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VERTICAL INTEGRATION IN THE U.S. AUTO INDUSTRY

A Note on the Influence of Transaction Specific Assets*

Scott E. MASTEN

University of Michigan, Ann Arbor, MI 48109, USA

James W. MEEHAN, Jr.

Colby College, Waterville, ME 04901, USA

Edward A. SNYDER

University of Michigan, Ann Arbor, MI 48109, USA

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Recent refinements in the theory of the firm suggest that organization form may be sensitive not only to the *degree* to which assets are specific to a transaction but also to the *type* of capital employed. This paper reports evidence regarding the relative influence of transaction-specific investments in physical and human capital on the pattern of vertical integration using new data obtained directly from U.S. auto manufacturers. The results support the proposition that investments in specialized technical know-how have a stronger influence than those in specialized physical capital on the decision to integrate production within the firm.

1. Introduction

Williamson (1975, 1979) and Klein, Crawford and Alchian (1978) argue that vertical integration is more likely to be preferred over market exchange when transactions are complex and when the buyer and seller must invest in specific assets.[1] Gradually, this proposition has been refined to distinguish both among types of asset specificity and between the governance and

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[1]Williamson (1985) and Joskow (1988) review the evidence relating asset specificity to the choice of institutions.

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ownership roles of the firm.[2] Monteverde and Teece (1982a, b), for example, suggest that human rather than physical assets play a more influential role in decisions to bring production within the firm, whereas 'quasi-integration' – ownership of the relevant assets without internalizing production – may be sufficient where transaction-specific investments reside in physical capital. Although there is some empirical work supporting this distinction, to our knowledge, no published studies of the pattern of vertical integration directly test for differences in the roles of specific physical and human assets.

Toward the goal of improving our understanding of decisions to vertically integrate, in this paper we report some evidence regarding the relative influence of transaction specific investments in physical and human capital on the pattern of vertical integration using new data obtained directly from U.S. auto manufacturers. In the next section we provide a brief overview of the issues. We describe our empirical tests and the data in section 3 and then report our findings in section 4.

2. Transaction costs and vertical integration

Because contingent performance is costly to stipulate and difficult for courts to enforce, contracts tend to be both incomplete and of limited duration.[3] Incomplete contracts inhibit the ability of parties to make efficient adjustments to changing circumstances which, in turn, raises the implicit costs of being bound to an agreement over extended periods. Inflexibility during the term of the contract and the prospect of hold-up problems at renewal intervals make contracting potentially hazardous. These concerns are greatest, moreover, when transactions are particularly complex, the associated economic environment is uncertain, and where efficient production requires large investments in durable, relationship-specific assets. In such settings, vertical integration may offer a variety of advantages over market exchange such as the potential to employ a wider range of payment schemes due to superior information. The benefits of integration are limited, however, by the loss of high-powered incentives and the increasing costs of managerial oversight as firms incorporate more activities.[4]

[2]Williamson (1983, p. 526) identifies four types of transaction-specific investments: transaction-specific know-how; site specificity; physical asset specificity, which we refer to as asset design specificity; and dedicated assets, which refer to generic investments of such magnitude that the market value of the assets would be depressed if the intended customer refused to purchase the seller's output. On the nature and role of the firm, see, in addition to the previous citations, Wiliamson (1980), Grossman and Hart (1986), Masten (1988) and Riordan (1988).

[3]Crocker and Masten (1988) analyze the tradeoff between the problems of inefficient adjustment to new conditions and the costs of opportunistic behavior and its influence on contract length.

[4]High-powered incentives refer to the incentive to minimize net receipts that derive from residual claimant status and contrast with the low-powered incentives accruing, for instance, to salaried employees [Williamson (1985, chapter 6)]. On both the advantages and disadvantages of integration, see generally Williamson (1975, 1985).

Of particular interest here are the ownership and governance roles of the firm and their relevance to decisions to internalize production. In the case of transaction-specific physical assets, ownership eliminates the hold-up problem by internalizing the quasi-rents that are the object of that behavior. Taking title to physical assets, however, does not require that production be governed within the firm. Indeed, a buyer may own the physical assets specific to production of a component but purchase the components from an outside supplier. In the case of the U.S. auto industry, it is in fact common practice for manufacturers to own specialized tooling whether or not they decide to internalize production. Thus, the decision to vertically integrate, by which we mean to internalize production, can be separated from the question of ownership of physical assets.

Since asset ownership is not an option where quasi-rents accrue to transaction-specific human capital, other means must be found to deal with conflicts over the distribution of rents when human assets are involved. Integration of production within the firm must therefore substitute alternative governance arrangements for those available to independent contractors to attenuate opportunism. Although the precise nature and role of the firm continues to be a matter of dispute, bringing production within the firm is usually recognized to offer superior managerial control and access to information.[5] It is with respect to these governance advantages that the terms *integration* and *the firm* are associated in common usage [Riordan (1988)] and with which they will be used here.

A practical implication of these insights is that the choice of organization form may be sensitive to the *type* as well as the degree of asset specificity. In a recent reconsideration of the often discussed acquisition of Fisher Body by General Motors, Klein (1988) emphasizes the importance of the distinction between human and physical asset specificity. He argues that if only physical asset specificity were involved, then 'General Motors could have owned their own dies and stamping machines and let Fisher use this capital to make auto bodies for them, avoiding the hold-up problem while taking advantage of whatever cost advantage Fisher possessed in producing bodies [footnote omitted]' (1988, p. 205). He notes, however, that since 'much of the specific investment necessary to produce automobile bodies consists of Fisher human capital investments' (1988, p. 206), integration must involve changes in the nature of the relationships among transactors rather than just ownership of assets.

A number of empirical studies provide indirect evidence in support of the

[5]On the status of the debate over the nature of the firm, see the special issue of the Journal of Law, Economics, and Organization 4, celebrating the 50th anniversary of Coase's treatise on the subject. Masten's article in that issue provides an overview of some of the legal bases for the advantages commonly attributed to internal organization. The importance of the legal differences between employees and independent contractors is not universally accepted, however. See Klein (1988) and Hart (1988).

proposition that asset type matters. Monteverde and Teece (1982a), for instance, emphasize the importance of 'specialized, nonpatentable know-how' in the decision to integrate production. Where the development 'process generates production as well as design knowledge,' exchange with outside suppliers may be particularly vulnerable to hold-up and information transfer problems.[6] Their study of 133 auto components found a positive and significant relationship between vertical integration and engineering effort, their proxy for transaction-specific technical know-how.[7] The existence of relationship-specific human capital also underlies the choice between internal and external sales representatives in Anderson and Schmettlein's study (1984) of the electronic components industry.

While neither of these studies examined the role played by physical asset specificity in these decisions, other studies have suggested that arrangements short of full integration of production may be sufficient when physical assets are involved. In a second article (1982b), Monteverde and Teece argued that retaining title to specialized physical capital required for input supply, and thus the right to transfer those assets to another supplier if necessary, may be sufficient to deter supplier opportunism. In support of this, they found a positive relationship between the value of specialized tooling used in auto component manufacturing and the probability of this form of quasi-integration.[8] Similarly, in his study of aerospace procurement decision-making, Masten (1984) found that, of the fifty-four investments in specialized tooling or test equipment in his sample, title was retained by the prime contractor in all but seven instances, and that those seven involved assets that either had relatively high alternative use values or short useful lives, or involved proprietary information. The apparently common use of quasi-integration to deal with hold-up problems where transaction-specific *physical* assets are at stake indicates that the extent to which *human* capital is specialized to a particular application may be the more important factor in the decision to integrate actual production.

3. Specification of the empirical test

The preceding discussion suggests that while some form of integration is

[6]See Monteverde and Teece (1982a, pp. 206–207). For a more complete discussion of the difficulties of using contracts when quasi-rents accrue to human capital, see Teece (1980 and 1982).

[7]Their vertical integration measure equals 1 if 80 percent or more of the component is produced in-house by either GM or Ford and equals 0 otherwise. Engineering effort is measured on a scale of 1 to 10. The data were provided by an automotive engineer employed by one of the major U.S. auto companies [Monteverde and Teece (1982a, pp. 207–208)].

[8]Monteverde and Teece (1982b) regressed a measure of quasi-integration (a dummy variable that identifies whether or not the specialized physical assets are owned by the auto maker) on a measure of quasi-rents (the product of tooling costs and the degree of specialization).

likely to be adopted the greater the investment in transaction-specific capital, the type of integration employed will tend to be related to the type of capital involved. In particular, if asset ownership sufficiently attenuates problems of opportunism associated with physical capital, full integration (by which we mean internal governance of production) will more closely correlate with the need to invest in specialized human assets. To test for possible differences in the role of physical and human capital, we estimate the following regression:

$$INTEGRATION = b_0 + b_1 * ENGINEERING + b_2 * ASSET + b_3 * SITE + b_4 * GM + b_5 * FORD + \text{error term.}$$

The dependent variable, *INTEGRATION*, is the percentage of the company's component needs produced under the governance of the firm.[9]

The advantage of this specification over those in previous studies is that it includes separate measures of specialized technical know-how and two types of physical asset specificity. In our data set, each of these independent variables is measured on a ten point scale, with a 1 indicating a low value (e.g., in the case of *ASSET*, the assets used to produce the component are 'relatively standard') and a 10 indicating a high value (e.g., the assets are 'design specific'). We also include two dummy variables to allow for company specific effects.[10]

Following Monteverde and Teece (1982a), *ENGINEERING* proxies for transaction-specific technical know-how. For components such as automatic transaxles and specialized coatings, the required engineering effort is substantial and is likely to yield know-how about the component's production process. Hence, *ENGINEERING* is likely to take on high values for these components, as compared to others in our sample such as radiators, starters, and hose assemblies.

Regarding the other proxies, *ASSET* measures the extent to which components are produced with physical assets that are specific to the auto maker. This variable is likely to take on high values due either to the specificity of the car's style (as in the case of door window frames) or due to the specificity of its technical design (as in the case of engine control modules). *SITE*, in turn, measures the importance of locating upstream

[9]We prefer this to the dummy variable used by Monteverde and Teece (1982a) because it captures more information (see note 7).

[10]The company dummies could pick up the effects of selection biases in the individual company samples or differences in their scaling of the independent variables, a well as differences in behavior. Monteverde and Teece (1982a) also include dummy variables for the auto maker and for various subsystems of components.

Table 1
Correlation matrix (118 observations).

	INTEGRATION	*ENGINEERING*	*ASSET*	*SITE*
INTEGRATION	–			
ENGINEERING	0.28	–		
ASSET	0.10	0.36	–	
SITE	0.05	0.22	0.44	–

production close to subsequent stages of the manufacturing process.[11] For components such as engine blocks that are costly to transport, for example, *SITE* will take on a high value.

As indicated above, transaction-cost arguments predict that *ENGINEERING* will have a positive effect on vertical integration ($b_1 > 0$). If the distinction between human and physical capital is not important, then similar predictions apply to *ASSET* and *SITE* ($b_2 > 0, b_3 > 0$). However, if quasi-integration offers good alternatives to full integration, then this would not be the case. Thus, the null hypothesis is that the coefficients on *ASSET* and *SITE* should equal zero. No predictions are made concerning company specific effects.

We obtained the data used to estimate the regression equation from Chrysler, Ford and General Motors.[12] To reduce the substantial costs of assisting us, we gave the auto companies leeway in defining the sample of components for which data were provided. Consequently, the size and composition of the sample varies by company. Furthermore, since the companies tend to have the best information about components whose sourcing had been reviewed recently, the companies tended to include these components in the sample. As a result, our sample of 118 components is over-represented by 'close calls' and components for new models.

4. Empirical results

Table 1 presents the correlation matrix for the variables used in the regression model. The simple correlation between *INTEGRATION* and *ENGINEERING* is positive. The correlations between *INTEGRATION* and the two measures of physical asset specificity, *ASSET* and *SITE*, are also positive but are lower.

Table 2 reports the coefficients of interest from the regression equation

[11]As defined and measured, *SITE* may imperfectly capture variations in the potential for opportunism. For example, even if proximity is critical during production, the issue of opportunism by the auto-maker is attenuated if the assets are easily moved.

[12]The sample includes only components produced within the last three years. At the request of the auto companies, we agreed to keep the data confidential.

Table 2
Regression results.

	OLS	Two-Limit Tobit	Logistic
Dependent variable: *INTEGRATION*[a]			
Independent variables (*T*-statistics in parentheses):			
ENGINEERING	4.45**	20.86*	0.57**
	(2.74)	(2.13)	(2.59)
ASSET	0.92	3.11	0.12
	(0.54)	(0.71)	(0.53)
SITE	−2.29	−10.47	−0.29
	(−1.42)	(−1.24)	(−1.36)
CONSTANT	10.47	−119.73	−5.24**
	(0.96)	(−1.86)	(−3.53)
Adjusted R^2	0.36		0.35
Equation test statistic[b]	14.35**	49.74**	13.63**

*Significant at the 0.05 level.
**Significant at the 0.01 level.
[a]The dependent variable for the OLS and Two-Limit Tobit models is the percentage of company's component needs produced in-house. The logistic regression is based on a transformation of *INTEGRATION* described in Kmenta (1971, p. 461).
[b]The statistic is the *F*-statistic for the OLS and logistic regressions; the Chi-Square statistic for the likelihood ratio test is reported for the two-limit tobit results.

estimated using OLS, two-limit Tobit, and a logistic model.[13] As expected, *ENGINEERING*, our proxy for specific human capital, has a positive and significant influence on the percentage of the component produced in-house. However, the variables proxying for physical asset specificity are not statistically significant. *ASSET*, which measures the extent to which the physical assets used to produce the component are specific to the company, has a positive but insignificant influence on the extent of vertical integration. The coefficient on *SITE* is negative but also insignificant. The regression also included dummy variables for company specific effects, but for confidentiality reasons their coefficients are not reported in table 2.

It should be noted from Table 1 that the independent variables are moderately correlated with each other. To ensure that multicollinearity did not influence our results, we estimated variations of the regression model

[13]Since the dependent variable is distributed between 0 and 100, the Tobit model is preferred to OLS which permits predicted values outside of the range of potential outcomes. However, the two-limit Tobit estimation produces a schedule of fitted values that is kinked. To avoid this and for purposes of comparison, we also report the results from the logistic model.

excluding independent variables both individually and in pairs. The latter results indicated that the tests of hypotheses in the full regression model were not affected by the correlations among the independent variables.

5. Conclusion

Our empirical analysis of vertical integration in the auto industry supports the proposition that investments in specialized technical know-how have a stronger influence than those in specialized physical assets on the decision to vertically integrate. This suggests that the critical advantages associated with vertical integration relate to the governance role of the firm. This is also consistent with the suggestion that parties may rely on various forms of quasi-integration to control the problems of opportunism and maladaptation in the case of specific physical assets.[14] However, since our analysis leaves much of the variance in the patterns of vertical integration unexplained (as indicated by the modest goodness of fit statistics), our findings should be viewed as tentative.

One avenue for future research is to obtain better data on the full range of governance mechanisms used by manufacturers and then to investigate whether in fact buyers and sellers tend to rely on quasi-integration when specific physical assets are central to the transaction. Our finding that the relative efficiency of vertical integration appears to be influenced by the nature of transaction-specific investments indicates, at a minimum, that further efforts should be made to discriminate among the types of transaction-specific investments in tests of transaction-cost theory.

[14]We do not suggest, however, that quasi-integration is a panacea. Monteverde and Teece (1982b, p. 326, n13) observe, as we have also learned, that disputes sometimes arise over ownership of specialized assets that were paid for (at least in part) by an auto maker but used by component suppliers. In addition, Williamson (1985, pp. 137–138) discusses the problems associated with misuse of assets used but not owned by suppliers.

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