Division of Research
School of Business Administration

April 1989

THE COSTS OF ORGANIZATION

Working Paper #603

Scott E. Masten
Edward A. Snyder
The University of Michigan
and
James W. Meehan
Colby College

ABSTRACT

This paper suggests ways of overcoming difficulties inherent in direct tests of economic theories of organization. Specifically, we discuss problems in testing transaction-cost arguments and identify parallels to familiar selection and censoring problems. 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 permits us, unlike earlier empirical studies of integration decisions, (i) to test the relationship between attributes of the transaction and the costs of organizing both within and between firms and (ii) to provide dollar estimates of those costs.

*We would like to thank participants at seminars at the University of California, Los Angeles, the University of Michigan, and the Antitrust Division of the U.S. Department of Justice for helpful comments. We gratefully acknowledge the cooperation of Bath Iron Works and thank Don Spann, Phil Nein, and especially Mark McAliffe who facilitated obtaining the data. The University of Michigan School of Business Administration and Colby College provided partial financial support.

**The University of Michigan, School of Business Administration, Ann Arbor, MI 48109-1234

***Colby College, Department of Economics, Waterville, ME 04901

The Costs of Organization

Scott E. Masten
James W. Meehan, Jr.
Edward A. Snyder

1. Introduction

Ronald Coase is widely esteemed as the father of the modern theory of the firm. It is ironic, therefore, that Coase, for his part, regards his heirs in the theory's development as wayward children. Although both regard the comparison of costs of transacting under alternative arrangements as determining organizational form, Coase has repeatedly emphasized the importance of variations in the costs of managing different transactions within the firm in the decision to integrate (Coase 1937, 1972, 1988), while more recent authors have stressed the role of market transaction costs and their sources in that decision (Williamson 1975, 1985, 1988; Klein, Crawford and Alchian, 1979; Klein, 1988). In particular, Coase questions the significance of asset specific investments in motivating the integration of production (1988, pp. 42-46) and suggests instead that understanding "the effect of activities in which a firm is already engaged on the cost of undertaking additional activities" (p. 40) is more likely to reveal why particular operations are organized within specific firms.[1]

The relative importance of variations in internal and external costs on the decision to integrate is ultimately an empirical question. To date, a number of empirical studies have examined the determinants of vertical integration.[2] This research, however, has focused exclusively on hypotheses relating integration to factors aggravating the hazards of market exchange.

Furthermore, the tests employed in these studies have been relatively weak; because of a variety of problems in observing and measuring transaction costs, analysts have had to rely on estimations of reduced form relationships between attributes of the transaction and observed organizational forms. As we explain below, such tests are incapable of discerning the relative contributions of internal and market costs of organization to the decision to integrate.

This paper suggests ways of overcoming the difficulties inherent in direct tests of transaction-cost arguments and discusses how econometric methods developed elsewhere can be used to reduce the information problems associated with estimating models of economic organization. Specifically, in the first part of the paper, we consider the obstacles confronted in testing transaction-cost arguments and identify parallels to familiar selection and censoring problems. 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 permits us, unlike earlier empirical studies of integration decisions, to test the relationship between attributes of the transaction and the costs of organizing both within and between firms and to provide dollar estimates of those costs.

Our results indicate that overall organization costs are substantial, representing about 14% 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%, while subcontracting work currently

performed inside the firm would, on average, generate market organization costs almost three times those incurred managing that work internally.

With regard to the relative importance of internal and market organization costs, we find that the costs of dealing across a market interface, and hence the incentive to integrate, rise the greater the potential for hold-ups in a given transaction, as recent theorists have argued. In addition, however, the results support Coase's contention that variations in the level of internal organization costs play an important role in the integration decision. 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. Measurement Problems in Assessing Organization Costs

The maintained hypothesis underlying transaction-cost analyses of organizational form is that transactors choose organizational arrangements to minimize the expected costs of governing the transaction over the life of the relationship.[3] If we let I* signify the institution chosen, a representative model of the choice between two institutions--typically internal organization (I^o) and market exchange (I^m)--would be

$$I^* = I^o, \quad \text{if } G^o < G^m \quad ; \quad \text{and}$$
$$I^* = I^m, \quad \text{if } G^o \geq G^m \quad . \tag{1}$$

Criticisms of early transaction-cost arguments derived from the difficulties of observing and measuring the costs of organization, in this case, G^o and G^m. The inability to ascertain these costs meant that it was easy to make and impossible to refute claims that observed institutions

minimized transaction costs. The problems of observing and measuring organization costs have several sources. First, many costs associated with organization, 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 assess the costs of organization must confront a basic selection problem: organization costs cannot be directly observed for organizational forms not chosen. Even if the costs associated with internal administration, for instance, 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 the costs of alternative institutions are impossible.

To address these criticisms and circumvent the measurement problems, 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.[4] Thus, suppose the true costs of organization are the following:

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

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

where X and Z are vectors of characteristics of the transaction, α and β are

coefficient vectors, and e and u are normally distributed random variables. By substituting into equation (1), the probability of observing institution I_o becomes $Pr(G^o < G^m) = Pr(e-u < \beta Z - \alpha X)$. Hypotheses regarding organizational 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 include previous empirical research on the economics of integration decisions by Monteverde and Teece (1982), Masten (1984), and Anderson and Schmittlein (1984). 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. Because the variance of e - u must also be estimated, the coefficients 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. Thus suppose, for example, that it is hypothesized 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 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. A finding that higher asset specificity leads to a larger probability of integration is therefore possible even if the hypothesis that asset specificity raises contracting costs is invalid. As a result, existing tests of transaction-cost theories, while generally supportive, have in this sense been relatively weak.

Stronger tests of the theory and estimation of the actual costs of organization are attainable 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 costs of organizational forms that <u>are</u> chosen. Thus, in integration decisions, if firms chose the lower cost organizational alternative and we could observe the transaction costs incurred under the institution adopted, then consistent estimates of the costs of both market and internal organization could be obtained for each transaction using switching regression techniques.[5] The data burden could be further reduced by estimating the structural equations as a censored regression model analogous 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

$$(4) \qquad G = G^o = \alpha X + e \ , \quad \text{if } G^o < G^m;$$

$$(5) \qquad G = G^m = \text{n.a.}, \quad \text{if } G^o \geq G^m;$$

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^0 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.

By distinguishing the effects of variations in internal and market organization costs on the integration decision, this approach stands to shed light on the debate identified at the outset of this paper. Whereas the recent transaction-cost literature has emphasized the role of asset specificity and complexity in determining the costs of market exchange, Coase has expressed doubts about the importance of holdup problems in market transactions and has consistently argued that the explanation for which activities get integrated lies elsewhere:

> 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 the 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, p. 64).

According to Coase, therefore, variations in the costs of internal organization (G_O) are likely to be central in explaining observed patterns of integration. Estimation of the costs underlying the integration decision would create the prospect of assessing such claims more rigorously.

3. Naval Shipbuilding: Assets, Attributes, and Operations

In the following, we apply the methodology described in the previous section to estimate the structure of organization costs in a specific application, namely, the procurement of components and services by a large naval shipbuilder. In addition to relying on reduced form estimations, most previous empirical research on the determinants of vertical integration has dealt with manufacturing applications. The process of building a ship, however, 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.

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. 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 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" (1981, p. 337). At these stages, tasks must be ordered strictly for work to proceed. As a result, delays in a key task can have system wide effects, meaning that progress on a group of operations is inhibited and that managers must wait until the antecedent task is completed or identify an alternative sequence of operations.

The prominence of timing and scheduling concerns in construction projects influences organization decisions in at least two important ways. First, the inability to smooth production interruptions through devices like buffer inventories, and the variety and complexity of tasks involved in a typical construction project are likely to severely tax bounded rationality. Generally, more of management's time and effort will be devoted to planning, scheduling, and oversight in construction operations than in the typical manufacturing setting. Because these activities place intense demands on management's attention, construction firms may be more reluctant than manufacturing firms to integrate activities outside of their basic realm of expertise--a conjecture consistent with the extensive use of subcontracting in the construction industry.

Second, the importance of timely performance makes delay 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.[8]

Contracting offers only an imperfect solution to such holdup problems. In principle, incentives for prompt performance could be created by specifying appropriate damages. And in fact, the use of performance and installment contracts are common in construction settings (see, for instance, Lee and Png, 1988). But the adequacy of contractual solutions varies with the nature of the transaction. Optimal design specifications or completion dates may change over the course of the project, which may require alterations to the original plan. Similarly, construction costs may vary in ways that dictate changes in the processes or materials that should be employed. While accounting contractually for all possible contingencies is impossible in all but the simplest settings, reliance on court determined remedies is hazardous where the full damages due to delay are difficult for courts to assess accurately, such as where the prime contractor's record on meeting contract dates influences the prospect of winning future contracts. Hence, in construction as in other settings, contracting is likely to become a less satisfactory solution where there is a high degree of complexity or uncertainty associated with the transaction.[9]

In sum, differences in the nature of construction and manufacturing influence the factors that underlie the choice of organizational arrangements. In particular, these differences lead us to expect that the degree to which activities require precise scheduling will be a major determinant of organizational form in construction settings. Of course, concerns about timing and the resulting potential for holdups are not absent

in other economic settings, including manufacturing, just as physical and human asset specificities may influence the organization of some construction activities, particularly the fabrication of certain subunits or components that are common across projects or used in significant numbers. In that regard, the difference between manufacturing and construction is a matter only of degree. Nevertheless, characteristics that tend to be associated with construction are (i) a higher likelihood that the party responsible for a given operation can put the whole project at risk and (ii) a greater difficulty of using mechanisms such as buffer inventories to protect the contractor against opportunistic delays.

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 immovable 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.[10] Holding buffer inventories as a safeguard against holdups, meanwhile, 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 any point in time. Demand for additional ships depends 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.

This uncertainty about demand combined with the extreme complexity of modern naval vessels also hampers contracting solutions to the holdup problem. 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.

The specialized design of military vessels also 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 require extended apprenticeships to develop and may have limited value outside of a specific shipyard. Physical assets used in ship construction, in contrast, 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 assets, like welding and pipe-fitting equipment, tend also to be of a relatively standardized nature.

Hypotheses relating these aspects of shipbuilding to the costs of market exchange, G^m, are summarized in the first column of table 1. The need for precise scheduling is expected to increase the potential for holdups in market exchange and thus raise the costs of dealing with subcontractors. The complexity of components and tasks is also expected to raise the costs of

market transactions by increasing the difficulties of contracting for required inputs and services. Finally, the traditional transaction-cost arguments emphasizing relationship-specific investments as a source of holdups suggest that both human and physical capital specificities should raise costs of market organization. But because the nature of construction makes the use of relationship-specific equipment less practical, physical asset specificities may be less important in this application.

In comparison to the body of research relating market organization costs to attributes of transactions, the attention given the factors influencing the level of internal organization costs has been meager. Coase's own early speculation was 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, pp. 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. Integrating dissimilar activities forfeits the benefits of specialization, while more complex or uncertain transactions demand a greater share of management's limited attention to administer.

Following Coase, we hypothesize that similarity between a particular activity and a shipbuider's primary operations reduce the cost of managing that activity within the firm, G^{o} (again see table 1). Hence, the cost of market exchange relative to internal organization, $G^{m} - G^{o}$, should be higher, and integration more likely, for activities that lie within a firm's basic area of expertise.

More complex activities are also expected to be more expensive to organize internally. But, because contracting demands prior anticipation of potential problems while internal organization permits adaptation to changing circumstances as they unfold, it is usually argued that greater complexity would raise the differential costs of market and internal exchange and therefore increase the probability of integration (see, e.g., Williamson, 1979).

Finally, while there is no reason to believe that relationship-specific physical capital should be harder to manage than standardized assets, integration may only imperfectly limit opportunism associated with relationship-specific skills and knowledge embodied in workers. Hence, it may be more expensive to manage workers with such skills. Nevertheless, we would expect the net effect on the difference between market and internal organization costs to be positive. Similarly, scheduling concerns may, by further taxing scarce managerial resources, also raise internal organization costs, G^{O}. The greater potential for strategic holdups in market transactions, however, should raise the costs of contracting relative to internal organization and thus also increase the probability of integration.

4. Organization Costs in Shipbuilding.

Data

Following the approach used in Monteverde and Teece (1982a), Masten (1984), and Anderson and Schmittlein (1984), we collected information on a variety of tasks and components from the make-or-buy program of a large, naval shipbuilder. The data included information on the importance of scheduling, the complexity of components, the amount of relationship-specific

human capital involved in production, and the specificity of physical assets, as well as the mode of organization adopted for each component or activity.

Unlike these earlier studies, however, we also collected data on the costs of organization to permit estimation of the structural cost equations as discussed in section 2. 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 generally associated with activities like planning, directing, and oversight--besides accruing to a single organization, tend to occur in a more routine fashion.[11] 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 integrated by the firm.

Definitions and descriptive statistics for the variables in our data are provided in table 2. Most of the variables in the table correspond directly to the hypotheses outlined in table 1 and should be self-explanatory.[12] Three others, ENGINEER, LABOR, and LOAD, deserve comment.

To gauge the similarity of a particular activity to the firm's main operations, we wanted variables that reflected essential features of those

operations. 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. Thus, as measures of similarity, we included rankings of the relative labor-capital intensity of the production process (LABOR) and the amount of engineering effort associated with a task or component (ENGINEER).[13] The costs of internal organization in this application are expected to be smaller, and thus the probability of using outside suppliers to decrease, the larger LABOR and the smaller ENGINEER.[14]

Finally, a problem posed by the lumpiness of the construction process is that some skilled employees may be underutilized in their primary use 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 a suitable candidate for "load leveling."[15]

Results

Estimations of the censored structural model represented by equations (4) and (5) were conducted using a two-stage procedure.[16] The first stage evaluates the selection decision as a probit model of whether to organize the process internally or to subcontract the work to an outside supplier. In the second stage, we estimated internal organization costs correcting for selectivity using an index constructed from the first stage results. External organization costs were then derived from the results of these two estimations.

Probit Estimations of the Make-or-Buy Decision. Table 3 presents results from three alternative specifications of the selection equation. Column (1) reports the results of a probit estimation of the decision to integrate production using just SCHEDULE and COMPLEX as the independent variables. The coefficient on SCHEDULE is positive as expected and significant beyond the .01 level, indicating that production is more likely to be integrated the more critical scheduling of the task is to the project. Initial estimations indicated an insignificant or slightly negative effect of complexity on the integration decision. Experimentation, however, revealed that complexity has a nonmonotonic effect on observed organizational arrangements. 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 with complexity. The results suggest that the deficiencies of contracting overcome the gains from specialization in this industry only for the most complex tasks and components.[17]

Columns (2) and (3) present results of estimations including the remaining explanatory variables. Column (2) includes the two variables, HUMAN and ASSET, intended to capture the standard transaction-cost hypotheses, while column (3) reports results including all of the previously discussed measures. The results with respect to both SCHEDULE and COMPLEX in columns (2) and (3) are similar to each other and to those in equation (1). The results with respect to the other transaction-cost variables differ, however, across specifications. Contrary to predictions, ASSET is significantly negative in column (2), while HUMAN is only marginally positive (the coefficient is significant at the .10 level in a one-tail test) in that specification. When ENGINEER, LABOR, and LOAD are included, however, the coefficient on ASSET becomes insignificantly different from zero and the significance of the coefficient on HUMAN improves substantially. In addition, the results indicate that the firm is more likely to integrate activities that are relatively labor intensive, use little engineering, and are suitable for use as "load levelers."[18] Overall, equation (3) predicts the organizational form adopted correctly for 64 of the 74 observations in the sample.

Organization Cost Estimates. Unlike earlier studies of procurement organization, our data contain information on the costs of organization that make estimation of the structural equations and dollar costs of organization possible. Our measure of the costs of internal organization is based on the number of hours devoted by management to planning, scheduling, and managing a particular component process for those activities organized <u>inside</u> the firm. Then, using the sample of integrated components, the coefficients for the

internal organization cost equation are estimated as a function of each of the independent variables in column (3) of table 2 (with the exception of LOAD[19]) and a selection correction factor constructed from the results of the previous probit estimations. 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 4 report estimates of the coefficients for both linear and log specifications of the internal organization cost equations. 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 observations in the integrated sample), 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 the linear and log specifications. The coefficient on SCHEDULE is not significant, indicating that the principal effect of SCHEDULE on the integration decision derives from the hazards of market exchange (see below). The degree of physical asset specificity also has no effect on the costs of internal organization. Contrary to expectations, HUMAN has a negative coefficient in these equations which implies that it is less costly to manage workers the more specific their skills. 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" would predict.

Estimates of 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). 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 variables, the only one that is statistically significant is ASSET which exhibits a moderately negative effect on contracting costs, contrary to the usual hypothesis. The effect of this variable on contracting costs, however, is not significantly different from its effect on organization costs, as indicated by the probit results.

Since the independent variables are all ordinal in value, there is no natural interpretation of the coefficients in these equations. However, the structural equations can be used to estimate the costs of organization for each component given its attributes. Table 5 presents actual and estimated costs of organization for the 74 components in the sample. The second row gives the total estimated organization costs for the components given the organization form actually adopted. The estimated organization costs for the entire sample is $3.6 million, which represents approximately 14% of the total value ($25.8 million) of these components. This figure is 13% for the make items and 17% 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 rows 3 and 4 of table 5. Thus, 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%. Such comparisons suggest that the savings from selective organization can be substantial.

5. Discussion

Transaction-cost reasoning has for some time offered plausible explanations for observed institutional arrangements. But it is only recently that transaction-cost propositions have been subjected to systematic testing. In general, the studies that have been conducted have tended to support the main transaction-cost hypotheses.[20] But, for reasons outlined in this paper, these tests have been indirect, and the size and consequence of various transaction costs have remained obscure.

To address this problem, we have utilized now 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 scheduling concerns can be a major determinant of organization in some settings. The results consistently indicate that the prospect of hold-ups where scheduling is important 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 a couple other settings in which timing

issues are important. Klein, Crawford, and Alchian, 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" (1978, p.301, fn. 6). Expropriation hazards associated with the need for prompt performance are also important in Gallick's discussion (1984) of 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 transaction-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 suggested by the theory. 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.

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 transaction-specific physical assets reduces the costs of governing exchange through contracts in this setting. These results may be somewhat less surprising in light of recent

theory and evidence suggesting that problems associated with transaction-specific physical investments can be adequately dealt with via "quasi-integration," i.e., the retention of title to specialized equipment by the prime contractor.[21] 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, and hence the reluctance to integrate, are likely to be greater 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 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 appear primarily to affect internal organization costs rather than contracting costs.

Taken at face value, these results have a number of interesting implications. 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 (1982) and Masten, Meehan, and Snyder (1988) 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. Given the results in this paper, 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 holdup.

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 make

employees more like independent contractors, for instance, could, according to our results, more than double the cost of organizing those agents. The results also provide a basis to assess the potential cost of antitrust prohibitions of meritorious vertical mergers.[22]

In weighing these results, several caveats are in order, however. 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 organization. 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.

Finally, 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) would not be measured as part of organization costs in our data.

Generally, the biggest obstacle confronting empirical research into

organization form is the lack of data. The independent variables used in existing studies, including this one, have almost all been qualitative and are typically imprecise proxies for the variables of true interest. There is need both for refinement of these measures and for new quantitative measures that permit cross-firm and cross-industry comparisons. Given the obstacles to obtaining even to the limited quantity and types of data used in this and earlier studies, progress in this area presents a serious challenge.

References

Anderson, E., and D.C. Schmittlein, "Integration of the Sales Force: An Empirical Examination," Rand Journal of Economics, 15, Autumn 1984, pp. 385-395.

Clarkson, K.W., R.L. Miller and T.J. Muris, "Liquidated Damages v. Penalties: Sense or Nonsense?" Wisconsin Law Review, 1978, pp. 351-390.

Coase, R.H., "The Nature of the Firm," Economica N.S., 4, 1937, pp. 386-405. Reprinted in G.J. Stigler and K.E. Boulding, eds., Readings in Price Theory. Homewood, Ill.: Richard D. Irwin, 1952.

_____, "Industrial Organization: A Proposal for Research," in V.R. Fuchs, ed., Policy Issues and Research Opportunities in Industrial Organization. New York: National Bureau of Economic Research, 1972.

_____, "The Nature of the Firm: Origin, Meaning, Influence" Journal of Law, Economics, and Organization, 4, Spring 1988, 3-47.

Crocker, K.J., and S.E. Masten, "Mitigating Contractual Hazards: Unilateral Options and Contract Length," Rand Journal of Economics, 19, Autumn 1988.

Davidson, W.H., and D.G. McFetridge, "International Technology Transactions and the Theory of the Firm," Journal of Industrial Economics, 32, March 1984, pp. 253-264.

_____, "Key Characteristics in the Choice of International Technology Transfer Mode," Journal of International Business Studies, Summer 1985, pp. 5-21.

Eccles, R.C., "The Quasifirm in the Construction Industry," Journal of Economic Behavior and Organization, 2, 1981, pp. 335-357.

Gallick, E.C., Exclusive Dealing and Vertical Integration: The Efficiency of Contracts in the Tuna Industry. Bureau of Economics Staff Report to the Federal Trade Commission, August 1984.

Hanoch, G., "A Multivariate Model of Labor Supply: Methodology and Estimation," in James P. Smith (ed.), Female Labor Supply: Theory and Estimation. Princeton University Press, 1980.

Heckman, J., "Sample Selection Bias as a Specification Error," Econometrica, 47, January 1979: 153-161.

_____, "Sample Selection Bias as a Specification Error with an Application to the Estimation of Labor Supply Functions," in James P. Smith (ed.), Female Labor Supply: Theory and Estimation. Princeton University Press, 1980.

Joskow. P., "Vertical Integration and Long-Term Contracts: The Case of Coal Burning Electric Generating Plants," Journal of Law, Economics and Organization, Spring 1985, pp. 33-80.

_____, "Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets," American Economic Review, March 1987, pp. 168-185.

Klein, B., "Vertical Integration as Organizational Ownership: The Fisher Body-General Motors Relationship Revisited," Journal of Law, Economics, and Organization, 4, Spring 1988, pp. 199-213.

Klein, B., Crawford, R.G., and Alchian, A.A., "Vertical Integration, Appropriable Rents and the Competitive Contracting Process," Journal of Law and Economics, 21, October 1978, pp. 297-326.

Lee, L.F., "Estimation of Limited Dependent Variable Models by Two-Stage Methods." Ph.D. dissertation. University of Rochester, 1976.

Lee, T.K., and I.P.L. Png, "The Role of Installment Payments in Contracts for Services," Anderson Graduate School of Management (UCLA) Business Economics Working Paper No. 88-5, August 1988.

Maddala, G.S., Limited-Dependent and Qualitative Variables in Econometrics. Cambridge: Cambridge University Press, 1983.

Masten, S.E., "The Organization of Production: Evidence from the Aerospace Industry," Journal of Law and Economics, 27, October 1984, 403-417.

_____, J.W. Meehan, and E.A. Snyder, "Vertical Integration in the U.S. Auto Industry: A Note on the Influence of Transaction-Specific Assets," Journal of Economic Behavior and Organization, (forthcoming).

Monteverde, K., and D.J. Teece, "Supplier Switching Costs and Vertical Integration in the Automobile Industry," Bell Journal of Economics, 13, Spring 1982(a), pp. 206-213.

_____, "Appropriable Rents and Quasi-Vertical Integration," Journal of Law and Economics, 25, 1982(b), pp. 321-328.

Nelson, F.D., "Censored Regression Models with Unobserved, Stochastic Censoring Thresholds," Journal of Econometrics, 6, 1977, 309-327.

Williamson, O.E., Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press, 1975.

_____, "Transaction-Cost Economics: The Governance of Contractual Relations," Journal of Law and Economics, 22, October 1979, 233-262.

_____, The Economic Institutions of Capitalism. New York: Free Press, 1985.

_____, "The Logic of Economic Organization," Journal of Law, Economics, and Organization, 4, Spring 1988, pp. 65-91.

Footnotes

1.It is important to note that Coase and later authors recognize the importance of both market and internal organization costs on integration decisions. Coase was, after all, the first to argue that market transaction costs are what motivate integration. But which transactions get integrated depend, in Coase's assessment, more on differences in the costs of internal organization across transactions than in market organization costs. Thus, the disagreement relates to what factors determine the magnitude of various organization costs and thus how best to explain observed patterns of integration.

2.See Williamson (1985) and Joskow (1988) for overviews of this literature.

3.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.

4.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) and Klein, Crawford, and Alchian (1979).

5.See the discussion and references in Maddala, 1983, pp. 223-8.

6. See, for example, Heckman, 1980; and Hanoch, 1980. 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 L.F. Lee, 1976; F.D. Nelson, 1977, pp. 309-27; and the discussion in G.S. Maddala, 1983, pp. 228-9.

8.Thus, to the four classifications of asset specificity identified by Williamson (1985, p.55) could be added a fifth labeled "temporal specificity."

9.See generally, Williamson, 1979. Clarkson, Miller and Muris (1978) provide an extended discussion of the limitations of stipulated damages using a construction contract as their principle illustration; see especially, pages 368-372.

10.An example is the installation of "interbottom piping" that carry 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.

11.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.

12.All of the variables are based on ordinal rankings of the items relative to other items in the production program.

13.Davidson and McFetridge (1984, 1985) also employ a measure of similarity in their study 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.

14.Note that in other studies (Monteverde and Teece; Masten, Meehan, and Snyder), ENGINEER has been used as a measure of the amount of transaction-specific knowledge generated in developing a component, implying an opposite effect on the probability of integration. As discussed above, we include a separate proxy, HUMAN, that we believe better measures the intended variable. Also see the discussion below.

15.The components and tasks that will be suitable as load levelers depend on the timing and skill requirements of the contractor and thus depend on the nature of the particular project. Nevertheless, such components tend to use relatively standardized skills and assets and permit flexibility in their scheduling.

16.See the references in footnote 7.

17.There was no evidence that other variables entered nonmonotonically. 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.

18.Since "load levelers" tend to employ standardized skills and assets, omitting LOAD from the estimation would tend to bias the coefficients on HUMAN and ASSET in the observed directions.

19.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.

20.For overviews of the empirical work in this area, see Williamson (1985) and Joskow (1988).

21.See Monteverde and Teece, 1982b; and Masten, Meehan, and Snyder, 1988, and cites therein.

22.The breakdown of market exchange where scheduling is important suggests an efficiency rationale for airline mergers at hubs where coordination of flight schedules is needed to minimize passenger layovers. In considering whether to hold a flight for a delayed connection, for instance, independent airlines

would tend to assess the effects of a delay on their own profits rather than on its collective value. Given the many legitimate reasons for deviating from announced schedules, these sorts of "strategic" delays would be difficult to prevent contractually.

TABLE 1

Summary of Hypotheses

	G^m	G^o	$G^m - G^o$
Scheduling	+	(+)	+
Complexity	+	+	+
Human asset specificity	+	(+)	+
Physical asset specificity	(+)		(+)
Similarity of transactions		-	+

TABLE 2

			Mean	Standard deviation
MAKE	=	1, if the production of the component or the task was organized internally; = 0, otherwise.	.5811	.4967
SCHEDULE	=	a ranking of the importance of having the component or performing the task on schedule.	5.703	2.922
COMPLEX	=	a ranking of the complexity of the component or task.	4.014	2.702
HUMAN	=	the degree to which skills, knowledge or experience of workers are specific to this application.	4.257	2.341
ASSET	=	the degree to which facilities and equipment used in the production process are specific to this application.	4.095	2.728
ENGINEER	=	a ranking of the amount of engineering effort involved in developing the component.	4.527	2.911
LABOR	=	an index of the relative labor/capital intensity of the production process.	5.973	2.041
LOAD	=	1, if the component or task had characteristics making it a candidate for "load leveling"; = 0, otherwise.	.1216	.3291
G^{O}	=	costs of planning, scheduling and management for integrated tasks or component*	$38,690	$54,030

Number of observations = 74

*Number of observations = 43

TABLE 3

Probit Make-or-Buy Estimations

(t-statistics in parentheses)

	(1)	(2)	(3)
CONSTANT	.69143	.77880	-2.6936
	(1.341)	(1.431)	(-2.550)
SCHEDULE	.24323	.26270	.43285
	(2.865)	(2.810)	(3.380)
COMPLEX	-.74023	-.77832	-.88865
	(-2.585)	(-2.569)	(-2.656)
$COMPLEX^2$	.04795	.05012	.06690
	(1.886)	(1.893)	(2.218)
HUMAN		.13358	.22327
		(1.501)	(2.154)
ASSET		-.16484	-.08512
		(-2.197)	(-.971)
ENGINEER			-.18139
			(-1.768)
LABOR			.42928
			(3.754)
LOAD			1.3955
			(1.895)
χ^2:	12.252	17.818	37.529
	(3 d.f.)	(5 d.f.)	(8 d.f.)

n = 74

TABLE 4

Costs of Organization

(t-statistics in parentheses)

	(1)	(2)	(3)	(4)
			$\ln(G^m)$	
	G^o	$\ln(G^o)$	$\beta_6,\beta_7=0$	$\sigma_{eu}=0$
CONSTANT	51323.6	9.9567	7.4009	6.4492
	(.870)	(7.558)	(3.656)	(6.8193)
SCHEDULE	-286.998	.12453	.59400	.68817
	(-.052)	(1.058)	(4.216)	(6.557)
COMPLEX	32029.2	.91355	-.01618	-.24362
	(2.090)	(2.615)	(-.043)	(-.791)
$COMPLEX^2$	-2995.95	-.08630	-.01374	.00081
	(-2.321)	(-2.874)	(-.420)	(.0286)
HUMAN	-10933.9	-.18772	.04874	.10301
	(-2.750)	(-2.104)	(.484)	(.942)
ASSET	1494.09	-.01961	-.12173	-.13045
	(.445)	(-.256)	(-1.421)	(-1.856)
ENGINEER	13491.4	.25686		.02066
	(4.113)	(3.592)		(.191)
LABOR	-10161.4	-.40561		.15339
	(-1.499)	(-2.652)		(.550)
LAMBDA	-45229.2	-.63044		
	(-1.799)	(-1.068)		
F (8, 34):	5.22077	10.71242		
R^2:	.55125	.71596		

Table 5

Estimated Organization Costs

(in dollars)

	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