateral setting and hence overlook the impact that vertical mergers may have on other players in the market, and hence on social welfare. In this paper, we use a simple multilateral setting to examine the divergence that may arise between social and private incentives to vertically integrate when processing firms face input supply and output demand uncertainty. Here backward integration provides the integrating firm better protection against these two types of uncertainties while making the unintegrated competitor more vulnerable. The integrated firm therefore has greater incentives than the unintegrated firm does to increase final product valuation. Given the oligopolistic setting that characterizes the food manufacturing industry today, our results suggest that an integrated firm is likely to invest beyond the socially optimal level in product differentiation, which in turn, leads to greater market concentration. Earlier studies have looked at the growing trends towards vertical integration, product differentiation and concentration in isolation. Our study suggests that, under certain conditions, there might be a synergistic link between these variables that needs to be explored further.

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I. Introduction

Recent studies in the food industry literature have identified a number of reasons to explain why farmers and processors might enter into different forms of vertical coordination (such as contracting and vertical integration) as opposed to operating on open markets. Thus, for instance, farmers may enter into contracts to reduce price risks, to get access to capital and new technology, and to assure an outlet for their final produce (Knoeber, Rhodes, Barry *et al,* Hayenga). On the other hand, processors may enter into contracts to assure consistent quality and quantity of inputs to run their processing plants efficiently (Hennesey, USDA 1996a).). It has also been suggested that processors may integrate backwards into agriculture to internalize the deadweight loss associated with market distortions which are internalized by integration (Henderson, Mitra et al.).[1]

The focus of this strand of literature has been to "explain" these institutional changes as a result of the private efficiency gains they entail in an environment of pervasive risks and imperfect information. Interestingly, there has been very limited investigation into the welfare implications of these alternative institutional forms. It is well known, however, that even if institutions perform certain important economic functions, they may not perform these functions optimally. In particular, as Stiglitz points out, pair-wise efficiency of contractual arrangements may not suffice to ensure social efficiency.

This possibility of a divergence between bilateral versus social efficiency has been overlooked largely because most of the analysis here is based on the assumption of a bilateral relationship, where a single seller produces some input for use by a single buyer. Casual observation, however, suggests that multilateral relationships in which a processing firm buys inputs from a number of farmers and /or a farmer supplies inputs to a number of processing firms, are far more widespread. In such a multilateral setting it becomes important to understand the "third party effects" of a merger between an upstream and a downstream firm. For instance,

[1] Perry in his survey in the Handbook of Industrial Organization suggests that vertical integration in this last case is "a relatively drastic solution to what is essentially a pricing problem" (p. 192). Tying arrangements, output or sales royalty and lump sum fee entry can all be used by the monopolist to eliminate and internalize the efficiency loss from simple monopoly pricing.

consider the case of a processing firm that faces high costs if its plant is not operated close to capacity. In the face of input supply uncertainty, vertical integration with the input supplier is likely to reduce this firm's supply assurance concerns while aggravating the supply assurance concerns of its competitors (Carlton). This is particularly true when the integrating firm has considerable market power in the either the upstream or the downstream market.

Some recent theoretical papers, such as Bolton and Whinston and Hart and Tirole, have used a simple multilateral setting to examine the effect of vertical integration on competition in the upstream and downstream market. However, apart from a recent study by Love and Burton on captive supplies in the beef industry, we are not aware of any study in the food industry literature that uses a multilateral setting to examine the motivation for and impact of vertical integration. Love and Burton examine how backward integration by a dominant processing firm may affect other processing firms by changing the spot market price for the common input but again they focus on the private efficiency gains from captive supplies and do not specifically examine its impact on social welfare. Also they assume a perfectly deterministic environment while, as we show in this paper, uncertainty in upstream input supply and in the demand for the final product play an important part in explaining why vertical integration emerges.

Understanding the "third party effects" of vertical integration within a multilateral setting is critical in the analyzing a number of concerns raised in recent years regarding vertical integration in agriculture. The beef packing industry, in particular, provides a good example. Over the past decade or so, cattle packers have increasingly made use of production contracts and vertical integration to obtain "captive supplies of cattle."[2] This has caused a lot of concern amongst unintegrated cattle feeders who have consistently complained that these captive supplies restrict their choice of sale outlets for cattle and depress prices received for fed cattle in the spot market (Martinez and Reed, USDA 1996a). Some industry observers also fear that large beef packers may use vertical coordination arrangements as a "means of blocking their small competitors from

[2] Captive supply takes the following forms: packer-owned cattle, formula cattle, futures cattle and custom-fed cattle.

sources of supply."(USDA, 1996a). Similar concerns have been raised in other food sectors also, notably the hog sector, where vertical coordination is increasing.

These concerns have led some states to enact corporate farming laws that restrict processor involvement in farming activities (Barkema). One of the arguments often given in favor of such legislation is that vertical merges and other forms of vertical coordination may amplify the potential for exercise of market power and hence are inefficient. However, this is highly controversial.[3] As Hart and Tirole point out

Few people would disagree that horizontal mergers have the potential to restrict output and raise consumer prices, but there is much less agreement about the anti-competitive effects of vertical mergers. Some commentators have argued that a purely vertical merger will not affect a firm's monopoly power, because the merger of an upstream and a downstream firm, each of which controls, say, 10 percent of its market, does not change market shares: other firms continue to possess 90 percent of each market. (p.205)

In the food industry literature, a number of studies provide evidence of a trend towards greater vertical integration and greater concentration (at both the farm level and processing stage) over time (Barkema et al., Reimund et al.) . These studies seem to implicitly suggest that vertical integration leads to market concentration but it is not very clear how this happens and what are its effects on social efficiency. A recent study initiated by the Packers and Stockyards Administration of USDA on "Concentration in the Red Meat Packing Industry" found the effect of captive supplies on short run prices paid for cattle to be negative, but very small. The study did not obtain any definitive results about the possible use of market power and attributes this largely to the several data and methodological difficulties encountered in examining the impact of vertical coordination and market concentration (USDA, 1996a: vii).

[3] This is very well illustrated by the controversy associated with the case of the Brown Shoe Company vs. United States. Brown Shoe Company was manufacturing shoes and wanted to integrate with a shoe retailer. The Supreme court ruled the merger to be illegal on the premise that the share of the market represented by the acquiring firm was no longer available to competing manufacturers, and hence was anti-competitive (Bolton and Whinston). Bork has been amongst the strongest critics of this anti-competitive doctrine. His main argument is that after integration, the acquiring manufacturing firm would attempt to maximize the profits of the integrated unit. Thus it would never force the acquired retailer to carry only its brands because any possible benefits from such an action to the acquiring firm would be offset by the loss to the acquired firm.

The above discussion points to the need to further explore the efficiency implications of vertical coordination in agriculture, both conceptually and empirically. In the present paper, we start with a somewhat modified version of the multilateral setting in the Bolton and Whinston (BW) paper and expand on it to clarify some of the issues raised above. In our model there is one upstream and two downstream production plants. The downstream plants use a common input, which is essential for production and used in fixed proportion. In any production period there is a positive probability that a shortage would arise for this input. This input supply uncertainty coupled with demand uncertainty for the final product, play a central role in our model in explaining the benefits to a downstream processing firm of integrating backwards into agricultural production. Using this model we address the following questions. First, what is the impact of such backward integration on the two merging parties and on the other unintegrated downstream firm in the market? In particular, how does vertical integration affect the investment decisions made by the integrated and the unintegrated downstream firm? Second, how do investment levels under non integration and vertical integration differ from what is socially optimal? Third, what is the mechanism through which backward integration by a processing firm affects concentration in the final product market? The results from our theoretical model also suggest a few hypotheses on how vertical integration, market concentration and product differentiation may be linked and we illustrate these linkages through some examples from the food manufacturing industry.

The rest of the paper is organized as follows. In section II, we discuss why input supply assurance concerns are an important motivation for processors to integrate backwards. In section III, we use some of these insights to develop a theoretical model on vertical integration in a multilateral setting. In section IV, the empirical implications of the main results from this model together with examples from the food manufacturing industry are discussed. Finally, in section V, we conclude.

II. Input Supply Assurance Concerns

The recent controversy, regarding the effects of captive supplies in the beef packing industry, provides a useful starting point to understand why input supply assurance concerns play a central role in our theoretical model. It has often been argued that captive supplies of fed cattle do not have any significant effect on short-run prices in the spot market because if through captive supplies, 20 percent of the demand for fed cattle is removed, so also is 20 percent of the supply. Hence, it is argued, the net effect on the market is zero (USDA, 1996b). While this argument seems convincing at first sight, the Minority Committee on "Concentration in Agriculture" made an interesting observation to counter this argument which we use as a stylized fact in the construction of our theoretical model. The report points out that the above argument is flawed because "captive supply ***cuts the tops off the market***, by assuring that the packers never get truly desperate for cattle, or ***"close to the knife"*** in industry terms. The packers have the flexibility to use the cattle they control when they want them without ever getting into the bidding wars that are the occasional salvation of feeders" (USDA, 1996b:30, emphasis added).

This suggests that to understand the motivation for and impact of vertical coordination, one must not just look at the total level of demand and supply, but more importantly at how fluctuations in these magnitudes affect and are affected by vertical coordination. An important motivation often given for why processors integrate backwards into agricultural production is that it provides them greater assurance regarding a smooth flow of inputs. Operating costs in many modern processing plants rise sharply if processing lines are not operated at optimal speed and so processing firms need a constant supply of inputs of consistent quality. However, this is often difficult, given the seasonality and uncertainty associated with agricultural production. Moreover, the perishable nature of many food products implies that storage may be a highly imperfect instrument for smoothing out the inter-temporal variability in farm production. The USDA study on "Role of Captive Supplies in Beef Packing" found that plant utilization is an important determinant of captive supplies for both large and small packing plants, with a relatively larger impact on small plants, reflecting high costs of slaughter levels below full capacity. The study also found that variability in cash market prices led to an increase in use of captive supplies (Ward et al.).

Thus the need to run processing plants close to capacity in an environment characterized by large uncertainty in input supply provides an important motivation for vertical coordination by processing firms. Vertical coordination can occur in various different forms, ranging from marketing and production contracts to strategic alliances, partnerships and vertical integration. Some previous studies have examined the rationale for the choice between these alternative forms (Williamson, Klien et al, Frank and Henderson). These studies suggest that vertical integration is most likely to be observed when it is difficult to write complete contracts that induce efficient relation-specific investments. In a recent theoretical paper, based on a bilateral setting, Wiggins shows that this situation is most likely to occur when the downstream firm faces both highly uncertain (input) cost conditions and (output) demand conditions. Here backward integration allows for greater flexibility and superior communication between the two stages of production. In the model presented in the next section we incorporate both these types of uncertainties to explain why vertical integration emerges and its impacts.

III. Theoretical Model

Consider the following simple vertical setting. There is one upstream production plant (U) and two downstream plants (D_i ; $i = 1, 2$).[4] We assume that the output of the upstream plant (e.g. the grown up animal) constitutes an essential input in the production process of the downstream plants (e.g. the packing or processing plants). Each downstream plant requires one unit of this input (in combination with other inputs) to produce one unit of the output. Randomness in the production of the upstream plant leads to supply assurance concerns for the downstream plants in the following way. Assume that there is a probability, λ, that the upstream plant can produce only one unit of

[4] The basic multilateral framework presented here is based on Bolton and Whinston. However, since the bargaining assumptions we make here are different from what they assume, the results regarding investment levels under alternative ownership patterns are different from what they get. Also in their model, the downstream firms do not directly compete in the final product market.

output and a probability (1-λ) that it can produce two units. In other words, there is some probability λ that a shortage would arise for the input required by the downstream plants.[5] The marginal costs of production of the upstream plant are fixed. To simplify the presentation, we assume these to be zero. With respect to the market for the final product, we consider two cases. We begin with the assumption that the two downstream firms do not directly compete in the final product market. This case serves as a useful benchmark. Later we consider the implications of relaxing this assumption.

III.1 No competition in the downstream market

Here we assume that the two downstream plants do not directly compete in the final output market. This may be because these firms sell in two segregated regions or because their products are not related in consumption. Each of these downstream firms has a single customer who demands at most one unit of the product. Let v_i denote the valuation of D_i 's output, net of D_i 's cost (except for the cost of input provided by U). We assume that v_i is randomly related to the level of unobservable investment, I_i, by D_i in the following way

$$v_i = v_i(I_i, s) \qquad i = 1, 2 \qquad (1)$$

where s is the state of nature. We assume that v_i is observable and is a differentiable, non-decreasing and concave function of I_i. The cost of this investment is given by $C_d(I_i)$, where $C_d(.)$ is an increasing and convex function of I_i. We assume that everyone observes the realized value of upstream production capacity and the downstream product valuation.

In this highly stylized setting there are three different (non-human) assets: one upstream and two downstream processing plants. Given these assets, the following types of ownership structures can arise

i) Non Integration (NI): all the three plants have different owners.

[5] Here we model supply assurance problem in the form of uncertainty regarding the production level of the upstream firm. However, supply assurance problem may take the form of uncertainty regarding the supply of any other attribute considered to be valuable by the processing plant such as the proportion of fat in market hogs or the amount of pesticide applied to a crop.

ii) Vertical Integration (VI_i): the upstream plant and the i^{th} downstream plant have the same owner.

iii) Horizontal Integration (HI): the two downstream plants have the same owner.

iv) Complete Integration (CI): all the 3 plants have the same owner.

To begin with, we assume that all parties are risk neutral and there are no wealth constraints so that each party can purchase any asset it is efficient for her to own. Later in the analysis we discuss the implications of dropping this assumption.

The time structure in this model is as follows. At time t_0, allocation of ownership titles takes place. Once the allocation of ownership titles is completed, then at time t_1, owners of the downstream plants choose their level of investment, I_i. At time t_2, the two types of uncertainties (i.e. regarding the production capacity of the upstream plant and the demand for the output of the downstream plants) are resolved. Thus, under these assumptions, investments at the downstream level have to be made before the resolution of uncertainty regarding upstream production capacity and downstream product valuation. Once these uncertainties are resolved, bargaining for the exchange of U's output takes place followed by production at the downstream level.[6]

To model the expost bargaining for U's output, we assume a non-cooperative Nash bargaining framework. The payoffs under the different ownership structures and different states of nature regarding upstream production (Q)are shown in table 1. First consider the case of horizontal integration (HI). If U's production is two units, then total gross revenue in this case is $v_1 + v_2$. Under the assumption of Nash bargaining, this revenue is split evenly between the integrated downstream firm and the upstream firm. If, on the other hand, U's production is a single unit, then the integrated downstream firm assigns this sole input to the plant with the higher realized value of

[6] We assume that it is very costly to specify complete ex-ante contracts that specify the exchange of U's output before downstream investments are made. This is because it may be too costly for both parties to specify the various eventualities that may occur and to agree on how to deal with such eventualities. Or it may be too costly to describe in detail, exante, the precise characteristics (often multidimensional) of the input that would be traded in the future. Note that if complete contracts could be written in this setting, the first best level could be achieved regardless of the type of ownership structure. It is precisely when complete contracts cannot be written that ownership structure over assets becomes important because of the transfer of residual rights of control (Grossman and Hart).

production. Thus total gross revenue in this case is the maximum of v_1 and v_2, and it is split evenly between the integrated downstream firm and the upstream firm.

Next consider the case of vertical integration (VI_1). If U's production is two units then the integrated firm uses one unit of the input for its own downstream plant (D_1) and sells the other unit to D_2. It gets all of the revenue from the sale of its own downstream product and half of the revenue from sale of D_2's output. If on the other hand, U's production is a single unit, then the picture is somewhat more complicated. Note that the integrated firm always has the option of using the sole input for its own downstream plant and thus v_1 is its reservation price. If $v_1 \geq v_2$, then the integrated firm uses this input in its own downstream plant and its gross payoff is v_i. If $v_1 < v_2$, then the integrated firm would be better off selling this input to the other downstream firm. Under the Nash bargaining framework assumed here, it would then get a payoff of $v_1 + ½(v_2 - v_1)$ which is greater than its reservation price of v_1.

Finally, consider the case of non-integration. Here if U's production is two units, both downstream firms get one unit of the input each and the surplus is shared evenly. If on the other hand, there is input shortage, both downstream firms would compete for the input. Under Nash bargaining, the downstream firm with higher valuation would get the input. Therefore, if $v_1 < v_2$, the second downstream firm would get the input and would pay a price of $v_1 + ½(v_2 - v_1)$. Note that the price paid by D_2 here is the same as what it would pay if the upstream firm was vertically integrated with D_1.

Given the above discussed payoff structure from bargaining, let us now look at the choice of investment levels under the different ownership scenarios.

i) Socially optimal investment level

Let S denote the set of the different states of nature in (1) and let $\mu(s)$ be the probability measure over S. To ease notation, let $S_1(I_1, I_2) \equiv \{s \mid v_1(I_1, s) \geq v_2(I_2, s)\}$ denote the set of states of nature when the output of the first downstream firm has a weakly higher value and let $S_2(I_1, I_2) = S - S_1(I_1, I_2)$ Then the social planner will maximize

$$\Pi_0 = \lambda\left\{\int_{S_1} v_1(I_1, s)d\mu(s) + \int_{S_2} v_2(I_2, s)d\mu(s)\right\} + (1-\lambda)\left\{\int_{S}[v_1(I_1, s) + v_2(I_2, s)]d\mu(s)\right\}$$

$$- C_d(I_1) - C_d(I_2) \tag{2}$$

The optimal choice of I_i here is given by

$$\frac{\partial \Pi_0}{\partial I_i} = \lambda \int_{S_i} \frac{\partial v_i(I_i, s)}{\partial I_i} d\mu(s) + (1-\lambda) \int_{S} \frac{\partial v_i(I_i, s)}{\partial I_i} d\mu(s) = C_d'(I_i) \tag{3}$$

ii) Horizontal Integration (HI)

In the case of horizontal integration, the revenue from the sale of the final output is split between the integrated downstream firm and the upstream firm. So the optimal level of investment I_i in this case, I_i*(HI) is given by

$$\tfrac{1}{2}\frac{\partial \Pi_0}{\partial I_i} = C_d'(I_i) \tag{4}$$

iii) Non Integration (NI)

The payoff to the owner of D_i in this case is

$$\Pi_{NI} = \lambda \int_{S_i} \frac{v_i(I_i, s) - v_j(I_j, s)}{2} d\mu(s) \;+\; (1-\lambda) \int_{S} \frac{v_i(I_i, s)}{2} d\mu(s) \;-\; C_d(I_i) \tag{5}$$

Therefore D_i's optimal choice of investment in this case I_i*(NI) is given by

$$\frac{\lambda}{2} \int_{S_i} \frac{\partial v_i(I_i, s)}{\partial I_i} d\mu(s) \;+\; \frac{1-\lambda}{2} \int_{S} \frac{\partial v_i(I_i, s)}{\partial I_i} d\mu(s) \;=\; C_d'(I_i) \tag{6}$$

iv) Vertical Integration (VI_j)

Consider the vertically integrated structure VI_j where the upstream firm is integrated with the jth downstream unit. The total payoff to the integrated firm in this case is

$$\Pi_{VI_j} = \lambda\left\{ \int_{S_i} \frac{v_i(I_i,s)+v_j(I_j,s)}{2} d\mu(s) + \int_{S_j} v_j(I_j,s)d\mu(s) \right\}$$

$$+(1-\lambda)\left[\int_{S} \left\{ v_j(I_j,s) + \frac{v_i(I_i,s)}{2} \right\} d\mu(s) \right] \quad - \quad C_d(I_j) \qquad (7)$$

The optimal level of investment by D_j in this case is given by

$$\frac{\lambda}{2}\int_{S_i} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) + \lambda \int_{S_j} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) + (1-\lambda)\int_{S} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) = C_d'(I_j) \qquad (8)$$

On the other hand, the payoff to D_i in this case is

$$\lambda\left[\int_{S_i} \frac{v_i(I_i,s)-v_j(I_j,s)}{2} d\mu(s) \right] + (1-\lambda)\int_{S} \frac{v_i(I_i,s)}{2} d\mu(s) \; - \; C_d(I_i) \qquad (9)$$

Therefore the optimal level of investment by D_i is given by

$$\frac{\lambda}{2}\int_{S_i} \frac{\partial v_i(I_i,s)}{\partial I_i} d\mu(s) + \frac{(1-\lambda)}{2}\int_{S} \frac{\partial v_i(I_i,s)}{\partial I_i} d\mu(s) \; = \; C_d'(I_i) \qquad (10)$$

Proposition 1: *(a) Under VI_j, D_j's equilibrium investment level is (weakly) higher than under NI. (b) Under VI_j, D_i's equilibrium investment level is (weakly) lower than that under NI.*

Proof (a): D_j's equilibrium investment level under NI is given by (using (6))

$$\frac{\lambda}{2}\int_{S_j} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) + \left(\frac{1-\lambda}{2}\right)\int_{S} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) = C_d'(I_j) \qquad (11)$$

while under VI_j, D_j's equilibrium investment level is given by (8), which can be rewritten as

$$\frac{\lambda}{2}\int_{S} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) + (1-\lambda)\int_{S} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) + \frac{\lambda}{2}\int_{S_j} \frac{\partial v_j(I_j,s)}{\partial I_j} d\mu(s) = C_d'(I_j) \qquad (12)$$

Given that $S_j \subseteq S$ for all (I_1, I_2) and the assumptions about concavity of $v_j(I_j, s)$ in I_j and convexity of $C_d(I_j)$ it follows that $I_j^*(NI) \le I_j^*(VI_j)$.

(b): Note that in all of the above formulations, the investment decision by ith downstream firm affects the investment decision of jth downstream firm through the determination of the sets S_i and S_j. Given that v_j is a non-decreasing function of I_j, it follows that the set S_i contracts (weakly) as I_j increases. Let $I_i^*(I_j / NI)$ denote D_i's best-response under non-integration to investment level, I_j, by D_j. Since the set S_i contracts (weakly) as I_j increases it follows from (6) that $I_i^*(I_j / NI)$ must be non-increasing in I_j. From (10) and (6) it is clear that, for a given level of I_j, D_i's equilibrium investment level under VI_j and NI are equal, i.e., $I_i^*(I_j / VI_j) = I_i^*(I_j / NI)$. But we know that $I_j^*(VI_j) \ge I_j^*(NI)$. Therefore, since $I_i^*(I_j / VI_j)$ and $I_i^*(I_j / NI)$ are non-increasing in I_j, it follows that $I_i^*(VI_j) \le I_i^*(NI)$.

Proposition 2*: a) In the special case where λ(the probability of input shortage) is zero, D_i's gross payoff under NI is the same as that under VI_j,* while the combined payoff of {U, D_j}is higher. In this case, vertical integration is welfare improving.
b) For *$\lambda > 0$, D_i's payoff under VI_j is (weakly) lower than that under NI while the combined payoff of {U, D_j} is higher. In this case the welfare effect is ambiguous.*

Proof: The first part of the proposition follows directly from a comparison of (5) and (9). To prove the second part, note that for $\lambda > 0$, D_i's payoff is non increasing in I_j. Therefore, using the fact that $I_j^*(VI_j) \ge I_j^*(NI)$ and $I_i^*(VI_j) \le I_i^*(NI)$, it follows that D_i's payoff under VI_j is weakly lower than that under NI.

Proposition 3*: For a given level of I_j,*
(a) Under NI, $D_{i'}$'s investment is (weakly) lower than the socially optimal level.
(b) Under VI_i , $D_{i'}$'s investment is (weakly) higher than the socially optimal level.
(c) Under VI_j, $D_{i'}$'s investment is (weakly) lower than the socially optimal level.

Proof (a): Under non-integration, D_i gets only half of the value of its investment at the margin and so it under-invests relative to the socially optimal level. Comparison of (2) and (5) proves (a). To prove claim (b) note that vertical integration allows the integrated unit (U, D_i) to get the entire value of its investment when there is no input shortage or when there is input shortage but $v_i \geq v_j$. This is identical to the socially optimal case. The divergence with the socially optimal case arises when where there is an input shortage and $v_i < v_j$, so that it is not optimal for D_i to produce. Here note that the payment that the integrated unit {U, D_i} receives for its sale of the input to D_i is proportional to the level of investment it makes in its downstream plant. Thus downstream investments here determine the bargaining power of the integrated unit and this leads it to invest beyond the socially optimal level. Finally, claim (a) together with the fact that $I_i^*(VI_j) \leq I_i^*(NI)$, lead to claim (c).

To summarize the main results from this section, note that when the probability of input shortage is zero, the vertically integrated firm invests at the socially optimal level. Here vertical integration is welfare improving. This result is analogous to the case generally derived using bilateral settings and we get it here because in the absence of input supply uncertainty the integrated downstream firm does not impose any externalities on the other unintegrated downstream firm. On the other hand, if there is some non-zero probability of input shortage, i.e. $\lambda > 0$, then vertical integration provides better protection to the integrated firm against this uncertainty while making the unintegrated firm more vulnerable. The integrated firm in this case has an incentive to invest beyond the socially optimal level as shown in Proposition 3. This is because investments by the vertically integrated structure in its downstream plant have two effects in the above model. First, these investments enhance the value of the product in the downstream market. Second, these investments increase the bargaining power of the integrated unit so that in states of nature when input shortages arise, it is able to extract a greater share of the gross surplus and hence increase its share of the market pie.

III.2 Competition in the downstream market

So far we have assumed that the downstream firms compete for the same input but they do not directly compete in the output market. In this section we allow for competition in the downstream market as well. In the context of the food manufacturing industry, it would be useful to think of the downstream processing firms as producing differentiated products, which are imperfect substitutes in consumption. Over the past few decades, changes in consumer tastes towards more health food (e.g. shift towards low fat and low cholesterol diet), more convenience (e.g. ready to eat food) and more variety have provided greater incentives for the development of specialized products and niche markets. There have also been major changes on the technological side, particularly in biotechnology, which have given producers greater control over what is produced. Quaker Oats, for instance, used to market only one type of oatmeal, today it markets three types and 12 flavors of oatmeal.

To fix ideas, let us begin by assuming that the two downstream firms (1 and 2), produce two brands (α and β respectively), of a specific food product say, apple cider. Further assume that the brands differ in only one attribute, say sweetness, which is valued differentially by the consumers. Following Hotelling (1929)'s spatial model of product differentiation, let the different points on the line segment OH in figure 1a, represent different degrees of sweetness of cider, with the degree of sweetness increasing as one moves towards the right end of this segment. In figure 1a, brand α is located at point O and brand β is located at point H on the line segment OH. Thus in this case, brand β denotes a sweeter variety.

As in the previous section, we continue to assume that there are two customers who demand a single unit of this product in each time period. An individual customer's location on the line segment OH indicates the exact degree of sweetness that she prefers most. To capture uncertainty in consumer preferences, we assume that the exact location of each customer, and hence her valuation of the two brands, is unknown at time t_0. In particular, we assume that the location of customer 1 is given by θ_1 and it is distributed uniformly over the unit interval [0,1], shown as OG, in figure 1a. The location of customer 2 is given by θ_2 and it is distributed uniformly over the unit interval [1,2], shown as GH, in figure 1a.. θ_2 is distributed independently of θ_1. Given their location, their valuation of the two brands is given by

$$v_c^{\alpha} = v_0 - |\theta_c - 0| \qquad for \quad c = 1,\ 2$$
$$v_c^{\beta} = v_0 - |\theta_c - 2| \qquad for \quad c = 1,\ 2 \tag{13}$$

where v_0 is a constant and θ_c denotes the location of the consumer c (c =1,2) on the line segment OH. The lines AD and EB, in figure 1a, represent the valuation of the two brands, α and β respectively, at each point along the line segment OH. By construction, consumer 1 is located in the left half of the line segment OH and thus (weakly) values brand α higher than brand β. The opposite is the case of consumer 2.

Let us first consider the case when there is no input supply uncertainty and the upstream firm produces two units of the input. We continue to assume, as in the previous section, that this is the only input required for downstream production and that each unit of the final output requires one unit of this input. Under the Nash bargaining framework, the upstream firm would find it optimal to supply one input to each of the two downstream firms. This is also the socially efficient allocation in this setting. The expected gross payoff of firm 1 would therefore be given by area AFOG while that for firm 2 would be given by FBGH. Under Nash bargaining, the upstream firm would get an expected payment of ½(AFOG + EFOG).[7] Therefore, the net expected payoff to downstream firm 1 would therefore be given by half of the area AFE. Similarly, the net expected payoff to downstream firm 2 would be given by half of the area FBD.

Now let us say that firm 1 is contemplating the introduction of a new brand at a point intermediate between the existing brands. Call this brand χ which is offered at point G in figure 1b. The dashed line segments QC and CP show the valuation of brand χ at different consumer locations along OH

$$v_c^{\chi} = v_0 - |\theta_c - 1| \qquad for \quad c = 1,\ 2 \tag{14}$$

[7] Note that this case is analogous to the case of non-integration with input shortage in table 1. There competition between the downstream firms for the scarce input leads the upstream firm to get a payoff of $\frac{1}{2}(v_1+v_2)$.

Let us assume that there are certain fixed costs of brand introduction (e.g. cost of research and advertising) entering given by X. Firm 1 would introduce this new brand only if the increase in its net expected payoff through introduction is greater than this cost. The increase in its net expected payoff here is given by half of the area ICFJ. So firm 1 would invest if ½ (area ICFJ) > X. On the contrary, note that it is socially optimal to introduce the new brand if area ICFJ > X. Thus it follows that under this case of non-integration, the downstream are likely to invest less than the socially optimal level in product differentiation.

Now let us consider the case where downstream firm 1 is vertically integrated with the upstream firm. Here the total payoff of the integrated firm prior to introduction of new brand would be AFOG + ½(FBHG + FDHG) = AFOG + FDHG + ½FBD. If the integrated unit introduces the new brand then its total payoff would increase by ICFJ + ½(FJK). Thus under vertical integration the downstream firm has greater incentives than if it is unintegrated to invest in product differentiation. This because under vertical integration it gets the entire value of its investment at the margin while when it is unintegrated it looses part of it under bargaining with the upstream firm. In fact, as shown here, a vertically integrated unit may invest in product differentiation even when it is not socially optimal. This is because investment in product differentiation also helps to increase market share and thus serves a strategic purpose. This leads to the following proposition

***Proposition 4**: If downstream firms compete in the output market then*

a) A vertically integrated firm is likely to invest more in product differentiation than an unintegrated downstream firm.

b) A vertically integrated firm is likely to invest beyond the social optimum in product differentiation.

Next let us consider the implications of input supply uncertainty in this setting. In the previous section we saw that with input supply uncertainty ($\lambda > 0$), the downstream firm has a greater incentive to integrate backwards compared to the case with an assured input supply ($\lambda = 0$). Since, as proved above, a vertically integrated firm invests more in product differentiation than an unintegrated firm, one is likely to observe more product differentiation and hence greater market concentration when there is input supply uncertainty.

In the above analysis, we have not considered the threat of new entry. However, in markets where this is important, product differentiation may also be used to deter entry. As Schamalansee points out, an incumbent firm may "seek to proliferate products to fill up those parts of the product space where there could be sufficient consumer demand to attract new entry" (p.315). In fact, he shows that if established firms collude to deter entry, then increasing the number of brands of a given product is a more jointly profitable strategy than limit pricing. Thus product differentiation leads to a situation where established firms earn excess profits but no potential entrant finds it attractive to launch a new brand. Padberg and Westgren (1979) in their study of the food manufacturing industry found product proliferation to be one of the major modes of competitive conduct of leading food manufactures. Clearly in markets where consumers have varied tastes, offering a wider variety of goods is likely to increase consumer welfare. However, investments in product differentiation may also serve a strategic purpose, as in the above-discussed cases, where it is used to increase market shares and may lead to socially excessive levels of product differentiation.

IV. Empirical Implications and Evidence from the Food Manufacturing Industry

The theoretical model presented in the previous section has the following broader empirical implications.

H1) The incentives for processing firms to integrate backwards into agricultural production are likely to be higher in cases where input supply assurance concerns are higher. Input supply assurance concerns are likely to be higher when: a) the input in question is essential to downstream production, b) there is a large uncertainty about its supply, c) the input is perishable and d) the costs of operating processing plants below capacity are high. Input supply assurance concerns are also likely to be higher when either the downstream or upstream market is highly concentrated.

H2) Vertical integration is likely to provide the integrating firm better protection against input supply and demand shocks. In cases where there is significant concentration in the upstream or downstream market, vertical integration is likely to aggravate the input supply assurance concerns of the other unintegrated downstream firm. It is also likely to (weakly) increase the total payoff of the integrated firm and (weakly) decrease the payoff of the unintegrated downstream firm.

H3) When supply assurance concerns are important, a vertically integrated firm is likely to invest more than an unintegrated firm to increase final product valuation. In oligopolistic settings where the downstream processing firms produce differentiated product that are imperfect substitutes in consumption, vertical integration is likely to lead to larger investment in product differentiation, which in turn, is likely to lead to greater market concentration.

H4) The above hypotheses together suggest the possibility of synergistic link between greater market concentration, vertical integration and product differentiation at the industry level. This is because supply assurance concerns are likely to be higher in industries where either the downstream or upstream market is highly concentrated. Excessive tendency towards vertical integration in such industries is, in turn, likely to lead to greater tendency towards product differentiation. Since product differentiation leads to further market concentration, it is likely to aggravate the tendency towards vertical integration and so on. In addition, note that if the production of differentiated products (say, leaner varieties of meat) requires more closely specified inputs (e.g. fed animals with more leaner tissue) then supply assurance concerns are likely to get aggravated leading to a greater motivation for vertical integration.

Before discussing the empirical validity of the hypotheses outlined above it is worth keeping in mind that our theoretical model is based on a very simple multilateral setting and some of our results are likely to be very sensitive to the assumptions we have made. For instance, we have assumed that there are no wealth constraints so that when it is privately beneficial for a downstream firm to integrate backwards it would do so. In practice, these constraints may be important as we show later in our examples from the food industry.

Also note that there is only one upstream and two downstream firms in our model. Therefore, by construction we have ruled out the possibility that a vertical merger may trigger a chain of other vertical mergers. If there are more upstream and downstream firms, this trigger effect is very likely and has been widely observed (Scherer). In such a case, a downstream firm that is considering the possibility of a vertical merger has to also take into account the expected response of other firms to its decision to merge. It may turn out that if other firms are also expected to respond by vertically integrating then it may not make sense for this firm to vertically integrate. It is also possible that vertical integration is a dominant strategy for everyone, but an equilibrium where everyone is vertically integrated is collectively irrational leading to a prisoner's dilemma kind of situation. Many other possibilities exist and in future work we hope to address these in greater detail.

Notwithstanding these limitations, we think our simple multilateral model helps to better understand the motivation for vertical integration and the effect of such an action on third parties and hence on industry structure. In work in progress, we are developing an econometric model to test for some of the above stated propositions. In this paper, however, we limit our attention to a discussion of evidence from existing studies that have used aggregated industry level data. The purpose of this part is to provide a broad perspective on the link between vertical integration, market concentration and product differentiation at the industry level to discuss the fourth hypothesis listed above. To test for the validity of the other three hypotheses relating to firm behavior, however, we would need to look at studies based on plant specific data.

A number of previous studies have found a positive relation between product differentiation and concentration at the industry level. For instance, Connor et al in their intensive study of the various food-manufacturing industries found that product classes with high levels of product differentiation also tended to be more concentrated. They argue that "product differentiation is the prime barrier to new competition in the food and tobacco manufacturing industries" (p.406). Using evidence from a number of econometric studies they estimate that the minimum efficient size of food manufacturing plants averaged only 2 to 3 percent of total industry shipments. Thus they contend that economies of size alone cannot explain or justify the levels or trends in market concentration observed in food manufacturing. Similarly, Marion and Kim cite the econometric analysis by Mueller and Rogers, which found a positive relation between advertising-created product differentiation and changes in market concentration in the period 1947-77. However, Marion and Kim argue that this pattern changed after 1977. They point out that in the late 1970s, industry groups with low levels of advertising, which had historically been characterized by low levels of concentration, increased sharply in concentration. Note that there was a significant relaxation in anti-trust regulation during the 1980s. Amongst the industry groups that showed a sharp increase in firm concentration ratios (CR4) were meat packing, broiler processing, flour milling, wet corn milling and cottonseed and vegetable oil mills. They found that in these industry groups mergers and acquisitions accounted for one third of the increase in CR4, while internal growth accounted for only one-third of the increase. This is further confirmed in a recent study by Ollinger et al. using the Census plant-specific data from the Longitudinal Research Database (LRD). This study found that the market share of plant acquisitions and firm expansions by incumbent firms in the meat and poultry industries exceeded the market share of new entrants and new plants in the period from 1962-1992.

None of the above mentioned studies explicitly looked at vertical mergers. To get some idea on how vertical integration may be linked to the above-mentioned trends, we have presented some statistics on extent of vertical integration, product differentiation and concentration in a cross-section of U.S. food manufacturing industries in Table 2. The industries are classified according to the 4 digit Standard Industrial Classification (SIC) and are presented in increasing order of vertical integration. The extent of vertical integration is measured by the percentage of farm-to-processor product flow that is accounted for by vertically integrated firms. The extent of product differentiation is difficult to measure directly and so it is fairly common to use the advertising to sales ratio as a proxy. This is because advertising is one of the major methods used by firms to maintain or strengthen the level of product differentiation (Connor et al.). In general, introduction of new products is accompanied by heavy advertising.[8] It is estimated that advertising expenditures

[8] However, this measure has several limitations too. For instance, as Connor et al point out, a firm that is so successful in differentiating its products so as to drive all others from the market would then drop its level of advertising. Also in highly concentrated industries, firms may collude to reduce their advertising outlays. Moreover, there are some products, like milk, which do not lend themselves much to brand advertising. These products may receive an industry-

per dollar of sales are higher for foods than nearly all other categories of goods (Connor et al.). Finally, the extent of concentration in table2 is measured by the percentage of total value of shipments accounted for by the four largest companies. Further details on the source and construction of the variables shown in this table are presented in the footnotes to the table.

The statistics presented in table 2 provide some support for the proposition that vertical integration is likely to be associated with greater product differentiation in oligopolistic markets. As shown in the table, industries that are highly vertically integrated also have medium to high levels of product differentiation. However, there are some important exceptions and this may at least partly be due to the fact that some products are more amenable than others to advertising-created product differentiation. So it might not be a profitable strategy for all brand manufacturers to advertise heavily. Thus for instance, attempts to differentiate brands of canned fruits and vegetables and fluid milk have met with limited success so far (Connor et al.).

Also note that most of the industry groups associated with high levels of vertical integration in 1982, were also highly concentrated at that time. What is perhaps more interesting is the fact that in these industry groups, the concentration ratio has shown an upward trend over the period 1967 to 1992. In table 2, the Macaroni and Spaghetti group has the highest level of vertical integration. Vertical integration of farming and processing stages has provided firms in this industry group with greater control over the quantity and quality of the grain produced and has enabled them to differentiate a variety of high-quality products preferred by health conscious consumers. The concentration ratio for this sector has more than doubled from 31% in 1967 to 78% in 1992.

Another interesting example here is that of preserved fruits and vegetables sector, which includes, canned, dehydrated and frozen vegetable and fruit industry groups. Here processors have integrated backward into farm production or entered into contracts to improve the scheduling of deliveries to their processing plants. This trend towards greater vertical coordination has been accompanied by a high degree of product differentiation through advertising national or regional

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supported generic advertising (such as the Drink Milk ads) but this type of advertising may have little or no effect on brand differentiation.

brands. Reimund et al argue that product differentiation has been the primary strategy employed by vegetable processors to "gain a larger market share and to increase their selling prices above competitive levels"(p.40).

The ready to eat breakfast cereal (hereafter, RTE) industry is often cited as a prime example of an industry with high level of product differentiation and concentration. The level of vertical integration here is moderately high (see table 2). The RTE industry has been highly concentrated since the post-war period with the top six firms accounting for more than 95% of the market in the 1960s. Between 1950 and 1972, these six leading firms introduced over 80 brands into distribution (Schamalansee). In 1972, the U.S. Federal Trade Commission issued a complaint charging that "these practices of proliferating brands, differentiating similar products and promoting trademarks through intensive advertising result in high barriers to entry into the RTE cereal market." In 1972, the share accounted by the top 4 firms (CR4) was 90%. It fell to 86% in 1982 and has remained relatively stable since then.

The only econometric study that we are aware of which has looked at vertical integration, concentration and product differentiation in an integrated framework is by Frank and Henderson. They were interested in examining the role of transaction costs as determinants of vertical coordination and found input supply uncertainty, downstream concentration ratio and advertising to sales to have a significant positive influence on the extent of vertical integration (measured as the ratio of sales to value added). A problem with their study, however, is that many of their explanatory variables, such as downstream concentration ratios and advertising to sales ratio are potentially endogenous. As we have shown in the theoretical model earlier, vertical integration is likely to affect concentration ratios and product differentiation and so a simultaneous equations model is likely to be more suitable.

The above-discussed evidence based on SIC 4-digit classification provides some preliminary support of a link between at vertical integration, concentration and product differentiation at the industry level. However, it does not throw much light on how exactly one variable affects the other. Also looking only at this level of aggregation may be misleading to some extent. Thus, for instance, consider the SIC 4-digit class, 2011, which is labeled "fresh and frozen food". It includes a wide variety of very different products such as beef, veal, lamb, pork and sausage. The motivation for vertical integration and its effects are likely to be very different across these products. In work in progress, we look at a more disaggregated classification using evidence from studies that have used plant-specific data.

V. Summary and Conclusions

Previous studies on vertical integration in the food industry have focused on providing a rationale for the growing trend towards vertical integration in terms of the private efficiency gains that integration entails. These studies generally assume a bilateral setting and thus ignore the possibility of third party effects, which may be very significant particularly in cases where the upstream or the downstream market is highly concentrated. In this paper we have used a simple multilateral setting to examine the divergence that may arise between social and private incentives to vertically integrate.

We show how backward integration by a processing firm provides it better protection against input supply shocks and demand uncertainty, and increases its payoff while decreasing the payoff of its competitor. Under the Nash bargaining framework assumed here, investments by the integrated firm increase its bargaining power and its share of the market pie, leading it to invest beyond the socially optimal level. In particular, given the oligopolistic setting that characterizes the food manufacturing industry today, our results imply that a vertically integrated firm is likely to invest more in product differentiation than an unintegrated firm. Since product differentiation, in general leads to greater concentration, this suggests that vertical integration is likely to lead to further increase in downstream concentration. Earlier studies have looked at the growing trends towards vertical integration, product differentiation and concentration in isolation. Our study suggests that, under certain conditions, there might be a synergistic link between these variables that needs to be explored further.

As vertical coordination grows, the spot market becomes thinner and thinner, and acts essentially as a shock absorber. Thus it is not surprising, as many studies find, that the overall effect of captive supplies on input prices may be low but their effect on market downturns may still be quite significant (Ward et al. provides a survey). In the next section we examine these implications of the supply assurance problem more rigorously in a multilateral context.

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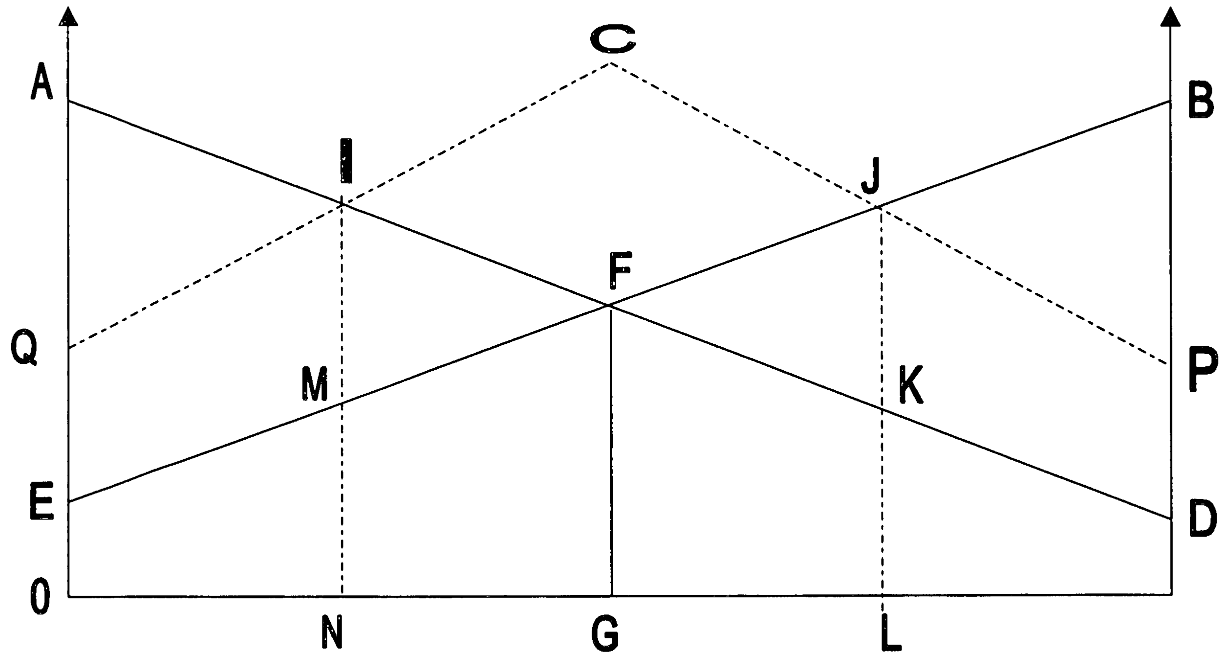

Figure 1a

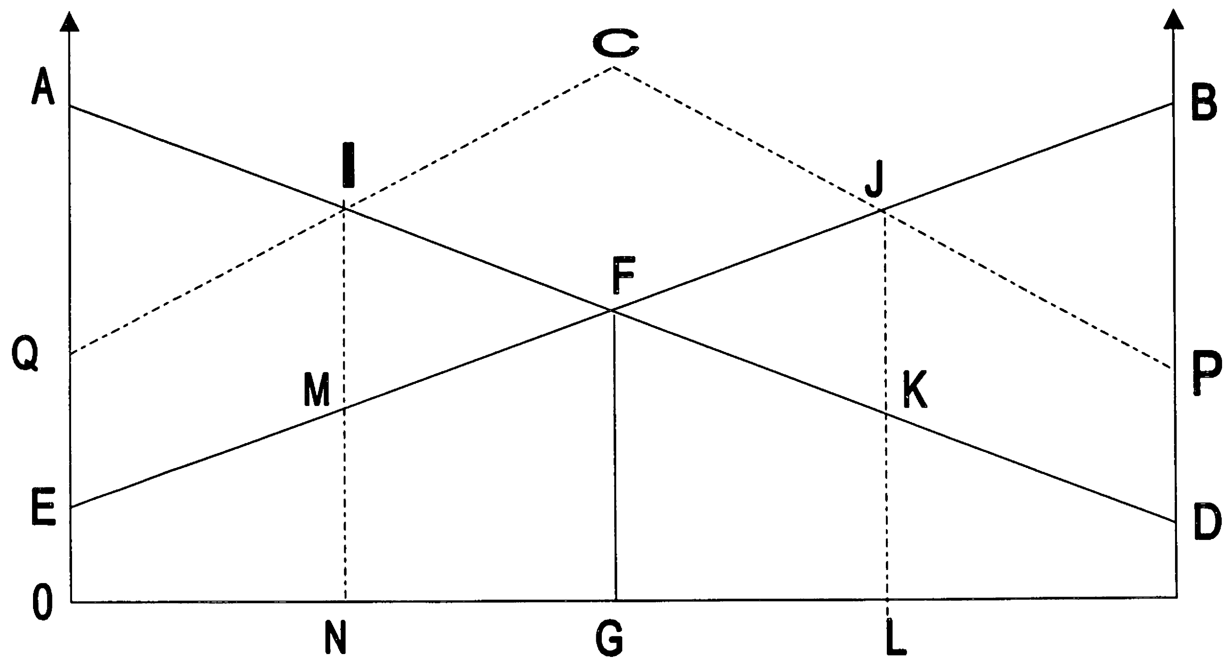

Figure 1b

Table 1:Nash Bargaining Gross Payoffs under Alternative Ownership Structures

Ownership Structure	**Upstream Production (Q)**	Bargaining Payoff to **U**	 D$_1$
HI	$Q = 2$	$\frac{1}{2}(v_1 + v_2)$	$\frac{1}{2}(v_1 +$
	$Q = 1$	$\frac{1}{2}\text{Max}(v_1, v_2)$	$\frac{1}{2}\text{Max}($
VI$_1$	$Q = 2$	$v_1 + \frac{v_2}{2}$	
	$Q = 1$ and $v_1 \geq v_2$	v_1	
	$Q=1$ and $v_1 < v_2$	$v_1 + \left(\frac{v_2 - v_1}{2}\right)$	
NI	$Q = 2$	$\frac{v_1 + v_2}{2}$	$\frac{v_1}{2}$
	$Q = 1$ and $v_1 > v_2$	$v_2 + \left(\frac{v_1 - v_2}{2}\right)$	$\frac{v_1 - v_2}{2}$
	$Q = 1$ and $v_1 \leq v_2$	$v_1 + \left(\frac{v_2 - v_1}{2}\right)$	0

Table 2: The Extent of Vertical integration, Product Differentiation and Concentration in Food Manufacturing Industries

(SIC 4 digit classification presented in order of increasing vertical integration)

	Vertical Integration[1]	Product differentiation[2]	Concentration Ratio[3] (CR4) 1967	1982	1992
Chocolate and Cocoa Products	0.0	Medium	77	75	75
Animal and marine fats and oils	0.0	Low	28	34	37
Shortening and Cooking Oils	0.0	Medium	43	43	35
Bottled and canned soft drinks	0.0	Medium	13	14	37
Canned and cured seafoods	0.00	Medium	44	62	29
Roasted Coffee	0.0	Medium	53	65	66
Flour and other grain mill products	0.5	Low	30	40	56
Rice milling	0.5	Medium	46	47	50
Wet corn milling	0.5	Low	68	74	73
Prepared feeds	0.5	Low	n/a	20	23
Soybean oil mills	0.5	Low	55	61	71
Other Vegetable Oil Mill Products	0.5	Low	56	52	89
Distilled Liquor	0.5	High	54	46	62
Dog, cat, and other pet food	0.7	High	n/a	52	58
Cottonseed oil mills	1.0	Low	42	51	62
Prepared fresh and frozen fish and seafood	1.0	Low	26	14	19
Creamery Butter	1.3	Low	15	41	49
Cheese, natural and processed	1.3	Low	44	34	42
Dried milk products and evaporated milk	1.3	Low	41	35	43
Fluid Milk	1.3	Low	22	16	22
Confectionery Products	2.7	Medium	25	40	n/a
Fresh and frozen meat	3.5	Low	26	29	50
Cereal Breakfast Foods	5.4	High	88	86	85
Ice Cream and Frozen Desserts	6.6	High	33	22	24
Poultry dressing plants	14	Low	n/a	22	n/a
Pickles, Sauces and Salad Dressings	21.5	High	33	56	41
Canned Fruits and Vegetables	23.6	Low	22	21	27
Canned Specialties	24.9	High	69	62	69
Bread, Cake and Related Products	25.0	Medium	26	34	34
Frozen Specialties	26.9	High	n/a	38	40
Wines, brandy, and brandy spirits	27.0	High	48	51	54
Dehydrated Fruit, Vegetables & Soup	27.7	Medium	32	42	39
Frozen Fruits and Vegetables	27.7	Medium	24	27	28
Macaroni and Spaghetti	44	High	31	42	78

Notes:

[1] Vertical integration is measured by the percentage of farm-to-processor product flow that is accounted for by vertically integrated firms. This data is taken from Frank and Henderson who calculate these percentages from the 1982 input-output transaction matrix between production agriculture (SIC 0111 to 0291) and food manufacturing (SIC 2,011 to 2,099) industries.

[2] Product differentiation is measured in terms of advertising to sales ratio (ADS). ADS less than 1% is classified as low, ADS between 1% and 3% as medium and ADS > 3% as high differentiation. The simple average of the product class ADS ratios for 1967, 1972 and 1977 was used. These figures are taken from Connor et al. and are based on data reported for advertising in six major media in the Leading National Advertisers Inc.

[3] Concentration Ratio (CR4) is measured by the percentage of total value of shipments accounted for by the four largest companies. This data is taken from the census of manufacturers.