Economic Impact of Vertical Coordination: A Multi-stage, Multi-player Analysis

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Short Summary
Using explicit theoretical models, this study analyzes the economic impact of alternative vertical coordination mechanisms in a three-stages production-marketing chain where interactions among multiples players at each stage, among players at different stages, and the price, output and welfare impact of such strategic behavior were computed. Policy implications are discussed.

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Introduction

Vertical coordination has become pivotal to the organization, conduct and performance in a production-marketing system of any product, particularly such consumer driven products as food. Vertical coordination refers to all possible economic arrangements involved in transferring resources between economic stages (Martinez, 1996). A firm's basic strategic decision to vertically coordinate or operate in the spot market is based on a number of factors, e.g. profit incentives, cost reduction and control incentives (Williamson, 1971). Some firms prefer to acquire or merge with an upstream firm (backward integration) or a downstream firm (forward integration). This type of ownership integration, where the integrated firms act as one firm, is also called vertical integration or vertical merger. Sometimes firms in subsequent stages may enter into an agreement regarding the production, supply and/or distribution of the product. Firms involved may place restriction on one another regarding pricing and non-pricing behavior, which is also called contractual integration.

The decisions made by firms at any level concerning supply and demand depends on the extent to which a firm has control over the demand and supply factors, and the random shocks that affect either the quantity supplied or demanded. Greenhut and Ohta (1979) found that the aggregate outputs and profits increase and prices lower when vertical merger or some other rationalization process takes place under oligopoly structure where firms are using fixed-proportion production technology. This is true when the successive stages of production involved independent monopolistic powers and greater efficiency in production derived from the integration process. Suominen (1992) proved that under variable proportions technology, vertical merger between a downstream and an upstream firm reduces the final product price when both stages of production are oligopolistic. Although the final output level increased, Suominen was unable to show the profit incentives for mergers in such a case.

Frank and Henderson (1992) empirically showed that reducing transaction costs are the primary motivation for vertical coordination in non-market arrangements. They also found that the most influential transaction cost factors are related to uncertainty, input supplier concentration, asset specificity, and scale economies. Vertical integration of successive oligopolists, using fixed proportion technology, led to an increase in the output, decrease in the prices, and increase in welfare (Greenhut and Ohta, 1979). Royer and Bhuyan (1995) analyzed the impact of vertical integration for cooperatives in a three-stage production-marketing chain under bilateral monopoly market structure. They found that vertical integration increases the total economic welfare making both the consumers and producer better off.

In the food marketing system, the number of market participants in each stage decreases as the product moves towards consumers. A concentrated market is likely to foster market power in the production-marketing chain (Cotterill, 1993). The market power that each participant exercises over the subsequent stage(s) or preceding stage(s) increases with the decrease in the number of participants in each stage. Such power would effect prices paid and received by various market participants at each stage. In addition, level of output and profits at various stages will be affected. Existence of buyer or seller power will influence economic welfare, which is decomposed into consumer surplus and producer surplus. However, the evolution of new technology and new areas of production have made the structure of the food industries more dynamic and the issues of market power and economic welfare at various stages of the food marketing chain have become more important. The meat industry (particularly beef packing) has seen drastic structural changes, both horizontally and vertically, over the past several decades and as a result has been the focus of numerous studies. Both contract production and full vertical integration in the pork and poultry industry have moved these industries to a more concentrated production, with fewer and smaller firms. Most analysts attribute the success of the poultry and pork industries to the high degree of vertical coordination between different links in production chain (Lamb, 1998). Vertical coordination has allowed them to become consumer-product driven industries while achieving significant cost reductions that has lowered retail prices. Relatedly, the issue of market power at different stages of the food production and marketing chain is a highly debated issue and there is no unanimous conclusions in this regard.

A review of the existing literature shows a lack of research on comparing various vertical relationships in terms of their market power and welfare effects on the food production-marketing chain. To the best of our knowledge, relevant agricultural marketing literature did not focus on various vertical coordination mechanisms and their impact on output, price and welfare in a food production-marketing chain with alternative market structure scenarios. For instance, there is a lack of research on how a bilateral oligopoly-oligopsony type of market structure along with varied demand and cost conditions would impact on farmers and consumers under alternative vertical coordination mechanisms, such as contract vs. full or ownership integration.

With this background, the general objective of this study is to analyze the impact of the backward vertical coordination of processor(s) and assembler(s) on market performance. It is hypothesized that a processor will integrate backwards or enter into a contract with an upstream firm only if it increases its profits. Market performance is measured in terms of output and prices at various levels as well as in terms of the resulting welfare gains (or losses) by consumers and producers. The current study will compare among different vertical coordination scenarios. This research has business as well as policy implications. It is typical in the food industry that the producers have no market power to charge higher price or manipulate the level of output. The processors on the other hand exercise market power on the final market and also the preceding production stage.

Analytical Framework: Modeling Vertical Coordination

In general, production-marketing chain consists of producers, assemblers or intermediaries, processors, wholesalers, retailers and consumers. It varies with the type of product and various other factors. For instance, farmers market selling vegetables and fruits would be an example of direct marketing single stage market structure. Processed beef on the other hand, has to go through several stages such as producers, slaughter house, assemblers, processors, manufacturers, wholesale/retailers and finally consumers. However, this study is limited to three stages, i.e., farmers, assemblers and processors. But the analytical models presented here can be extended to incorporate more stages or reduce the number of stages.

Farmers are assumed to produce the raw agricultural products (e.g., cattle) required to produce the final consumer product (e.g., beef in supermarkets). Farmers sell their product to the assemblers, who add value through intermediate processing (e.g., feeding, grading , cleaning, sorting, etc). Assemblers sell the partially value-added agricultural raw product (x) to the processors for the final processing. While there are numerous farmers, we assume that the number of assemblers and processors are limited, due to barrier to entry or other reasons. It is further assumed that the processors compete in a single homogenous output market, where q_i denotes the output of any of the firm (i = 1, 2,.., n). The total final output , Q_C, is the sum of all individual firms' output, i.e., q_1, q_2 ,…., q_n. Both assemblers and processors simultaneously and independently choose their respective output levels given their assumptions about the rivals' reactions to their output choice. These assumptions regarding rivals reaction are called conjectural variations. For firm *i* this equals the change in x_i, as indicated by *j*'s reaction function, in response to a unit change in x_i. The control over the demand and supply is also reflected by the conjectural variation.

Royer and Bhuyan (1995) illustrated that processing of many agricultural products is invariant to the alternate production processes that may be employed. Hence, the product technology is assumed to be fixed-proportions i.e., a processor employs the raw product in fixed proportion to other intermediate inputs, to produce the final product. This is the most commonly followed assumption for two reasons. Firstly, the food industry has a non-substitutability of key inputs, such as cattle or grain. Secondly, fixed proportion assumption allows researchers to develop mathematically more tractable models that provide insights into vertical coordination issues.

All models are operationalized using simulation with the parameter values taken from existing studies. To fulfill the study objectives, a theoretical model of oligopoly and oligopsony in a three-stage production-marketing setting is developed to determine output, price levels and profits at each stages. The impact of vertical coordination on price, output and profits is then measured.

In this study, we allow change in demand parameters to capture the impact of vertical coordination regimes on consumer welfare. Demand shocks capture changes in consumer preferences towards any good. Economic theory predicts that changes in cost would inversely impact the quantity supplied by market participants. Thus, changes in demand and cost have important implications on the welfare of market participants and the economy. Therefore, the effect of vertical coordination on the welfare of final consumers, intermediate market participants, and farmers in different oligopoly-oligopsony market structures is compared.

Farmers act competitively to determine their production decision where their marginal cost (MC_A) of production is equal to the price (P_A). Thus, aggregate supply function for the mean farm production is given by;

$$MC_A = P_A.$$

Assemblers face an aggregate upward-sloping raw product supply curve. Assume that an assembler's cost of handling the raw product is *h* per unit and the processor's per unit of processing cost is *c*, and they are constant.

Also assume that the market demand function for the final homogeneous product is negatively sloped and the input supply function facing the processor is positively sloped. There are large number of buyers of the final product who generate the following inverse demand function for i^{th} firm:

$$P_c = P_c\,(Q_c)$$

where, P_c denotes the output price of the final product. There are no other buyer(s) or seller(s) for the input. Then by definition, $Q_A = Q_B = Q_C$. As fixed proportion technology is used, the output quantity would remain the same in both the final output market and the input market. For simplicity, we assume that firms in a particular production-marketing statge have identical production function, e.g., at the processing stage, each processor has a production function which is identical to another processor.

The strategic decisions of the assemblers and the processors to integrate or to enter into contract alter the market outcome in regard to output levels and prices. In the following section three alternative vertical coordination scenarios are discussed viz., market transactions, full integration and full supply contract.

Market Transactions or the Spot Market

In this scenario, the transaction of intermediate goods between market participants in different stages is accomplished in an arms-length spot market. The structure of market transaction regime is illustrated in Figure 1. The assemblers are assumed to have market power (buyer power) over the farmers. The processors are assumed to have market power over the assemblers (buyer power) and the retail market (selling power). This assumption is in consonant with Azzam's (1990) finding that there is non-competitive behavior in the meat-packing industry in the input and the output market. In such a vertical structure where there is successive oligopsony, we follow the forward sequential solution procedure and hence start at the first stage, i.e., farmers. The i^{th} processor (i = 1, 2,..., n) is dominant and hence the j^{th} assembler (j = 1, 2,...r) takes the price it receives as given while exercising market power in the raw product market.

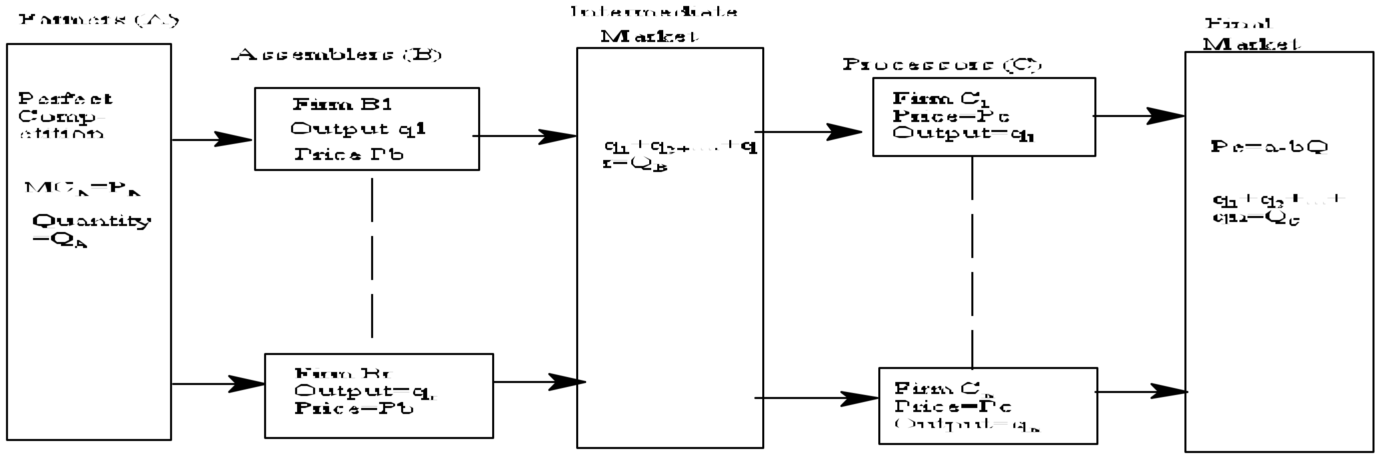

Figure 1: Spot Market Regime

Profit function of the j^{th} assembler is,

$$\pi_j^B = P_B q_j - P_A q_j - h\, q_j; \qquad j = 1,2,....,r \tag{1}$$

The first order conditions of profit maximization for the j^{th} assembler is given by;

$$\frac{\partial \pi_j^B}{\partial q_j} = P_B - P_A - q_j \frac{\partial P_A}{\partial q_j} - h = 0$$

$$P_B = P_A + q_i \frac{\partial P_A}{\partial q_i} + h \tag{2}$$

Equation (2) could be rewritten as,

$$P_B = MFC_{B_i} + h \tag{3}$$

The price received by the j^{th} assembler is equal to its marginal factor cost plus cost of assembling. Equation (3) shows the equilibrium condition for the j^{th} assembler. Aggregating (2) and dividing by the number of assemblers, we obtain the supply function facing each assembler as follows,

$$P_B = P_A + \left(\frac{Q}{r}\right)\frac{\partial P_A}{\partial q_j} + h \tag{4}$$

The profit function of the i^{th} processor is given by;

$$\pi_i^C = P_C\, q_i - P_B\, q_i - c\, q_i; \qquad i = 1, 2, \ldots, n \tag{5}$$

Substituting (3) in to (5) and then finding the profit maximizing first order condition for the i^{th} processor yields;

$$\frac{\partial \pi_i^C}{\partial q_i} = P_C + q_i \frac{\partial P_C}{\partial q_i} - \frac{d(MFC_B q_i)}{dq_i} - h - c = 0 \tag{6}$$

Rewriting equation (6), we can express the profit maximizing condition of processors as follows;

$$MR_{C_i} = \frac{d(MFC_{A_i})}{dq_i} + h + c \tag{7}$$

Aggregating equation (6) and dividing by n, we obtain the supply function facing each processor, i.e.,

$$P_C + \left(\frac{Q}{n}\right)\frac{\partial P_C}{\partial q_i} = \frac{d(MFC_B q_i)}{dq_i} + h + c \tag{8}$$

In economic terms, it could be rewritten as follows: $MRP = MVP$.

Full Supply Contract

In supply contract, each assembler is assumed to have an exclusive contractual relationship with a processor. The contractual relationship prevents the processor (assembler) from switching its vendor (buyer) of intermediate inputs, i.e., once the contract is signed, neither party can renege without severe penalty. Therefore, B_1 supplied only to processor, C_1 (Figure 2). Price of the semi-processed product is determined between each assembler and processor under contract thereby, eliminating intermediate input market. Thus, assembler cannot observe the actions of its competitor. But each assembler infers its rival's move from the observed output in the final goods market. Assumption of homogenous good and same conjectural variation at all levels, equalizes the price (P_B) for both assemblers.

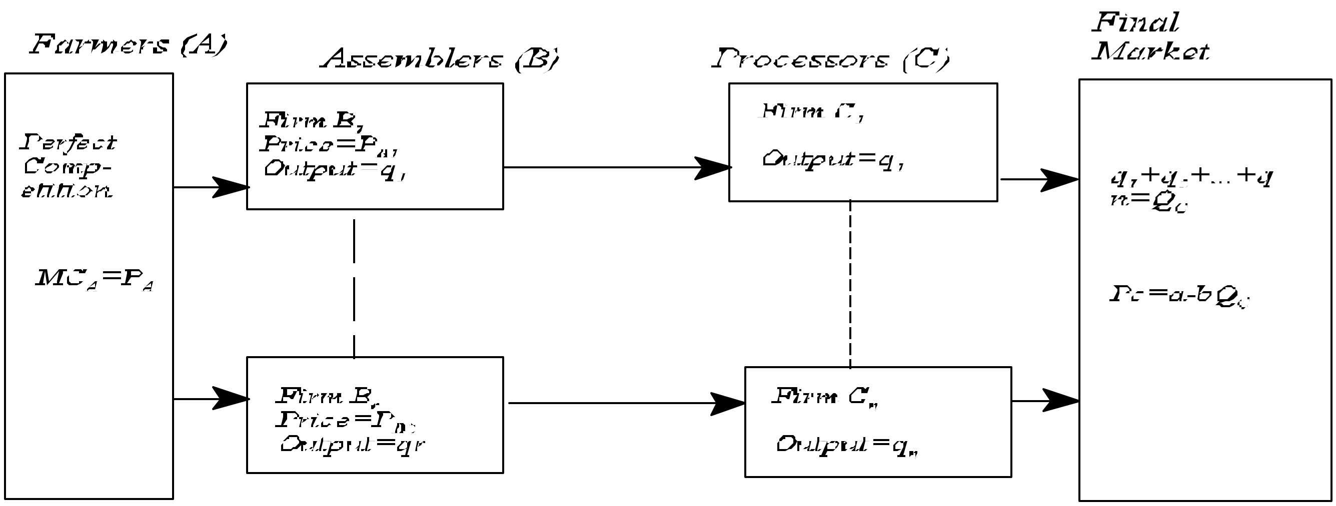

Figure 2: Full Supply Contract Regime

Processors have no oligopsony power over assemblers once the price is set through contracts. In such a vertical structure, an assembler would first know the price it receives from the processor and then decide how much to pay the farmer given its buyer power over farmers.

To arrive at market solution, we proceed with deriving the profit maximization condition;

$$\frac{\partial \pi_i^C}{\partial q_i} = P_C + q_i \frac{\partial P_C}{\partial q_i} - P_{B_i} - c = 0 \qquad (9)$$

This condition (9) can be rewritten as

$$MR_C = P_{B_i} + c \qquad (10)$$

where P_{Bi} is the contractual price paid to the assembler under contract. A processor would maximize profit at the level at which its marginal revenue equals the price it pays to the assembler plus processing cost. By aggregating equation (9) over n processors and dividing by n, we get the demand function facing each processor,

$$P_C + \left(\frac{Q}{n}\right)\frac{\partial P_C}{\partial q_i} = P_B + c \tag{11}$$

Assembler's profit function is given by;

$$\pi_j^B = P_B q_j - P_A q_j - h q_j \tag{12}$$

The first order condition for profit maximization yields;

$$\frac{\partial \pi_i^B}{\partial q_i} = P_B - P_A - q_i \frac{\partial P_A}{\partial q_i} - h = 0 \tag{13}$$

Equation (13) can be rewritten as;

$$P_B = MFC_A + h \tag{14}$$

The assembler maximizes its profit when its marginal factor cost plus the per-unit handling cost equals the price it receives from the processor. By aggregating equation (13) over r assemblers and dividing by r we get the demand function facing the producers.

$$P_B = P_A + \left(\frac{Q}{r}\right)\frac{\partial P_A}{\partial q_j} + h \tag{15}$$

Full Integration regime

Here each processor is assumed to have acquired one assembler i.e., each processor is fully integrated backwards (Figure 3). Now the integrated firm, which does both assembling and processing, buys the raw product from farmers. The full integration regime is depicted in figure 3.

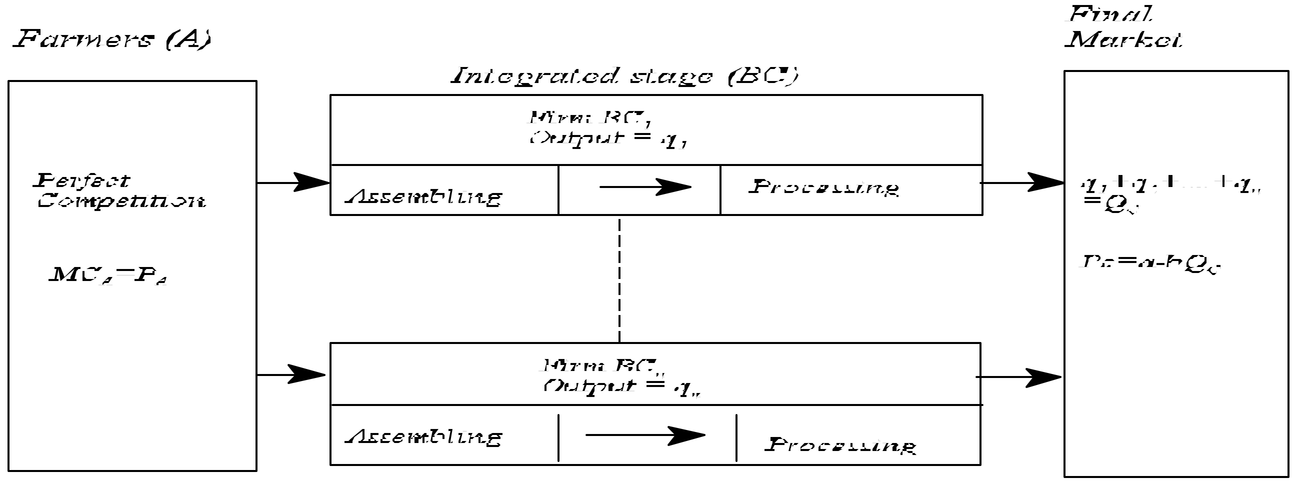

Figure 3: Full Integration Regime

In this post-integration scenario, the market can be represented in a two-stage oligopsony model. Because the independent assembler no longer exists, the market situation is no longer successive oligopsony. The new scenario is oligopoly in the product market and oligopsony in the raw product market. The integrated firm will maximize the joint profits from assembling and processing the raw product.

Profit function of the fully integrated i^{th} processor is given by;

$$\pi_i^{BC} = \pi_i^C + \pi_i^B \qquad i = 1, 2, \ldots, n.$$

The first-order conditions from profit maximization of the integrated firm is given by;

$$\frac{\partial \pi_i^{BC}}{\partial q_i} = P_C + q_i \frac{\partial P_C}{\partial q_i} - P_A - q_i \frac{\partial P_A}{\partial q_i} - h = 0 \tag{16}$$

The above condition could be rewritten to give an economic meaning as below;

$$MR_C = MFC_A + h \tag{17}$$

Aggregating over n processors and dividing by n, we get the supply function of each integrated firm as follows;

$$P_C + \left(\frac{Q}{n}\right)\frac{\partial P_C}{\partial q_i} = P_A + \left(\frac{Q}{n}\right)\frac{\partial P_A}{\partial q_i} + h + c \tag{18}$$

The integrated firm maximizes its profit when its marginal factor cost plus the per-unit handling cost equals its marginal revenue.

The equilibrium conditions are summarized in Table 1. Equilibrium condition at any stage in the vertical chain depends on the market power (buyer or seller power) that the market participants at that stage exercises. The farmers produced competitively and hence, the equilibrium condition remained the same in all regimes. Assemblers had market power in the input market (oligopsony) in both the spot market transactions and full integration regime hence, the equilibrium condition remained the same in both cases. This condition is equivalent to *MVP = MFC.*

Processors have market power in the input market (oligopsony) and on the output market (oligopoly) and hence, their equilibrium condition is *MRP = MFC* in the full integration regime. When the processor is operating in the open market, the equilibrium condition becomes *MRP = marginal of MFC.* Processors do not have market power over the assemblers in the supply contract regime and hence, the equilibrium condition changes to *MVP = MFC.* Since the product is homogenous, *MVP = Price*. Understanding of the underlying assumptions and structure of each regime leads us to the next step of obtaining solutions for output, prices, profits and welfare. The following section discusses the solutions obtained after simulation using specific functional forms.

Results and Discussions

In order to obtain comparable results for the three alternative vertical coordination regimes, parameters in model solutions were substituted by numeric values (Table 2). These values were based on existing research, e.g. Royer and Bhuyan (1995). Each model was simulated to examine the impact of conjectural variations, demand and cost on prices, output, profits and welfare.

Comparative analysis will help us understand the effect of conjectural variation, demand and cost on the above mentioned variables, under different regimes. The outcomes of the alternative vertical coordination scenarios have also been compared to give economic insights and compare them from the policy perspective.

Impact of Demand Change

Increase in *b* reduced the percentage of output difference between full integration or supply contract and open market (Table 3). Output in open market was lower in full integration or supply contract, when *b* was lower. Increase in *a* did not cause any change in the output difference for a given number of firms, in any of the regimes. Increase in *b* increased the difference in the price of the final product among different regimes. Percentage difference of P_C between open market and full integration or supply contract did not change due to change in *a*. In the supply contract regime, P_B was pre-determined and did not change for any number of firms, whether assemblers or processors. The increase in *b* had different impact in P_B on different regimes. P_B increased when *b* increased in the supply contract, but it decreased in the open market regime. Price of the raw agricultural product was lower when *b* decreased in all the regimes. Farmers received higher price in full integration and supply contract compared to open market regime.

Processors' profits in full integration remained higher than in other regimes for any values of *a* and *b* (Table 4). Assemblers' profits were always higher in supply contract than in open market. For any value of *a* and *b*, farmers' profits were higher in supply contract, than in full integration and least in open market. Consumer surplus was higher in full integration and supply contract than in open market for any value of *b* and *a*. Increase in *b* reduced the difference of consumer surplus between open market and full integration or supply contract by a meager amount. Producer surplus, consumer surplus and total welfare was highest in full integration and then in supply contract and least in open market for all values of *a* and *b*. Hence from a welfare point of view, full integration is always preferred for any value of *a* and *b,* i.e., either shift in the demand curve or a change in its slope.

Impact of Cost Change

Increase in cost had a negative impact on all the variables considered in this study. Increase in *f* and *e* decreased output for any number of processors and assemblers (Table 5). Percentage difference of output due to change in cost parameters in full integration or supply contract, and open market was almost the same. Change in *f* had a bigger impact than the change in *e* in any regime. Increase in cost lead to an increase in price at each of the respective stage in all regimes. Consumers paid the highest price in open market than in full integration or supply contract regime for any value of *e* and *f*. But the price difference between full integration or supply contract, and open market reduced at higher values of *e* and *f*. For instance, the difference between full integration or supply contract, and open market, was $0.91 and $0.53, when *f* was 0.5 and 1.0, respectively, and when n=r=1. This also indicates that for higher values of *e* and *f*, P_C tends to be the same for different regimes. Assemblers had to pay higher price to the farmers, when cost increased.

Increase in cost, reduced the profits of all the market participants, in all the regimes (Table 6). The impact of increase in cost offset the effect of increase in prices. No market participants were better off when cost increased. Processors obtained lower profits in supply contract and higher in the full integration regime. This is indicative of the impact of market power over the upstream or downstream firms. In other words, any market participants who does not face market power, is better off than those who faces it. Additionally, producer surplus decreased considerably, due to an increase in the costs. Increase in P_C and decrease in output reduced consumer surplus. Percentage decrease in consumer surplus was much greater than the percentage decrease in producer surplus in all the regimes. Consumer surplus, producer surplus and total welfare was the lower in the open market.

Impact of Conjectural Variation Change

Assemblers and processors in supply contract regime are assumed to react in the same way to the change in one another's output choices, as integrated firms in full integration. Hence quantity, P_C, P_A and consumer surplus were the same for both full integration and supply contract. Output was lowest in the open market regime, for any value of conjectural variation and any number of firms (Table 7). Output in open market was only 0.9 percent lower than in full integration, when n=100 and CV=0. Whereas, it was 47.6 percent lower for one firm. In full-collusion, i.e., CV=1, output was constant and equivalent to that in successive monopsony and monopoly situation in all the regimes. Processors' market power over assemblers did not exist in supply contract and full integration regime, and therefore, output was higher in supply contract and full integration.

Final product price (P_C) was higher in full integration and supply contract regime than in the open market. Assemblers did not face oligopsony power from the processors and therefore, received very high price in supply contract compared to open market. In monopoly situation, P_B was nearly 50 percent lower in open market than in supply contract. But this difference narrows down for higher number of firms. For higher values of conjectural variation, this difference remains high since higher values of conjectural variation indicates that the market situation is approaching monopoly-monopsony or full-collusion.

Farmers received higher price in full integration and supply contract than in open market. Processors' profits were higher in full integration compared to supply contract and open market (Table 8). In full integration, the two stages, viz., processing and assembling, were managed by processors, which increased their profits. There is double markup in supply contract regime which is reaped by processors when they integrate with assemblers. Hence, processors' profits in the full integration are higher than the combined profits of processors and assemblers in the supply contract regime. Assemblers made higher profits in supply contract than in open market due to the absence of oligopsony power from processors. Farmer obtained low profits in open market. The difference among regimes is much less for lower values of conjectural variation. Therefore, market structure primarily influences the market power.

Consumer surplus in the open market was approaching that in full integration and supply contract when the market situation was approaching Cournot situation, i.e., conjectural variation decreasing, and number of firms was increasing. Consumers benefitted the most whenever the number of firms increased and conjectural variation decreased. Additionally, absence of market power in any level increased consumer benefits (surplus). High profits earned by processors in full integration increased producer surplus more in the full integration more than in any other regime. Producer surplus was lower in the open market. The difference in producer surplus between supply contract and open market increased whenever the number of firms decreased and conjectural variation increased. Total welfare was highest in full integration than in supply contract and least in open market for any value of conjectural variation and for any number of firms.

Overall, processors were better off (in terms of profits) in the full integration; and the assemblers and farmers in the supply contract regime. Farmers obtained higher profits whenever the number of firms increased, conjectural variation decreased, demand increased, and cost decreased. Consumers were better off in full integration or supply contract than in open market regime. Total welfare was higher in full integration than in any other regime for any value of conjectural variation, or demand and cost change. In the following section, the results are summarized and concluded.

Summary and Conclusions

Simulation results show some interesting insights, some of which are predicted by standard economic theory. For instance, as expected output was the lowest in a monopoly-monopsony situation and under full-collusion (where firms acted as a single firm). Output increased whenever the number of firms in the intermediate stages, i.e., either processors or assemblers, increased. Or that increased market power decreased output and increased price, i.e., had adverse effect on welfare, particularly consumer welfare. Conversely, rise in the number of firms in any intermediate stages of the production-marketing chain or lack of market power therein benefitted farmers because they received higher price for their agricultural produce. However, this study finds that vertical coordination in the form of supply contract is better than open market transactions if market power exist in one of the intermediate stages, e.g., at the processing stage. When demand was inelastic consumers paid higher price for the product regardless of the market structure and type of vertical coordination regime, *ceteris paribus*. Firms at the intermediate stage (e.g., assembling) received higher price when there were more number of firms downstream and/or when those downstream firms did not have monopsony power. Relatedly, it may benefit intermediate firms to go into contract with their downstream firms if these downstream firms do have monopsony power. However, downstream firms (e.g., processors) were better-off in full integration, i.e., when they owned both assembling and the processing. Processors benefit was the highest when they were able to exercise market power as buyers of agricultural raw material (e.g., cattle) and as sellers of processed food products (e.g., boxed beef).

In terms of implications, this study shows the impact of market structure and alternative vertical coordination mechanisms on consumer as well as producer welfare, including that of farmers and food processors. In terms of business strategy, it was clear from the study that keeping the consumer demand inelastic, food processors can increase their share of consumer surplus (perhaps that is why there is so much emphasis on advertising!), or that it is better for upstream producers (e.g., farmers) to get into contracts with the downstream firms (e.g., processors) if the downstream firm posses buyer power.

Although simplified assumptions about production technology and demand and cost structures were made (mainly for the purpose of our ability to tract the economic model), we acknowledge that the “real world” is more complex and will require modifications to our models. For instance, the price of the final product is influenced by several factors other than quantity, such as price of a substitute, income, among others, or the more realistic production technology may be that of variable proportion technology. One of the positive aspect of this study, however, is that the models developed here could be applied to production-marketing chain of any non-food sector. Finally, in terms of future research agenda, we plan to extend our study to include partial supply contract and partial integration regimes as well as modify some of our study assumptions.

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Table 1: Summary of Equilibrium Conditions under Alternative Vertical Coordination Scenarios

Regimes	Farmers (A)	Assembler (B)	Processor (C)
Market Transactions	$MC = P_A$	$P_B = MFC_A + h$	$MR_C = \frac{d(MFC_A q_i)}{dq_i} + h$
Full- Integration	$MC = P_A$	- NA -	$MR_C = MFC_A + h$
Full- Supply Contract	$MC = P_A$	$P_B = MFC_A + h$	$MR_C = P_{B_i} + c$

Table 2: Parametric Values used in the Simulation Models

Attributes	Values in Different Scenarios		
Conjectural Variation	0.0	0.5	1.0
Demand	a = 45 b = 0.05	a = 45 b = 0.25	a = 90 b = 0.05
Cost	e = -2 f = 0.5	e = -2 f = 1.0	e = -4 f = 0.5

Table 3: Prices and Output under Alternative Vertical Coordination Scenarios and Demand

Prices/Output	Regimes	Demand parameters					
		a=45 b=0.05		a=45 b=0.25		a=90 b=0.05	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100
P_C ($)	FI	42.89	41.65	37.27	32.7	85.85	83.39
	SC	42.89	41.65	37.27	32.7	85.85	83.39
	OM	43.9	42.28	40.36	34.5	87.82	84.65
P_B ($)	FI	-	-	-	-	-	-
	SC	40.28	40.28	42.29	42.29	40.83	40.83
	OM	20.2	32.28	16.66	24.5	41.62	65.43
P_A ($)	FI	19.09	31.54	13.47	22.6	39.55	64.08
	SC	19.09	31.54	13.47	22.6	39.55	64.08
	OM	9.05	25.18	7.28	18.99	19.76	51.54
Output (million lbs)	FI	42.18	67.09	30.93	49.2	83.09	132.15
	SC	42.18	67.09	30.93	49.2	83.09	132.15
	OM	22.1	54.36	18.56	41.99	43.52	107.08

Note 1: e=-2, f=0.5, conjectural variation= 0.25. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: *a* and *b* are the intercept and the slope of the demand function. Note 4: P_C, P_B and P_A refers to prices received by processors (C), assemblers (B) and farmers (A), respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.

Table 4: Profits and Welfare under Alternative Vertical Coordination Scenarios and Demand (Million Dollars)

Profits/ Welfare	Regimes	Demand parameters					
		a=45 b=0.05		a=45 b=0.25		a=90 b=0.05	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100
Profit at stage C	FI	1783.91	2753.68	1134.22	1579.28	7083.12	10941.22
	SC	88.97	57.95	239.22	155.82	345.21	224.85
	OM	512.61	516.52	430.59	398.96	1989.04	2004.21
Profit at stage B	FI	-	-	-	-	-	-
	SC	889.65	579.48	478.44	311.63	3452.05	2248.53
	OM	244.1	380.49	172.24	227.01	947.16	1476.4
Profit at stage A	FI	442.83	1123.21	237.22	603.11	1724.02	4364.07
	SC	446.83	1127.21	241.22	607.11	1728.03	4368.07
	OM	120.05	736.82	84.12	438.79	471.58	2864.8
Consumer Surplus	FI	44.48	112.52	119.61	302.56	172.6	436.61
	SC	44.48	112.52	119.61	302.56	172.6	436.61
	OM	12	74	43	220	47	287
Producer Surplus	FI	2227	3877	1371	2182	8807	15305
	SC	1425.4	1764.6	958.9	1074.6	5525.3	6841.5
	OM	876.76	1633.84	686.95	1064.76	3407.78	6345.41
Total Welfare	FI	2271.22	3989.42	1491.05	2484.95	8979.75	15741.9
	SC	1469.9	1877.2	1078.5	1377.1	5697.9	7278.1
	OM	889	1708	730	1285	3455	6632

Note 1: e=-2, f=0.5, conjectural variation= 0.25. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: *a* and *b* are the intercept and the slope of the demand function. Note 4: C, B and A are the processors, assemblers and farmers, respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.

Table 5: Prices and Output under Alternative Vertical Coordination Scenarios and Costs

Prices/Output	Regimes	Cost parameters					
		e=-2 f=0.5		e=-2 f=1		e=4 f=0.5	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100
P_C ($)	FI	42.89	41.65	43.9	43.24	43.16	42.08

	SC	42.89	41.65	43.9	43.24	43.16	42.08
	OM	43.9	42.28	44.43	43.59	44.04	42.63
P_B ($)	FI	-	-	-	-	-	-
	SC	40.28	40.28	42.29	42.29	40.83	40.83
	OM	20.2	32.28	20.73	33.59	23.34	33.86
P_A ($)	FI	19.09	31.54	20.1	33.14	22.36	33.21
	SC	19.09	31.54	20.1	33.14	22.36	33.21
	OM	9.05	25.18	9.32	26.22	13.62	27.67
Output (million lbs)	FI	42.18	67.09	22.1	35.14	36.73	58.41
	SC	42.18	67.09	22.1	35.14	36.73	58.41
	OM	22.1	54.36	11.32	28.22	19.24	47.33

Note 1: a=45, b=0.05, conjectural variation=0.25. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: *e* and *f* are the intercept and slope of the supply function. Note 4: P_C, P_B and P_A refers to prices received by processors (C), assemblers (B) and farmers (A), respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.

Table 6: Profits and Welfare under Alternative Vertical Coordination Scenarios (Million Dollars)

Profits/ Welfare	Regimes	Cost parameters					
		e=-2 f=0.5		e=-2 f=1		e=4 f=0.5	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100
Profit at stage C	FI	1783.91	2753.68	956.62	1498.54	1563.25	2422.94
	SC	88.97	57.95	24.41	15.9	67.44	43.93
	OM	513	517	263	268	389	392
Profit at stage B	FI	-	-	-	-	-	-
	SC	889.65	579.48	488.2	317.99	674.45	439.31
	OM	244.1	380.49	128.08	205.08	185.05	288.45
Profit at stage A	FI	442.83	1123.21	242.1	615.46	335.22	851.02
	SC	446.83	1127.21	246.1	619.46	339.22	855.02
	OM	120.05	736.82	62.04	396.2	90.53	558
Consumer Surplus	FI	44.48	112.52	12.2	30.87	33.72	85.3
	SC	44.48	112.52	12.21	30.87	33.72	85.3
	OM	12.2	73.88	3.2	19.91	9.25	56.01
Producer Surplus	FI	2226.73	3876.89	1198.72	2114	1898.47	3273.96
	SC	1425.45	1764.65	758.71	953.36	1081.11	1338.26
	OM	876.76	1633.84	452.67	869.42	664.19	1238.13
Total Welfare	FI	2271.22	3989.42	1210.92	2144.87	1932.19	3359.27
	SC	1469.93	1877.17	770.91	984.23	1114.84	1423.57
	OM	888.96	1707.72	452.87	889.33	673.44	1294.14

Note 1: a=45, b=0.05, conjectural variation=0.25. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: *e* and *f* are the intercept and slope of the supply function. Note 4: C, B and A are the processors, assemblers and farmers, respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.

Table 7: Prices and Output under Alternative Vertical Coordination Scenarios and Conjectural Variations

Price/Output	Regimes	Conjectural Variations					
		0.0		0.5		1.0	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100

P_C ($)	FI	42.89	40.82	42.89	42.2	42.89	42.89
	SC	42.89	40.82	42.89	42.2	42.89	42.89
	OM	43.9	40.86	43.9	43.08	43.9	43.9
P_B ($)	FI	-	-	-	-	-	-
	SC	40.28	40.28	40.28	40.28	40.28	40.28
	OM	20.2	39.9	20.2	27.01	20.2	20.2
P_A ($)	FI	19.09	39.76	19.09	26.03	19.09	19.09
	SC	19.09	39.76	19.09	26.03	19.09	19.09
	OM	9.05	39.39	9.05	17.21	9.05	9.05
Output (million lbs)	FI	42.18	83.53	42.18	56.06	42.18	42.18
	SC	42.18	83.53	42.18	56.06	42.18	42.18
	OM	22.1	82.8	22.1	38.4	22.1	22.1

Note 1: a=45, b=0.05, e=-2, f=0.5. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: CV refers to conjectural variation. Note 4: P_C, P_B and P_A refers to prices received by processors (C), assemblers (B) and farmers (A), respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.

Table 8: Profits and Welfare under Alternative Vertical Coordination Scenarios and Conjectural Variations (Million Dollars)

Profits/ Welfare	Regimes	Conjectural Variations					
		0.0		0.5		1.0	
		n=r= 1	n=r= 100	n=r= 1	n=r= 100	n=r= 1	n=r= 100
Profit at stage C	FI	1783.91	3359.81	1783.91	1579.28	1783.91	1783.91
	SC	88.97	3.49	88.97	79.34	88.97	88.97
	OM	512.61	38.03	512.61	598.15	512.61	512.61
Profit at stage B	FI	-	-	-	-	-	-
	SC	889.65	34.88	889.65	793.41	889.65	889.65
	OM	244.1	34.26	244.1	372.68	244.1	244.1
Profit at stage A	FI	442.83	1742.25	442.83	783.56	442.83	442.83
	SC	446.83	1746.25	446.82	787.56	446.83	446.83
	OM	120.05	1710.96	120.05	366.99	120.05	120.05
Consumer Surplus	FI	44.48	174.42	44.48	78.56	44.48	44.48
	SC	44.48	174.42	44.48	78.56	44.48	44.48
	OM	12.2	171.3	12.2	36.9	12.2	12.2
Producer Surplus	FI	2226.73	5102.06	2226.73	3115.31	2226.73	2226.73
	SC	1425.45	1784.62	1425.45	1660.31	1425.45	1425.45
	OM	876.76	1783.25	876.76	1337.82	876.76	876.76
Total Welfare	FI	2271.22	5276.48	2271.22	3193.87	2271.22	2271.22
	SC	1469.93	1959.04	1469.93	1738.87	1469.93	1469.93
	OM	888.96	1954.54	888.96	1374.71	888.96	888.96

Note 1: a=45, b=0.05, e=-2, f=0.5. Note 2: 'n' and 'r' refer to the number of processors and assemblers, respectively. Note 3: CV refers to conjectural variation. Note 4: C, B and A are the processors, assemblers and farmers, respectively. Note 5: FI, SC and OM refers to full integration, supply contract and open market, respectively.