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THE MEASUREMENT AND DETERMINANTS OF VERTICAL COORDINATION: A TRANSACTIONS COST APPROACH

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ABSTRACT

There is increased interest in vertical coordination as a more comprehensive industry structural variable than the traditional vertical integration measure. Vertical coordination includes not only vertical integration but all other vertical coordinating structures. Previous studies of vertical industrial organization did not examine the role of non-market exchange mechanisms outside the domain of vertical integration. The concept of a vertical coordination variable incorporating all coordinating structures bridges the gap in the dichotomy of market versus ownership coordination.

There is an extensive literature examining the factors affecting vertical integration. More recently, attention has focussed on transactional inefficiencies as a primary motivation for vertical integration. However, little empirically has been done to examine the economic motivations for vertical coordination. This paper proposes an innovative measure of vertical coordination and examines the determining factors motivating the use of vertical coordinating structures.

The vertical coordination measure incorporates product flow interdependencies between vertically related firms/industries plus coordinating structures utilized in the transfer of control. Coordinating structures examined include: 1) spot markets, 2) market specification contracts, 3) production management contracts, 4) resource providing contracts, and 5) integration.

To explain the food industries' incidence of vertical coordination due to transactional inefficiencies, several industrial characteristics affecting transaction costs are examined. These factors include future demand growth and uncertainty, market power, product and technical differentiation, flow economies, and firm size and specialization.

Based on four progressively comprehensive specifications of vertical coordination, the empirical analysis confirms the hypothesis that transaction costs are a primary motivation for vertical coordination. The most comprehensive vertical coordination measure incorporating product flow linkages and coordinating structures performed very well. The transaction cost factors most influential were those related to research and development, internal costs, flow economies, and input supplier concentration. Moreover, a comparison of the vertical coordination and vertical integration measures revealed the significance of the use of coordinating structures as a response to transactional inefficiencies.

THE MEASUREMENT AND DETERMINANTS OF VERTICAL COORDINATION: A TRANSACTIONS COST APPROACH

Increasing interest has arisen in vertical coordination as a more comprehensive industry structural variable than vertical integration. When considering the organization, synchronization, and efficiency of economic sub-sectors, vertical integration is only but one aspect. Vertical coordination includes not only vertical integration but all other forms of vertical harmonization. As such, it not only captures the process(es) of vertical synchronization, but also the interdependence between the vertical components in a sub-sector. The number and magnitude of vertical linkages provide insight into the importance of vertical coordination. Moreover, the mechanisms of coordination between interdependent stages affect not only the level of transactional efficiencies, but ultimately, the sub-sector's ability to meet consumer demands.

Commonly cited studies examining vertical coordination in the food manufacturing industries by Mighell and Jones and Marion (1976) qualitatively discussed the antecedents and implications of vertical coordination. These casually linked transaction costs to vertical integration. Recent work by Frank has demonstrated the robustness of the more comprehensive concept, vertical coordination, in terms of explaining economic performance. The purpose of this paper is to examine transaction costs and related factors as determinants of vertical coordination in the food industries.

Vertical Coordination and Transaction Costs

Mighell and Jones (pg. 1) define vertical coordination as "the general term that includes all the ways of harmonizing the vertical stages of production and marketing. The market price system, vertical integration, contracting, and cooperation singly or in combination are some of the alternative means of coordination." This may be interpreted as the many ways in which vertically interdependent stages are controlled and directed through various governance structures. Marion (pg. 180, 1976) further defines vertical coordination as the "process by which the various functions of a vertical value adding system are brought into harmony."

There is an extensive literature examining vertical integration, but relatively little on the more comprehensive concept of vertical coordination. Both Coase and Williamson (1975, 1979) have theoretically examined factors affecting the organization of production in a market-hierarchy framework. In this framework, the criterion for organizing production is the minimization of production and transaction costs (Williamson, 1979). Transaction costs are associated with the exchange of goods or services. Williamson (1979, pg. 233) suggests that transaction costs are the primary force behind vertical integration, stating that "if transaction costs are negligible, the organization of economic activity is irrelevant." That is, the form of vertical structure utilized is motivated by economic considerations (transaction costs).

Structural and environmental factors which affect transaction costs include market uncertainties (i.e. demand and price), the complexity and frequency of transactions, small numbers bargaining problems, and idiosyncratic investments. These factors lead to bounded rationality and/or opportunism. The institutional mechanisms of vertical coordination are a response to the degree to which bounded rationality (the intellectual and physical limitations of human behavior) and/or opportunism occur.

Past empirical studies have examined the effects of transactional inefficiencies on vertical integration (ownership), but not on vertical coordination. For instance, Levy and MacDonald examined the costs of using the market (transaction costs) to explain the incidence of vertical integration across manufacturing industries. That research found significant linkages between market costs and vertical integration. However, linkages between transaction costs and vertical coordination have not been empirically analyzed. Further, little empirical analysis has been reported on the effects of transaction costs on vertical linkages between farms and food manufacturing industries.

Classification of Vertical Coordination

The theory of vertical integration assumes ownership of assets in neighboring stages of production, allowing for complete control over the production process. However, control over adjoining stages of production need not be accomplished through direct ownership. Vertical coordination focusses attention on the role of contractual and implicit arrangements in vertical relationships. Contractual arrangements discussed by Mighell and Jones range from virtually no control to those that transfer almost complete control from one firm to another. Tacit arrangements (e.g. providing technical expertise and advice, increased credit, etc.) as discussed by Blois and Blair and Kaserman allow firms some control over vertically interdependent enterprises that are owned by others.

Williamson (1979) put forth a theoretical scheme for classifying solutions to coordination problems by identifying three classes of contracts; classical, neoclassical, and relational. Classical contracts are based on a set of legal rules with formal documents and self-liquidating transactions. Neoclassical contracts generally involve longer-term arrangements that do not cover all future contingencies. This contract scheme maintains a "trading" environment, but with additional governance structure (i.e. arbitration). As the duration and complexity of contract relationships progressively increase, the ability to achieve a discrete transactional equilibrium diminishes. Under these circumstances, relational contracts focus not only on the original agreement, but the entire spectrum of the contracting parties' relationship, including tacit as well as explicit arrangements.

In this scheme, increases in transaction complexity, frequency, and uncertainty, accompanied by idiosyncratic investments, results in a shift in the control or coordination structure from classical to neoclassical to bilateral and finally to unilateral relational contracts. Typically, under this progression, one party acquires increasing control.

Williamson's contract structure provides theoretical insight into the structure of vertical coordination. In an analysis of the food and fiber system, Mighell and Jones identified three general types of contracts: market specification, production management, and resource providing. These can be viewed to parallel Williamson's theoretical treatment of vertical coordination in terms of transferring control.

Market specification contracts are standardized contracts in which the supplier transfers part of the risk and management functions to the contractor. Transferred management only regards the decision of what to produce and when and where the product is to be delivered. Production management contracts are similar to market specification contracts except the contractor has increased control over the production process. When the contractor is concerned with the quality of production, the transfer of managerial decisions usually takes the form of resource specification. Finally, resource providing contracts are the closest to vertical integration. The contractor not only provides a market for the production, but also is a major provider of inputs into the production process.

However, when comparing Williamson's theoretical contract scheme and Mighell and Jones' contract classification, some limitations become obvious. Williamson uses "relational contracts" as a rather all encompassing term. It captures the explicit contractual ties of interdependent industries as well as the implicit arrangements between firms. Thus, "relational contracts" capture a dynamic relationship between interdependent firms. Interdependent firms establish a set of implicit trading relationships or standard operating procedures. Relational contracts entail adjustment processes as trading relations develop through time. By contrast, the Mighell and Jones' classification captures a more discrete and explicit form of inter-relationship between firms. As defined, these contracts do not reflect the tacit dynamics of many industrial relationships. Thus, these contracts do not capture the entire relationship as it evolves through time, understating the extent of common or shared control among vertically interdependent firms.

Empirical Measurement of Vertical Coordination

A specification which includes both ownership and explicit and tacit contractual relationships of vertically interdependent firms or industries should more completely measure vertical coordination than the traditional measures of vertical integration. Such a specification should include both the direct and indirect transfer or sharing of control, as well as the degree of interdependency among firms and industries.

Empirical research has examined vertical coordination primarily in the context of vertical integration. Studies by Adelman, Tucker and Wilder, Laffer, and Levy used variations of the value-added to sales ratio to calculate vertical integration. However, this ratio is influenced by such factors as firm profitability and the position of the firm in the production process. Moreover, it does not capture the partial transfer or sharing of control between vertically related firms/industries through contracts and agreements.

A second measure of vertical integration examines the linkages between industries through production functions. Maddigan advanced this measure, which considers the input-output interdependencies between firms. These interdependencies are captured by aggregate production functions and are expressed by physical input-output coefficients.

Because a complete specification of vertical coordination incorporates industry inter-relationships, plus the direct (ownership) and indirect (contractual) structures of control, a starting point for measuring vertical coordination is Maddigan's Vertical Industry Connection (VIC) index. This index exploits the interactions of the Leontief input-output model. Briefly, the Leontief model is based upon the theory of the firm. It is assumed each firm maximizes profits subject to its production function and final demand for its output. With the necessary and sufficient conditions satisfied, an optimal solution vector of inputs for each firm is determined. The optimal level of output for each firm is then obtained by substituting the solution vector of inputs into the firm's production function. The whole system of firms attains equilibrium when the value of the outputs supplied by each industry equals the demand for inputs by each industry and final output by consumers.

It is assumed each firm is characterized by a linear expansion path independent of the scale of operations. A less severe assumption is that firms have a linear expansion path over the relevant range of production. Therefore, the model describing the relative level of interaction between industries can be expressed in an input-output matrix by the consistent aggregation over products and firms. In the Leontief framework, each x_{ij} in the input-output transactions matrix X is the optimal value of industry i's output used as an input by industry j.

To examine the vertical relationship between production agriculture and food manufacturers, the input-output transactions matrix is constructed as illustrated in Figure 1. The four digit S.I.C.[1] scheme is used to classify or group firms into industries. The industries examined include those within the production agriculture sub-sector (S.I.C. 0111 to 0291) and the food manufacturing sub-sector (S.I.C. 2011 to 2099).

The input-output transactions matrix is manipulated to form the initial component of the up- and down-stream connections of the vertical coordination index. Two matrices A and B are created (Figure 2). Matrices A and B capture all net production interrelationships for the linkages between farms and food processors. Equations 1 and 2 depict matrices A and B, respectively:

$$A = I - [x_{ij} / (z_j - x_{jj})] + [y_{ij}] \tag{1}$$

and

$$B = [x_{ij} / (z_i - x_{ii})] - [y_{ij}] - I \tag{2}$$

where;

I = identity matrix, r x r,

x_{ij} = the value of the i^{th} industry's output used as an input to the j^{th} industry; $i, j = 1,\ldots,r$,

z_j = total value of the output of industry j; $j = 1,\ldots,r$,

y_{ij} = $[x_{ii} / (z_i - x_{ii})]$ if $i = j$; 0 if $i \neq j$; $i, j = 1,\ldots,r$.

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[1] Standard Industrial Classification.

	Agriculture						Food Manufacturing			Rest Of Economy	Total
	(4 - digit SIC)										
	0111	...	0191	0211	...	0291	2011	...	2099	ROE	
0111	$	...	$	.	...	.	.	...	$	$	$
.	.										.
.	.	.									.
.	.		.								.
0191	$			.							.
0211	$										
.	.										
.	.				.						
.	.										.
0291	.					.					.
2011							.				.
.	.										
.	.							.			
.											.
2099	$								.		
ROE	$	...	.	.	...	.	.	...	$	$	.
Total	$	...	.	.	...	.	.	...	.	$	

Figure 1. U.S. Input-Output Transactions Matrix.

$$A = \begin{bmatrix} 1 & \frac{-X_{12}}{Z_2 - X_{22}} & \cdot \quad \cdot \quad \cdot & \frac{-X_{1r}}{X_r - X_{rr}} \\ \frac{-X_{21}}{Z_1 - X_{11}} & 1 & \cdot \quad \cdot \quad \cdot & \frac{-X_{2r}}{Z_r - X_{rr}} \\ \vdots & \vdots & & \vdots \\ \frac{-X_{r1}}{Z_1 - X_{11}} & \frac{-X_{r2}}{Z_2 - X_{22}} & \cdot \quad \cdot \quad \cdot & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} -1 & \frac{X_{12}}{Z_1 - X_{11}} & \cdot \quad \cdot \quad \cdot & \frac{X_{1r}}{Z_1 - X_{11}} \\ \frac{X_{21}}{Z_2 - X_{22}} & -1 & \cdot \quad \cdot \quad \cdot & \frac{X_{2r}}{Z_2 - X_{22}} \\ \vdots & \vdots & & \vdots \\ \frac{X_{r1}}{Z_r - X_{rr}} & \frac{X_{r2}}{Z_r - X_{rr}} & \cdot \quad \cdot \quad \cdot & -1 \end{bmatrix}$$

Figure 2. The Up and Down Stream Connections Matrices.

Each element of matrix A, a_{ij}, represents the percentage of the value of industry j's net output contributed by industry i. Each element of B, b_{ij}, represents the percentage of the value of industry i's output used as an input by industry j. In short, matrix A is the up-stream industry connections and matrix B is the down-stream industry connections. Notationally, inputs are negative as values used in production and outputs are positive.

In order to calculate vertical coordination at the industry level, two matrices, C_K and D_K, are defined for each food manufacturing industry (four digit S.I.C., 2011 to 2099). Matrices C_K and D_K capture industry k's primary and secondary interindustry connections. For matrix C_K, for column j where $j = k$, industry k has a primary input relationship with industry i and for column j, $j \neq k$, industry k has a secondary input relationship with industry i. It is the obverse for matrix D_K, for row i, $i = k$, industry k has a primary output relationship with industry j and for row i, $i \neq k$, k has a secondary output relationship with industry j. The division of industry k with its interdependent industries is determined by the flow of net production. These matrices are constructed using the rows and columns of matrices A and B, specifically, the columns of A and the rows of B. Matrices C_K and D_K are represented by equations 3 and 4:

$$c_{ij} = a_{s(i)s(j)} \tag{3}$$

and

$$d_{ij} = b_{s(i)s(j)} \tag{4}$$

where;

s(i) = industries with which industry k is associated, indexed by i; $i = 1...n$ ($n \leq r$),

c_{ij} = the percentage of the value of industry s(j)'s net output contributed by industry s(i),

d_{ij} = the percentage of the value of industry s(i)'s net output used as an input to industry s(j).

Previous attempts to measure the degree of vertical coordination (Laffer, Tucker and Wilder, Ravenscraft, Maddigan, Levy, and MacDonald) did not fully incorporate coordinating arrangements (i.e. spot markets, various contracts, and integration) between interdependent industries. To complete the vertical coordination index, the degree of administrative control that is transferred to the contractor/integrator must be specified.

Administration of vertical interdependencies may be accomplished through direct ownership and/or a wide variety of contractual relationships. This implies the existence of a progressive relationship of shared control between the end points of no shared control (spot markets) and complete integration. Along this continuum, as firms use various types of contracts to transfer resources, the contractor-integrator internalizes increasing degrees of control over productive resources.

To calculate the vertical coordination for the food processing industries, it is necessary to have data regarding the use of various coordinating structures in agriculture. There is no systematic reporting and collection of agricultural contract data. But, a number of researchers have provided various estimates on contracts consistent with the Mighell and Jones classification. Contract data in accordance with Williamson's contract scheme would be preferable. Such data are not available. Therefore, to examine vertical coordination, the Mighell and Jones contract scheme is utilized.

To capture an industry's primary and secondary contractual interactions, matrices E_K and F_K are created. Each e_{ij} represents the measure of shared control for industry k with the up-stream industry i. Similarly, each f_{ij} represents industry k's shared control with down-stream industry j. The elements of matrices E and F are equal to the sum of the products of; the relative use of each coordinating structure and its degree of shared control between industries i and j. Five coordination structures are used: 1) spot markets, 2) market specification contracts, 3) production management contracts, 4) resource providing contracts, and 5) integration. To measure control, each coordinating structure is assigned a value representing the percent control transferred. A decreasing marginality functional relationship is specified for the transfer of control via each coordinating structure. This relationship represents the control transfer increasing at a decreasing rate for each successive coordination structure, moving from spot markets (0%) to integration (100%).[2] Equation 5 represents the calculation for matrices E and F:

$$e_{ij} \text{ and } f_{ij} = \sum_{g=1}^{n} \sum_{h=1}^{5} P_g L_{gh} S_{gh} \tag{5}$$

where;

g = number of products produced in each industry, $g = 1...n$,
h = type of contract, $h = 1...5$,
L = assigned value of control,
S = percent of production coordinated by each transaction type,
P = product g's percentage of industry i's output.

With matrices C, D, E, and F, the Vertical Coordination index can be calculated.

Equation 6 is the generalized formulation of the Vertical Coordination index for industry k:

$$VC_k = 1 - [1 / \prod_{i=1}^{n} (C^i)^P (D_i)^P (E^i)^P (F_i)^P] \tag{6}$$

where;
C^i = column i of industry k's up-stream connections matrix,
D_i = row i of industry k's down-stream connections matrix,
E^i = column i of industry k's up-stream control matrix,
F_i = row i of industry k's down-stream control matrix,
P = vector dot product,
n = number of industries which industry k is interdependent.

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[2] Several specifications for the degree of control transferred via various coordinating structures were examined. These included decreasing marginality, constant marginality, and increasing marginality. In an analysis of the three relationships, the decreasing marginality specification provided a stronger degree of explanatory power. Refer to Frank, pp. 38-44 and 61-71 for a detailed discussion.

The specified functional form of Vertical Coordination (VC) has several desirable properties.

1. VC increases (decreases) when an input industry becomes relatively more (less) important by accounting for a larger (smaller) percentage of the total value of output of another industry.

2. VC increases (decreases) when relatively more (less) of the output of an industry is used as an input to another industry.

3. VC increases (decreases) as an industry increases (decreases) its number of vertical interactions with other industries.

4. VC increases (decreases) as an industry exercises increased (decreased) up- and/or down-stream administrative control.

5. The range of VC is between 0 and 1.

Data on the usage of each type of vertical structure by food processors were unavailable. In order to approximate the up-stream control of the food manufacturing industries, data on the types of contracts utilized and the percentage of output transacted under each type of contract by the farm sector were used.

The values for each coordinating structure (i.e. spot markets, contracts, and integration) in Table 1 are used to represent the percentage of each used to coordinate farm commodity inputs in each food manufacturing industry. These figures represent only the food processing industries' use of such structures to organize their primary linkages with farm output.

The utilization of contracts and integration by the food processing industries may be understated. For many of the farm products marketed, the first handler is a food processor. The integration figures may be too low because the value of products

Table 1. Percentage of U.S. Food Processing Industries' Farm Originated Inputs Coordinated Through Various Structures.

		Contracts			
Industry	Spot Markets[a]	Market Specification	Production Management	Resource Providing	Integration
			(percent)		
Meat Packing	89.5	7.0	0.0	0.0	3.5
Sausages and other prepared meats	89.3	7.2	0.0	0.0	3.5
Poultry dressing	13.0	0.0	0.0	73.0	14.0
Poultry and egg processing	6.5	0.0	18.5	48.2	26.8
Creamery butter	17.7	81.0	0.0	0.0	1.3
Cheese, natural and processed	17.7	81.0	0.0	0.0	1.3
Condensed and evaporated milk	17.7	81.0	0.0	0.0	1.3
Ice cream and frozen desserts	19.0	70.8	3.6	0.0	6.6
Fluid milk	17.7	81.0	0.0	0.0	1.3
Canned specialties	30.1	6.2	38.8	0.0	24.9
Canned fruits and vegetables	35.4	10.4	30.6	0.0	23.6
Dehydrated fruits, vegetables and soups	24.9	14.0	33.4	0.0	27.7
Pickles, sauces, and salad dressings	36.9	1.3	40.3	0.0	21.5
Frozen fruits and vegetables	24.9	14.0	33.4	0.0	27.7
Frozen specialties	19.3	14.0	15.7	24.1	26.9
Flour and other mill products	91.7	7.8	0.0	0.0	0.5
Cereal breakfast foods	81.6	13.0	0.0	0.0	5.4
Rice milling	91.5	8.0	0.0	0.0	0.5
Wet corn milling	92.5	7.0	0.0	0.0	0.5
Dog, cat, and other pet food	93.3	6.0	0.0	0.0	0.7
Prepared feeds, n.e.c.	92.4	7.1	0.0	0.0	0.5
Bread, cake, and related products	40.0	35.0	0.0	0.0	25.0
Cookies and crackers	100.0	0.0	0.0	0.0	0.0
Raw & refined cane and beet sugar	0.0	0.0	69.0	0.0	31.0
Confectionery products	85.0	12.3	0.0	0.0	2.7
Chocolate and cocoa products[b]	100.0	0.0	0.0	0.0	0.0
Cottonseed oil mills	82.3	16.7	0.0	0.0	1.0
Soybean oil mills	89.5	10.0	0.0	0.0	0.5
Vegetable oil mills, n.e.c.	89.5	10.0	0.0	0.0	0.5
Animal and marine fats and oils	100.0	0.0	0.0	0.0	0.0
Shortening and cooking oils	100.0	0.0	0.0	0.0	0.0
Malt beverages	93.2	6.0	0.0	0.0	0.8
Malt	92.5	7.0	0.0	0.0	0.5
Wines, brandy, and brandy spirits	32.0	41.0	0.0	0.0	27.0
Distilled liquor, except brandy	92.5	7.0	0.0	0.0	0.5
Bottled and canned soft drinks[b]	100.0	0.0	0.0	0.0	0.0
Flavoring extracts and syrups, n.e.c.[b]	100.0	0.0	0.0	0.0	0.0
Canned and cured seafoods	100.0	0.0	0.0	0.0	0.0
Fresh or frozen packaged fish	96.0	3.0	0.0	0.0	1.0
Roasted coffee[b]	100.0	0.0	0.0	0.0	0.0
Macaroni and spaghetti	11.0	0.0	45.0	0.0	44.0
Food preparations, n.e.c.	79.0	16.0	0.0	0.0	5.0

[a] Residual values.

[b] Industry had no up-stream linkages.

Sources: Compiled from Marion 1986, Krause, Crom, Lasley, Van Ardsall et al., Flinchbaugh, Reimund et al., and Buckley et al..

transferred internally are not accounted for. For example, in the dairy industry, only the coordinating structure data for fluid milk were available. Thus, the same data were utilized for each dairy processing industry, even though processed dairy products (e.g. butter, cheese, etc.) are often manufactured at the same facility producing fluid milk products, that is, are vertically integrated. To the extent this occurs, the percentages for integration may be understated and for spot markets overstated for some of the food processing industries.

The coordinating structure data, Table 1, represents only the linkages between the farm output and food manufacturing sectors. There is a need for intra-food industry data. Many of the food manufacturing industries acquire their inputs from other food processing industries. However, food manufacturing industry down-stream coordinating structure data are not available. Therefore, the F-matrix in the Vertical Coordination index cannot be calculated. The absence of such data bias the vertical coordination index values downward. Moreover, this bias does not uniformly affect each food processing industry. If industry data were available, a clearer understanding of the vertical coordination relationships of the food manufacturing industries should result.

Empirical Specification of Transaction Costs Variables

To explain the incidence of vertical coordination between farm and food manufacturing industries due to transactional inefficiencies, several industrial characteristics affecting transaction costs are examined. These include future demand growth and uncertainty, market power, product and technical differentiation, and firm size and specialization (Table 2).

Future demand growth and the uncertainty of demand influence organizational characteristics. Williamson (1979, pg. 260) states, "as generic demand grows and the number of supply sources increases, exchange that was once transaction specific loses this characteristic and greater reliance on market mediated governance is feasible." As future demand increases, the motivation to vertically coordinate by means of non-market institutions diminishes. However, as demand uncertainty increases, market transactions become increasingly costly. With increased uncertainty, firms rely more on various governance structures to attenuate the costs associated with uncertainties. To capture anticipated demand growth (ADG) and unanticipated demand uncertainty (UNANT), the log of food industry sales are regressed on a time trend.[3] The values for ADG and UNANT are the time trend coefficient and the variance of the error term, respectively.

As the number of buyers and sellers in a market diminishes, "small numbers bargaining problems" become more prevalent. In such circumstances, firms utilize non-market institutions to reduce potential opportunistic behavior. To capture the buyer concentration and market power for the food industries, the food manufacturing industries' four firm concentration ratio (CR4) is used. Two variables capturing seller (input supplier) concentration, one each for the farm output industries and food manufacturing industries, were calculated. The variable FSGC is the farm output industry's GINI coefficient weighted by the net contribution of each farm output industry

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[3] Measures developed by Levy.

Table 2. Explanatory Variables Used In Analysis of Vertical Coordination.

Explanatory Variable	Description	Expected Sign
CR4	Four Firm Concentration Ratio	+
RD	Ration of Research and Development Expenditures to Sales	+
AS	Ratio of Advertising Expenditures to Sales	+
KS	Ratio of Capital to Sales	+
AESS	Average Establishment Size by Sales	-
SPCR	Industry Specialization Ratio	-
ADG	Anticipated Demand Growth	-
UNANT	Unanticipated Events	+
FPDI	Food Production Dispersion Index, A Proxy For Flow Economies	-
FSGC	Farm Output Sector Weighted Gini Coefficient	+
FUSC	Up-Stream Food Manufactures' Weighted Four Firm Concentration Ratio	+

as a supplier to each food industry.[4] Similarly, the variable FUSC is the weighted four firm concentration ratio of the food manufacturing industries that supply inputs to food processors (e.g. meat packing industry supplying inputs to the sausage and prepared meats industry).

Firms that produce specialized or differentiated products are particularly concerned about their product demand and input supply. Such firms may have increased asset specificity (i.e. idiosyncratic investments). Likewise, industries with highly intensive technical production processes may require some form of idiosyncratic investment. Both factors may result in a differential advantage for that particular industry, leading to an increased need to vertically coordinate. To measure these differential characteristics, the industry advertising to sales ratio (AS) and industry ratio of research and development expenditures to sales (RD) are utilized.

Firms have the incentive to vertically coordinate to capture flow economies in the production process. The closer the stages of production, the greater the incentive to vertically coordinate. Utilized as a proxy for flow economies, the food production dispersion index (FPDI) captures the proximity of output-input enterprises. As the index increases in value, the lesser the incentive to vertically coordinate. The FPDI for industry k is:

$$FPDI_k = \sum_{c=1}^{n} W_c \left[\sum_{i=1}^{n} |F_i^c - P_i^k| \right] \qquad k = 1 \text{ to } 42. \qquad (7)$$

where; F_i^c = the percent of farm output for commodity c produced in region i,
P_i^k = the percent of processed food k manufactured in region i,
W_c = percent of commodity c's net contribution to food industry k.

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[4] The farm industry GINI coefficient was calculated from Lorenz curves based upon the ratio of cumulative percent of output to cumulative percent of farms in each size classification, using Census of Agriculture data.

The costs of internalizing transactions must also be considered. Firms will internalize transactions up to the point where the market costs of an activity equal the cost of internalization. Several firm/industry characteristics may determine internal costs of administrative control. These include firm size, firm specialization, and capital intensity. Variables to proxy these characteristics include average firm (establishment) size in sales (AESS), the industry specialization ratio (SPCR), and the capital to sales ratio (KS). In the short run, increases in firm size lead to diseconomies and their associated costs, thus reducing the incentive to vertically coordinate. Stigler has demonstrated that as a firm specializes in a particular product, it vertically disintegrates to more fully capture increased scale economies. Finally, the greater the capital intensity, concomitant with uncertainty, firms will vertically coordinate to maintain production capacity.

Results

Using variations of equation 6, four progressively comprehensive vertical coordination measures are specified: 1) VC1, the food industry's up-stream linkages; 2) AVCC, the up-stream transfer of control via coordinating structures; 3) VC2C, up-stream linkages plus up-stream control; 4) VC3C, the up- and down-stream linkages plus up-stream control. The amount of information incorporated into the four vertical coordination measures progressively increases from VC1 to VC3C. As the amount of information increases, the value of the index increases, revealing the importance of each coordinating factor.

The estimated coefficients for the vertical coordination variable incorporating only industry up-stream connections, VC1 (Table 3), are generally mixed regarding

Table 3. Transactions Costs Effects On Vertical Coordination.

Explanatory Variables	Dependent Variables			
	VC1	AVCC	VC2C	VC3C
	(t-statistics in parenthesis)			
constant	0.31 (1.00)	1.38^{c} (2.90)	1.18^{c} (3.04)	0.98^{c} (2.73)
CR4	-0.003^{aa} (1.75)	0.0004 (0.12)	-0.0014 (0.49)	0.0001 (0.052)
RD	11.44^{c} (2.55)	0.58 (0.057)	7.51 (1.10)	10.55^{b} (2.23)
AS	-1.39 (1.53)	1.41 (0.75)	-0.94 (0.60)	-2.93^{bb} (2.50)
KS	-0.59^{cc} (4.44)	0.31 (1.07)	-0.19 (0.77)	-0.063 (0.28)
AESS	0.0037^{cc} (3.93)	-0.0052^{c} (2.55)	-0.0008 (0.54)	-0.0006 (0.33)
SPCR	-0.0005 (0.16)	-0.017^{c} (3.71)	-0.013^{c} (3.47)	-0.011^{c} (3.20)
ADG	0.0057 (0.005)	-1.36 (0.98)	-1.34 (1.23)	-1.28 (1.20)
UNANT	1.03^{a} (1.41)	-1.59 (1.17)	0.35 (0.36)	0.83 (1.03)
FPDI	-0.032^{a} (1.62)	0.007 (0.20)	-0.02 (0.77)	-0.036^{a} (1.55)
FSGC	0.27^{c} (3.50)	0.005^{c} (6.66)	0.005^{c} (9.30)	1.01^{c} (10.98)
FUSC	0.0003 (0.24)	0.005^{c} (3.21)	0.005^{c} (3.89)	0.004^{c} (3.64)
R^2	0.36	0.65	0.74	0.75
F-value	1.52	5.12^{c}	7.80^{c}	8.15^{c}
DF	30	30	30	30

Note: a, b, and c are significant at the 0.90, 0.95, and 0.99 level for a one-tailed test, respectively.
aa, bb, and cc are significant at the 0.90, 0.95, and 0.99 level for a two-tailed test, respectively.

expected signs. The coefficients for RD, UNANT, FPDI, and FSGC are of expected sign and significant. Estimates for CR4, KS, and AESS are of opposite sign and also significant. The coefficients for AS, ADG, SPCR, and FUSC were not statistically different from zero. This equation attained a relatively low coefficient of determination (R^2 = 36) and the set of explanatory variables failed to significantly explain the variation in the dependent variable (F-value, Table 3).

Focussing on the vertical coordination variables that incorporate governance structures (AVCC, VC2C, and VC3C), the coefficients for CR4, RD, AESS, SPCR, ADG, UNANT, FPDI, FSGC, and FUSC are generally of expected sign (Table 3). For these coefficients, all are significant to at least the 0.10 level except CR4, ADG, and UNANT. The coefficients for AS and KS were generally of opposite sign while only AS was significantly different from zero. Each of these three estimated relationships explained at least 65 percent of the total variation in vertical coordination as illustrated by the coefficient of determination (R^2). Moreover, the test of the overall relation (F-value) for each equation is significant at the 0.99 level. Interestingly, the vertical coordination measure incorporating only up-stream linkages, VC1, was not revealing while the measure of up-stream governance structures, AVCC, was quite significant. Also of particular importance, the two measures that combined contractual type governance structures with input-output linkages (VC2C and VC3C) are associated with the largest R^2's and F-values.

Further, based on the combined regression equation characteristics of R^2, F-value, and number of significant independent transaction cost variables, VC3C, the vertical coordination measure incorporating the greatest amount of information, both input-output linkages and the use of coordinating structures, appears to be the most robust specification. Hypothetically, a VC4C measure which incorporates the F-matrix of down-stream coordination structures would perform even better.

A comparison of the most robust vertical coordination measure, VC3C, with more conventional measures of vertical structure is presented in Table 4. First, Maddigan's VIC index which captures up- and down-stream linkages was examined with the same set of transaction cost explanatory variables. The coefficients for RD, UNANT, FPDI, and FSGC are of expected sign and statistically significant. The estimates for AS, KS, and AESS are also statistically significant but of opposite sign. The estimated coefficients for the remaining independent variables, CR4, SPCR, ADG, and FUSC were not statistically different from zero. Overall, VIC did not perform well. Its estimated equation achieved a relatively low coefficient of determination ($R^2 = 0.37$) and the overall test of the relationship was not significant (F-value, Table 4). The vertical coordination measure, VC3C, which adds coordinating structures to VIC, performed considerably better. Thus, recognition of coordinating structures as a factor of interdependence appears to be empirically important when examining vertical coordination.

The other variable examined is the traditional measure of vertical integration, VI, which is defined as the value-added to sales ratio. The coefficients for CR4, AS, KS, AESS, and FUSC are of expected sign and statistically significant. Only the estimate for UNANT was of opposite sign and significant. The coefficients for the remaining independent variables, RD, SPCR, ADG, FPDI, and FSGC, were not different from

Table 4. Comparisons of Transactions Costs Effects On Vertical Coordination and Vertical Integration.

	Dependent Variables		
Explanatory Variables	VIC	VI (t-statistics in parenthesis)	VC3C
constant	0.11 (0.36)	0.06 (0.28)	0.98^{c} (2.73)
CR4	-0.001 (0.28)	0.004^{c} (3.01)	0.0001 (0.052)
RD	12.70^{b} (2.26)	-1.36 (0.35)	10.55^{b} (2.23)
AS	-3.62^{cc} (4.61)	2.05^{b} (2.28)	-2.93^{bb} (2.50)
KS	-0.43^{cc} (2.89)	0.18^{a} (1.49)	-0.063 (0.28)
AESS	0.0038^{cc} (3.23)	-0.003^{c} (2.50)	-0.0006 (0.33)
SPCR	0.0016 (0.54)	0.0004 (0.24)	-0.011^{c} (3.20)
ADG	-0.26 (0.22)	0.13 (0.25)	-1.28 (1.20)
UNANT	1.45^{b} (1.85)	-1.88^{cc} (3.22)	0.83 (1.03)
FPDI	-0.045^{a} (1.56)	0.005 (0.35)	-0.036^{a} (1.55)
FSGC	0.30^{c} (3.44)	-0.02 (0.33)	1.01^{c} (10.98)
FUSC	-0.0008 (0.59)	0.003^{c} (4.99)	0.004^{c} (3.64)
R^2	0.37	0.69	0.75
F-value	1.72	6.06^{c}	8.15^{c}
DF	30	30	30

Note: a, b, and c are significant at the 0.90, 0.95, and 0.99 level for a one-tailed test, respectively.
aa, bb, and cc are significant at the 0.90, 0.95, and 0.99 level for a two-tailed test, respectively.

zero. The estimated equation for VI performed relatively well with an R^2 of 0.69 and an F-value significant at the 0.99 level.

A comparison between the estimated coefficients in the equations for VI and VC3C is revealing. Only one independent variable, FUSC, has the same sign and is significant in both equations. Another variable, AS, is significant in both equations, but with different signs. The variable, ADG, is not statistically significant in either estimated equation. The estimated regression coefficients for all other explanatory variables (CR4, RD, KS AESS, SPCR, UNANT, FPDI, and FSGC) are significant in one but not both equations. This suggests that the two alternative concepts of vertical structure are influenced by different transactional cost factors. The explanatory variables with significant coefficients in the VC3C equation may be better proxies for capturing the factors influencing contractual use, whereas some of the variables in the VI equation are more strongly related to such factors as profitability (i.e. CR4) which are inherent in the traditional value-added/sales specification of vertical integration.

<u>Summary and Conclusions</u>

Based upon a specification of vertical coordination that incorporates product flow linkages and the use of coordinating structures between vertically interdependent firms, empirical analysis confirms the hypothesis that transaction costs are a primary motivation for vertical coordination. The transaction cost factors found to be most influential are those specifically related to research and development, internal costs, flow economies, and input supplier concentration. Two factors affecting internal costs were negatively related with vertical coordination, firm size and specialization.

Comparison of the results between the vertical coordination measures VIC and VC1, which capture only product flow interdependencies,[5] and the other specifications, AVCC, VC2C, and VC3C, which capture interdependencies plus coordinating structures, reveals the importance of non-market exchange mechanisms in attenuating transactional inefficiencies. In addition, comparison of the traditional VI measure and VC3C reveals differences in the factors affecting each. In previous studies of vertical industrial organization, the role of non-market exchange mechanisms outside the dominion of vertical integration (ownership) was not empirically examined. The results herein demonstrate that a variable capturing coordinating structures bridges the gap in the dichotomy of market versus ownership coordination (vertical integration).

While this is a promising start in specifying a robust measurement of vertical coordination, much work remains. Simply to improve the accuracy of the measure, much greater detail on the types of coordinating structures used and their relative importance is needed. Not only is information on coordinating structures between farms and food processors needed, but also among processors and down-stream distributors and ultimately, consumers.

Additionally, better measures of factors influencing transaction costs should yield greater insight into the determinants of vertical coordination. In the end, much analysis is needed regarding the relationships between vertical coordination and market performance. To what extent, for example, does vertical coordination reduce transactional inefficiencies, enhance competitiveness, influence profitability, and affect economic welfare.

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[5] VC1 is based on matrix C, the food processor up-stream product flow linkages, while VIC incorporates both up- and down-stream linkages, matrices C and D.

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