Paper to be presented at the DRUID 2011

on

INNOVATION, STRATEGY, and STRUCTURE -
Organizations, Institutions, Systems and Regions
at
Copenhagen Business School, Denmark, June 15-17, 2011

Process Innovation, Transaction Costs and Make or Buy Decisions

gordon walker
southern methodist university
strategy and entrepreneurship
gwalker@smu.edu

Abstract

This study examines process innovation in a transaction cost framework. The basic premise is that decisions to invest in a new process are based first on a cost comparison between in-house production and market supply, but also that supplier asset specificity can stimulate a buyer to invest in a new process to avoid transaction costs, akin to arguments in the literature on technical change. The data come from a component fabrication division that is similar to but not the same as that studied by Walker and Weber (1984). The results show that supplier asset specificity does predict buyer process innovation and that such innovation gives the buyer a production cost advantage over the supplier?s market price. Further, a close replication of Walker and Weber?s (1984) model shows that, in contrast to this paper?s results, only production costs and not imputed transaction costs influence the make or buy decision. The effect of transaction costs on vertical integration is therefore indirect through their influence on buyer process innovation which lowers the buyer?s production costs compared to the supplier?s price and justifies internalizing the activity. The implications for research on the relative importance of transaction costs and organizational competences are discussed.

Jelcodes:L22,-

Process Innovation, Transaction Costs and Make or Buy Decisions

November, 2010

Preliminary – please do not cite without permission

Process Innovation, Transaction Costs and Make or Buy Decisions

Abstract

This study examines process innovation in a transaction cost framework. The basic premise is that decisions to invest in a new process are based first on a cost comparison between in-house production and market supply, but also that supplier asset specificity can stimulate a buyer to invest in a new process to avoid transaction costs, akin to arguments in the literature on technical change. The data come from a component fabrication division that is similar to but not the same as that studied by Walker and Weber (1984). The results show that supplier asset specificity does predict buyer process innovation and that such innovation gives the buyer a production cost advantage over the supplier's market price. Further, a close replication of Walker and Weber's (1984) model shows that, in contrast to this paper's results, only production costs and not imputed transaction costs influence the make or buy decision. The effect of transaction costs on vertical integration is therefore indirect through their influence on buyer process innovation which lowers the buyer's production costs compared to the supplier's price and justifies internalizing the activity. The implications for research on the relative importance of transaction costs and organizational competences are discussed.

Introduction

The purpose of this study is to expand behavioral research on vertical integration by examining the importance of buyer process innovation in make or buy decisions. As the initialization of new routines within a firm, process innovation is a necessary part of the development of organizational capabilities. Its relationship to vertical integration is therefore important for understanding how capabilities and organizational boundaries are related to each other over time. This dynamic has been central to research arguing that technological variables should be weighted more strongly in transaction cost studies of vertical integration (Winter, 1988; Jacobides and Hitt, 2005; Jacobides and Winter, 2005) and conversely that vertical integration should be a primary variable in analyses of technological development (Argyres and Zenger, 2010). The present study tries to address both of these arguments.

Background

By far the dominant theory motivating empirical research on vertical integration is transaction cost economics, as developed by Williamson (1981, 1985). One of the striking omissions in almost all studies in this research program, however, is the absence of the relative production cost difference between the buyer and supplier. This lacuna is important since Williamson (1981) and Riordan and Williamson (1985) include production costs in their models of vertical integration. Also, it seems unlikely that managers would ignore such a salient variable. As proof, Walker and Weber (1984) found that a buyer’s relative production advantage over the supplier predicted vertical integration much more strongly than transaction cost variables, which were also important factors in the make or buy decision.

This result by no means indicates that the fundamental insight of transaction cost theory is incorrect. There are too many large-sample studies, as well as a wide range of anecdotal evidence, that support the theory for such a conclusion to be reached. However, Walker and Weber's (1984) finding does suggest that much of this research, especially those using manufacturing data, suffers from an important specification bias by omitting measures of differences in buyer-supplier process technologies.

To address this problem, a number of recent empirical studies have focused intensively on the relative production cost or competence side of the story (Poppo and Zenger, 1998; Schilling and Steensma, 2002; Leiblein and Miller, 2003; Jacobides and Hitt, 2004; Hoetker, 2005). This useful and interesting body of research varies substantially in its results. Poppo and Zenger (1998) find no support for a competence or knowledge based approach. Schilling and Steensma (2002) conclude that the promise of a competitive advantage has no effect on technology sourcing, in contrast to the strong effect of the threat of opportunism. Both Leiblein and Miller (2003) and Jacobides and Hitt (2004) demonstrate that production capabilities influence vertical scope significantly in conjunction with transaction cost variables. Rawley and Simcoe (2010) show that investment in information technology increases the scope of vertical integration as the firm expands into a labor market whose members benefit from the new capability. Finally, Hoetker (2005) demonstrates that internalization is more likely when the likelihood of process innovation is high, even controlling for the relative competence of the firm and its suppliers.

Hoetker's (2005) study is interesting since it highlights an important underlying issue in these studies: competence development is a function of the firm's decision to make or buy. Specifically, the computer manufacturers Hoetker studied brought an operation in-house not to leverage an existing competence but to establish a new one. This kind of interplay between technology development and vertical integration is central to Jacobides and Winter's (2005) essay on the evolution of technology and firm boundaries within an industry. Likewise, Argyres and Zenger (2008) argue that differences in organizational capabilities between a buyer and a supplier are not only a determinant of vertical integration decisions, as Walker and Weber (1984) show, but an outcome of these decisions and perhaps therefore of transaction costs.

Following this research, the present paper builds and tests a model that links vertical integration to process innovation, relative production costs and supplier asset specialization. In testing this model, the paper highlights the importance of focusing on activities that require a new make or buy decision, as opposed to legacy operations for which a decision is neither needed nor made. It also stresses the distinction between those decisions that ratify the status quo and those that involve a shift in governance. These critical elements for understanding how new process development and make or buy decisions are related require a close examination of the empirical context in which such decisions are made, as described in the next section.

Empirical Context

The approach in this paper is micro-analytic, which is traditional in transaction cost research on vertical integration starting with Coase's (1937) original insights. Micro-analysis focuses on transactions that surround a specific activity, such as component manufacturing (Monteverde and Teece, 1982; Walker and Weber, 1984), IT services

(Poppo and Zenger, 1998), rail car production (Palay, 1984), or selling electronics (Anderson and Schmittlein, 1984).

Figure One, following Williamson (1981), illustrates the basic empirical context. The figure portrays the activities in a hypothetical manufacturing firm's value chain, the relationships between them (the thin solid lines), and the boundary separating the activities owned and operated by the firm from those owned and operated by market suppliers (the thick solid line). Following Williamson (1981), the diagram identifies three types of activity: First are activities for which a new make or buy decision is made (the dotted lines as for Components I and III). For these transactions, something has changed in the market or the firm, either technologically or contractually (or both), to warrant an evaluation. Second are activities, whether inside or outside the firm's boundary, for which no change has occurred and are therefore simply ongoing and can be considered status quo (the solid lines as for Components II and IV). Last are those that involve tapered integration: that is they are partially in-house and partially in the market (Distributors I and II).

There are four possible decision outcomes: 1) A market supply relationship has become sufficiently costly compared to vertical integration that the outsourced activity may be brought in-house (e.g. Component I); 2) a market supply relationship has become less costly than in-house transfers and so the activity may be outsourced (possible for Component III); 3) the firm may keep an already outsourced activity in the market (again, possible for Component I); and 4) the firm may decide not to outsource an activity that is already in-house (again, for Component III). These transactions and their associated activities are a subset of those in the overall business.

Note that there are no activities specifically involving hybrid relationships. Using Makadok and Coff's (2008) framework, the internalized activity analyzed here falls into their Type II, defined as a cost center over which the firm has strong control of incentives and task design decisions. The activity in the market supplier in turn is a Type VIII in that it is in an independent firm that owns its own assets and also controls the activities' incentives and task design. Thus for both the firm and its supplier, incentives and task design are aligned with asset ownership. These two configurations of control dimensions are standard in tests of transaction cost theory, and the emerging literature on capability development has not addressed them specifically. Comparing these two configurations thus ties the present study closely to current research. Also, expanding beyond them (see e.g. Walker and Poppo, 1991) adds a layer of complexity that is beyond the scope of the present theory.

The empirical context described above has three characteristics which have an impact on how vertical integration and organizational competences are related:

First, the framework focuses on the institutional location (make or buy) for discrete activities. Higher level routines can be important for an organization's performance over time (Teece, Pisano and Shuen, 1997; Helfat and Peteraf, 2009). However, vertical integration decisions are typically made for the kinds of technologically bounded activities shown in Diagram I. This focus on the activity is consistent with the data used in the studies on vertical integration and firm competence listed above.

Second, the framework distinguishes between two types of activity which differ in their decision process. For the first type (Components I and III), the firm collects and analyzes data for a new make or buy decision in order to assess the relevant production and transaction cost factors, as in Walker and Weber (1984). For the second type of activity (Components II and IV), the firm continues with the status quo (make or buy) – without collecting new detailed data - based on a qualitative assessment that the combination of transaction and production costs support the previous decision. But because these two factors have only a joint effect, it is impossible to estimate their separate contributions to either vertical integration or organizational competence in an activity. This is so especially because the two factors may have evolved for the activity since the earlier vertical integration (or outsourcing) decision in ways that are unrelated to it. Thus, only activities for which decisions are currently being made and therefore for which new data have been collected – not data-free ratifications of the status quo– are amenable for the kind analysis made in the present study.

Third, the framework differentiates make-to-make decisions from buy-to-make decisions. In the case of a make-to-make decision (possibly Component III), either the activity's current process is more efficient than suppliers, or the firm must invest in a new process that will be more efficient. In contrast, if the decision is buy-to-make (possibly Component I), there is no pre-existing process within the firm for comparison to the market, and the firm must invest in a process innovation. The exceptions are activities for which there is tapered integration (Distribution I and II) or that benefit from significant technological spillovers from other activities within the firm. Even with these exceptions, however, process innovation should be more frequent for buy-to-make decisions than for make-to-make (see Figure 2).

Investment in a new process is a discrete event that initializes the development of a new capability within the firm (see e.g., Rawley and Simcoe, 2010). In the empirical context studied here, the investment is made contemporaneously and as a part of the choice to make or buy. This means that when a new process is being considered, the vertical integration decision occurs in conjunction with it, not separately (as may occur in Hoetker's [2005] study). Of course more generally, new process and vertical integration decisions need not be concurrent. A process innovation may be observed in an activity subsequent to its vertical integration in an earlier time period (see Hoetker, 2005; and possibly Rawley and Simcoe, 2010). But, from the perspective of vertical integration decision-making, this kind of activity would be categorized as the status quo type as described above; and, as argued previously, the relative contributions of production and transaction costs to developing organizational competences through investing in a new process would not be able to be determined. The contemporaneity of process innovation and the make or buy decision is thus an important characteristic of the empirical context studied here. (It is noteworthy that in Hoetker (2005) and Rawley and Simcoe (2010) process innovation is solely an exogenous variable that conditions or predicts vertical integration, whereas here process innovation is also a decision that is endogenous to supplier specialization and other variables.)

Theoretical Assumptions

The studies cited above argue from the same theoretical foundations that vertical integration and capability development are related. But the variation across these studies in measurement, research design and results, indicate that fundamental questions about this relationship remain. To frame the arguments of the present study, four of these problems are addressed below:

What is the relationship between buyer and supplier capabilities?

Poppo and Zenger (1998), Jacobides and Hitt (2005) and Rawley and Simcoe (2010) argue, either explicitly or implicitly, that buyer and supplier capabilities are substitutes. That is, they represent alternative and non-reinforcing competences. Similarly, Langlois (1992; Langlois and Robertson, 1989) presents anecdotal evidence that early automobile assemblers vertically integrated because their suppliers would or could not allow their existing labor-intensive processes to conform to the new mass production techniques the assemblers were implementing. Further, Walker and Weber's (1984) strong results regarding the effect of comparative production costs suggest that the firm and its supplier have significant differences in the design and execution of the activity. This substitutability logic will be important in the development of the hypotheses below.

How does the firm's performance in an activity enter into the make or buy and process innovation decisions?

As part of a make or buy decision, the relevant performance assessment of a capability is comparative – firm vs. supplier (Walker and Weber, 1984; Poppo and Zenger, 1998; Hoetker, 2005; Rawley and Simcoe, 2010). The reason is that the mere existence of a capability is insufficient to explain the make or buy decision for the activity in which the capability is found. Rather, there must be an economic comparison of the firm's and supplier's performance (actual or estimated). Some of the studies include such a variable (e.g., Walker and Weber, 1984) but many do not.

How are an activity's relative performance against suppliers and the firm's investment in new technology related?

First, they should each be measured as separate variables (Poppo and Zenger, 1998; Hoetker, 2005; Rawley and Simcoe, 2010). Although Walker and Weber (1984) showed that relative production costs were a powerful predictor of make or buy decisions, their result says nothing directly about the development of new capabilities. Alternatively, capability development by itself is insufficient to measure whether or not vertical integration was determined by relative performance differences, since relative transaction costs may have played a role. Second, once new process investment and relative production costs are measured independently, one can argue that their relationship is reciprocal. The reason is that the relative performance measure is a function of the investment itself, not of the firm's previous technology. Assessing how transaction and production costs determine the development of the firm's capabilities therefore requires simultaneous equations.

What is the relationship between new process investments and the make or buy decision?

Not all activities will have a higher performing innovation to substitute for the supplier's process. If a new process is available, then the investment may influence the make or buy decision (see Rawley and Simcoe, 2010). The reverse relationship (the influence of make or buy decisions on new process investments) has also been posited in the literature (Winter, 1988; Argyres and Zenger, 2010). However, testing this argument is problematic when the decisions to invest and integrate are made contemporaneously. The reason is that when process innovation occurs only in-house, as in the empirical context described above (compare Hoetker, 2005), the endogenous make or buy decision is highly collinear with its determinants, especially relative production costs. Whether this collinearity confounds the empirical relationship between the process innovation and make or buy decisions is conditional on the data.

Hypotheses

Transaction costs and process innovation

There are two alternative but consistent arguments that link transaction costs in the market with the firm's investment in a new process. In the first argument, the investment is reactive in that it is a response to high transaction costs created by supplier asset specialization. The firm's innovation is necessary to improve its comparative production costs beyond the point where vertical integration is the preferred option. Lowering these costs requires a new process because increased supplier specialization may improve its production costs compared to the buyer (contrary to Williamson [1981] but consistent with the argument that buyer and supplier technologies are substitutes). In this way, transaction costs associated with supplier asset specificity can be considered an inducement mechanism (Rosenberg, 1969; Dosi, 1997; Ruttan, 1997) that stimulates the buyer to adopt a new process in order to raise its efficiency and bring the process in-house. In the second argument, the buyer's new process technology is proposed independently of the current sourcing situation (make or buy) and the evaluation of the innovation is benchmarked in terms of total cost (transaction and production) against market alternatives, either a prospective supply relationship or a new one. If supplier asset specialization is assumed to create or actually does create higher transaction costs, as Williamson (1975, 1985) proposes, then it will increase the costs of sourcing in the market and therefore the likelihood of the buyer's investment in the new process. The hypothesis is:

Hypothesis One (H1): Controlling for comparative production costs, supplier asset specialization will increase the likelihood of buyer process innovation.

Process innovation and make or buy decisions. The empirical context described above implies that, assuming that comparative production costs are a significant determinant of vertical integration, a buy to make decision necessitates a process innovation. This is so since the activity was not performed in-house prior to being integrated. A make to make decision, however, has no such requirement because the existing process may still be more efficient than the market. The distinction between these two types of decision is therefore important for understanding how process innovation affects vertical integration. The hypothesis follows:

Hypothesis Two (H2): Process innovations are more likely to predict buy to make decisions than make to make decisions.

Specification

To test the hypotheses, the following simultaneous equation system is estimated:

1) $\text{ProcIn} = \alpha_1 + \beta_{11}\,\text{CPC} + \beta_{12}\,\text{AssSpec} + \beta_{13}\,\text{PriorMB} + \beta_{14}\,\text{BuyExp} + \beta_{15}\,\text{Proscope} + \varepsilon_1$

2) $\text{CPC} = \alpha_2 + \beta_{21}\,\text{ProcIn} + \beta_{22}\,\text{AssSpec} + \beta_{23}\,\text{PriorMB} + \beta_{24}\,\text{BuyExp} + \beta_{25}\,\text{ScFavSup} + \varepsilon_2$

3) $\text{MBdec} = \alpha_3 + \beta_{31}\,\text{CPC} + \beta_{32}\,\text{AssSpec} + \beta_{33}\,\text{BuyExp} + \beta_{34}\,\text{VolUnc} + \beta_{35}\,\text{TechUnc} + \beta_{36}\,\text{ProcIn} + \varepsilon_3$

Where:

Procin	=	Process Innovation
CPC	=	Comparative Production Costs (logged and signed)
AssSpec	=	Supplier Asset Specialization

PriorMB	=	Whether the activity was previously performed in-house or by a supplier (0=buy, 1=make)
BuyExp	=	Buyer Experience
Proscope	=	Economies of Scope of the activity after the make or buy decision
ScFavSup	=	Whether scale in the activity favors the supplier's technology
MBDec	=	Current make or buy decision (0=buy, 1=make)
Volunc	=	Volume Uncertainty
Techunc	=	Technological Uncertainty

The expected signs for these equations are shown in Figure 3. H1 is tested in the equation 1) through β_{12}, which is expected to be positive and statistically significant. Equation 2) is necessary because of the reciprocity of process innovation and comparative production costs. H2 is tested in equation 3) (see the section on estimation below).

The additional RHS variables in the two equations are controls and tests of assumptions. If the process innovation is truly new to the firm, Buyer Experience should be negatively associated with it. At the same time, Buyer Experience should be positively associated with the CPC, as in Walker and Weber (1984). If H2 is true, then process innovation should be more likely if the activity was sourced in the market before the make or buy decision (PriorMB). Given the very strong correlation between PriorMB the CPC shown by Walker and Weber, PriorMB also acts as a proxy for the CPC of the earlier make or buy decision for the activity. The scope of the new process (ProScope) should predict its incidence, given the economic advantages associated with economies of scope. Finally, if the supplier benefits from scale advantages (ScFavSup), the CPC should favor it. Equation 3) is a replication of Walker and Weber's (1984) model relating transaction costs and make or buy decision with process innovation added to test H2. The expected signs of the variables in the equations are shown in Figure 3. The measurement of the variables is outlined below.

Data

The data were collected in a large component division of a very large US consumer durables organization. The division had 42 product lines, each with many products sold to customers inside and outside the corporation. Divisions in the firm were required to include a make or buy analysis in their proposals for new process technology. They were also mandated to perform a make or buy analysis for all manufacturing processes every five years. Since the overall administrative costs of performing an evaluation for these processes could be quite large, division cost analysts, consulting with division managers, reviewed previous make or buy assessments and determined whether the economics of the product and supplier markets had changed. If no change was apparent, the division reported to the corporate parent that the earlier analysis was still correct. If there was a change, then a new evaluation was made. The archives of the division's make or buy committee, made available to the author, therefore provided a complete source of data on both proposed process innovations and on other activities within the division for which new information had emerged and necessitated a re-evaluation of the firm's boundaries.

During the five years studied here, the division made make or buy evaluations for 59 processes. Twenty seven of these processes were for component fabrication; twenty five for assembly; three for logistics; and five for secondary activities. For all but two processes the CPC was recorded (see below for how this variable was calculated in the division).

No other data were systematically available in the archive. Therefore, a questionnaire was developed to collect further information. The questionnaire was distributed to the process engineers in the division who were listed in the archive as participants in the decisions. These engineers were chosen as key informants because they knew both the old and new production processes - especially when the supplier had specialized labor and equipment - the make or buy decision-making procedure and the outcome. In face to face and telephone interviews with the author, the engineers demonstrated very good recall of the information pertinent to the study. Only six engineers were involved in more than one project in the archive, and none of these participated in more than four projects.

It was not possible to identify engineers responsible for nine projects. There was no indication in the archive that the division invested in new equipment for any of these processes. Also, in two cases it was apparent that the archival information did not match the process described in the questionnaire. Neither of these cases was listed as a process innovation. These discrepancies could not be explained, and so the cases were dropped from the analysis. The supplier listed in the archive for five cases was a Latin American facility operated jointly by the division and another division in the corporation. Because the make or buy decisions for these cases was clearly ambiguous in terms of the institutional status of the supplier, they were also dropped from the analysis. The questionnaires for three of the remaining 43 cases contained significant missing data, leaving a final total of 40 cases to test the hypotheses. The pattern of make or buy decisions for these cases matched strongly the pattern for the overall sample and is shown in Table 1. It is noteworthy that this pattern is similar to that found by Walker and Weber

(1984) in their analysis of a similar division. This division, however, had a proportionately fewer number of processes kept in-house and a proportionately larger number brought in-house.

Thus, like Walker and Weber (1984) but unlike most other studies of vertical integration, the present research uses a simultaneous equation system to test the hypotheses. Several other articles have considered the problem of endogeneity: of boundary choice to supplier performance (Poppo and Zenger, 1998), of management costs to boundary choice (Masten, Meehan and Snyder, 1991), and of supplier performance to asset choice (Walker, 1995). The approach here is to treat both relative production costs and the decision to invest in a new process as endogenous, which reflects more accurately both the administrative and economic facts on the ground.

Methods

Measurement and Construct Validation

Appendix 1 shows the constructs, the items that indicate them and the questions that measure the items. Five constructs have multiple indicators:

Process Innovation has two indicators: 1) investment in a new process; and 2) learning from a new process. These variables measure directly whether the division invested in a new process and the extent to which the process involved the development of new knowledge. Although the second indicator is obviously dependent on the first, both are necessary for a significantly new process to be present.

Supplier Asset Specificity is measured by three indicators: 1) Supplier proprietary technology; 2) Unique supplier labor; and 3) Unique supplier equipment. Walker and Weber (1984) showed that supplier proprietary technology was strongly negatively correlated with measures of supplier market competition. Walker and Poppo (1991) showed that unique supplier labor and equipment were significantly related to lower transaction costs in-house than in the market, as predicted by transaction cost theory.

Buyer Experience has two items: 1) Similar tools and equipment; and 2) Similar expertise. These indicators are identical to those used by Walker and Weber (1984).

Technological Uncertainty is measured by: 1) Expected technological improvements; and 2) Expected specification changes. Again, these indicators are the same as in Walker and Weber (1984).

Volume Uncertainty is indicated by: 1) Uncertain volume estimates; and 2) Expected volume fluctuations. Walker and Weber (1984) used the same measures.

Two constructs have one indicator each: Economies of Scope and Scale Favored Supplier.

The production cost comparison (CPC) measure was based on calculations of the process engineers responsible for the make or buy decision who subtracted the division's real or expected total annual payout to the supplier for the output of the process from the division's real or expected factory costs for the process. Payout to the supplier was the product of the experienced or estimated supplier's price or price quote and expected volume. Adjusted factory cost entailed variable costs plus those fixed costs that could be allocated specifically to the process. When a make or buy decision was made for an in-house process without a proposed innovation, the division's costs were projected on the basis of historical expenses. When an innovation was proposed for the process, whether the process was made in-house or to be brought in-house as a replacement for market supply, the division's costs were those expected for the new process. The division's CPC estimate for each decision was positive when vertical integration predicted production cost savings and negative when outsourcing was more economical in production cost terms. The CPC variable was created using the logged (absolute) values of the engineer's calculations which were then re-signed to accord with the evaluation.

Table 2 shows the means, standard deviations and correlations among the items. The items for constructs with multiple indicators were factor analyzed and the factor loading matrix was transformed using Varimax rotation. The rotated factor loadings are shown in Table 3. All five constructs exhibit reasonable convergent and discriminant validity. The reliabilities (Cronbach alpha) of the constructs are: Process Innovation - .79; Supplier Asset Specificity - .78; Buyer Experience - .61; Technological Uncertainty - .83; and Volume Uncertainty - .84. The statistics for the last three of these constructs are comparable to those found by Walker and Weber (1984). The first two constructs – process innovation and supplier asset specificity – were not in their model. Composite variables for these constructs were created by adding the indicator values and dividing by the number of indicators.

Hypothesis Testing

Although two-stage least squares (2SLS) is the modal choice of technique for simultaneous equation models, it is well known that it is biased in finite samples with weak instruments (see e.g., Nelson and Startz, 1990; Bound, Jaeger and Baker, 1995). A number of studies have shown that the Limited Information Maximum Likelihood (LIML) estimator has lower bias than 2SLS in small samples when the instruments are weak (Buse, 1992; Staiger and Stock, 1997; Blomquist and Dahlberg, 1999; Chao and Swanson, 2005). Davidson and Mackinnon (1993, chapter 18) suggest using both 2SLS and LIML and inspecting the similarity of their results. If the coefficients across the two methods are close, then there is good reason to believe in their robustness to small sample and weak instrument problems. This method is adopted here. The standard errors of equations 1) and 2) are robust to unobserved heterogeneity in the decisions analyzed.

Equation 3) is estimated using multinomial logit so that the make decision can be separated into two types: a make to make decision and a buy to make decision. In this test, the baseline condition for comparison is a make to buy decision. Thus this test captures a standard prediction of make or buy, except that the make decision has two categories, across which we can compare the effects of the explanatory variables, consistent with Hypothesis 2. Both CPC and ProcIn are endogenous, based on the estimated values from equations 1) and 2).

Results

The results for testing H1 in equation 1) are shown in Table 4A. The hypothesis is supported: supplier asset specialization predicts the firm's investment in a new process, controlling for comparative production costs and other factors. The CPC also predicts process innovation, as expected. Further, process innovations are more likely for activities that were previously performed in the market (buy to make decisions), consistent with the empirical context of this study; and they are negatively related to the firm's knowledge as represented by Buyer Experience.

Table 4B shows the estimates for equation 2). The assumption that process innovation and comparative production costs have a reciprocal relationship is supported. So the division does not invest in new processes whose production costs are not lower than the best alternative in the market, and comparative production costs in-house are lower when the division has invested in a process innovation. Also, Supplier Asset Specialization determines a supplier production cost advantage, consistent with the assumption that the supplier's process technology is a substitute for the firm's. Note that this result is inconsistent with the argument that specialization decreases economies of scale, as argued by Williamson (1981; Riordan and Williamson, 1985) and shown in Walker and Weber (1984). Higher asset specificity thus has two effects on the CPC which differ in their signs. The first is direct and negative; the second is indirect and positive through the instigation of process innovation investments. Buyer Experience is positively related to the CPC, as Walker and Weber (1984) also found.

Regarding the potential problem of weak instruments, the LIML and 2SLS coefficients are reassuringly close to one another. This suggests that the weak instruments problem often cited for simultaneous equation models with small sample data sets is not worrisome here.

The test of H2 is found in Table 5. The results predicting make or buy decisions show that process innovation predicts the decision significantly for both make-to-make and buy-to-make and the effect on buy-to-make decisions is greater, supporting the hypothesis. It is important to observe that, contrary to theory but in line with its effect on the CPC, supplier asset specialization predicts a buy decision, indicating that the production cost benefit specialized vendors render to the firm is superior to the transaction costs they may create. This finding contrasts with Walker and Weber's (1984) results, which show that supplier market competition - the negative of specialization - induces a buy decision.

Discussion

What do we mean when we say that capability development depends on resolving transaction cost problems?

A jaundiced view of the present research is that it is yet another transaction cost study using manufacturing data, reputedly the standard setting for testing this theory. However, an important benefit of testing the theory on manufacturing firms is the relatively straightforward measurement of buyer production costs, as opposed to their measurement in service or high technology firms, where the boundaries of specific activities may be harder to delineate. In the unit studied here, as in that examined by Walker and Weber (1984), production cost estimates were carefully calculated by the managers involved and compared to the supplier's price, providing in one way what Williamson (1999) calls "operational content" to the variation of buyer and supplier competences in performing the activity. Moreover, it is apparent that this variation was sufficient to lead to a change in the ownership of production in 28 of the 40 decisions (see the make to buy and buy to make decisions in Table 1). This pattern is quite similar to that found in Walker and Weber's (1984) sample of make or buy decisions in a similar manufacturing unit. Given these results, it seems very difficult to maintain the assumption that technology can be held constant in transaction costs studies or to assume, as in the efficient boundaries model, that the technology the buyer adopts when it vertically integrates is identical to the supplier's at the time integration occurs.

The present results support what Williamson (1988) calls a semi-strong form of technological determinism in that relative competence of the firm and its supplier determines vertical integration. But the approach here is lacks the neoclassical economics motivation that Williamson associates with this form of theory. Rather the approach is behavioral in that organizational factors determine separate and alternative capabilities in the firm and its suppliers for each activity (see Winter, 1988; Williamson, 1991), and it is only semi-strong because the firm develops its capabilities partially in response to higher supplier specialization. By imputation, transaction costs in the relationship emerge when the supplier's commitment toits current technology, as shown by its specialized investments in labor and equipment, creates problems that the firm solves by innovating in-house. These problems contribute to the firm's innovation decision over and above the supplier's lower costs which its specialized assets determine.

In reaching these findings, the present study contributes several novel features to the recent literature on technology and transaction costs. First, process innovation, as an indicator of capability development, is endogenous to characteristics of the supplier and other variables (compare Hoetker, 2005; Rawley and Simcoe, 2010). Second, capabilities and comparative production effectiveness are measured separately (compare Leiblein and Miller, 2003; Jacobides and Hitt, 2005). Third, unlike previous research, two types of vertical integration decision are examined here as significantly different conditions (buy to make and make to make), as laid out in the description of the empirical context. Fourth, in contrast to much other research in this area (Walker and Weber [1984] and Poppo and Zenger [1998] are exceptions), this study uses a simultaneous equation system that enables a stronger test of hypotheses and assumptions than single equation models.

Importantly, increasing specialization here lowers relative production costs, consistent with the literature arguing that organizational practices improve efficiency (Langlois, 1992; Langlois and Foss, 1997; Jacobides and Winter, 2005), and in contrast to the propositions of Williamson (1981) and Riordan and Williamson (1985) and to the results of Walker and Weber (1984). This finding supports the assumption that buyer and supplier process technologies are substitutes. Moreover, the effect of asset specialization occurs controlling for the ownership of the activity before the make-or-buy decision, a variable that serves as a rough proxy for the CPC in the earlier period. It is apparent then that the The fact that the determinants of relative supplier efficiency in this division were substantially different from those found by Walker and Weber (1984) reinforces the suggestion made above that a technology-agnostic approach to studying transaction costs is no longer credible in manufacturing settings.

Moreover, the findings regarding the prediction of the make or buy decisions here are not consistent with Walker and Weber's (1984). Their result was that asset specificity (as measured by low market competition) predicts vertical integration decisions, controlling for the CPC. But here the effect of the CPC is confounded by Supplier Asset Specialization, so that only this variable along with Process Innovation predict the make or buy decision, notably in opposite directions. The other variables in this equation – Technological Uncertainty, Volume Uncertainty, and Buyer Experience - are the same as three of four variables in Walker and Weber's (1984) paper. These results together suggest that, not only do firms or business units differ in the extent of vertical integration (see, e.g., Monteverde and Teece, 1982), but they also vary in the strength and direction of the effects of supplier specialization on their make or buy decisions and on their relative cost performance. Again, it is logical that technological issues would be important for explaining these differences.

The results here show that Supplier Asset Specialization has both a direct and a partially countervailing indirect effect on the make or buy decision. The indirect effect is through the CPC and Process Innovation. Supplier specialization improves supplier's cost position relative to the buyer and at the same time creates the potential for conflict over the range of adjustments the buyer introduces as the relationship progresses, consistent with the coordination cost argument made by Langlois and colleagues (1992; Langlois and Robertson, 1989) and by Foss (1993). Also, to the extent the buyer is forced to innovate to avoid increasing costs in the market, the results are related to the theory of technical change (Nelson and Winter, 1982; see Dosi, 1997). In spite of the cost benefits of supplier specialization to the firm (see the results of equation 2]), specialized suppliers are also more likely to induce the firm to vertically integrate through process innovation. The tension between these conflicting forces represents a major challenge for suppliers that have invested in relatively unique labor skills and equipment.

Missing from equation 1) is the Make or Buy Decision (MBDec) as a predictor of Process Innovation. It was assumed that this decision would be highly collinear with the other determinants of Process Innovation, especially CPC. The right columns of Table 4 show that this is so. When an endogenous estimate of MBDec based on a linear probability model is included in the equation, the signs for CPC, PriorMB and Buyex – but not AssSpec - change, indicating instability in the estimates. MBDec does have a significant relationship with Process Innovation in the expected direction. It is apparent therefore that specifying a fully endogenous simultaneous model with the present data set is problematic. Larger data sets with similar variables will be needed to examine these relationships.

In this study, evaluating process performance has been focused exclusively on efficiency for the clear reason that this measure was the one the division used. However, more generally, performance may be either value or cost related or both (Madhok, 1996). It is noteworthy that the division studied here was aware of this and in a few instances violated its cost-comparison rule in favor of a supplier's superior quality. These cases were useful anecdotal counterpoints to the otherwise dominant emphasis on cost reduction in the archive. They suggest that studies of larger samples might develop more complete measures of supplier and buyer competences so that the contrary effects of specialization on vertical integration, as described above, might be examined in a more nuanced way.

A critical part of this study is the availability of data, not just on the make or buy decision, but on where the activity was produced before the decision was made – in-house or in the market. Without knowing the prior location of the activity, it would not be possible to show that process innovations were more prevalent for buy to make decisions than for make to make decisions. It is striking that the division invested in a radically new process for all activities brought in-house. Of course, investments were made for some activities that kept in-house, but the incidence of these was obviously smaller to a statistically significant extent. The kind of data used in the present study therefore adds a significant institutional dimension to the study of process innovation and technical change in general (see e.g., Dosi, 1982; Pavitt, 1984).

By restating the problem as "make or buy for an activity" or process, in addition to choosing the most efficient institution for governing transactions (market vs. hierarchy), it was possible here to examine more carefully two important but relatively ignored facets of vertical integration decisions: 1) differences in the capabilities of buyer and supplier, and 2) the inevitable changes in the design and execution of an activity when it is vertically integrated. The first of these has been recognized in earlier research but not the second. Together they form the basis for a more robust theory of vertical integration, in conjunction with the fundamental premise of transaction cost theory: that firms vertically integrate when the costs of coordination with a supplier are too high to support the continuation of a market relationship. However, such an emphasis on the activity constitutes a reversion of sorts to focusing on the technology of a production function, a focus that Williamson has adamantly and persistently opposed in his advocacy of transactions as the appropriate unit of analysis. The approach taken here thus, in a sense, brings the production technology back into the research frame, but specifically as a function of transaction cost problems (see Jacobides and Winter, 2005 for an extensive discussion of this issue).

An obvious disadvantage of the present research is that the data are a small convenience sample which poses problems of statistical robustness and, correspondingly, generalizability. In turn the obvious advantage such a sample provides is that one can acquire very good knowledge of each decision, especially through direct discussions with the engineers involved. Also, the activities are very similar in their characteristics to those analyzed in Walker and Weber's (1984) earlier study and therefore add information in an incremental way to the empirical literature on transaction costs and vertical integration.

References

Anderson, Erin and David Schmittlein, 1984, "Integration of the sales force: An empirical examination," Rand Journal of Economics, 15:385-395.

Argyres, Nicholas and Todd Zenger, 2010, "Capabilities, Transaction Costs and Firm Bondaries: A Dynamic Perspective," working paper, Olin School, Washington University.

Blomquist, Soren and Matz Dahlberg, 1999, "Small Sample Properties of LIML and Jackknife IV Estimators: Experiments with Weak Instruments," Journal of Applied Econometrics, 14: 69-88.

Bound John, David A. Jaeger, Regina M. Baker, 1995, "Problems with Instrumental Variables Estimation When the Correlation Between the Instruments and the Endogeneous Explanatory Variable is Weak," Journal of the American Statistical Association, 90:443- 450.

Buse, A., 1992, "The Bias of Instrumental Variable Estimators," Econometrica, 60:173-180.

Chao, John C. and Norman R. Swanson, 2005, "Consistent Estimation with a Large Number of Weak Instruments" Econometrica, 73:1673-1692.

Coase, Ronald, 1937, "The nature of the firm," Economica, 4: 386-405.

Davidson, Russell and James, MacKinnon, 1993, Estimation and inference in econometrics, Oxford University Press: New York.

Dosi, Giovanni, 1982, "Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change," Research Policy, 11:147-162.

Dosi, Giovanni, 1997, "Opportunities, incentives and the collective patterns of technological change," Economic Journal, 107: 1530-1547.

Foss, Nicolai, 1993, "Theories of the firm: Contractual and competence perspectives," Journal of Evolutionary Economics," 3:127-144.

Helfat, Connie and Margaret Peteraf, "Understanding dynamic capabilities: Progress along a developmental path," Strategic Organization, 7:91-102.

Hoetker, Glenn, 2005, "How much you know versus how well I know you: Selecting a supplier for a technically innovative component," Strategic Management Journal, 26: 75–96.

Jacobides, Michael and Lorin M Hitt, 2005, "Losing sight of the forest for the trees? Productive capabilities and gains from trade as drivers of vertical scope," Strategic Management Journal, 26: 1209-1227.

Jacobides, Michael and Sidney Winter, 2005, "The Co-evolution of Capabilities and Transaction Costs: Explaining the Institutional Structure of Production," Strategic Management Journal, 26: 395–413

Langlois, Richard, 1992, "Transaction-cost economics in real time," Industrial and Corporate Change, 1:99-127.

Langlois, Richard and Paul Robertson, 1989, "Explaining vertical integration: Lessons from the American automobile industry," Journal of Economic History, 49:361-375.

Langlois, Richard and Nicolai Foss, 1999, "Capabilities and governance: The rebirth of production in the theory of economic organization," Kyklos, 52: 201-218.

Leiblein, Michael and Douglas Miller, 2003, "An Empirical Examination of Transaction- and Firm-Level Influences on the Vertical Boundaries of the Firm," Strategic Management Journal, 24:839-859.

Madhok, Anoop, 1996, "The organization of economic activity: transaction costs, firm capabilities and the nature of governance," Organization Science, 7:577-590.

Makadok, Richard and Russell Coff, 2009, "Both Market and Hierarchy: An Incentive-Systems Theory of Hybrid Governance Forms," Academy of Management Review, 34: 297-320.

Masten, Scott, James Meehan and Edward Snyder, 1994, "The costs of organization," The Journal of Law, Economics and Organization," 7: 1-25.

Monteverde, Kirk and David Teece, 1982, "Supplier switching costs and vertical integration in the automobile industry," Rand Journal of Economics, 13:206-213.

Nelson, Charles R. and Richard Startz, 1990, "Some Further Results on the Exact Small Sample Properties of the Instrumental Variable Estimator," Econometrica, 58:967-976.

Nelson, Richard and Sidney Winter, 1982, An evolutionary theory of economic change, Cambridge, MA: Belknap Press, Harvard University.

Palay, Thomas, 1984, "Comparative Institutional Economics: The Governance of Rail Freight Contracting," The Journal of Legal Studies, 13:265-287.

Pavitt, Keith, 1984, "Sectoral patterns of technical change: Towards a taxonomy and a theory," Research Policy, 13:343-373.

Poppo Laura and Todd Zenger, 1998, “Testing alternative theories of the firm: transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services, Strategic Management Journal, 19: 853–878.

Rawley, Evan and Tim Simcoe, 2010, “Capabilities and Asset Ownership: Evidence from Taxicab Fleets,” working paper, Wharton School, University of Pennsylvania.

Riordan, Michael and Oliver Williamson, 1985, “Asset Specificity and Economic Organization,” International Journal of Industrial Organization, 3:365-378.

Rosenberg, Nathan, 1969, “The direction of technological change: inducement mechanisms and focusing devices,” Economic Development and Cultural Change, 18:1-24.

Ruttan, Vernon, 1997, “Induced innovation, evolutionary theory and path dependence: sources of technical change,” The Economic Journal, 107:1520-1529.

Schilling, Melissa and H. Kevin Steensma, “The Use of Modular Organizational Forms: An Industry-Level Analysis,” The Academy of Management Journal, 44:1149-1168.

Staiger, Douglas and James H. Stock, 1997, “Instrumental Variables Regression with Weak Instruments,” Econometrica, 65:557-586.

Teece, David, Gary Pisano and Amy Shuen, 1997, “Dynamic Capabilities and Strategic Management,” Strategic Management Journal, 18:509-533.

Walker, Gordon, 1994, “Asset choice and supplier performance in two organizations – US and Japanese,” Organization Science, 5:583-593.

Walker, Gordon and David Weber, 1984, “A transaction cost approach to make or buy decisions,” Administrative Science Quarterly, 29:373-391.

Walker, Gordon and Laura Poppo, 1991, “Profit centers, single source suppliers and transaction costs,” Administrative Science Quarterly, 36: 66-87.

Williamson, Oliver, 1975, Markets and Hierarchies, New York: Free Press.

Williamson, Oliver, 1981, “The economics of organization: The transaction cost approach,” American Journal of Sociology, 87:548-577.

Williamson, Oliver, 1984, “The Economics of Organization: Framework and Implications,” Journal of Theoretical and Institutional Economics, 140:195-223.

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

Williamson, Oliver, 1988, “Technology and Organization: A Reply,” Journal of Economic Behavior and Organization, 10:355-363.

Williamson, Oliver, 1999, “Strategy research: Governance and competence perspectives,” Strategic Management Journal, 20: 1087-1108.

Winter, Sidney, 1988, “On Coase, competence and the corporation,” Journal of Law, Economics and Organization,” 4: 163-180.

Figure 1

Diagram of a Firm's Simplified Value Chain
(Adapted from Williamson, 1981)

- Activities within the heavy line are owned and operated by the firm
- Activities outside the heavy line are owned and operated by market suppliers
- A dashed line linking two activities means that there is new information regarding the relative transaction and production costs inside and outside and so the firm undertakes a make or buy analysis
- A solid line with an arrow means the firm has no new information and so no make or buy analysis is performed

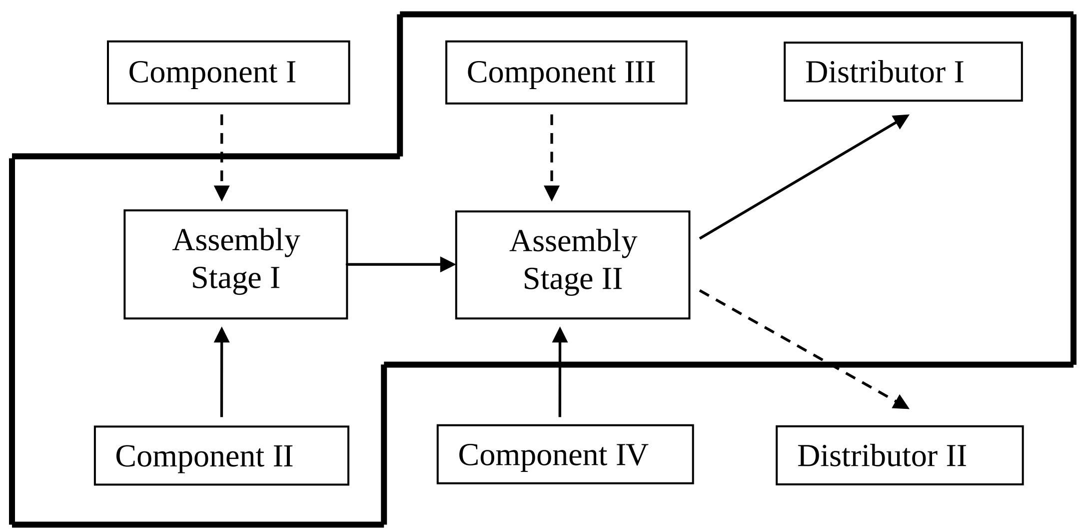
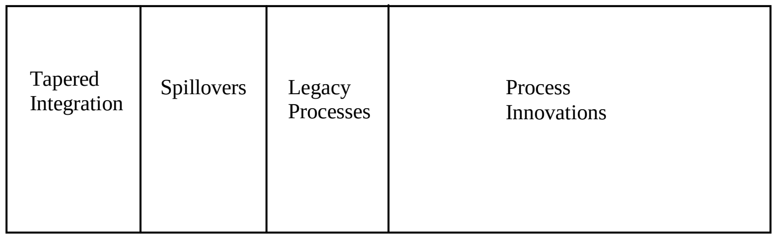


Figure 2

Process Innovation, Make-to-Make Decisions sand Buy-to-Make Decisions

<u>In-House Processes For Make to Make Decisions</u>



<u>In-House Processes For Buy to Make Decisions</u>

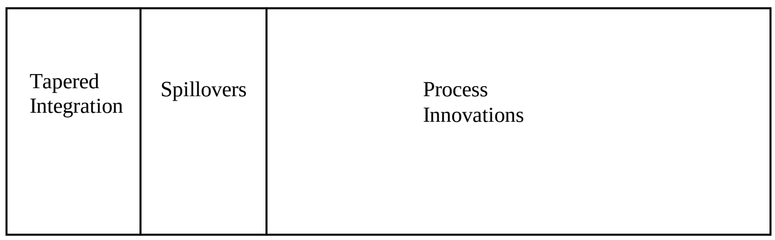


Figure 3

Hypothesized Signs for Coefficients in Equations 1) and 2)

Equation 1		Equation 2	
Dependent Variable: ProcIn		Dependent Variable: CPC	
Coefficient/ Variable	Expected Sign	Coefficient/ Variable	Expected Sign
β_{11} CPC	+	β_{21} ProcIn	+
β_{12} AssSpec	+	β_{22} AssSpec	-
β_{13} PriorMB	-	β_{23} PriorMB	-
β_{14} BuyExp	-	β_{24} BuyExp	+
β_{15} Proscope	+	β_{25} ScFavSup	-

Table 1

Number of Decisions Changing or Maintaining
the Institutional Location of the Process

	Number of Decisions
Make to Make	11
Make to Buy	20
Buy to Make	8
Buy to Buy	1

Table 2

Means, Standard Deviations and Correlations

Variable	Mean	St. Dev.	Correlations														
buynewpro	3.00	2.45	1.00														
newknow	3.84	2.11	0.67	1.00													
suppropt	2.40	1.65	-0.19	0.09	1.00												
suplabsk	3.40	1.88	0.22	0.31	0.57	1.00											
suptlseq	3.77	1.85	-0.16	0.09	0.41	0.70	1.00										
buytlseq	4.23	2.11	-0.23	-0.41	-0.32	-0.53	-0.45	1.00									
buyexperi	4.84	1.72	-0.26	-0.21	-0.04	-0.03	0.09	0.44	1.00								
specch	3.19	1.93	0.59	0.42	0.01	0.25	-0.05	-0.09	-0.01	1.00							
techimp	2.88	1.82	0.48	0.53	0.07	0.10	0.10	-0.08	-0.02	0.70	1.00						
volunc	2.95	1.53	0.45	0.21	-0.03	0.07	-0.02	-0.09	-0.08	0.65	0.38	1.00					
volfluct	2.86	1.66	0.45	0.28	-0.11	0.27	0.21	-0.09	0.08	0.59	0.44	0.72	1.00				
scfavsup	3.97	2.4	-0.53	-0.44	0.46	0.20	0.39	-0.33	-0.10	-0.43	-0.42	-0.32	-0.36	1.00			
proscope	3.58	2.34	0.46	0.53	0.05	0.25	0.11	-0.37	-0.11	0.59	0.51	0.41	0.34	-0.14	1.00		
CPC	0.56	0.50	0.65	0.41	-0.32	-0.09	-0.21	0.21	-0.04	0.60	0.59	0.36	0.33	-0.58	0.39	1.00	
MBDec	0.52	0.50	0.59	0.39	-0.25	-0.10	-0.36	0.12	-0.05	0.48	0.47	0.35	0.25	-0.46	0.26	0.77	1.00

Table 3

Factor Loadings on Varimax Rotated Principal Components for Indicator Variables

	Supplier Asset Specificity (AssSpec)	Volume Uncertainty (VolUnc)	Buyer Process Innovation (ProcIn)	Technological Uncertainty (TechUnc)	Buyer Expertise (BuyExp)
buynewpro	-0.04	0.35	***0.65***	0.27	-0.15
newknow	0.18	0.11	***0.77***	0.26	-0.20
suppropt	***0.54***	-0.13	-0.15	0.15	-0.12
suplabsk	***0.85***	0.10	0.15	0.07	-0.11
suptlseq	***0.82***	0.07	-0.09	-0.02	-0.03
buytlseq	-0.49	-0.04	-0.17	0.06	***0.68***
buyexperi	-0.09	0.03	-0.09	-0.03	***0.61***
specch	0.11	0.26	0.23	***0.63***	-0.01
techimp	-0.02	0.55	0.33	***0.75***	0.07
volunc	0.37	***0.83***	0.19	0.19	-0.09
volfluct	0.15	***0.79***	0.21	0.17	0.09

Table 4

Dependent Variables:
Make or Buy Decisions, Buyer Process Innovation, and the Production Cost Comparison

A. Dependent Variable: Buyer Process Innovation

Independent Variables:	LIML Est. (s.e.)	2SLS Est. (s.e.)	LIML Est. (s.e.)	2SLS Est. (s.e.)
CPC (endogenous)	0.185*** (0.0438)	0.166*** (0.0350)	-0.511 (0.436)	-0.248** (0.109)
Prior make or buy (PriorMB) (0=Supplier, 1=Buyer)	-1.538** (0.647)	-1.573** (0.616)	5.024 (5.177)	2.157 (1.563)
Supplier asset specialization (AssSpec)	0.473** (0.233)	0.430** (0.209)	0.876** (0.387)	0.627*** (0.145)
Buyer Expertise (BuyExp)	-0.511** (0.222)	-0.476** (0.202)	0.313 (0.480)	0.0228 (0.190)
Process Scope (Proscope)	-0.132 (0.187)	-0.0807 (0.162)	0.173 (0.160)	0.135 (0.102)
Make/Buy Decision (endogenous)			-21.17 (15.08)	-12.12*** (3.819)
Constant	4.171** (1.722)	3.991** (1.589)	11.32* (6.056)	7.944*** (1.726)
R-squared	0.392	0.487	0.485	0.724

B. Dependent Variable: CPC

Independent Variables:	LIML Est. (s.e.)	2SLS Est. (s.e.)
Buyer process innovation (ProcIn) (endogenous)	9.68*** (2.696)	9.476*** (2.616)
Supplier asset specialization (AssSpec)	-4.401* (1.835)	-4.305* (1.795)
Prior make or buy (0=Supplier, 1=Buyer) (PriorMb)	16.329* (6.800)	15.943* (6.643)
Buyer Expertise (BuyExp)	3.927** (1.442)	3.858** (1.412)
Scale Favors Supplier (ScFavSup)	2.209 (1.571)	2.104 (1.531)
Constant	-40.755 * (16.098)	-39.718* (15.689)
R-squared	.422	.428
F- Value - df – 5,39	5.41***	5.54***

*** p<0.01, ** p<0.05, * p<0.1

Table 5

Comparing Make to Make and Buy to Make Decisions[1]
(Make to Buy [Outsourcing] decisions are the baseline)

	Make to Make Decision	Buy to Make Decision	Make to Make Decision	Buy to Make Decision	Make to Make Decision	Buy to Make Decision	Make to Make Decision	Buy to Make Decision
	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)
CPC (endogenous)	.162** (.055)	.137** (.057)	.0960 (.067)	.0861 (.071)	-.019 (.077)	-.265 (.2)	-0.0056 (0.0643)	-0.101 (0.0916)
Supplier Asset Specialization (AssSpec)			-.836* (.493)	-1.04* (.536)	-1.44* (.783)	-2.71** (1.19)	-1.43** (0.707)	-2.37*** (0.895)
Buyer Expertise (BuyExp)			-.29 (.381)	-.514 (.411)	-.027 (.497)	1.68 (1.13)		
Technological Uncertainty (TechUnc)			.548 (.463)	.258 (.512)	.282 (571)	-.533 (.813)		
Volume Uncertainty (VolUnc)			-.049 (.437)	.102 (.473)	-.179 (.532)	.073 (.677)		
Process Innovation (ProcIn) (endogenous)					1.437* (.770)	5.607** (2.53)	1.475** (0.711)	2.971*** (1.016)
Constant	-.753 (.479)	-1.08** (.535)	1.78 (3.00)	3.51 (3.22)	-1.086 (4.34)	-23.18* (14.02)	-0.976 (2.144)	-5.602* (3.228)
Chi-Squared	17.07**		24.93		47.76		42.57	
Pseudo-R^2	.216		.315		.604		.539	
AIC	65.96		66.12		45.26		44.46	

Comparison of MM and BM

(log)CPC (signed)	$\chi^2(1) = .33$	$\chi^2(1) = .04$	$\chi^2(1) = 1.71$	$\chi^2(1) = 1.73$
Supplier Specialization		$\chi^2(1) = .22$	$\chi^2(1) = 1.96$	$\chi^2(1) = 2.57$
Process Innovation			$\chi^2(1) = 2.98$*	$\chi^2(1) = 4.25$**

*** p<0.01, ** p<0.05, * p<0.1

[1] (Signed) logCPC and Process Innovation are endogenous (2SLS) using the specification in equations 1) and 2)

Appendix 1

Questionnaire Items

Latent Variable	Acronym	Item Description	Questions (1 to 7 Likert scale, from Low to High)
Process Innovation (ProcIn)	buynewpro	New Process	To what extent did your division invest in a new process or improve its old process so that it gained a production cost advantage over the supplier?
	newknow	New Knowledge	If your division invested in or improved its production process to increase its competitiveness, to what extent do division engineers and personnel learn new skills and practices through hands-on exposure to the technology of this activity?
Supplier Asset Specificity (AssSpec)	suppropt	Supplier Proprietary Technology	To what extent does the leading outside supplier for this activity possess proprietary technology (e.g., patents) that gives it an advantage over other producers?
	suplabsk	Supplier Unique Labor	To what extent does the activity require labor skills that are relatively unique to outside suppliers?
	suptlseq	Supplier Unique Equipment	To what extent does this activity require tools and equipment that are relatively unique to outside suppliers?
Buyer Expertise (BuyExp)	buytlseq	Buyer Similar Equipment	How similar are the tools and equipment required for this activity to those already employed by your division?
	buyexperi	Buyer Similar Technology	To what extent does your division possess strong experience or expertise in the technology that comprises this activity?
Technological Uncertainty (TechUnc)	techimp	Expected Technological Improvements	At the time of the decision, what was the probability of future technological improvements for parts produced by this process?
	specch	Expected Specification Changes	At the time of decision, how frequently were changes expected in the specifications of the parts produced by this activity?
Volume Uncertainty (VolUnc)	volunc	Uncertain Volume Estimates	At the time of the decision, to what extent did you consider the volume estimates for the part or parts produced by the activity to be uncertain?
	volfluct	Expected Volume Fluctuations	At the time of the decision, to what extent did you expect significant fluctuations in the volume requirements for this activity?
Process Scope	proscope	Process Scope	If the division invested in or improved its production process to increase competitiveness, to what extent were the components of the new process useful for the production of other parts or part families?
Scale Favors Supplier	scfavsup	Scale Favors Supplier	To what extent do substantial differences in the scale of operations for this activity between your division and outside suppliers favor the outside suppliers?