The Costs of Organization

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1. Introduction

The tenet to which all transaction-cost economists subscribe is that the choice among alternative organizational arrangements turns on a comparison of the costs of transacting under each. To impart empirical content to this fundamental insight, theorists began to relate the incidence of transaction costs to observable attributes of transactions (Williamson, 1975, 1979; Klein et al.). These efforts, however, concentrated on factors aggravating the hazards of market exchange. By contrast, the limitations of internal organization have been treated primarily as a barrier to be overcome before integration would occur.

Although the empirical research to date has been generally supportive of the central transaction-cost propositions,[1] recognition that variations in internal organization costs may also play a role in the decision to integrate exposes an inherent weakness in the nature of these tests. Because of difficulties in observing and measuring transaction costs, analysts have had to rely on es-

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1. See Williamson (1985) and Joskow for overviews of this literature.

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timations of reduced-form relationships between observed characteristics and organizational forms. As we explain below, such indirect tests are unable to distinguish whether observed patterns of organization resulted from hypothesized changes in market transaction costs or from systematic, but as yet unexplored, variations in the costs incurred organizing production internally.

In this article, we give explicit attention to the role of internal organization costs in integration decisions and identify ways of overcoming the difficulties inhibiting direct tests of transaction-cost arguments. In particular, we show how econometric methods developed elsewhere can be used to reduce the information problems associated with estimating models of economic organization. We then apply these methods to analyze the organization of a sample of components from a large naval construction project. The nature of our data and the application of censored regression techniques permit us, unlike earlier empirical studies of integration decisions, to isolate the effects of attributes of transactions on the costs of organizing within and between firms and to provide dollar estimates of those costs.

Our results indicate that overall organization costs represent about 14 percent of total costs for the components and activities in our sample. Moreover, we find that these costs vary systematically with the nature of the transaction and that the savings from choosing organizational arrangements selectively can be substantial. Mistaken integration of the typical subcontracted component in our sample, for instance, would increase organization costs by approximately 70 percent, while subcontracting work currently performed inside the firm would, on average, generate market organization costs almost three times those incurred managing that work internally.

But the broader implications of the study lie in our findings regarding the relative contribution of variations in internal and market organization costs to the integration decision. Specifically, we find that the costs of dealing across a market interface, and hence the incentive to integrate, rise the greater the potential for holdups in a given transaction, as recent theorists have argued. In addition, however, the evidence indicates that variations in the level of internal organization costs also play an important role in integration decisions. Indeed, the importance of internal organization costs in our results leads us to reassess some of the earlier empirical literature on the determinants of vertical integration.

2. Conceptual Issues

2.1 The Form and Estimation of Transaction-Cost Arguments

2.1.1 A Tautological Formulation. The maintained hypothesis underlying transaction-cost analyses of organization form is that transactors choose organizational arrangements to minimize the expected costs of governing the transaction over the life of the relationship.[2] If we let I^* signify the institution

2. Governance or organization costs should be broadly construed to include both direct costs of conducting exchange and any corresponding inefficiencies in production or allocation as a result of these costs.

chosen, a representative model of the choice between two institutions—typically internal organization (I^o) and market exchange (I^m)—would be

$$I^* = \begin{cases} I^o, & \text{if } G^o < G^m, \\ I^m, & \text{if } G^o \geq G^m, \end{cases} \tag{1}$$

where G^o and G^m represent the costs of organizing under the corresponding alternative.

Analyses of organizational form requiring direct comparisons of the costs of transacting have been subject to criticism, however, on the grounds that such costs are difficult to observe and measure. Many hazards of exchange, such as inflexibility in response to changing circumstances or the need to litigate performance, are either implicit or latent to the transaction. And others, such as the increased demands placed on a manager's, regulator's, or judge's attention by bringing an additional transaction under his purview, or the losses due to withholding of information by either employees or subcontractors, while manifest, are often difficult to quantify.

In addition, attempts to compare the costs of organization must confront a basic selection problem: organization costs cannot be directly observed for organizational forms not chosen. Thus, even if the costs associated with internal administration could be adequately measured for supplies procured internally, the costs that would have occurred had the same supplies been acquired externally under, say, a long-term contract would not, by virtue of the integration decision itself, be observable. At best, one observes costs for the institution chosen so that direct comparisons with costs of alternative institutions are impossible. As a consequence, early claims that observed institutions minimize transaction costs were easy to make and impossible to refute.

2.1.2 Reduced-Form Analysis. To address this criticism, transaction-cost theorists began to relate the incidence of transaction costs to observable characteristics of the transaction and then base predictions of organizational form on those observed features.[3] Thus, suppose the true costs of organization are

$$G^o = \alpha X + e, \tag{2}$$

$$G^m = \beta Z + u, \tag{3}$$

where X and Z are vectors of attributes thought to influence the respective organization costs, α and β are coefficient vectors, and e and u are normally distributed random variables. After substituting into Equation (1), the probability of observing institution I^o becomes $\Pr(G^o < G^m) = \Pr(e-u < \beta Z - \alpha X)$.

3. An explicit statement of the need for matching institutions with attributes of the transaction can be found in Williamson (1979). Other contributions include Williamson (1975, 1985) and Klein et al.

Hypotheses regarding organization form can then be based on the signs and relative magnitudes of the coefficients α and β, rather than on the costs G^o and G^m.

The resulting model is amenable to qualitative choice estimation techniques such as probit and logit. Examples are previous empirical research on the economics of integration decisions by Monteverde and Teece (1982a), Masten (1984), and Anderson and Schmittlein. Again, the common strategy in each of these studies is to estimate organizational form as a function of observable characteristics such as the degree of asset specificity and the level of uncertainty or complexity associated with the transaction.

Since the coefficients in Equations (2) and (3) relate the exogenous variables to the costs of organization, these parameters have an appealing interpretation as the structure of organization costs underlying the choice among the observed institutions. Resulting estimates from qualitative choice models, however, provide at best only ordinal measures of those costs. The coefficients from a probit estimation, for instance, are the normalized difference between the coefficients of the underlying structural equations, or $(\beta-\alpha)/\sigma$, where σ is the standard deviation of $e - u$. Without independent information about the variance of $e - u$, the structural coefficients of the organization-cost equations can be identified only up to a proportionality factor.

Furthermore, if X and Z share common elements, only the difference between α and β can be identified.[4] Consider, for example, the hypotheses that the costs of market exchange, but not those of internal organization, rise as assets become more specific to a particular transaction. If we let β_k and α_k represent the corresponding coefficients, then it is possible to test the derived hypothesis that $\beta_k - \alpha_k > 0$. However, it is not possible to refute the underlying hypotheses that β_k and α_k are nonnegative. Thus, a finding that higher asset specificity leads to a larger probability of integration could, in principle, obtain even if the hypothesis that asset specificity raises contracting costs were invalid. As a result, existing tests of transaction-cost theories, while generally supportive, have in this sense been relatively weak.

2.1.3 Direct Tests. Stronger tests of the theory, and estimation of the actual costs of organization, are possible only if the measurement problems discussed at the beginning of this section can be resolved. Some now fairly standard econometric techniques can be helpful in this regard. For example, even though the costs associated with institutions not chosen cannot be observed for a particular transaction, the full structure of organization costs can be estimated if we know the selection process and if we can obtain data or proxies for the costs of organizational forms that *are* chosen. Thus, in integration decisions, if firms chose the lower-cost organizational alternative, and we

4. If a characteristic is thought to influence only one cost, then the corresponding coefficient in the other equation is implicitly zero and the numerator of $(\beta-\alpha)/\sigma$ contains only the remaining coefficient.

could observe the transaction costs incurred under the institution adopted, then application of switching regression techniques could provide consistent estimates of the costs of both market and internal organization.[5] The data burden could be further reduced by estimating the structural equations as a censored regression model analogously to the way actual and reservation wages are estimated in labor supply applications.[6] In that case, only cost data for one of the institutions is required. Thus, were G^o but not G^m available, the model would become

$$G = \begin{cases} G^o = \alpha X + e\,, & \text{if } G^o < G^m, \quad (4) \\ G^m = \text{n.a.}, & \text{if } G^o \geq G^m. \quad (5) \end{cases}$$

Consistent estimates of the coefficients of Equations (2) and (3) could then be obtained using either maximum likelihood or two-stage methods as long as either (i) an independent variable in X is not in Z or (ii) the covariance between e and u is 0.[7] In effect, the full set of coefficients is estimated by asking what structure of procurement costs most likely generated the observed pattern of procurement decisions given the observations of G^o and the characteristics of the transactions X and Z.

Generally, the ability to estimate the structural equations of the preceding model would offer two advantages over the reduced-form estimations used in prior research. First, unlike qualitative choice methods, censored regression techniques yield dollar estimates of the costs of organization. Second, while reduced-form models provide evidence about how characteristics of a transaction influence the relative costs of organizing under alternative arrangements, censored regression estimation can identify the magnitude of individual coefficients in the cost equations and therefore permits tests of hypotheses regarding the costs of organizing under each institution.

2.2 Transaction-Cost Differentials

By introducing the prospect of estimating the structural relationships underlying organization decisions, application of censored regression techniques stands to shed light on the issue raised at the outset of this article, namely, whether and to what extent variations in internal rather than market organization costs are responsible for observed variations in organizational form.[8] A

5. See the discussion and references in Maddala (223–8).

6. See Heckman (1980) and Hanoch. In the labor applications, wages are observed only for those who actually work. Nevertheless, one can infer from the decision to work and characteristics of workers the reservation wage schedule that most likely generated the pattern of observed employment given observed wages.

7. See Lee, Nelson, and the discussion in Maddala (228–9).

8. In terms of the model of the preceding section, recent transaction-cost theories have assumed a positive intercept but zero or small coefficients on the explanatory variables in the G^o equation.

prerequisite to conducting such tests, however, is the need to distinguish between the costs of internal and market exchange and then relate the incidence of each to the attributes of transactions in a discriminating way.[9]

As noted previously, recent transaction-cost arguments have tended to emphasize factors exacerbating the hazards of bargaining and incomplete contracting, activities identified most intensively with market organization. According to these arguments, the resources expended attempting to negotiate a favorable distribution of the gains from trade tend to be larger where relationship-specific investments have engendered appropriable quasi-rents (Williamson, 1975, 1979; Klein et al.). Efforts to suppress opportunism contractually, meanwhile, are limited by the costs of writing and enforcing contractual agreements, which rise, in turn, with the complexity and uncertainty associated with the transaction.

Organization within the firm mitigates these problems[10] but, by attenuating the residual claimant status of upstream transactors, sacrifices the high-powered incentive advantages of market exchange and, consequently, demands greater investments in monitoring and administration (Williamson, 1985:70,131–62; 1990). Although the costs associated with these activities present a clear deterrent to integration, theorists have paid scant attention to the factors that influence the level of these costs.

A prominent exception to this generalization is Ronald Coase, who has repeatedly asserted that understanding "the effect of activities in which a firm is already engaged on the cost of undertaking additional activities" is essential to explaining why particular operations are organized within specific firms (1988:40).[11] His own early speculation as to the incidence of those costs was

9. Meeting even the first part of this requirement is not straightforward. The sharp distinction often drawn between internal and market organization costs, while expedient, is artificial. In reality, organization entails a multiplicity of activities independent of the governing institution. Planning, bargaining, contracting, monitoring, enforcing, and so on are common to both internal and market exchange. What the choice of organization form does is influence the allocation of effort across the elements of this list. Hence, perceived differences in the incidence of organization costs within and between firms turn ultimately on one's conception of the nature of the firm—itself a matter of considerable dispute among economists. (For a sampling of opinions on the nature of the firm, see the Spring 1988 issue of this journal celebrating the 50th anniversary of Coase's treatise on the subject.) Inasmuch as our primary purpose in this article is to test received hypotheses, we will not explore these issues in depth. Arguments in support of the distinctions referred to below can be found in Williamson (1985:Chapter 6, 1990), Klein, and Masten (1988).

10. See the references in the note 9.

11. According to Coase,

> The way in which industry is organized is . . . dependent on the relation between the costs of carrying out transactions on the market and the costs of organizing the same operations within that firm which can perform this task at lowest costs. Furthermore, the costs of organizing an activity within any given firm depends on what other activities it is engaged in. A given set of activities will facilitate the carrying out of some activities, but hinder the performance of others. It is these relationships which determine the actual organization of industry. (1972:64)

Others who have argued the importance of internal organization costs are Demsetz, and Alston and Gillespie.

that "[t]he costs of organizing and the losses through mistakes will increase with an increase in the spatial distribution of the transactions organized, in the dissimilarity of the transactions, and in the probability of changes in the relevant prices" (1952:342–3). In other words, internal organization costs are likely to be higher for transactions that are differentiated—by either their location or characteristics—from other activities in which the firm is engaged, and for which there is a greater degree of uncertainty. Supervision and management of employees will be more difficult where managers are unfamiliar with the production process, while more complex or uncertain transactions demand a greater share of management's limited attention and would also tend, therefore, to be more expensive to administer.

Although Coase's predictions regarding the effects of similarity and uncertainty on internal organization costs seem reasonable, predictions about the choice among organizational arrangements require a comparative assessment. Thus, as already noted, complexity and uncertainty aggravate the costs of market exchange, as well as those of internal organization. Indeed, the differential effect of uncertainty and complexity is likely to favor integration over subcontracting: Whereas contracting demands prior anticipation of potential problems, internal organization permits adaptation to changing circumstances as they unfold (Williamson, 1975:25). Hence, higher levels of uncertainty and complexity should lead, on net, to a larger probability of integration.

The similarity of transactions, on the other hand, is unlikely to generate counteracting effects on the costs of market exchange for two reasons. First, parties engaged in bargaining across a market interface care primarily about final outcomes and not the manner in which goods or services are produced. Provided that the attributes of items exchanged can be adequately verified, high-powered incentives relieve the parties of the need for detailed knowledge about the production operations of their trading partners.[12] Second, to the extent that market exchange relies more heavily than internal organization on third-party dispute resolution, the knowledge and experience of judges and juries rather than of the transactors themselves will have a greater impact on the course and cost of litigation. Even if familiarity of the transactors with each others' techniques increases the probability of detecting opportunistic efforts to evade contractual obligations, it may do nothing to improve the prospects of successful enforcement.[13] Consequently, the effect of similarity on the costs of market exchange is likely to be insubstantial.

In Table 1, we summarize the relations between attributes and organization

12. Moreover, independent contractors have formal legal rights only over the results and not over the means by which the work of subcontractors is performed. See, for instance, Masten (1988:186). Notice that acquisition of expertise through hiring of a manager familiar with the relevant processes does not eliminate the added administrative burden incurred when unrelated activities are integrated within the firm; top management's ability to assess the performance of that manager—hence, the quality of the low-powered incentives they can bring to bear on him—will depend on their comprehension of the operations he oversees.

13. In other words, familiarity may help to make performance "observable" to the contracting parties but is unlikely to affect whether or not it is "verifiable" to a third party such as a court.

Table 1. Summary of General Hypotheses

	G^m	G^o	$G^m - G^o$
Transaction specificities	+	(+)	+
Uncertainty/complexity	+	+	+
Similarity of transactions		−	+

costs identified in the preceding discussion. (Parentheses indicate a potential but uncertain influence.) Transaction specificities and uncertainty and complexity tend to aggravate organization problems both between and within firms, but the differential effects consistently favor integration. Familiarity with an operation facilitates monitoring and supervision—activities engaged in most heavily within the firm. Hence, those transactions that are similar to ones in which the firm is already engaged are more likely to be integrated.

3. Naval Shipbuilding: Assets, Attributes, and Operations

In the remainder of this article, we apply the methodology described in Section 2.1 to estimate the structure of organization costs in a specific application, namely, the procurement of components and services by a large naval shipbuilder. Whereas previous empirical research on the determinants of vertical integration has dealt with manufacturing applications, the process of building a ship more closely resembles a construction project. Differences in the nature of construction and manufacturing operations, in turn, influence the circumstances that give rise to opportunism and that determine the level of organization costs more generally. Hence, before turning to the empirical results, we provide some background, first, on distinctive aspects of construction processes in general, and, then, on the nature and costs of naval construction in particular.

3.1 Distinctive Features of Construction Operations

The most salient feature distinguishing construction projects from manufacturing operations is the large, discrete, and immobile nature of the final product.[14] Whereas most manufacturing entails continuous processing of large quantities of products as they move from station to station, construction typically involves erection on site of a single or small number of finished units. This basic distinction underlies a number of differences in the nature of the production processes and assets employed in manufacturing and construction. In manufacturing operations, for instance, the portability of goods in-process means assets can be fixed, while high-volume production often makes specially designed and tooled assets economical. The capital and equipment used in construction, in contrast, are less likely to be specific to a particular transaction. To the extent that each construction project takes place on a

14. The role of mobility in distinguishing goods covered by the Uniform Commercial Code from construction, which is not covered, parallels the distinction made in the text. See Goetz.

unique site, the assets themselves are more likely to be mobile. And because the final product is often unique or produced in limited quantities, construction assets need to be adaptable for use in varying applications. As a result, physical asset specificities are less likely to be important determinants of organizational form in construction than in manufacturing.

The high-volume and continuous nature of most manufacturing operations also makes it possible to hold buffer inventories that absorb fluctuations and permit work to continue at one stage of production when problems arise elsewhere. The unique design and location aspects of construction projects, on the other hand, often limit the ability to hold inventories of work in progress. In such settings, timing and coordination become critical. As Robert Eccles notes, "Coordinating the work of [a large number of] labor specialties over the course of a project is a complex task. At any point in time a number of these specialties will be simultaneously involved on the project and often the work of one cannot proceed until a phase of work has been completed by several others" (337). At these stages, tasks must be strictly ordered for work to proceed. As a result, delays in a key task can have system-wide effects, hindering progress on a group of operations and forcing managers either to wait until the antecedent task has been completed or to uncover an alternative sequence of operations.

Where timely performance is critical, delay becomes a potentially effective strategy for exacting price concessions. Knowing that interruptions at one stage can reverberate throughout the rest of the project, an opportunistic supplier may be tempted to seek a larger share of the gains from trade by threatening to suspend performance at the last minute. Even though the skills and assets necessary to perform the task may be fairly common, the difficulty of identifying and arranging to have an alternative supplier in place on short notice introduces the prospect of strategic holdups. Expanding Williamson's original four-way classification, we refer to this latter source of holdups as *temporal specificity*.[15]

In principle, incentives for prompt performance could be created by specifying appropriate damages. And in fact, performance and installment contracts are common in construction settings (see, for instance, Lee and Png). But, in construction as in other settings, contracting offers only an imperfect solution to the problem of opportunism and is likely to become less attractive as the degree of complexity or uncertainty associated with the transaction increases.[16]

3.2 Determinants of Organization Costs in Naval Shipbuilding

In most critical dimensions, shipbuilding fits the construction model. Although the final product is obviously mobile, the bulk of the vessel is immov-

15. The original four are physical asset specificity, site specificity, human asset specificity, and dedicated assets (Williamson, 1985:55).

16. See, generally, Williamson (1979). Clarkson et al. provide an extended discussion of the limitations of stipulated damages using a construction contract as their principle illustration; see, especially, pp. 368–72.

able during most of its fabrication, requiring that much of the work going into a ship be performed on site. Furthermore, assembly of major subunits and of the ship itself must proceed in a precise order to avoid costly delays.[17] Meanwhile, holding buffer inventories as a safeguard against holdups is made impractical by uncertain demand and the low-volume, nonstandardized nature of many components. As a rule, a naval shipbuilder will have in process no more than a handful of ships and often only one or two ships of a particular class at a point in time. Orders for additional ships depend on the shipyard's performance history, its ability to make competitive bids, and congressional budgeting and allocation. Even for ships under contract, component specifications are often changed during the course of the contract to accommodate technological and military developments.

Moreover, modern naval vessels are complex entities. A navy cruiser, for instance, includes over 1,000,000 feet of cable, some 10,000 valves, and 150,000 feet of pipe. In addition to its basic structure, a ship must contain living quarters for its crew, propulsion and navigation equipment, and sophisticated communications, weapons, and guidance systems. Its military applications make the reliability of these complex systems critically important. Writing contracts with enough precision to assure desired performance but enough flexibility to permit adjustment in component and task specifications as circumstances require can be a formidable challenge.

In contrast to other construction applications, the specialized design of military vessels contributes to fairly high degrees of human asset specificity. Given the complexity of the tasks and the small number of producers of such ships, the skills, knowledge, and experience required of workers often demand extended apprenticeships to develop and may have limited value outside of a specific shipyard. Physical assets used in ship construction, on the other hand, tend to be much less relationship specific. Although some equipment such as cranes and ways—the platforms upon which ships are constructed—are location specific, most of the physical assets used in the construction process tend to be mobile to permit employment at various locations around the ship. And many basic assets, like welding and pipe-fitting equipment, also tend to be of a relatively standardized nature.

Finally, shipbuilding, like other construction operations, mainly involves organizing and coordinating a variety of relatively low-technology, labor-intensive activities associated with the physical fabrication and assembly of the final product. Highly technical, engineering-intensive activities, in contrast, tend to lie outside of a shipbuilder's main area of expertise.

3.3 Hypotheses

In Table 2, we relate the general hypotheses summarized in Table 1 to the particulars of shipbuilding. Again, the traditional transaction-cost arguments

17. An example is the installation of "interbottom piping" that carries fuel and ballast for the ship. These pipes run through the bottom or "tank" of the ship and must be fitted and covered by a layer of plating before successive tasks can be performed. If the work is not complete, subsequent stages of construction are, in the words of the firm's managers, "closed out." Delays at this stage of construction would ripple throughout the entire schedule.

Table 2. Summary of Specific Hypotheses

	G^m	G^o	$G^m - G^o$
Transaction specificities			
Physical asset	(+)		(+)
Human asset	+	(+)	+
Temporal	+	(+)	+
Uncertainty/complexity			
Complexity	+	+	+
Similarity of transactions			
Labor/capital intensity		−	+
Engineering intensity		+	−

regarding the role of relationship-specific investments suggest that both human and physical capital specificities should raise the costs of market organization, although the nature of construction may make physical asset specificities less important in shipbuilding than in other applications. The effects, if any, of these two variables on internal organization costs are expected to be smaller than on the costs of market exchange. There is no a priori reason why relationship-specific physical capital should be harder to manage than standardized assets. And, although integration may only imperfectly limit opportunism associated with relation-specific skills and knowledge embodied in workers, the net effect of human asset specificity on the difference between market and internal organization costs is generally argued to be positive (Williamson, 1975:29–30; Klein).

Of more consequence in this setting is the need for precise scheduling (temporal specificity) that raises the potential for strategic delays and thus the prospective cost of dealing with subcontractors. Scheduling concerns, by further taxing scarce managerial resources, may also raise internal organization costs. But the greater potential for strategic holdups in market transactions should increase the costs of contracting relative to internal organization and thus also increase the probability of integration. Similarly, complexity should also raise the cost both of contracting for required inputs and services and of administering production internally. But again, the differential effect should, for reasons outlined above, favor integration.

Finally, following Coase's argument, the similarity of a particular activity to the firm's primary operations should reduce the cost of managing that activity internally relative to subcontracting. Since shipbuilding primarily involves coordinating a large number of low-technology, labor-intensive tasks, we hypothesize that internal organization costs will be smaller, and thus the likelihood of integration greater, the more labor-intensive and the less engineering-intensive the production process.[18]

18. In other studies (Monteverde and Teece, 1982a; Masten et al.), engineering intensity has been used as a proxy for the amount of transaction-specific knowledge generated in developing a component, which would imply an opposite effect on the probability of integration. In this study, we include a separate measure for human asset specificity that we believe better captures the intended variable. See also the discussion in Section 5.

4. Evidence on the Structure and Costs of Organization in Shipbuilding

4.1 Data

To test the preceding hypotheses, we collected data using a survey design based on previous surveys by Monteverde and Teece (1982a), Masten (1984), and Anderson and Schmittlein. The survey covered a sample of tasks and components from the make-or-buy program of a large, naval shipbuilder and elicited information on each of the variables discussed in Section 3.3 as well as the mode of organization adopted for each component or activity.[19] A team of company officials consisting of the assistant to the vice president for production and the managers of the production planning and purchase specifications departments responded to each item on the survey based on their collective judgement.[20]

Definitions and descriptive details for the variables contained in the data are provided in Table 3. The independent variables corresponding to the hypotheses in Table 2 are based on ordinal rankings of each component relative to others in the production program using a 10-point scale and should be self-explanatory. Our examination of shipbuilding operations also revealed an auxiliary motive for integration not directly related to the transaction-cost hypotheses outlined previously. Given the lumpiness of orders for ships and of the construction process itself, shipbuilders may be unable to utilize skilled employees fully in their primary application for significant periods of time. To occupy these workers until their specialized skills are again needed, a company may integrate production of a variety of components that use related skills and that can be produced during slack periods and stored for later use. As a result, some components that would normally be procured by subcontract, like storage bins and spare parts boxes that require only ordinary sheet metal bending and welding skills, are produced inside the firm to balance the work loads of employees whose main duties are irregularly demanded. To control for this, a dummy variable (LOAD) was included as an indicator of whether a particular component or task had characteristics that would make it suitable for "load leveling."[21]

19. Random selection from a list of components and operations subject to procurement review on a regular basis generated 58 of the observations in the sample (32 make and 26 buy items). Because this list did not cover all aspects of ship production, the sample was supplemented with 16 additional items (11 make and 5 buy) drawn from the production program at large.

20. To gauge the reliability of the responses to the survey, we obtained a second set of responses for each transaction-cost variable from a naval architect who had been previously employed by the shipbuilder. The second respondent provided rankings for 72 of the 74 components in the original sample. The correlations between the two sets of responses for each variable were SCHEDULE, .73; HUMAN, .48; ASSET, .19; COMPLEX, .60; ENGINEER, .53; and LABOR, .45. Although the correlations are positive and significant for all six variables, the particularly low correlation between responses on the physical asset specificity measure suggests a high degree of measurement error for this variable. The advanced positions and greater collective experience of the primary respondents support use of the original data on a priori grounds.

21. Seven of the make and two of the buy items in our sample were identified as potential load levelers. Generally, the characteristics that make a component suitable for load leveling depend on the timing and skill requirements of the contractor and thus depend on the nature of the

In addition to these independent variables, we collected data on organization costs to permit estimation of the structural cost equations as discussed in Section 2.1. The difficulty of acquiring even the minimal information required to identify the censored regression model varies with the nature of the institutions and their costs. The problems of obtaining reasonable data on the costs associated with contracting, for instance, are likely to be severe. First, such costs will generally be incurred by each party to a transaction, so that information must be collected from two (or more) sources. Second, the most acute contractual failures occur only probabalistically over a period of time in the future, which requires that data be collected on the intangible expectations of the decision-makers.

In contrast, the costs of internal organization—expenses associated with activities like planning, directing, and oversight—besides accruing to a single organization, tend to occur in a more routine fashion.[22] Where costs have this nature, actual measurement or formulation of reasonable proxies may be possible. Accordingly, our efforts focused on obtaining data on the costs of internal organization *for those processes and components actually organized within the firm.* Specifically, our measure of the costs of internal organization was constructed as the number of hours devoted by management to planning, directing, and supervising a particular component or process times the average hourly management wage rate.

4.2 Empirical Results

Estimations of the censored structural model represented by Equations (4) and (5) were conducted using a two-stage procedure.[23] In the first stage, we estimated as a probit model the selection decision regarding whether to organize the process internally or to subcontract the work to an outside supplier. The reduced-form estimations at this stage are similar to estimations in earlier empirical studies of integration decisions except for the inclusion of proxies for temporal specificity and similarity.

In the second stage, we estimate the structural equations of the model. This is done, first, by estimating internal organization costs correcting for selectivity using an index constructed from the first-stage results. Estimates of the coefficients in the (unobserved) external organization-cost equation are then, in effect, inferred from the parameters of the probit and internal organization-cost estimations. The following subsections report results from each stage of the estimation and present estimates of the dollar costs of organization. Dis-

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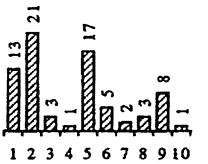
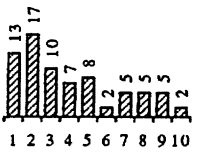
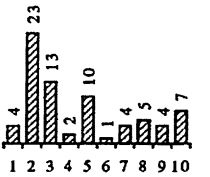
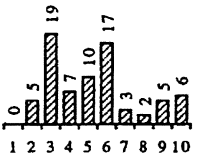
particular project. Nevertheless, such components will tend to use relatively standardized skills and assets and permit flexibility in scheduling.

22. Not all internal organization costs fit this description. To the extent that a portion of the costs of internal organization result from things like labor strikes, which are probabilistic and for which some of the costs accrue to labor rather than the firm, the difficulties associated with measuring contracting costs apply as well to transactions within the firm. See Section 5.

23. See the references in note 7.

Table 3. Variable Definitions and Descriptive Statistics

MAKE	= 1, if the production of the component or task was organized internally; = 0, otherwise	43 observations 31 observations
SCHEDULE	= a ranking of the importance of having the component or performing the task on schedule (median = 6)	
HUMAN	= the degree to which skills, knowledge or experience of workers are specific to this application (median = 7)	
ASSET	= the degree to which facilities and equipment used in the production process are specific to this application (median = 3)	
COMPLEX	= a ranking of the complexity of the component or task (median = 3)	
ENGINEER	= a ranking of the amount of engineering effort involved in developing the component (median = 3)	
LABOR	= an index of the relative labor/capital intensity of the production process (median = 5)	
LOAD	= 1, if the component or task had characteristics making it a candidate for load leveling; = 0, otherwise	9 observations 65 observations
G^{o}	= costs of planning, directing, and oversight for integrated tasks or components ≡ (number of management hours × management wage rate)	Mean = $38,690[a] Std. dev. = $54,030

Number of observations = 74.
[a]For the 43 make observations.

cussion of the findings and their relationship to prior empirical research is deferred to Section 5.

4.2.1 Probit Estimations of the Make-or-Buy Decision. In Table 4, we present results from three alternative specifications of the selection equation. Column (1) shows results of a probit estimation of the decision to integrate production using only the proxies for specificity and complexity plus the variable LOAD to control for load-leveling concerns. This specification thus emphasizes the factors argued to aggravate market exchange hazards in the recent transaction-cost literature. Of the transaction-specificity variables, the coefficient on SCHEDULE is positive and significant as expected, indicating that production is more likely to be integrated the more critical scheduling of a task is to the project. Contrary to predictions, however, ASSET is significantly negative, while HUMAN is only marginally positive (the coefficient is significant at the .10 level in a one-tail test). Initial estimations indicated an insignificant or

Table 4. Probit Make-or-Buy Estimations

	(1)	(2)	(3)
CONSTANT	0.40531 (0.672)	−3.1229 (−2.720)	−2.5112 (−2.247)
SCHEDULE	0.29222 (3.027)	0.43285 (3.380)	0.37010 (3.031)
HUMAN	0.13899 (1.541)	0.22327 (2.154)	0.19888 (1.998)
ASSET	−0.15051 (−1.981)	−0.08512 (−0.971)	−0.10024 (−1.164)
COMPLEX	−0.75654 (−2.500)	−0.88865 (−2.656)	−0.85055 (−2.613)
COMPLEX^2	0.04744 (1.781)	0.06690 (2.218)	0.06291 (2.166)
ENGINEER		−0.18139 (−1.768)	−0.13805 (−1.429)
LABOR		0.42928 (3.754)	0.39893 (3.575)
LOAD	0.85908 (1.451)	1.3955 (1.895)	
χ^2	20.046 (6 d.f.)	37.529 (8 d.f.)	33.296 (7 d.f.)

t-statistics in parentheses. $n = 74$.

slightly negative effect of complexity on the integration decision. Specification tests, however, revealed a nonmonotonic effect of complexity on observed organizational arrangements in this setting. Specifically, for relatively simple components, increases in complexity make it less likely that production would be internalized. Beyond some threshold, however, the probability of integration begins to increase as complexity rises. The results suggest that the deficiencies of contracting begin to overcome the administrative burden of internal organization in this industry only for the most complex tasks and components.[24] The effect of LOAD is also positive but only marginally significant.

The specification reported in column (2) incorporates measures reflecting the prediction that similarity favors integration as well as the variables embodying conventional transaction-cost concerns. The coefficients on both LABOR and ENGINEER are significant and support the hypothesis that integration is, in this application, more likely for more labor-intensive and less engineering-intensive activities. With respect to the other transaction-cost variables, the results for both SCHEDULE and COMPLEX are similar to those in column (1). The inclusion of ENGINEER and LABOR, however, alters the estimated effects of human and physical asset specificity. In particular, the coefficient on ASSET becomes insignificantly different from zero and the significance of the coefficient on HUMAN improves substantially.[25] The results also indicate that the firm is more likely to integrate activities that are suitable for use as "load levelers." Overall, the comprehensive model represented by the specification in column (2) predicts the organization form adopted correctly for 64 of the 74 observations in the sample.

Finally, column (3) shows for comparison results of the full model omitting LOAD. Although the results are similar to those in column (2), the exclusion of LOAD weakens the estimated correlations between integration and HUMAN, ENGINEER, and SCHEDULE. Since potential load levelers tend to use relatively standard skills and assets, involve little engineering, and

24. Because of the small sample size and large number of "steps" in the scale used to evaluate the independent variables, the resulting cells have too few observations to permit meaningful estimation using dummy variables for each step. We chose, therefore, to test for nonlinearities by adding quadratic terms for each of the variables both simultaneously and sequentially. We found no evidence that variables other than COMPLEX entered nonlinearly. The quadratic terms for complexity yield a minimum of 8.0 for the specification reported in column (1) and of 6.6 and 6.8 for columns (2) and (3). In the only other study that attempted to measure complexity, Masten (1984) found a lower probability of integration for relatively simple items but no significant difference between highly and moderately complex items. Further investigation of the effects of complexity in the present study revealed that the strength of the observed nonlinearity rests heavily on the 13 observations for which COMPLEX = 1.

25. The predicted effect of omitting ENGINEER and LABOR is consistent with the observed bias in the coefficients on HUMAN and ASSET: Since engineering intensity reduces the probability of integration, omission of ENGINEER, which is positively correlated with both HUMAN and ASSET, would bias the coefficients on HUMAN and ASSET downward. On the other hand, LABOR, which is negatively correlated with HUMAN and ASSET, is expected to increase integration. Hence, its exclusion reinforces this downward bias.

require flexibility in scheduling, the observed changes in the estimated parameters are consistent with the bias that we would expect from omitting this variable.

Overall, this stage of the analysis, which estimates a reduced-form model analogous to those employed in previous transaction-cost studies of integration, supports the proposition that variations in *both* market and internal organization costs influence the organization of economic activity. In particular, the results are consistent with hypotheses regarding (i) the potential for holdups in market transactions fostered, in this setting, by temporal and human asset specificities, and (ii) the costs of managing dissimilar, and, hence, unfamiliar activities within the firm.[26] But, as previously noted, the inability to identify the underlying cost structures using a reduced-form model tempers the strength of these conclusions.

4.2.2 Organization-Cost Estimates. In contrast to earlier studies, our data on internal organization costs permit us to estimate both the structural organization-cost equations and dollar costs of organization. Using the sample of integrated components, we estimated the coefficients for the internal organization-cost equation by regressing our measure of internal organization costs against each of the independent variables (with the exception of LOAD[27]) and a selection correction factor constructed from the probit results reported in column (3) of Table 4. Specifically, the organization-cost equations include the inverse Mills ratio $\lambda = f(z)/F(z)$, where z is the estimated value from the probit equation and f and F are the standard normal density and distribution functions, respectively.

Columns (1) and (2) of Table 5 report estimates of the coefficients for both linear and log specifications of the internal organization-cost equations.[28] The log specification has the advantage of constraining organization costs to be positive and provides a substantially better fit to the data. Despite the small sample size (only 43 "make" observations), both equations provide remarkably good estimates. As in the probit equations, complexity appears to have a nonmonotonic affect in the internal organization-cost equations, peaking at a value of approximately 5.3 in both specifications. The coefficient on SCHEDULE is not significant, indicating that the principal effect of SCHEDULE on

26. Davidson and McFetridge (1984, 1985) also employ a measure of similarity in their studies of technology transfer modes. Although their measure is different from ours, they find similar results with respect to the effects of similarity on the incentive to integrate.

27. The hypothesis that load-leveling activities are not more or less costly to manage than other activities is supported by the data. Inclusion of all eight independent variables in the organization-cost equation causes the estimated correlation coefficient between the errors in the selection and structural equations to exceed its logical upper bound, which causes problems in the correction of the standard errors for the endogeneity of the selection criterion. This is a fairly common problem with small samples such as the present one.

28. The internal organization-cost equations were estimated using LIMDEP version 5.1. The standard errors for these equations are corrected for both heteroskedasticity and the endogeneity of the selection correction index.

Table 5. Costs of Organization

	(1)	(2)	(3)	(4)
			$\ln(G^m)$	
	G^o	$\ln(G^o)$	$\beta_6,\beta_7 = 0$	$\sigma_{eu} = 0$
CONSTANT	61,458.1 (0.856)	10.3623 (7.080)	7.4009 (3.656)	6.4492 (5.704)
SCHEDULE	−286.998 (−0.049)	0.12453 (1.058)	0.59400 (4.216)	0.68817 (4.010)
HUMAN	−10,933.9 (−2.443)	−0.18772 (−2.104)	0.04874 (0.484)	0.10301 (0.715)
ASSET	1494.09 (0.404)	−0.01961 (−0.256)	−0.12173 (−1.421)	−0.13045 (−1.777)
COMPLEX	32,029.2 (1.853)	0.91355 (2.615)	−0.01618 (−0.043)	−0.24362 (−0.563)
COMPLEX^2	−2995.95 (−2.027)	−0.08630 (−2.874)	−0.01374 (−0.420)	0.00081 (0.023)
ENGINEER	13,491.4 (3.765)	0.25686 (3.592)		0.02066 (0.192)
LABOR	−10,161.4 (−1.375)	−0.40561 (−2.652)		0.15339 (0.809)
LAMBDA	−45,229.2 (−1.550)	−0.63044 (−1.068)		
$F(8, 34)$	5.2208	10.7124		
R^2	0.55125	0.71596		

t-statistics in parentheses.

the integration decision derives from the hazards of market exchange (see next paragraph). The degree of physical asset specificity also has no effect on the costs of internal organization, as expected. Contrary to expectations, however, HUMAN has a negative coefficient in these equations, suggesting that workers with more specific skills are less costly to manage. Finally, organization costs for this firm appear to be lower the more labor-intensive the process and the less engineering effort associated with the component, as the "Coase hypothesis" predicts.

The coefficients for the contracting cost equation corresponding to the log organization-cost estimates in column (2) are derived under two alternative assumptions: first, that the variables ENGINEER and LABOR affect only the

costs of internal organization [column (3)]; and, second, that the errors in the internal organization cost and contracting cost equations are independent [column (4)].[29] The results under both assumptions are similar. Specifically, the coefficient on SCHEDULE is highly significant in both equations, indicating that scheduling concerns substantially increase the costs of contractual exchange in this application. Of the other traditional transaction-cost variables, only the physical asset specificity measure has a statistically significant influence on contracting costs, exhibiting a moderately significant, negative coefficient, contrary to hypothesis. The effect of ASSET on market organization costs, however, is not significantly different from its effect on those of internal organization, as indicated by the probit results. Finally, as predicted, the similarity measures ENGINEER and LABOR have no significant effect on contracting costs.

The second-stage results confirm the predictions of the theory and the findings of the first-stage selection estimation with regard to the effects of temporal specificity and the similarity of transactions. In particular, scheduling concerns raise the probability of integration by increasing the hazards of market exchange, while similarity fosters integration through its effects on internal organization costs. Complexity also exhibits a nonmonotonic effect on administrative costs that, although unanticipated, is consistent with the influence of this variable on the selection decision found in the first-stage estimates.[30] Finally, the second-stage estimates indicate that the correlation between human asset specificity and the likelihood of integration found in the first stage is a consequence of a decrease in internal organization costs rather than the increase in the costs of market exchange that the theory predicts. Hence, this result illustrates the hazards of relying on estimates from reduced-form models of economic organization.[31]

29. Intuitively, the coefficients for the market organization-cost equation, β, are found by substituting estimates of the coefficients from the internal organization-cost estimation, α, and of the covariance of e and u, σ, into the expression for the probit equation coefficients, $(\beta-\alpha)/\sigma$. See Hanoch, and Maddala (228–9, 252–5) for descriptions of the procedures used to calculate the coefficients and standard errors for these equations.

30. The second-stage findings with regard to complexity are in fact more troubling than those of the first stage. Although the nonmonotonic effect of complexity on the probability of integration would be consistent with a strictly positive, concave internal organization-cost equation and a strictly positive, convex market organization-cost equation, the nonmonotonicity in the internal organization-cost equation suggests a measurement or specification problem. The data, for instance, do not distinguish between product and process complexity, even though some of the items in the sample are more aptly classified as tasks than components. Other results, however, are robust to both omission and changes in specification of the complexity measure.

31. A possible explanation for the negative coefficient on HUMAN in the internal organization-cost equation is that relationship-specific human assets create a hostage that fosters cooperation by employees. Alternatively, skilled workers, whether their skills are general or specific, may require less oversight and supervision. If true, the latter would argue for including measures of both general and specific skill requirements in future empirical work. Neither of these explanations, however, can explain the differential effect of HUMAN on internal and market organization costs revealed in the probit selection estimation.

4.2.3 Estimated Organization Costs. Since the independent variables employed in this study are all ordinal in value, there is no natural interpretation of the coefficients in the second-stage equations. However, the structural equations can be used to estimate the costs of organization for each component given its attributes. In Table 6, we present estimated costs of organization for the 74 components in the sample. The first row shows the total estimated organization costs for these components given the organization form actually adopted. The estimated organization costs for the entire sample are $3.6 million, which represents approximately 14 percent of the total value ($25.8 million) of these components. This figure is 13 percent for the make items and 17 percent for those bought from outside suppliers. Note also that the estimated organization costs would rise substantially if all items were required to be either made internally or subcontracted, as indicated by the second and thirds rows of Table 6. The costs of organization for the 43 make items would rise from $1.86 million to $5.43 million, or from an average of $43 thousand to $126 thousand, were production of these components subcontracted. Integrating the "buy" items, on the other hand, increases estimated organization costs for the typical component by about 70 percent.[32] By this measure, the savings from selective organization appear to be substantial.

5. Discussion

In the preceding, we have applied fairly common econometric techniques and a new data set to advance the study of the determinants of organizational form and to estimate dollar costs of organization. The results support some but not all of the standard transaction-cost arguments. One of the principal findings is that temporal specificity can be a major determinant of organization form in some settings. The results consistently indicate that the prospect of holdups where the timing of performance is critical represents a significant hazard of contractual exchange in construction projects and increases the likelihood of integrating the corresponding activities.

Although generalization of this finding to other industries is hazardous, the literature suggests at least two other settings in which timing issues are important. Klein et al., in explaining why newspaper publishers tend to own their own presses while book publishers do not, observe that relative to newspapers, books are "planned further ahead in time and can be economically released with less haste. . . . No press is specialized to one publisher, in part because speed in publication and distribution to readers are generally far less important for books than newspapers, and therefore appropriable quasi rents are not created" (301, n. 6). Expropriation hazards associated with the need for prompt performance are also important in Edward Gallick's discussion of

32. No particular significance should be attributed to the asymmetries between the figures for organization costs as a percent of production costs or for the costs of mistaken integration, which would obviously be sensitive to the distribution of transactions in the sample.

Table 6. Estimated Organization Costs

	Make Items (n = 43)	Buy Items (n = 31)	Total (n = 74)
Estimated costs	$1,863,620	$1,717,710	$3,581,330
Costs if all components made internally	1,863,620	2,945,930	4,809,260
Costs if all components subcontracted	5,435,200	1,717,710	7,155,060

the organization of tuna fishing and processing where perishability issues are prominent.

Our results also provide evidence that integration becomes more likely in the presence of relationship-specific human capital and for at least very complex components. However, the organization-cost estimations indicate that this incentive to integrate arises primarily from the effects of these two variables on the costs of *internal* organization rather than on the costs of market exchange as the theory suggests. Furthermore, complexity has an unexpected nonmonotonic affect on both internal organization costs and the probability of integration, initially increasing and then decreasing the costs of organizing within the firm, with opposite effects on the likelihood that a transaction will be integrated. Fully satisfactory explanations for these findings are elusive.

The effects of physical asset specificity on both organization costs and integration vary across specifications of the equations. If anything, there is a weak indication that the need to employ relationship-specific physical assets reduces the costs of governing exchange through contracts in this setting. This finding may be somewhat less surprising in light of recent theory and evidence suggesting that problems associated with relationship-specific physical investments can be adequately dealt with via "quasi-integration," that is, the retention of title to specialized equipment by the prime contractor.[33] In fact, taking title to specialized tooling is a common practice in defense procurement (Masten, 1984).

Finally, the results of the probit estimations indicate that the particular firm we studied is less likely to integrate engineering-intensive activities and more likely to internalize labor-intensive ones. Our interpretation of these results is that the costs of internal organization are likely to be greater (both absolutely and relative to market organization costs) for activities outside of the firm's main area of expertise. Since management in construction settings largely specializes in administering the activities of diverse labor specialties focused on fabrication and assembly of a basic structure (in this case a ship), a

33. See Monteverde and Teece (1982b), and Masten et al. and cites therein.

construction firm is likely to find it easier to manage relatively low-technology, labor-intensive activities similar to its main line of business. The results of the structural equation estimations further support this interpretation. Specifically, ENGINEER and LABOR affect the costs of monitoring and supervising operations internally but not the hazards of market exchange.

Taken at face value, these results have a number of interesting implications.[34] First, while transaction-cost theory has emphasized the ways in which attributes of the transaction influence costs of market or contractual exchange (for which the probit results are supportive), the independent variables in our estimations, with the exception of SCHEDULE, have their principal influence on the costs of *internal* organization. This both illustrates the hazards of testing transaction-cost hypotheses using reduced-form equations and argues that greater attention should be paid to the determinants of internal organization costs as Ronald Coase has long contended.

Second, the findings regarding the effects of engineering effort on the integration decision raise questions about the interpretation of this variable in previous studies. Both Monteverde and Teece (1982a) and Masten et al. regard the positive effect of engineering effort on the decision to integrate production in the U.S. automobile industry as evidence that transaction-specific know-how generated in the process of developing new products creates quasi-rents that favor integration. Not only do the data in this study reveal no evident concern about appropriability problems associated with contracting for products embodying heavy doses of engineering know-how, but contracting actually becomes more likely as a component's engineering content increases. Given these results, the possibility must be considered that U.S. auto firms have developed over the years an expertise in managing engineering-intensive activities that reduce the costs of organizing the production of associated components internally and that the decision to integrate those components reflects more this proficiency in management than changes in the potential for holdups.

The importance of scheduling and load-leveling concerns and the effects of the engineering- and labor-intensity variables also underscore the need to know the industry being studied. Although the conditions of bounded rationality and opportunism may be universal, the factors that influence their incidence are likely to vary from one industry to another. As a result, it is almost imperative that case study techniques be combined with more formal-empirical analysis.

On a policy level, the cost estimates suggest that changes in regulations or legal rules that alter the nature of institutional arrangements can have significant efficiency implications. A change in legal rules that makes employees more like independent contractors, for instance, could, according to our results, more than double the cost of organizing those agents. The results also

34. Important qualifications regarding the robustness and generality of these conclusions follow.

provide a basis to assess the potential cost of antitrust prohibitions of meritorious vertical mergers.

However, in weighing these results, several caveats are in order. The present study was conducted with a small number of observations from a single firm in a fairly idiosyncratic industry. The complexity of the production process and scheduling issues may imply a disproportionate and atypical role for internal organization-cost considerations in construction settings. In addition to the construction aspects of shipbuilding, the organization of production in this application may also be influenced by government defense acquisition regulations (see Masten, 1984). Furthermore, since only data on internal organization costs were available, the burden of estimating both the internal and market organization-cost equations rests heavily on the 43 observations for the integrated components.

The cost equation estimates also depend critically on our internal organization-cost measure. To the extent that we miss important costs that are systematically related to one or more of the independent variables, our results will be biased. Thus, the negative correlation between organization costs and the amount of human asset specificity might result, for example, if union organization of skilled workers substituted in part for management organization or if costs associated with collective bargaining were split between employees and management. These costs (which might emerge as higher employee wages) and others of a similar nature would not be measured as part of organization costs in our data.

More generally, allowances must be made for the quality of the data used in both this and earlier studies of integration decisions. The independent variables employed in these studies have almost all been qualitative and are typically imprecise proxies for the variables of true interest. Results both supporting and opposing received theory may say more about the quality of the data than the validity of the theory. There is obviously a need both for refinement of these proxies and for new quantitative measures that permit cross-firm and cross-industry comparisons.

Given the idiosyncracies of shipbuilding and the limitations of the data, a recommendation that we redirect our research efforts toward improving our understanding of the nature and sources of internal organization costs would be premature. Nevertheless, the surprising importance of internal organization costs in this first attempt to distinguish their influence from that of market transaction costs suggests that analyses of integration decisions be broadened to encompass variations in costs of organizing within, as well as between, firms. Unfortunately, checking hypotheses against actual behavior poses a serious challenge, given the obstacles to obtaining even the limited quantity and types of data employed here.

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