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Modeling the Division of Managerial Responsibilities Between Segments of a Supply Chain

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ABSTRACT

This paper examines how firms in a supply chain can optimally choose the organizational form that governs their business transactions. Alternative organizational forms are characterized by the allocation of managerial decision rights, by information flows, and by transaction cost levels. We focus on the case where one firm or operating division bases its choice of organizational form on: its own costs and capabilities for information gathering and use, the quality of information provided by its trading partner, noise in information transmission channels, the relative importance of investments in site-specific assets and market information, and institutional factors that affect the costs of making transactions under different organizational forms. The model is used to explain observed patterns of organizational change in the U.S. retail food industry.

KEYWORDS. Managerial control rights, Information flows, Transaction costs

INTRODUCTION

With the globalization of markets, advances in information technology, and rapid changes in consumer demand, firms' flexibility and responsiveness to their changing environment are critical for their survival and growth. In this context, firms can improve and maintain their economic performance by making organizational innovations and by choosing the organizational form that best governs their business transactions.

This paper introduces a simple model that helps explain how transactors in a supply chain choose the organizational form that governs their business relationships. In the model, alternative organizational forms are represented by differences in the allocation of managerial responsibilities, information flows, and transaction costs. Transactors can either be two operational divisions of a single firm or divisions from two distinct firms. The main characteristic of the model is that a firm's own investments in information and site-specific assets, the characteristics of its trading partner, and institutional factors that affect the costs of making transactions all affect the choice of governance form. The model addresses two linked questions. (1) When is it be optimal for one operational division to coordinate productive activities and management decisions with another operational division? (2) When coordination is optimal, what is the optimal organizational form for governing it? The model is used to explain ongoing organizational changes in the U.S. retail food industry.

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MODEL SET UP

Given a state of the art technology and an institutional environment, consider an operational division (e.g., logistics, production, marketing) that represents one segment of a supply chain. This operational division performs a set of site-productive activities. These are activities which: (a) must be performed partially or in their entirety at the physical facilities of the operational division under consideration, (b) require knowledge and information that are better acquired by the members of the operational division, and (c) may be performed better by using knowledge and information that can be acquired more effectively by a firm or division operating in another segment of the supply chain.

The set of site-productive activities considered here can change through time due to technological or institutional changes. In some cases, new site-productive activities will appear. In other cases, activities may become redundant, be merged into another productive activity, or be shifted to another segment of the supply chain.

Let S denote an operational division that owns and initially manages the site-specific assets of a productive activity. Let P denote another operational division. S can be a downstream operation that buys goods from P, an upstream operation, or vice versa. S and P establish a business relationship that lasts for one period. During this period, there can be repeated interaction between S and P.

We focus on how S organizes its transactions with P. It is assumed that S faces a diversity of trading partners, P, that are willing to have transactions with S be governed under alternative organizational forms. The objective of S is to improve its overall performance. One way S can improve its performance is by finding ways to maximize the net operating margin of its site-productive activities. S can achieve this goal by choosing the organizational form that best governs its business transactions.

Define the net operating margin for S as follows:

$$V_K(I_S, m_S; f_S, m_P) = T_K(I_S, m_S; f_S, m_P) - OC_K(I_S, m_S; f_S, m_P) \quad (1)$$

The first term on the right-hand side of Eq. 1 is the managerial decision technology. It captures the effect on the net operating margin of the decision variables I_S and m_S. This term can be thought of as the value-added of an operational division. Subsumed within T_K are revenues from the sale of products and services and many of the fixed and variable costs associated with producing them. T_K differs across organizational forms, indexed by K. The second term on the right-hand side of Eq. 1 represents the organizational costs for establishing a business relationship. It also differs across organizational forms. In the rest of this paper, I_S represents the quality of site-specific information about internal operations, m_S is the quality of local market information, f_S is the site-specific assets of S (which serves as a proxy for firm size), and m_P represents the quality of global market information. We consider f_S and m_P fixed in the short run.

Site-specific assets are S's physical investments in productive assets not easily transferred to another location and/or of no use in other business activities. S's site-specific assets are represented on a scale between zero and one — i.e., $f_S \in (0,1)$. On this scale, low values of f_S represent small firms with little investment in site-specific assets,

while high values of f_S represent large firms with considerable investment in site-specific assets.

During the performance of site-productive activities, two kinds of information are used: site-specific information, I_S, and market information, I_M. Site-specific information can only be generated by S. It pertains to internal operating processes, activities, and outcomes.

Market information, I_M, is generated by combining local and global market information. Let m_S denote the quality of local market information. It is based on knowledge and information that is idiosyncratic to S (e.g., knowledge of local competition and customers' tastes and demographics). Let m_P denote the quality of global market information. It is based on knowledge and information that is non-idiosyncratic to S (e.g., knowledge about broad market trends driven by changes and innovations in markets, technology, and regulations). We assume that $m_S > 0$ and that larger values imply better local market information. We assume that the quality of global market information, m_P, is measured on a scale between zero and one — i.e., $m_P \in (0,1)$. Values of m_P closer to zero imply that the quality of global market information is low, while values closer to one imply that the quality of global market information is high. S chooses m_S but has no control over m_P, since global information comes from the trading partner, P. The quality of market information, I_M, is given by a Cobb-Douglas function with constant returns to scale,

$$I_M = m_S^{\tau_1} m_P^{\tau_2} \quad (2)$$

I_M is concave in m_S and m_P with positive but decreasing marginal returns. The parameters τ_1 and τ_2 are both positive and sum to one. They represent, respectively, the marginal contributions of m_S and m_P to I_M. All potential trading partners are assumed to have the same level of m_P. As will be explained later, however, the choice of organizational form affects effective levels of both m_s and m_p.

Managerial decision technology

As noted in the discussion of Eq. 1, different organizational forms, K, have different managerial decision technologies. For all organizational forms, however, the managerial decision technology, T, is assumed to be Cobb-Douglas with constant returns to scale. T is concave in its arguments with positive but decreasing marginal returns. In its simplest form, the managerial decision technology is given by:

$$T(I_S, m_S; f_S, m_P) = A f_S^{b_1} I_S^{b_2} (m_S^{\tau_1} m_P^{\tau_2})^{b_3} \quad (3)$$

where A is a strictly positive scale parameter, $f_S \in (0,1)$, $I_S > 0$, $m_S > 0$, $m_P \in (0,1)$, $\tau_j \in (0,1)$ for
$j = \{1,2\}$, $\tau_1+\tau_2 = 1$, $b_i \in (0,1)$ for $i = \{1,2,3\}$, and $b_1+b_2+b_3 = 1$.

Organizational costs

Organizational costs, OC, are comprised of information costs and transactions costs. S incurs information costs for obtaining certain quality levels for site-specific information and local market information. S incurs transaction costs for establishing and

maintaining a business relationship with P. Information costs do not vary by organizational forms, but transaction costs do. Also, institutional factors, such as industry standards, or trading rules and regulations, can alter transaction costs and, in turn, generate transaction costs differentials across organizational forms.

The general form of the organizational cost function for organizational form K is:

$$OC_K(I_S, m_S; f_S, m_P) = vI_S + wm_S + \phi_K + \delta_K T_K(I_S, m_S; f_S, m_P) \quad (4)$$

The first two terms on the right-hand side of Eq. 4 are information costs; the last two terms are transaction costs. Let v denote the unit cost of generating site-specific information and w denote the unit cost of generating local market information. It is assumed that $v > 0$ and $w > 0$. Transaction costs are assumed to be comprised of fixed and variable costs. For a given organizational form K, fixed transaction costs are denoted by ϕ_K, and variable transaction costs per unit of value-added are denoted by δ_K. S incurs fixed transaction costs for investments in relationship-specific assets. These expenses can include, for example, costs for remodeling building and facilities and for updating information systems to conform with trading partner specifications. These specific investments are made to harmonize the site-specific investments of firm S with the investments of trading partner P. It is assumed that $\phi_K > 0$. Variable transaction costs consist of payments for services to P (which can be positive or negative) and costs for coordinating these services. It is assumed that total variable transaction costs are always positive, but they cannot exceed the value-added generated by S's operations. Notationally, this implies that for all K, variable transaction costs are given by $\delta_K T_K(I_S, m_S; f_S, m_P)$, where $\delta_K \in (0,1)$.

CHOICE OF ORGANIZATIONAL FORM

Organizational forms are differentiated by their allocation of managerial responsibilities, information flows, and transaction costs. Differences in how managerial responsibilities are divided between transactors and in how information flows between them give rise to different organizational forms, which, in turn, have different transaction costs. We consider four organizational forms: autonomy, share information, decision transfer, and decision partnership. In order to explain how managerial decision technology differs among these forms, we need to describe the transmission of information and the sources of informational noise.

Transmission of Information and Informational Noise

During the performance of site production activities, there can be transmission of information between S and a business partner P. S may transmit I_S and m_S to P, or P may transmit m_P to S. When the provider of information is not a decision maker, we assume the transmission of information creates informational noise.

Informational noise reduces the receiving firm's ability to take advantage of the information transmitted to them by the other party. Noting that informational noise occurs when the party that generates information is not the party that uses the information to make decisions, there is informational noise: (i) when S transmits I_S and m_S to P, and S is not a decision maker and (ii) when P transmits m_P to S, and P is not a decision maker.

Let ε denote the informational noise from the transmission of site-specific information, I_S. Let σ_{SP} denote the informational noise from the transmission of local market information, m_S. Let σ_{PS} denote the informational noise from the transmission of non-site market information, m_P. We assume that informational noise can be represented by an index. This index takes values between zero and one. Hence, $\varepsilon \in (0,1)$; $\sigma_{SP} \in (0,1)$; and $\sigma_{PS} \in (0,1)$. When the index takes values closer to zero, it indicates low informational noise. When the index takes values closer to one, it indicates high informational noise.

Informational noise affects the effective quality of information. When S is the sole decision maker and P transmits global market information to S, the effective quality of that information is $m_P(1-\sigma_{PS})$. When P is the sole decision maker and S transmits site-specific and local market information to P, the effective quality of site-specific information is $I_S(1-\varepsilon)$ and the effective quality of local market information is $m_S(1-\sigma_{SP})$.

Organizational Forms

S can organize its site-productive activities according to four organizational forms: autonomy, share information, decision transfer, and decision partnership. Autonomy is an organizational form that requires no coordination with other firms or operating divisions. The other three organizational forms require some interaction and coordination with other trading partners. Share information is the organizational form that requires the least coordination and interaction between transactors. Decision transfer follows share information. Decision partnership is the organizational form with the highest degree of coordination and interaction between transactors.

Autonomy (Au). Under autonomy, S makes decisions without acquiring information from another firm. S is the only decision maker, all information is generated within the firm's boundaries and there is no informational noise ($\varepsilon = 0$, $\sigma_{SP} = 0$, $\sigma_{PS} = 0$).[1] There are no transaction costs for maintaining a business relationship with another firm. Organizational costs are only given by S's information costs. The net operating margin is given by:

$$V_{Au}(I_S, m_S; f_S, m_P) = Af_S^{b_1} I_S^{b_2} (m_S^{\eta} \kappa^{\eta})^{b_3} - vI_S - vm_S \quad (5)$$

Share Information (SI). Under this organizational form, there is some coordination between S and P. P transmits global information to S, but S retains managerial control rights over decisions and is the only decision maker. Since there is transmission of information from P to S, there is informational noise for global market information. Organizational costs include both information costs and transaction costs. Because S maintains a business relationship with P, transaction costs are positive. Since there is informational noise in the transmission of market information from P to S, I_M is affected by σ_{PS}. The net operating margin is given by:

$$V_{SI}(I_S, m_S; f_S, m_P) = Af_S^{b_1} I_S^{b_2} (m_S^{\eta} [m_P(1-\sigma_{PS})]^{\eta})^{b_3} [1-\delta_{SI}] - vI_S - vm_S - \phi_{SI} \quad (6)$$

[1]For computational purposes, it is convenient to assume that when $m_P = 0$, the effective quality of global market information is κ, where κ is a small positive number such that $\kappa \to 0$.

Decision Transfer (DT). Under decision transfer, there is more extensive coordination between S and P. S transmits site-specific and local market information to P and delegates managerial control rights to P — i.e., P is the decision maker. Since S transmits information to P, there is informational noise ($\varepsilon > 0$, $\sigma_{SP} > 0$). Organizational costs again include both information costs and transaction costs. The net operating margin is given by: (7)

$$V_{DT}(I_S, m_S; f_S, m_P) = A f_S^{h_1}[I_S(1-\varepsilon)]^{h_2}([m_S(1-\sigma_{SP})]^{r_1} m_P^{r_2})^{h_3}[1-\delta_{DT}] - vI_S - vm_S - \phi_{DT}$$

Decision Partnership (DP). Under a decision partnership, S and P share decision responsibilities for the functional operations of S. Because there is a constant flow and feedback of information between S and P, there is no information noise. S has positive information and transaction costs for maintaining a business relationship with P. Since there is no informational noise, I_S and I_M are not affected by ε, σ_{SP}, or σ_{PS}. The net operating margin is given by:

$$V_{DP}(I_S, m_S; f_S, m_P) = A f_S^{h_1} I_S^{h_2}(m_S^{r_1} m_P^{r_2})^{h_3}[1-\delta_{DP}] - vI_S - vm_S - \phi_{DP} \quad (8)$$

Optimal Choice of an Organizational Form

S is assumed to choose the organizational form that maximizes net operating margin. Let V_K^* denote the maximum net operating margin for organizational form K. Let V^* be the operating margin for the optimal organizational form. The maximization problem of S is described sequentially by Eq. 9 and Eq. 10 as follows:

$$V_K^* = \max_{I_S, m_S} V_K(I_S, m_S; f_S, m_P) = T_K(I_S, m_S; f_S, m_P) - OC(I_S, m_S; f_S, m_P) \quad (9)$$

$$V^* = \max\{V_{Au}^*, V_{SI}^*, V_{DT}^*, V_{DP}^*\} \quad (10)$$

These imply that, given site-specific assets (f_S) and the quality of information that is provided by other firms (m_P), S chooses the optimal value for the quality of its investments in site-specific information (I_S) and local market information (m_S) that maximize the net operating margin for each organizational form. S then chooses the organizational form that yields the maximum value added.

PATTERNS OF ORGANIZATIONAL FORMS IN THE RETAIL FOOD INDUSTRY

The U.S. retail food industry is in the midst of dramatic, far-reaching change. The Efficient Consumer Response (ECR) initiative is an industry-wide institutional innovation that supports the current changes of vertical relationships among firms in the retail food

chain. As a set of trading rules and standards, the ECR initiative involves not only making investments in information technology and physical assets, but also making managerial investments for the reorganization of trading activities, information flows, and the formation of new forms of competition and cooperation among retail food firms. The ECR initiative focuses on restructuring business transactions in four processes that run through the entire supply chain:

(i) efficient assortment (the selection of items offered in each product category), (ii) efficient replenishment (a move toward inventory reductions throughout the chain and more efficient logistics for product delivery), (iii) efficient product promotion, and (iv) efficient product introduction (an attempt to reduce excess product proliferation). More detailed descriptions of the ECR initiative can be found in Kurt Salmon Asociates (1993), King and Phumpiu (1996), and Kahn and McAlister (1997).

Prior to the recent innovations in information technology, more competitive markets, and the institutional framework provided by the ERC initiative, vertical coordination was limited at the retail end of the food supply chain. Information was not routinely shared between the store and its suppliers, management and investment decisions were not coordinated, and the delivery of products to the store was supply driven other than consumer driven. Supermarkets internally generated most of the information needed for store operations and made many of their day-to-day management decisions by themselves. Autonomy was the organizational form governing business relationships between most supermarkets and their suppliers.

Over the past several years, vertical coordination has increased significantly in the retail food supply chain. Findings from a study of grocery stores in Minnesota reported by King and Phumpiu (1997) and Phumpiu (1997) show that higher adoption of store-level ECR practices is associated with both a significant increase in vertical coordination and superior performance for stores located in the metropolitan area and for larger size stores.

In this section, we use the model developed above to help explain why not all stores are participating equally in the adoption of ECR practices. In particular, we address the question of how the interaction of the institutional framework provided by the ECR initiative with store location and size may affect a store's choice of an organizational form. We argue that store location and size matter because: (1) stores in metro areas have access to a more developed network of informed suppliers and (2) given access to a more developed network of informed suppliers, the fixed transaction costs for coordinating decisions are lower for large stores than for small stores.

On the issue of location, we argue that stores' suppliers, by basing more of their business operations in the metro area, are more likely to have a higher expertise about markets in the metro area rather than about markets in out-state areas. These suppliers are the ones who have and can transmit to stores a better quality of information and knowledge about market trends and changes on demand and price relationships for a variety of goods within different product categories. On the issue of size, we argue that size matters because it allows stores to use the same specific investments in physical and human capital assets more intensively (e.g., through higher volume) in different store product categories and, when applicable, at other corporate or independent chain stores.

Following the model, S is a supermarket and P is a store supplier (e.g., a manufacturer or distributor). Table 1 presents the parameter values of the model. Apart from the benchmark case, we consider two cases. Case 1 represents stylized model parameters for a store located outside the metro area, while Case 2 represents stylized

model parameters for a store located in the metro area. We emphasize that our simulation results are qualitative rather than quantitative. In Table 1 the numbers in bold represent parameter changes with respect to the benchmark case.

The benchmark case corresponds to a situation prior to the innovations in information technology, more competitive markets, and the ECR initiative. This is the situation for most U.S. supermarkets in the 1980s. Investments in site-specific assets and in information have relatively the same effect on the average added value for selling groceries — i.e., the parameters b_1, b_2 and b_3 have the same value. Also, because the technical means and coordination mechanisms for gathering, analyzing, and communicating knowledge and information across transactors are minimal, noise from the transmission of information among the store and its suppliers is relatively high. Additionally, since firms along the supply chain do not have any particular incentives to coordinate investment and managerial decisions with other firms under any particular organizational form, fixed transactions costs are the same for the organizational forms of sharing information, transferring decisions and decision partnership.

Table 1: Model parameter values for supermarkets.

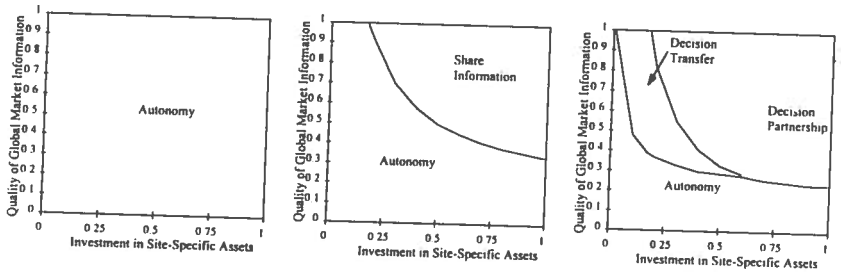
Parameters	Notation	Values			
				Case 1	Case 2
				Non-metro	
Metro					
Location		Benchmark		Location	
Average Added Value of a Productive Activity	A	3	4		4
Marginal effect of site market information	τ_1	0.5	0.5		0.5
Marginal effect of non-site market information	τ_2	0.5	0.5		0.5
Marginal effect of site-specific assets	b_1	0.33	**0.2**		**0.2**
Marginal effect of site-specific information	b_2	0.33	**0.4**		**0.4**
Marginal effect of all market information	b_3	0.33	**0.4**		**0.4**
Costs of obtaining site-specific information	v	0.9	0.9		0.9
Costs of obtaining local market information	w	0.9	0.9		0.9
Noise from transmitting site-specific information	ε	0.8	**0.6**		**0.6**
Noise from transmitting local market information	σ_{SP}	0.8	**0.6**		**0.6**
Noise from transmitting global market information σ_{PS}		0.8	**0.6**		**0.6**
Variable transaction costs for sharing information	δ_{SI}	0.2	0.2		0.2
Variable transaction costs for transferring decisions	δ_{DT}	0.3	0.3		0.3
Variable transaction costs for decision partnership	δ_{DP}	0.4	0.4		0.4
Fixed transaction costs for sharing information	ϕ_{SI}	0.4	**0.3**		**0.3**
Fixed transaction costs for transferring decisions	ϕ_{DT}	0.4	**0.2**		**0.1**
Fixed transaction costs for decision partnership	ϕ_{DP}	0.4	**0.2**		**0.1**
Constant, global market information not acquired	κ	0.01	0.01	0.01	
Quality of global market information	m_P	(0,1)	(0,1)	(0,1)	
Investments in site-specific assets (size of firms)	f_S	(0,1)	(0,1)	(0,1)	

Case 1 and Case 2 in Table 1 show the parameter values for the situation where there are innovations in information technology, more competitive markets, and institutional changes due to the ECR initiative. The main difference in parameter values between Case 1 (outside the metro area) and Case 2 (inside the metro area) is in the fixed transaction costs for vertical coordination under the organizational forms of transferring decisions and decision partnership.

With advances in information technology used in grocery stores — such as the use of scanning at the front-end and in the backroom, the use of computers to monitor item movement and forecast sales, and, in some cases, generate orders automatically — we consider the scale parameter, A, for store operations to have increased. Because technological practices are similar between stores located in and outside of the metro area, we increase A by the same amount in both Case 1 and Case 2. We also assume that the parameters b_1, b_2 and b_3 have changed with respect to the benchmark case. Specifically, with the need to be more responsive to changes in consumer preferences and with the need to keep and exchange more accurate and detailed records of production practices and outcomes, investments in information have become relatively more important for supermarkets than investments in site-specific assets. This implies that b_1 is lower than b_2 and b_3. We also assume that market information is as important as site-specific information — i.e., b_2 is equal to b_3.

As an institutional innovation, the ECR initiative affects the quality of information transmitted among trading parties and the fixed transaction costs for sharing and coordinating managerial decisions. By setting industry-wide standards for trading rules, operational procedures, implementation steps, and the ongoing evaluation of best practices, the ECR initiative lowers: (a) the informational noise during the transmission of information between the store and its suppliers, and (b) the fixed transaction costs for establishing, developing, and maintaining business relationships among the store and its suppliers. The decrease in informational noise is represented by lower values for the parameters ε, σ_{SP}, and σ_{PS} in Cases 1 and 2 relative to the benchmark case. Decreases in transaction costs achieved through the establishment of industry-wide standards are represented by lower values for the parameter ϕ_{SI}, ϕ_{DT}, and ϕ_{DP} for Cases 1 and 2. Finally, because stores in the metro area experience the added benefit of access to a more developed network of informed suppliers, these fixed transaction cost parameters have lower values for the metro stores in Case 2 than for the non-metro stores in Case 1.

Figure 1 summarizes the model results for the three sets of parameters. In each panel, the horizontal axis represents store size, f_S, and the vertical axis represents the quality of information provided by a store supplier (e.g., a food manufacturer), m_P. The information on optimal organizational forms in each panel is the result of repeated optimizations for a grid of (f_S, m_P) combinations. Therefore, each panel shows how optimal organizational form varies with firm size and quality of information provided by the supplier under a specific set of assumed parameter values.



Panel A: Benchmark Panel B: Non-Metro Stores Panel C: Metro Stores

Figure 1. Patterns of organizational forms in the retail food industry.

As shown in Panel A, Autonomy is always the optimal organizational form in the benchmark case. Under this form, stores do not acquire global market information from their suppliers. Results for Case 1, the parameter values assumed for non-metro, post-ECR stores are summarized in Panel B. Autonomy remains optimal for smaller stores, regardless of the quality of information provided by their suppliers, and for larger stores whose suppliers do not provide high quality global market information. When both store size and market information quality are relatively high, however, Share Information becomes the optimal form in this case. This conforms with findings reported by Phumpiu and King (1997), which suggest that larger stores outside the Minneapolis-St. Paul metropolitan area have adopted information technology such as EDI and scanning and business practices for ordering and receiving that support information sharing but have been slower to adopt practices such as category management and continuous replenishment that involve sharing or transferring decision responsibilities. Finally, results for Case 2, the parameter values for metro, post-ECR stores are summarized in Panel C. Here, the firm size-information quality region where autonomy is optimal is smaller than in Panel B, and the Decision Transfer and Decision Partnership forms have replaced Share Information as optimal forms of coordination. These qualitative results suggest that organizational forms built on closer working relationships between stores and suppliers should be observed in metro area stores. This coincides with findings reported by Phumpiu and King (1997). Larger stores in the Minneapolis-St. Paul metropolitan area were much more likely than other stores to have adopted category management practices and to have transferred greater decision responsibility to direct store delivery (DSD) vendors.

CONCLUSIONS

How firms organize their transactions is important for their economic efficiency. There is a variety of organizational forms that firms can use to govern their business transactions. In this paper we have examined the conditions under which firms may choose different organizational forms. In the U.S. retail food chain, new patterns of organizational forms are emerging. We argue that the firms' new choices of organizational forms, which imply a higher degree of vertical coordination, may be explained by institutional factors that affect the transaction costs for establishing and maintaining more complex business relationships, informational investments, the access to a more developed network of informed suppliers, and the size of stores.

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