Make or Buy Decisions and Investments in New Process Technology

Abstract

This paper examines a firm's investment in new production technology in the context of vertical integration decisions. The basic premise is that decisions to invest in a new process are based first on a production cost comparison between in-house production and market supply, but also that supplier asset specialization can stimulate a buyer to invest in a new process to avoid transaction costs. The results show that asset specialization does predict buyer process innovation and that such an innovation gives the buyer a production cost advantage over the supplier's market price. 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 capabilities are discussed.

Introduction

The purpose of this study is to expand behavioral research on vertical integration by examining how buyer investments in new processes are inherently tied to make or buy decisions. Process innovations, if they are truly new technologies for the firm, initialize the development of routines and so are necessary for the creation of organizational capabilities (Rawley and Simcoe, 2010). Relating make or buy decisions to new process investments thus links vertical integration directly to the growth of capabilities.

This connection has been central to two current research programs. The first argues that technological variables should be weighted more strongly in transaction cost studies of vertical integration (Winter, 1988; Walker and Poppo, 1991; Jacobides and Hitt, 2005; Jacobides and Winter, 2005). Conversely, the second states that vertical integration decisions should be included in analyses of technological development (Hoetker, 2005; Argyres and Zenger, 2010). By focusing on how process innovation and make or buy decisions are jointly related the present paper addresses both of these concerns.

Background

By far the dominant theory motivating empirical research on vertical integration is transaction cost economics, as developed by Williamson (1981, 1985). An important omission in almost all studies in this research program, however, is the absence of a measure of the relative production cost difference between the buyer and supplier. This lacuna is significant for two reasons, one theoretical and the other empirical. First, regarding theory, relative production costs are included in Williamson's model of vertical integration (Williamson, 1981; Riordan and Williamson, 1985). But they play no role in his concept of the Fundamental Transformation wrought in the buyer-supplier relationship by the supplier's investment in specialized assets. In his model, the specificity of the asset reduces the generalizability of production output to other buyers and so limits supplier cost reduction from economies of scale. However, this does not mean that specialization cannot improve the supplier's costs relative to those of the buyer in ways other than economies of scale – as his model does not show. Second, on the empirical side, it seems unlikely that managers would ignore such a salient variable. Walker and Weber (1984), for example, found that a buyer's relative production advantage over the supplier predicted vertical integration much more strongly than transaction cost variables.

Their result by no means indicates that the fundamental insight of transaction cost theory is tangential to a story based on comparative production costs. 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 studies using manufacturing data, suffers from an important specification bias by omitting a relative production cost variable. Moreover, including potential process innovation and its relative cost broadens the analytic focus to add the production activity itself to the classic theoretical frame of market or hierarchy. Conflicts between a buyer and supplier in a relationship occur over decisions made for a concrete activity, and it is the activity that is brought in-house when these conflicts become too severe.

To address this specification problem, a number of recent empirical studies have focused intensively on the 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.
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 relative production costs and process innovation, which is here defined as an investment in new process technology. The key question we ask is whether the specialization of the supplier in the labor and equipment required for production stimulates the buyer to innovate, net of production efficiencies associated with the new technology, and consistent with the spirit of transaction cost theory.

Empirical Approach

Understanding how process innovation and make or buy decisions are related requires a close examination of the empirical context in which the decisions are made. The empirical approach of 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 related to 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), and selling electronics (Anderson and Schmittlein, 1984).

Williamson (1981) presents a simple diagram that shows how such activities can be conceived for the purpose of studying make or buy decisions in a hypothetical manufacturing firm's value chain, as shown in Figure One. A thick solid line represents the boundary separating the activities owned and operated by the firm from those owned and operated by market suppliers, and thin lines – both dotted and solid - show the relationships between the activities. Following Williamson (1981), the diagram identifies two types of activity: The first are activities for which something has changed in the firm or the market, technologically or contractually, since the last make or buy decision, creating the need for a new evaluation (Components I and III – see the dotted lines). The second are activities for which no change has occurred since the last decision and so no new analysis is required (Components II and IV – see the thin solid lines). Note that this distinction can apply to instances of tapered integration - that is, an activity that is partially in-house and partially in the market – as in Distribution I and II.

The empirical setup has two salient characteristics that help to clarify how vertical integration and organizational competences are related:

First, the framework focuses on the institutional location (make or buy) of discrete activities and assumes that higher level routines within the firm have only a marginal significance for the make or buy decision. 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 Figure One. 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: one that involves a *current* make or buy decision and the other that does not. For type one (Components I and III), the firm perceives that technological and contracting conditions have changed materially, and so it collects new data. Then management assesses the current strengths of production and transaction costs in the firm and the market and decides anew to make or buy. Walker and Weber (1984) studied this kind of activity. For type two (Components II and IV), the firm sees nothing new that would potentially reverse the last decision, so it collects no data and continues with the status quo (make or buy). This kind of activity presents a quandary for the analyst. The problem is that without specific data on current transaction and production costs, it is impossible to separate their effects on the continuation of the status quo. Using old data won't help, unfortunately, since the levels of the two kinds of cost may have changed since the earlier decision, even as their combined effect does not force a re-evaluation of it. For example, suppose the firm originally vertically integrated an activity to lower production costs (see Walker and Weber, 1984) and the outside supplier at the time had a low level of asset specialization, meaning low transaction costs. Moreover, imagine that over time the degree of asset specialization within the firm increased, as is probable. In this case, if the level of current asset specialization is observable, an analyst might suppose, erroneously, that the market supplier involved in the earlier decision had the same (high) level of asset specificity as found for the activity in-house currently and conclude therefore that the original decision was made to keep transaction, not production, costs low. One way to solve this problem is to collect data on the current relative production costs (and on current potential suppliers). But if the firm does this, the earlier decision becomes moot and the activity becomes type one, as above. It follows that only by collecting data for a current decision can the relative weights of production and transaction costs be reliably identified.

Third, the framework distinguishes between two types of vertical integration decision - make-to-make and buy-to-make. These have different implications for investments in new process technology. Regarding a make-to-make decision (possibly Component III), either the activity's current process is already more efficient than suppliers, or the organization must invest in a new process that will be more efficient. However, if the decision is buy-to-make (possibly Component I), no pre-existing process exists within the organization for comparison to the market. In this case, with two exceptions, the organization must invest in new process technology for which it has little relevant experience. The exceptions are activities that involve tapered integration (Distribution I and II) or benefit from technological spillovers from other activities within the organization (see Figure Two).

In the empirical context studied here, the investment in a new process is made contemporaneously with and as a part of the choice to make or buy. This means that when new process technology is being considered, the vertical integration decision occurs in conjunction with it, not separately. This contrasts with both Hoetker (2005) and Rawley and Simcoe (2010) in which process innovation conditions or predicts vertical integration, but not the reverse. Of course more generally, new process and vertical integration decisions need not be concurrent. An investment in new process technology may be observed subsequent to vertical integration in an earlier time period (see possibly Rawley and Simcoe, 2010). But this kind of activity would be categorized as the status quo type described above (no new make or buy decision is required or made); and, as argued previously, if one were to study this type of activity, it would not be possible to determine the relative contributions of production and transaction costs to investing in a new process.

Theoretical Background

The studies cited above build on the same theoretical foundations in which vertical integration and capability development are related. But the variation across these studies in measurement, research design and results indicates that fundamental questions about this relationship remain. Four of these questions are addressed below to frame the arguments of the present study. The discussion is summarized in Figure Three.

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 technological alternatives with opposing investment paths. Langlois (1992; Langlois and

Robertson, 1989) makes the same argument. He presents anecdotal evidence that early automobile assemblers replaced the labor-intensive processes of their suppliers with mass production, an alternative process technology. Further, Walker and Weber's (1984) strong results regarding the effect of comparative production costs on make or buy decisions suggest that the firm and its supplier differ significantly in how the activity is designed and executed. This substitutability between firm and market process technologies will be important in the development of the hypotheses below.

The role of the firm's performance in an activity in the make or buy decision. An organization's assessment of its own performance in an activity is relevant for a make of buy decision only when compared to a supplier (Walker and Weber, 1984; Poppo and Zenger, 1998; Hoetker, 2005; Rawley and Simcoe, 2010). The reason is that both the make or buy decision and the decision to invest in a new technology involve a comparison between the firm and the market. So the mere existence of an apparently strong capability inside the firm does not indicate whether it is the better alternative to sourcing in the market. Some studies of vertical integration decisions include such a comparison between the firm and its suppliers, based on actual or estimated performance, (e.g., Walker and Weber, 1984) but many do not.

The relationship between the firm's investment in new technology and the firm's relative production performance compared to suppliers. The investment decision and the performance comparison should be measured as separate variables (Poppo and Zenger, 1998; Hoetker, 2005; Rawley and Simcoe, 2010). There are three reasons. First, 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. Also, capability development by itself is insufficient to measure whether or not vertical integration was determined by relative performance differences, since transaction costs may have played a role (Argyres and Zenger, 2010). Finally, new process investment and the performance comparison have different sets of predictors and so need to be measured separately.

But even though they have separate predictors as individual constructs, new process investment and relative production costs have a reciprocal relationship. When management proposes an investment in new process technology, the expected performance of the new process is compared to market alternatives. Similarly, such an investment is unlikely to be made if this comparison favors the market. Testing how transaction and production costs determine the development of new capabilities therefore requires two equations. In the first, (expected) relative production costs are determined by the firm's proposed investment in new process technology, and in the second whether or not the firm invests in the new process is a function of (expected) relative production costs. It should be said again that, in addition to influencing each other, the dependent variables in these equations have different predictors.

The relationship between new process investments and the make or buy decision. In this paper, because process innovations occur only in-house, the decisions to invest in the new technology and the make or buy decision are made contemporaneously. However, these decisions are not identical and need to be measured separately. They influence each other in similar but not identical ways.

First, if a new process is available, then the investment may influence the make or buy decision (see Rawley and Simcoe, 2010). In this case, the process innovation may lower the firm's production costs compared to the supplier enough to determine a make decision. The differences in this effect between activities currently in-house and those sourced from the market will be explored below.

Second, the reverse relationship (the influence of make or buy decisions on new process investments) has also been proposed in the literature (Winter, 1988; Argyres and Zenger, 2010) and is obviously logically necessary. The incidence of process innovation is clearly contingent on a make decision. However, including the make or buy decision as a predictor of process innovation is problematic. The reason is that when the decisions to invest and integrate are made contemporaneously, the (endogenous) make or buy decision (as influenced by process innovation) is highly collinear with its own determinants, especially relative production costs, when specified as a predictor of process innovation itself. How much this collinearity confounds the relationship between the process innovation and make or buy decisions is an empirical issue.

The logic introduced above thus adds two important variables to the standard theory of vertical integration and transaction costs: 1) the buyer's investment in a new process and 2) the need to specify the kind of decision: buy-to-make, make-to-buy, make-to-make, or buy-to-buy (rarely analyzed by management). Below we develop hypotheses that propose how these variables can be integrated into the received theory as shown in Williamson (1981) and tested in Walker and Weber (1984). Moreover, we will show in our tests how the inclusion of these variables into the standard model expands its importance for the literatures on both transaction costs and new process development.

Hypotheses

Supplier asset specialization and process innovation. There are two arguments that link a firm's investment in a new process to higher transaction costs with market suppliers. In the first argument, the investment is reactive. That is, it is a response to high transaction costs created by supplier asset specialization. The firm innovates to lower its production costs relative to the supplier so that 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. If supplier asset specialization, prospective or current, is predicted to create or actually has created higher transaction costs in adapting to buyer requests for changes in the relationship, as Williamson (1981, 1985) proposes, then it will increase the costs of sourcing in the market and thereby raise the likelihood that the buyer will invest in the new process. The hypothesis is as follows:

Hypothesis 1 (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 predicting how process innovation affects vertical integration and the reverse. The hypotheses follow:

Hypothesis 2b (H2a): Process innovations are more likely to occur when the activity was previously sourced from a market supplier.

Hypothesis 2b (H2b): Process innovations are likely to predict buy-to-make decisions more strongly than make-to-make decisions.

Process innovation and buyer experience. For the new process to be a discrete innovation that initializes a capability, and not a recombination of existing expertise, the firm should have little prior experience regarding the technology required for activity. If this is true, we can be more confident that the firm is not making the investment to further a technology platform involving planned spillovers across activities, as highlighted in the literature on core competence (Hamel and Prahalad, 1990). Further, if the firm has little prior experience with the new process technology, it cannot have specialized in it. Several studies (Walker and Poppo, 1991; Poppo and Zenger, 1998) have found a positive effect of asset specialization on transaction performance for internal suppliers. It is important therefore to examine whether such an effect may exist here regarding the firm's investment in a new process. To assess this question, the hypothesis follows:

Hypothesis 3 (H3): Lower buyer experience is positively related to process innovation.

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 manufacturing customers inside and outside the corporation. Divisions in the firm were required to include a make or buy analysis in their proposals for investments in new process technology. They were also mandated to perform a make or buy analysis for all manufacturing processes at least once 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 product and supplier markets had changed enough to warrant a new analysis. If no change was apparent, the division reported to the corporate parent that the earlier analysis was still correct. If there was a significant change, then a new evaluation was made. The archives of the division's make or buy committee, made available to the author, thus 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 production cost comparison between the division and its suppliers (hereafter CPC) was recorded (see below for how this variable was calculated in the division).

Given the small size of the data set, it is useful to describe several representative make or buy cases (see Appendix One). These descriptions are meant to broaden the empirical content of this study by showing in mid-level detail the kind of issues the division recorded in its archive. All cases contain a production cost comparison, whose recommendation regarding make or buy is disregarded in rare instances. Also, many cases mention control issues, supplier capability, and market competition, consistent with the literature on vertical integration.

The archive perhaps predictably did not systematically contain data of theoretical interest. So it was necessary to collect these data using a questionnaire. 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 technological, market contracting and other issues related to the decisions 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.

After attenuation due to missing data, both in the archive and questionnaire responses, a total of 40 cases remained 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 One. This pattern is quite similar to Walker and Weber's (1984) data.

Two characteristics of these cases are worth noting. First, for both the firm and its supplier, incentives and task design are aligned with asset ownership. That is, no activities involve hybrid relationships. Using Makadok and Coff's (2008) scheme, an 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. These two configurations of control dimensions are standard in tests of transaction cost theory. Expanding beyond them (see e.g. Walker and Poppo, 1991) would add a layer of complexity that is beyond the scope of this paper. Second, there are no instances of the buyer acquiring the supplier to internalize the activity. Although acquisitions are a prevalent form of vertical integration for capability development (a well-known example is Disney's purchase of Pixar), in the present paper the buyer invests de novo when it brings the activity in-house.

Methods

Measurement and Construct Validation

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

Process Innovation. 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 Specialization. The measures of supplier specialization are: 1) Supplier proprietary technology; 2) Unique supplier labor; and 3) Unique supplier equipment. Because of the focus here is on both competence and vertical integration of activities, the measures of asset specialization are activity-specific; and their meaning has both a competence and a transaction dimension. Such a dual interpretation has been common in the literature (Walker and Weber, 1984; Poppo and Zenger, 2002). On the competence side, asset specialization, especially as it is protected from competitors, heightens the substitutability between the process technologies of the firm and the supplier. On the transaction side, specialized supplier investments in an activity are a necessary condition for transaction-specific customization and in many studies have been used as a proxy for it. Parmigiani and Mitchell (2009) showed that the presence of suppliers with non-unique skills predicted a buy decision, consistent with Langlois (1992). This operationalization is also consistent with Klein, Crawford, and Alchian (1978: 300), who argued that unique assets enable suppliers to appropriate quasi-rents in the contracting process. Walker and Weber (1984) showed that supplier proprietary technology was strongly negatively correlated with measures of supplier market competition (see also Parmigiani, 2007, and Parmiginiani and Mitchell, 2009), and Walker and Poppo (1991) found that supplier asset specialization was also strongly negatively related to market competition.

Buyer Experience. Following Walker and Weber (1984), Buyer Experience is measured using two items: 1) Similar tools and equipment; and 2) Similar expertise.

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

Economies of Scope. Parmigiani (2007) shows that buyer scope economies increase the likelihood of a make decision. The variable is measured with a single indicator.

Scale Favoring the Supplier. Walker and Weber (1984) used this variable as an indicator of buyer production advantage (negative relationship). Their measure is used here.

Comparative Production Costs (CPC). The CPC was based on calculations of the team responsible for the make or buy decision. They 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 annual 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 activity, whether it was 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 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 used in the analysis was created using the logged absolute values of the engineer's calculations which were then re-signed to positive or negative in accordance with the original number.

Table Two shows the means, standard deviations and correlations among the measures. 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 Three. 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 Specialization – were not in their model. Composite variables for all multi-item constructs were created by adding the indicator values and dividing by the number of indicators.

It is worth noting that these data come from a production unit whose components are part of an end product in the mature stage of its life cycle. It is likely then that the process innovations made by the division are jointly constrained by both a single dominant design for the end product and a relatively fixed degree of modularity among the stages of the production process (see Argyres and Bigelow, 2010). Variation in across the activities examined here therefore occurs at a more granular level of analysis than found in industry studies of technology development and vertical integration over the industry life cycle.

Hypothesis Testing

Like Walker and Weber (1984), the present research uses a simultaneous equation system to test the hypotheses. Several other articles that test transaction cost theory on micro-data have considered the problem of endogeneity: Poppo and Zenger (1998) of boundary choice to supplier performance; Masten, Meehan and Snyder (1991) of management costs to boundary choice; and Walker (1995) of supplier performance to buyer asset choice. The approach here is to treat both relative production costs (the CPC) and the buyer's decision to invest in a new process as predictive of each other. Since the firm would not invest in a new process generally unless it could show a superior cost advantage over the supplier, and a superior cost advantage was a function of the buyer's superior process technology, either current or proposed, the co-dependence of these variables reflects both the administrative and the economic facts on the ground. The make or buy decision is predicted separately. The equation system is as follows:

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 (defined as investment in new process technology in the activity)
CPC	=	Comparative Production Costs - logged and signed (higher values favor the buyer)
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

In equation 1), H1 is tested as β_{12}; H2a through β_{13}; and H3 through β_{14}. Equation 2) is necessary because of the reciprocity of process innovation and comparative production costs. H2b is tested in equation 3). Equation 3) is an almost complete replication of Walker and Weber's (1984) model relating transaction costs and make or buy decision with process innovation added to test H2b. Two of their measures of supplier competition are replaced here by Supplier Asset Specialization indicators (Supplier Proprietary Technology is exactly their measure). Also, the CPC variable in this study is calculated in the same way as their measure of (log) annual savings to make, which is an indicator of the supplier's production advantage.

The additional predictors in the two equations are controls and tests of assumptions. The scope of the new process (ProScope) should predict the incidence of process innovation, given the economic advantages and the higher likelihood of a make decision associated with economies of scope (Parmigiani, 2007). Buyer Experience should improve the business unit's production cost position relative to the supplier (Walker and Weber, 1984). Correspondingly, if buyer and supplier technologies are substitutes, Supplier Asset Specialization should shift the CPC towards the supplier. Further, if the supplier benefits from scale advantages (ScFavSup), it should predict the CPC negatively, that is, shift it towards the supplier, consistent with Walker and Weber's, 1984 results.

Equations 1) and 2) comprise a simultaneous equation model. Although two-stage least squares (2SLS) is the conventional technique for this type of analysis, it is biased when the instruments are weak (see e.g., Nelson and Startz, 1990; Bound, Jaeger and Baker, 1995). A number of studies have shown that when the sample is small, as is the case here, the Limited Information Maximum Likelihood (LIML) estimator has lower bias than 2SLS (Buse, 1992; Staiger and Stock, 1997; Blomquist and Dahlberg, 1999). Unfortunately, however, LIML does not have finite moments, complicating the choice of estimator in small samples. To address this problem, Davidson and Mackinnon (1993, chapter 18) suggest using both 2SLS and LIML and comparing their results. If the coefficients of the two methods are close, then there is good reason to believe that the estimates are robust. This is the method adopted here. Also, both the 2SLS and LIML coefficients are estimated with robust standard errors.

As for equation 3), the make or buy decisions are predicted using multinomial logit. This method provides a standard prediction of make or buy, except that the make decision is separated into two types - make-to-make and buy-to-make - so that Hypothesis 2b can be tested. The baseline condition is the make to buy decision. The values for both CPC and ProcIn are the estimated values from equations 1) and 2).

Results

The results for equation 1) are shown in Table Four (A). H1 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. Supporting H2a, process innovations are more likely for activities that were previously performed in the market (buy-to-make decisions), as argued in the section on Empirical Approach above; and they are negatively related to the firm's knowledge as represented by Buyer Experience, supporting H3.

Table Four (B) shows the estimates for equation 2). The assumption that process innovation and the CPC have a reciprocal relationship is supported. Also, Supplier Asset

Specialization is positively related to a CPC that favors the supplier, consistent with the assumption that the supplier's process technology is a substitute for the firm's. Note that this result calls into question 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 specialization thus has two effects on the CPC which differ in their signs. The first is indirect and favors the buyer through the instigation of process innovation and the second is direct and favors the supplier. Also, Buyer Experience is positively related to the CPC, as Walker and Weber (1984) also found. Finally, the LIML and 2SLS coefficients are reassuringly close to one another.

Table Five presents the results for equation 3). Process innovation predicts both make-to-make and buy-to-make decisions significantly; and the effect on buy-to-make decisions is greater, supporting H2b. It is important to observe that, contrary to transaction cost theory but consistent with its effect on the CPC, supplier asset specialization leads to a buy decision. This result indicates that the effect of the lower production costs of specialized vendors outweighs that of the transaction costs they may create. Transaction costs thus influence buyer process innovation, as shown in Table Four (A), not make or buy decisions. This conclusion is a major consequence of including buyer process innovation in the transaction cost/make-or-buy framework.

Discussion

How are capability development and vertical integration decisions related? To address this question, capabilities that are new (process innovations) need to be distinguished from those that are ongoing (no process innovations). The reason is that the former are predicted more strongly by both transaction and production costs, as the results in this paper show.

Further, the data presents a rather stark picture of competition between a firm and market suppliers in the performance of an activity over time. It is fair to conclude that, when rigorous make or buy decisions are made for an in-house activity, it is uncommon for an existing process to remain in-house without new investment in its equipment and labor practices. Those activities staying in-house without innovation (a subset of make-to-make decisions) could be considered core activities whose superiority to market alternatives goes against this trend.

An important benefit of testing the theory on manufacturing firms is the relatively straightforward measurement of buyer production costs. In the unit studied here, as in that examined by Walker and Weber (1984), production cost estimates were carefully calculated 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. 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 One). This pattern is quite similar to that found in Walker and Weber's (1984) sample of decisions in a similar manufacturing unit.

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 direct effect is through the benefits supplier specialization offers the buyer, most likely through a lower price due to low costs. Table Five shows these lead to outsourcing. The indirect effect is through the CPC and Process Innovation. Here supplier specialization improves supplier's cost position relative to the buyer, 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). This finding supports the assumption that buyer and supplier process technologies are substitutes. But at the same time, specialization creates the potential for conflict over the adjustments the buyer asks for as the relationship progresses, as argued by Langlois and colleagues (1992; Langlois and Robertson, 1989) and by Foss (1993). Thus, in spite of the production cost benefits of supplier specialization, specialization raises transaction costs that 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.

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 costs 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. These are buy-to-make and make-to-make decisions, which process innovations affect differently. 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.

It is apparent that the determinants of relative supplier efficiency in this division were substantially different from those found by Walker and Weber (1984). It seems very difficult then to maintain the assumption that technology can be held constant in transaction costs studies. It is also perilous to assume, as in the efficient boundaries model (Williamson, 1981), that the technology the buyer adopts when it vertically integrates is identical to the supplier's at the time integration occurs. 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 may explain these differences.

It is important to note that the Make or Buy Decision (MBDec) is missing from equation 1) 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 Five 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, Prior Make or Buy and Buyer Experience– but not Supplier Asset Specialization-change, indicating instability in the estimates. MBDec does have a significant relationship with Process Innovation in the expected direction.

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 related to either value or cost or, more likely, to both value and cost (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 (see the brief case examples in Appendix One). 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).

An obvious disadvantage of the data in the present research is they 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.

Finally, 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 (see Jacobides and Winter, 2005, for an extensive discussion of this problem). 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.

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Figure One

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

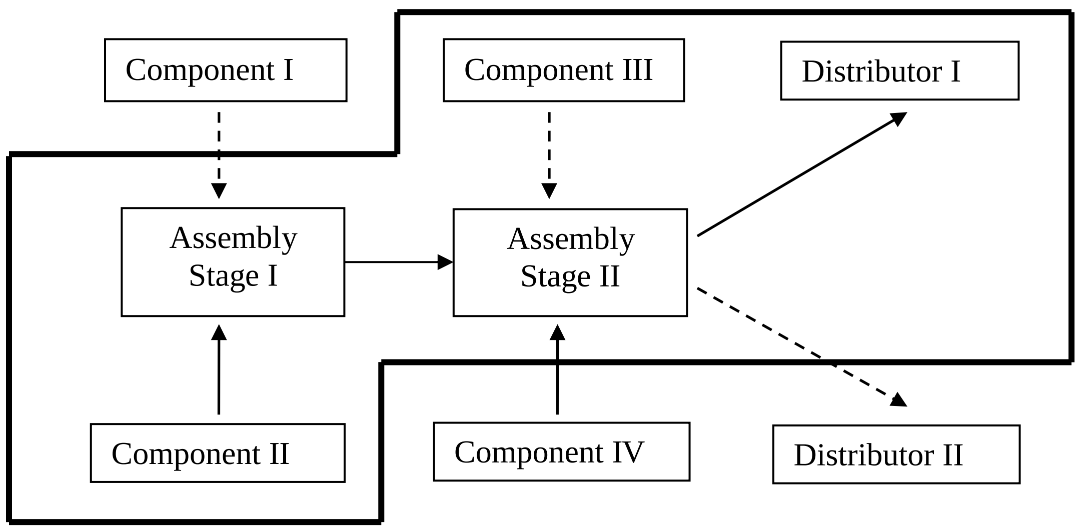
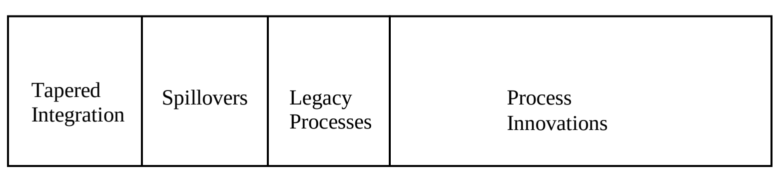


Figure Two

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

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



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

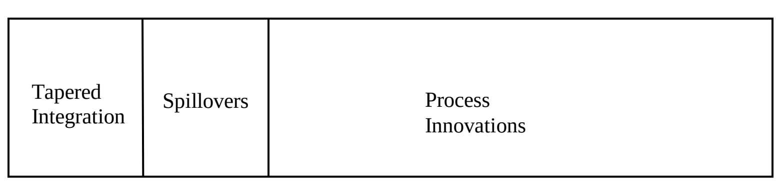


Figure Three

Summary of Theoretical Assumptions

Issue:	Assumption:
What is the relationship between the firm’s and its supplier’s capabilities?	They involve different technologies and paths of investment and are substitutes.
How does the firm’s performance in an activity enter into the make or buy decision?	The firm’s performance is relevant to the decision only in comparison with the performance of a market supplier.
What is the relationship between process innovation and relative performance in an activity?	They influence each other and should be measured separately.
What is the relationship between an investment in a new process and the make or buy decision?	These decisions are made contemporaneously but separately, and they influence each other, but for different reasons.

Table One

Number of Decisions Maintaining or Changing
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 Two

Means, Standard Deviations and Correlations Among the Indicators

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 Three

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 Four

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

A. Dependent Variable: Buyer Process Innovation

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

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***

Table Five

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 One

Brief Case Descriptions from the Archive

Except for economic variables, the engineers were not required to record characteristics of their projects systematically. Descriptions of intangible aspects therefore vary substantially in degree of detail and type of content. The following descriptions thus are meant to give some background of the kinds of decisions the business made rather than represent each type of case (Make-to-Make, Make-to-Buy, Buy-to-Make).

Make-to-Make Cases:

1) Plating process. This activity was kept in-house because of potential delivery problems, high potential shipping costs, and the need to maintain operating flexibility and quality. However, the production cost comparison favored outsourcing.
2) Plastic molding process. This process remained in-house because of superior in-house quality and the need to exercise control over the process, especially tolerances. The production cost comparison favored in-house production.
3) Fabrication of temperature sensor. This activity was kept inside the business in order to invest in a new process. The new process design involved higher automation and was projected to reduce warranty costs. The project's production cost was lower than sourcing in the market.
4) Plastic finishing process. This activity stayed in-house for the following reasons: There was only one potential outside vendor; immediate feedback regarding quality was critical; it was important to minimize inventories, shipping costs and packaging costs; and the business wanted one management over manufacturing. The production cost comparison favored a make decision.

Make-to-Buy Cases:

1) Finishing process. There were cost control advantages of sourcing to two suppliers. Outsourcing allowed a more timely startup. Also, the unit would achieve added flexibility if volume increased. But the comparison of production costs favored vertical integration.
2) Assembly process. This activity was outsourced to two suppliers, one of which was an existing source for another input. The production cost comparison favored the suppliers.
3) Assembly process. In this case, the business knew supplier costs and bought inputs for the supplier. The process involved minor engineering changes. The production cost comparison favored the supplier.
4) Component fabrication. This process was labor intensive and low volume. The supplier had experience with a related product and offered free transportation. Outsourcing produced 5% productivity gains. The production cost comparison indicated outsourcing.

5) Assembly process. The supplier had a good reputation and had low labor cost. The activity itself had low profitability for the business. The production cost comparison favored the supplier.

Buy-to-Make Cases:

1) Component fabrication. The business invested in a new automated process, experienced good entry timing and had increasing volume. The production cost comparison favored vertical integration.
2) Component fabrication. The business unit invested in a process that was less labor intensive. The process was high volume and the product was proprietary. Production costs indicated vertical integration.
3) Component fabrication. This decision involved a new process. Production costs favored vertical integration.
4) Extrusion process. Vertically integrating this activity involved a new process technology. The existing supplier had poor quality. The production cost comparison indicated bringing the operation in-house.
5) Component fabrication. The division planned for small production runs with a new technology and expected to increase volume later with new applications. The production cost comparison favored vertical integration.

Appendix Two

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?