CONCURRENT SOURCING: WHEN DO FIRMS BOTH MAKE AND BUY?

by

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ABSTRACT

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In this dissertation, I ask, "When and why do firms simultaneously make and buy a particular input?" I term this strategy concurrent sourcing. While extant theory typically treats the sourcing decision as a dichotomous choice, in practice firms can and do simultaneously make and buy the same input. Traditional reasons for this partial integration strategy involve hedging against volume uncertainty and gaining complementary knowledge. By including supplier's incentives, my work counters the hedging logic and unpacks the knowledge argument. The key benefits of concurrent sourcing include an improved ability to monitor suppliers due to reduced information asymmetries and increased learning due to the combination of deep tacit knowledge gained from internal production and more diverse knowledge gleaned from external sources. I posit that concurrent sourcing is a stable sourcing mode since making and buying can be synergistic activities under certain conditions.

By combining a resource-based and transaction cost approach, I identify conditions that lead firms to choose among the three primary sourcing modes: making, buying, and concurrent sourcing. I empirically test my propositions by conducting a survey of production tooling and services sourcing decisions in North American metal forming firms. Analysis of this data confirmed the existence and stability of concurrent sourcing. Firms were more likely to concurrently source if their production costs were similar to those of their suppliers by having sufficient expertise and moderate scope economies from both internal and external suppliers. They also concurrently source in cases of high technological uncertainty, indicating the benefit of learning from both internal and external suppliers. Concurrent sourcing was also more evident if performance ambiguity was low, markets were thin, inputs were similar, and firms were unionized, suggesting quality monitoring advantages. These findings do not support the traditional argument that volume uncertainty motivates firms to choose this mode, but rather support the view that knowledge motivates firms to concurrently source. This research underscores the complexity of sourcing decisions and suggests that the concurrent sourcing option should be included when investigating "make-or-buy" choices.

To John

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CHAPTER 1

INTRODUCTION: RESEARCH QUESTION AND MOTIVATION

In this dissertation, I ask, "When and why do firms simultaneously make and buy a particular input?" I term this strategy concurrent sourcing. Existing theory typically treats the sourcing decision as a dichotomous choice, to make or to buy (e.g., Williamson 1975, Monteverde and Teece 1982b, Conner 1991, Grant 1996, Conner and Prahalad 1996). In practice, however, firms can and do both make and buy the same input. Traditional reasons for this partial integration strategy involve hedging against volume uncertainty and gaining complementary knowledge. By including supplier's incentives, my work counters the hedging logic and unpacks the knowledge argument. The key benefits of concurrent sourcing include an improved ability to monitor suppliers due to reduced information asymmetries and increased learning due to the combination of deep tacit knowledge gained from internal production and more diverse knowledge gleaned from external sources. I posit that concurrent sourcing is a stable sourcing mode since making and buying can be synergistic activities under certain conditions.

Researchers have long maintained that firms determine their boundaries by deciding which inputs to make and which to buy (Coase 1937; Williamson 1975; Tirole 1988). Theoretical support for this dichotomy blossomed with Williamson's work on transaction cost economics (TCE), outlining the distinctive attributes of the two polar forms corresponding to buying and making, market and hierarchy (Williamson 1975; Williamson 1985; Williamson 1996). Scores of empirical studies further buttress the distinction between these two sourcing modes, many in the TCE tradition and most reinforcing the traditional precepts of this theory (for reviews see Rindfleish and Heide 1997 and Crocker and Masten 1996). Strategy theorists steeped in the resource-based tradition also adopt this dichotomy, arguing that firms will make goods for which they have relevant competencies and expertise and buy goods when they lack such skills (Prahalad and Hamel 1990; Rubin 1973; Conner 1991). Empirical work has also generally supported these theoretical predictions (e.g., Argyres 1996).

However, the make/buy dichotomy ignores the complexity of firms' sourcing choices. Firms may use sourcing methods that, while ostensibly fitting into one of the two dichotomous categories of market or hierarchy, actually combine aspects of both. Examples include transfer pricing between internal units of a firm or sole external sourcing for a particular input (Walker and Poppo 1991). In addition, firms may explicitly combine market and hierarchy forms of control, by simultaneously making and buying a given input (Bradach and Eccles, 1989). This concurrent sourcing mode, also known as partial or tapered integration, is the focus of my research.

In my dissertation, I view concurrent sourcing as a distinct sourcing mode rather than some combination along a make/buy continuum and contrast this choice with those of making and buying. Firms using this mode employ two forms of control simultaneously for the same function; scholars have termed this a "plural mode" strategy

(Bradach and Eccles 1989). Firms are using both the authority of the firm and the incentives of the market, indicating that these are independent mechanisms that are not mutually exclusive. This approach contrasts with the continuum perspective of hybrid sourcing modes, which sets making at one end of a spectrum and buying at the other, and suggests that making and buying are substitutes and mutually exclusive (Williamson, 1985). This view cannot explain why firms would choose to use both sourcing modes (Dutta et al 1995). Moreover, this view suggests that concurrent sourcing should occur for intermediate levels of attributes that, in the extreme, would typically steer firms toward making or buying (e.g., production costs, asset specificity, etc.). My research argues that in some cases, more extreme levels of these attributes lead toward concurrent sourcing (e.g., high technological uncertainty) and intermediate levels of attributes lead toward polar sourcing modes (e.g., moderate performance ambiguity leads toward solely making), contradicting the continuum view.

Two examples that highlight the distinction between the continuum and plural mode views include sales distribution systems and franchising. Dutta and colleagues discuss how sales territories can be managed by inside salespeople, outside representatives, or a combination of the two. If a firm chooses to use both inside and outside sales forces for a particular territory, this would be considered to be a plural form, akin to concurrent sourcing. However, if the firm uses all inside salespeople for certain territories and all outside representatives for others, the firm is not using a plural mode since the mode for each territory is a distinct choice. The continuum perspective could not distinguish between these two cases, since they both appear to be between the poles of all internal or all external sourcing, whereas the plural mode view does so (Dutta et al 1995).

Similarly, franchising is best understood as a plural mode. Franchisors typically both operate company-owned outlets and contract with independent franchisees to operate outlets. In this fashion, franchisors are simultaneously using both internal and external governance mechanisms, thus using a dual distribution system (Bradach 1997). A scholar investigating franchising from a continuum perspective may concentrate on the percentage of inside vs. franchisee outlets; however, this does not address the initial decision or the ongoing management of the franchisors to use both types of outlets. The franchisor is not necessarily more "firm like" because it chooses to use a greater percentage of internally-operated outlets since it still must manage external franchisees. Moreover, this type of franchise structure is very stable in many industries and the franchise percentage tends to be firm-specific and relatively constant over time (Lafontaine and Slade 2000, Lafontaine and Shaw 2003). The more interesting questions are why do certain firms choose to operate both internal and external outlets and how do they manage this choice. I maintain that firms using concurrent sourcing first choose this mode and then choose the distribution of internal and external production. Even if a firm chooses to outsource 90% of its requirements of a particular input and only produce 10% in-house, or vice versa, the firm is still using two sourcing modes concurrently, making and buying. The determinants of the plural mode choice, concurrently making and buying, are at the crux of my research agenda. The percentage distribution between making and buying is a secondary decision and one I hope to investigate in future work.

I use a discrete structural alternatives approach to this research question, such that each sourcing mode has a distinct set of features relative to the criteria that a sourcing firm uses to choose the best way to procure an input. These criteria include production costs, quality monitoring costs, dispute resolution costs, and the incentive stability of the exchange. In turn, each of these criteria is affected by input, sourcing firm, supplier, and environment attributes that ostensibly determine the sourcing mode choice. Therefore, firms will undertake concurrent internal and external sourcing only when input, firm, supplier, and environment attributes warrant this choice. Certain attributes will provide symmetric and continuing benefits for both the firm and the outside suppliers to enter into and sustain the sourcing relationship. Such amenable attributes include performance ambiguity, technological uncertainty, economies of scope for both sets of suppliers, and superior supply management skills of the sourcing firm. Conversely, other attributes can prevent concurrent sourcing from being a viable sourcing strategy due to asymmetric conditions that clearly favor either internal or external sourcing. These include significant asset specificity, volume uncertainty, or a distinct production cost advantage for either the internal or external supplier.

Prior research suggests that concurrent sourcing is quite prevalent. For example, in the classic make-or-buy work by Monteverde and Teece (1982b), they define as "make" any component for which the firm produces 80% of more its requirements. Thus, many of these inputs were actually concurrently sourced (Bradach and Eccles 1989). Other scholars have investigated the empirical existence of partial integration in sales distribution channels (Anderson and Schmittlein 1984; Dutta et al 1995), in product development tasks (Azoulay and Henderson 2001), and in general manufacturing activities (Harrigan 1985).

Scholars have defined partial integration as a firm supplying some but not all of its own requirements for an input through internal production (Adelman 1949, Cannon 1968, Williamson 1975, Carlton 1979, Porter 1980, Perry 1989, Oster 1994). Harrigan extended this definition to include the possibility of selling excess requirements to outside customers and renamed the concept tapered integration (Harrigan 1984, Harrigan 1985). To better connect with the traditional theory, my dissertation focuses on intermediate product markets, where firms make and buy a common input. I define an input as being based upon a uniform technology and used in the same function downstream, regardless of whether procured internally or externally. This fits with Carlton's assumption that both internal and external suppliers use similar technologies to produce the focal input (Carlton 1979). Traditional logic suggests two primary reasons why firms would use partial integration: to hedge against volume uncertainties and to gain complementary knowledge. My arguments somewhat counter and augment the former view, but support the latter.

A well-known argument as to why firms would both make and buy a particular input is to hedge against volume uncertainty risks. Firms can keep their internal plants at full production by using outside suppliers to handle the fluctuating additional volumes, thereby running more efficiently (Adelman 1949; Williamson 1975; Carlton 1979; Porter 1980). This position makes two critical assumptions: that internal production provides a significant portion of the firm's requirements and that a robust spot market exists, consisting of a sufficient number of qualified outside suppliers willing and able to vie for the firm's business. If the firm is producing a significant quantity of its requirements, it suggests that it can do so due to greater expertise, scale or scope economies, specific investments, or some combination of these. Therefore, the sourcing firm should have lower per unit production costs than outside suppliers, otherwise the sourcing firm would simply outsource all of its requirements. Outside suppliers, therefore, will have higher base production costs (Adelman 1949). But, the actual prices they charge the sourcing firm may be even higher, due to the risk they are bearing by having unused capacity during slack times and by not knowing when the "low probability" demand will occur (Carlton 1979). Indeed, suppliers may charge opportunistic premiums for lower volumes and short lead times since they know they are merely "overflow outlets" for the sourcing firm (Hill 1994; Harrigan 1984). Sourcing firms may be able to avoid these premiums in industries that are highly fragmented and competitive or if specific investments are not necessary (Porter 1980). However, multiple low cost suppliers typically prevail in these types of industries, thus implying that the sourcing firm would be better off completely outsourcing and not producing any of its requirements internally (Pindyck and Rubenfeld 1984; Williamson 1975).

The nature of the volume uncertainty may dictate partial integration as a reasonable sourcing choice. If volumes are fluctuating, but predictable (e.g., seasonal), then outside suppliers can fill their capacity with other business during the slower times and perhaps not charge a premium to the sourcing firm. These volumes can be contracted upon and, in such a case, partial integration may be a stable sourcing strategy. Contracting is also feasible if the sourcing firm simply wants protection against uncertainties due to emergencies, shortages, or strikes, much as firms do in other insurance markets. This protection actually results from using multiple suppliers, not necessarily from combining internal and external sources of supply; using additional outside suppliers provides similar results. Securing supply flows in and of itself is not a sufficient reason to source both internally and externally.

Supplier incentives are largely ignored in the traditional partial integration argument. If a thick market exists, such that external suppliers can absorb the fluctuations of the focal sourcing firm's volume uncertainty by obtaining other customers' business, then the traditional logic holds since both the sourcing firm and the outside suppliers' incentives are aligned. For example, this may be the case if the focal sourcing firm produces a relatively customized input internally, but procures a more generic version of the input externally, and uses these generic inputs for the fluctuating volumes. The external suppliers can sell these more generic inputs to other customers, thus absorbing any fluctuations from the focal sourcing firm. In this case, the sourcing firm is actually using two different inputs, making the custom one and buying the generic one, thus the firm is not concurrently sourcing as defined here as it is not making and buying the *same* input. In many commercial transactions, supply markets are relatively thin due to some specific investment or expertise required and thus sourcing firms have few potential external suppliers. In these circumstances, the sourcing mode chosen must engage the cooperation of the suppliers. By including supplier incentives, my theoretical arguments suggest that partial integration is unlikely due to the likelihood of manipulation and disputes.

When volumes are not predictable and efficient production requires some level of specific investment, disputes are more likely to arise which will render concurrent sourcing untenable. In cases of volume uncertainties and their related disputes, coordination costs will increase (Porter 1980), as will bargaining or haggling costs (Williamson 1985). Concurrent sourcing involves using multiple sources, the internal producer and at least one external supplier. This mode also uses sources that are distinctively different from each other, due to the differing incentives of inside vs. outside suppliers and the different control mechanisms available to the sourcing firm for governing each type of supplier. Using multiple suppliers will make coordination more challenging, due to the need to communicate with more diverse agents. The distinct incentives of internal vs. external suppliers will make bargaining more difficult, since different tactics will be used for each type of supplier.

The additional communication required in cases of volume uncertainty contravenes a partial integration sourcing strategy. The sourcing firm is the sole conduit through which any supplier, internal or external, gains knowledge of end demand volumes. In cases of unpredictable volume fluctuations, suppliers will not know if the demand figures are true or manipulated by the sourcing firm for its advantage. Outside suppliers may assume that the sourcing firm is massaging the volumes to benefit its internal production unit and keep its employees at work. The internal production unit may assume the opposite type of manipulation since it is easier for outside suppliers to end the relationship with the sourcing firm than for inside suppliers to halt production. Therefore, the sourcing unit of the firm may aim to smooth their demand figures and court outside suppliers' business, letting insiders bear the fluctuations. This supposition may be especially prevalent in firms organized as business units where each unit has a different manager compensated solely on the performance of her own unit (Walker and Poppo 1991; Eccles 1981). Even if the firm does not source the majority of its requirements internally, these issues related to disputes caused by volume uncertainty still deter concurrent sourcing. Overall, the fundamental problem in the case of volume uncertainty is the information asymmetry between the sourcing firm and its suppliers in conjunction with non-trivial amounts of specific investments which affect the incentives between the three parties – the sourcing unit of the firm, the internal production unit of the firm, and the outside suppliers. Due to these differing incentives, in cases of volume uncertainty, concurrent sourcing is unlikely to be a stable sourcing strategy.

The other traditional argument for partial integration, or concurrent sourcing, involves knowledge benefits. By using both internal and external suppliers, the sourcing firm will learn more about costs and have greater access to cost-saving measures (Adelman 1949; Cannon 1968; Porter 1980; Harris and Wiems 1980). In addition, the sourcing firm will gain an increased understanding of the quality attributes of the input and be more able to monitor both internal and external suppliers, spurring each to improve their offerings (Harrigan 1984). As a sanctioning device, using a concurrent sourcing approach provides the sourcing firm with the ability to credibly threaten to switch suppliers and either totally vertically integrate or outsource its requirements, thus disciplining suppliers (Porter 1980). It also allows the sourcing firm access to both outside suppliers' research and technology developments as well as its own internal knowledge of the input and its related production processes (Porter 1980; Harrigan 1984). Since outside suppliers may charge higher prices, the key benefit of concurrent sourcing is the "net gain in the know-how and the trade connections" (Adelman 1949).

My theoretical arguments for concurrent sourcing are consistent with some of the traditional partial integration logic, but extend it in important directions. Symmetric benefits can exist for the sourcing firm, the internal supplier, and the outside supplier, aligning their incentives. For the sourcing firm, internal production provides a deep, tacit understanding of the input and its processes (Kogut and Zander 1992; Grant 1996). However, this deep knowledge can be a barrier to learning new techniques and improvements to production methods (Leonard Barton 1992, Mitchell and Singh 1992). By having outside suppliers who are motivated by the market and other customers to innovate, the sourcing firm can pass on this knowledge to their internal production unit. Symmetrically, outside suppliers can learn from the sourcing firm's internal production efforts. Outside suppliers can benefit by having a more knowledgeable customer, better able to evaluate its product (Lincoln et al 1998). The outside suppliers can also use the competition of the inside supplier to motivate its production unit toward greater efficiencies.

I empirically test the propositions derived from my theoretical arguments through a survey of the production tooling and services sourcing decisions of metal forming firms. This provides a rich context for sourcing choices, including cases of all internal, all external, and concurrent internal and external sourcing. In this way, I follow the advice of Dutta and colleagues who suggested that a "congenial context for such a study (of plural modes) would be an industrial purchasing decision where buyers engage in buy-only, make-only, and make-plus-buy choices". Using such a context, I can better distinguish the determinants of each type of sourcing mode choice.

The investigation of concurrent internal and external sourcing contributes to the field of strategy in several ways. First, I investigate a plural governance form that has been comparatively understudied in the strategy literature, as compared to intermediate hybrid forms such as alliances. I counter the traditional volume uncertainty logic for partial integration, or concurrent sourcing, while I support the argument that this mode offers significant and unique knowledge gains. Second, my work expands the transaction cost framework to include a wider range of firm characteristics, including internal and external supplier incentives and the ability of the sourcing firm to manage its suppliers. While including many traditional transaction-level attributes, my dissertation develops the production cost effects of expertise, scope, and scale, which are fundamentally firm-based and theoretically grounded in and the resource-based view of the firm. I also explicitly consider the mutual incentives of both suppliers and the firm to enter into a supply agreement. Third, this research aids in understanding how firms combine seemingly disparate activities and routines in a synergistic manner, particularly those based upon combining internal and external knowledge. Fourth, this work sheds light on the sourcing process by providing a more holistic view of this decision, taking into account more sourcing options and more attributes (those of the input, sourcing firm, supplier, and the environment) than prior studies. Finally, from a practical perspective, it assists managers in making sourcing choices by providing a framework of comparison that includes relevant decision variables.

The remainder of this dissertation is organized as follows. Chapter 2 provides the theoretical grounding underlying the choices between concurrent sourcing, making, and buying and the criteria on which these decisions are made. Chapter 3 presents hypotheses based upon these theoretical arguments. Chapter 4 describes the metal forming industry and the inputs chosen for my empirical work. Chapter 5 discusses survey development, administration, and the initial data analysis, including scale development. Chapter 6 connects these measures to the sourcing modes through a multinomial logit model and compares these results to the hypotheses. Chapter 7 concludes and suggests extensions for future work.

CHAPTER 2

THEORETICAL FRAMEWORK: SOURCING CRITERIA AND MODES

My dissertation investigates when firms would choose to source an input both internally and externally. I take a discrete structural analysis approach to this question by assuming that each sourcing mode has unique attributes that cannot be replicated in another sourcing mode (Simon 1978, Williamson 1991). I describe various criteria firms take into account when making a sourcing decision, compare a firm's sourcing mode choices (e.g., to make, to buy, or to both make and buy) in light of these criteria, and discuss how input, environment, firm, and supplier attributes affect these criteria and thus influence the sourcing mode choice. Throughout, I emphasize why firms choose concurrent sourcing rather than only making or only buying.

I focus on business-to-business exchanges in intermediate product markets where firms are considering the extent to which they backward vertically integrate. I assume that firms choosing to fully or partially backward integrate do not sell the focal input to any customers other than their internal downstream unit. My rationale for this assumption is that since I am interested in the combination of internal and external suppliers and their influence on the firm, I want to omit the overt effect of a firm's customers (who, in this case, are also likely its competitors). Typically a firm's primary motivation for vertical integration is not to sell to its competitors, but rather to gain an internal source of supply and the accompanying control (Perry 1989, Oster 1994).

I am interested in a firm's decision to source a particular input. I define an input as an intermediate level of good or service that is used in the production process and converted by the firm into an output that is sold to its customers. Regardless of sourcing mode, inputs share a common technology and are destined for the same function in the downstream production process. Inputs are based upon the same scientific principles, developed at the same period of technological maturity so are of the same product generation, and are produced by similar methods. They use similar raw materials, human skills, and physical equipment in their production processes. For downstream users of these inputs, no significant alteration in production routines need be made when switching between inputs procured from individual suppliers, be they external or internal.

Managers make sourcing decisions at the input level. This level of aggregation is more strategic than the daily, tactical level that would involve decisions such as delivery frequency or inventory management. Tactical decisions such as these are more commonly made by production floor supervisors or other plant employees and assume the source of supply is already in place. The input level is more fine-grained than a factor of production, such as overall labor or equipment requirements. Inputs have common traits but are sufficiently specific to be described to both a supplier and the internal downstream unit and all would agree to make decisions at this level. For example, an input for a metal processing firm could include progressive stamping dies, while the tactical level may be a die for a particular part and the factor of production level could be process equipment and tooling. The designation of what constitutes an input is firm specific, depending upon the business of the firm. For example, for most firms "office supplies" as a class may be considered an input, but for firms that specialize in printing services, "white, letter-size paper" may be an input. Moreover, input decisions often include a group of individual items whose requirements are spread over time, making this unit of analysis broader than the Williamsonian definition of a transaction being a "good or service transferred across a technologically separable interface" (Williamson 1985 p. 1). Although transaction cost research typically uses the transaction as its unit of analysis for theoretical development, empirically a wide range of phenomena are used, from individual items to entire firms (Rindfleisch and Heide 1997). My definition of input strives to be consistent in both its theoretical development and empirical operationalization to more precisely describe how sourcing managers make these decisions.

When firms make sourcing decisions, they take into account both production and exchange cost criteria, including direct production costs, quality monitoring costs, delivery and dispute resolution costs, and any incentive-related costs involved in using a source of supply. Production costs are directly observable and known prior to the firm's sourcing decision. Exchange costs reflect more indirect costs of sourcing and are relatively unknown until the sourcing agreement is in place, but can substantially impact the overall costs the firm incurs to procure the input. The next section will describe each of these criteria in more detail and discuss why each is important to the firm.

Sourcing Criteria – Production Costs

Production costs may be the most obvious consideration a sourcing firm considers when sourcing an input. The price a firm pays reflects the directly observable costs it incurs and is commonly a function of the competitiveness of the input market, the volume of input required, and the supplying firm's production costs (Haluch 2000). Prices will be lower in more competitive markets, due to a greater number of capable suppliers, low switching costs, and the incentive for suppliers to capture significant volume. Sourcing firms will select a supplier that offers lower prices, which, in turn, are based upon that supplier having lower production costs. Production costs are based upon three factors: scale economies, scope economies, and production expertise. These factors originate from the input technology and the supplying firms' resources and experience.

Based upon the input technology, scale economies are achieved by a producing firm when it incurs lower per unit production costs by producing a larger quantity of the input. These economies are typically the result of high fixed costs associated with underlying production assets. Sourcing firms that demand high volumes of a particular input should be able to obtain lower per unit prices, since suppliers will be able to produce at the natural minimum efficient scale (MES) quantity, minimizing production costs (Pindyck and Rubenfeld 1995). Generic inputs should have lower production costs, since suppliers can better aggregate production volumes and serve a wider market (Williamson 1975). Also, producing firms can be expected to improve their processes over time, moving down the learning curve, and pass this cost reduction onto sourcing firms in the form of price reductions (Haluch 2000). This reinforces the effect of higher volumes resulting in lower prices.

In addition to scale economies, scope economies also affect total production costs. Scope economies relate to a firm's ability to jointly produce two inputs more cost effectively than either one alone by virtue of producing them either simultaneously or sequentially (Panzar and Willig 1981, Helfat and Eisenhardt 2001). This typically arises from a common, indivisible base input (e.g., a building) that is underutilized if only one of the items is produced or from a common input that can offer two outputs for two distinct markets (e.g., sheep producing both mutton and wool). Scope economies between the focal input and other items in the producing firm's portfolio indicate the extent of synergies that could potentially be generated, either contemporaneously or in the future (Panzar and Willig 1981, Bailey and Friedlaender 1982, Helfat and Eisenhardt 2001). By producing the focal input and others that together provide the scope economies, the firm can appropriate all the relevant gains and better coordinate and control the production process to ensure that each affected item is produced in the most efficient manner for the overall firm. This, in turn, should result in lower production costs and thus lower prices for the sourcing firm.

The experience of the producing firm also determines its production costs. This experience will include the resources, capabilities, and knowledge of the producing firm, which are idiosyncratic and historically determined (Penrose 1959, Wernerfelt 1984, Grant 1996). Firms that have gained prior expertise in the technologies surrounding the input and have the appropriate personnel and equipment should be better equipped to produce the input than other suppliers that do not have these related skills. Thus, firms with more expertise related to the input should be able to produce it more efficiently than firms without such expertise (Rubin 1973, Prahalad and Hamel 1990, Conner 1991). These firms may also possess complementary assets, such as distribution channels or technical expertise, which can provide an advantage for the firm in producing several classes of products (Teece 1986) and result in lower prices for the sourcing firm. Firms with more fungible resources will have more options in their portfolio of products and processes, particularly if these resources involve organizational knowledge (Peteraf 1993, Teece 1982). This fungibility can also lead to scope economies, greater efficiency, and thus lower production costs.

Sourcing Criteria – Exchange Costs

Firms consider various properties of an exchange relationship when sourcing an input. The quality of the input, the effort required for dispute resolution, and the stability of the supply relationship can all affect the sourcing firm's costs, albeit less overtly than the purchase price. Since it is possible that suppliers may slack on input quality, resulting in higher costs, sourcing firms must have some type of mechanism in place to both evaluate inputs and to sanction underperforming suppliers. Suppliers who do not deliver a smooth flow of inputs or who are contentious in resolving disputes also increase a sourcing firm's overall costs. Since it is costly to set up the initial sourcing mode and to change suppliers as well as modes, sourcing firms prefer a more stable exchange relationship. This section will further discuss these exchange criteria.

Quality Monitoring

Due to the potential for supplier opportunism, sourcing firms must monitor their suppliers to guarantee their conformance to quality specifications. These activities involve measuring aspects of the input to ensure that suppliers adhere to all contract provisions and enforcing these provisions by sanctioning uncooperative suppliers and changing their behavior. Sourcing firms use several methods to monitor quality. They can purchase and thus compare inputs from multiple suppliers as a way to evaluate the performance of each (Haluch 2000). Sourcing firms can rely on third parties, supplier inspection with appropriate documentation, and/or internal inspection to ensure the input quality. Buyers may employ their own internal experts or use their connections with industry associations and other outside groups to benchmark the quality of their inputs with other firms (Ali 2000). Sourcing firms often also use internally developed, customized supplier selection and evaluation systems (Stump and Heide 1996, Harding and Harding 2000).

Monitoring quality performance of a supplier can be difficult in cases where the sourcing firm cannot determine the quality of the input by inspection. This may be because the sourcing firm does not have a sufficient understanding of the input or how it is produced and thus cannot tell whether a defective input results from supplier shirking or from some other source. Evaluation problems can also arise if the input performance is only known after the sourcing firm uses it, such as in experience goods (Vining and Globerman 1999). In all of these cases, an information asymmetry arises between the buyer and the supplier that the supplier could exploit (Milgrom and Roberts 1992, Poppo and Zenger 1998).

To keep supplier opportunism and quality shirking in check, the sourcing firm needs sanctioning mechanisms. The most common mechanism is the threat of switching suppliers. If suppliers are plentiful and competing for the sourcing firm's business, then the suppliers will be less likely to quality shirk in order to retain the firm as a customer. While ease of supplier switching can be an effective sanctioning tool, the sourcing firm has to be able to determine when to switch based upon poor supplier performance. If it cannot adequately evaluate performance, the sourcing firm may end up switching too infrequently, resulting in poor input quality, or too frequently resulting in high costs of search and negotiation with new suppliers.

Dispute Resolution

Another exchange criterion that sourcing firms consider in sourcing decisions is the reliability of delivery and the likelihood of disruptions and disputes. The reliability of input and information flow to the sourcing firm impacts the ongoing costs. The daily activities of ordering, shipping, receiving, and paying for an input require numerous communications between the buyer and supplier. If these activities are carried out smoothly, with little or no disruption to the production process, the sourcing firm will incur lower costs (Ellram 2000). Ideally, many of these details will be worked out at the time of the initial purchase order, contract, or agreement. However, unforeseen events will occur in an exchange relationship that can disrupt the product and information flows, resulting in even more communication to reschedule, rework, and resolve disputes. Williamson termed these "bilateral efforts to correct ex-post misalignments" as "haggling costs" (Williamson 1985, p 21).

Haggling costs involve the short-term adjustment and dispute resolution costs incurred when the agreement must be renegotiated, most likely due to an environmental change (e.g., end product demand volumes). To some degree, these costs are inevitable due to the inherent incompleteness of any contract (Williamson 1985). Haggling costs include the costs of coordinating and bargaining with suppliers. The former primarily depends upon the number of parties the sourcing firm must communicate and negotiate with to resolve the dispute, while the latter involves the size of potential gains for the firms involved. Dispute resolution costs will be higher if more firms are involved or if the potential for gain is significant.

Stability and Incentives

A third exchange criteria for the sourcing firm is the stability of the sourcing arrangement. Typically, it is costly for the sourcing firm to switch suppliers and is even more costly to switch among sourcing modes (e.g., from only making to only buying an input). For this reason, sourcing firms would prefer to have a stable supply relationship; for this to occur the buying and supplying firms must both gain from the exchange (Long 2000). Two types of incentives influence a firm's willingness to enter into and remain in an exchange relationship. First, firms will have to determine how to set the price and split the gains of trade; this consideration is largely based upon economic self-interest.

This type of incentive is based upon the pricing system of the market, leading to autonomous adaptation by individual firms and static efficiency (Hayek 1945, Williamson 1975). High powered, market-based incentives may motivate firms to get all they can at the expense of the other party and can lead to more adversarial relations. Second, both buying and supplying firms recognize that they need to cooperate in order to reach agreement and make efficiency and innovation gains, particularly if they wish their relationship to endure into the future. These incentives to coordinate activities and adapt toward a common purpose can lead to greater efficiency over time (Barnard 1938, Ghoshal and Moran 1996). All firms involved in a sourcing exchange will need to recognize, balance, and satisfy these autonomous and coordinative incentives.

Generally, suppliers will be motivated by the profit potential of the relationship. They will change and adapt their processes to improve their costs because they can retain most, if not all, of the resulting savings. The sourcing firm, too, is motivated by profits and this can lead to an adversarial relationship with suppliers. This is the standard economic approach of a buyer/supplier exchange as a zero sum game (Porter 1980). If the input market is competitive, this may be an appropriate approach for the sourcing firm, who can easily change to another supplier. Buyers will seek the lowest prices and suppliers will only bid for their business if they are competitive. By promoting an adversarial approach to suppliers, the sourcing firm will motivate suppliers to respond in kind (Hayes, Wheelwright et al. 1988). Suppliers will innovate to reduce their costs, but will not necessarily pass these savings along to their customers.

While motivated by self-interest, firms also recognize the benefit from engaging in stable, cooperative relationships. Cooperation between buyers and suppliers can lead to greater gains from trade for both of them, essentially making the exchange a greater than zero sum game (Axelrod 1984). These gains can arise from finding ways to make the suppliers' and buyers' systems and personnel work more efficiently. A myriad of opportunities for savings exist in the tactical realm of a buyer/supplier exchange, such as paperwork modification or reduction, material handling and packaging changes, and shipping improvements. If the firms can create more complementary routines, the potential savings for all involved will be greater (Nelson and Winter 1982, Dyer and Singh 1998). Suggesting and implementing these changes requires communication and cooperation between the buyer and supplier.

In order to improve the exchange, the buying and supplying firms need to have an understanding of the other firm, which could require investments specific to that relationship. Buyers and suppliers in long-term relationships develop routines to share knowledge and complementary systems and processes, which can result in a competitive advantage (Dyer and Singh 1998). These mutual investments include learning how to work together effectively and customizing both products and logistical activities to match each other's operations (Williamson 1985). Relationship-specific assets, particularly in human capital, strengthen the bond between firms, lead to bilateral dependence, and reduce the likelihood of dissolution of the relationship (Levinthal and Fichman 1988). These investments can also facilitate cooperation and coordination between the firms.

Long-standing, open-ended relationships tend to increase cooperation between buyers and suppliers (Axelrod 1984, Heide and Miner 1992). The value of future sales will assist in enforcing contract terms and preserving reputations of the parties (Klein and Leffler 1981). This repeated games framework, with frequent and continuing trade, can replace the need for formal, legal enforcement by creating reputations for both firms, not only with each other but also in the wider business community. Both economic forces of self-interest and social forces of relational norms work together in bolstering the role of reputation in maintaining these agreements (Lyons 1996).

Autonomous and coordinative incentives both affect innovativeness of the sourcing firm. Suppliers also represent a significant source of innovation and know how that can benefit the sourcing firm (von Hippel 1988). Suppliers provide a "vital role as innovators who can bring new components and new arrangements of existing components to the notice of consumers" (Langlois and Robertson 1995). Suppliers also often have connections to a sourcing firm's competitors and to firms in other industries. These second-order relationships can be important sources of knowledge that the sourcing firm may like to access, but can only do so via a robust relationship with its suppliers. To take advantage of suppliers' expertise and connections, sourcing firms may develop partnerships involving a few, highly skilled suppliers, multiple contacts, and substantial information transfer (Hayes, Wheelwright et al. 1988). Relationships such as these can enable entry into new markets for both suppliers and buyers, and reduce the risk of supplier failure (Martin, Mitchell et al. 1995, Swaminathan, Hoetker et al. 2000). These relationships take a significant amount of time and resources to nurture and develop, as mutual trust and respect must be in place prior to an exchange of technologically sensitive information that could lead to innovations. Tension exists between the sourcing firm trying to appropriate knowledge only to benefit itself versus sharing its own complementary knowledge with the supplier to increase innovation for both firms.

Sourcing Mode Choices

Sourcing firms will select among several sourcing modes to best satisfy the above sourcing criteria. This selection process will be limited by the firm's ability to only select from modes it considers to be feasible and are within its ability to execute, such that "impossibly complex and hopelessly naïve" modes will be excluded (Williamson 1996b, p 56). Sourcing firms are boundedly rational, in that they will gather and process information rationally, but cannot ever obtain all relevant details to make the perfect decision (Simon 1957). They will make the best decision they can, given the information and time available and their unique foresight based upon their history and position. Sourcing firms will also assume that their potential suppliers, including internal suppliers, may be opportunistic in that they may be self-interested with guile, potentially providing incomplete or distorted information. Suppliers may "lie, cheat, steal, mislead, disguise, obfuscate, feign, distort, and confuse" (Williamson 1985). Not all suppliers are assumed to be dishonest, but some may be dishonest some of the time, making it difficult to distinguish their true character. Symmetrically, suppliers will consider buyers to also be potentially opportunistic.

Sourcing firms recognize that each sourcing mode has its own distinct structural features that other modes cannot duplicate (Williamson 1991). Each mode is defined by a "syndrome of attributes" that is unique and consistent to that mode, providing it with advantages and disadvantages over other modes (Williamson 1996a, Poppo and Zenger 1998) . Sourcing firms understand that by selecting one sourcing mode, they forgo the benefits of the modes not chosen. Firms cannot selectively intervene and choose an optimal combination of attributes, but rather must select the mode as a whole. Thus, sourcing firms qualitatively compare the different modes and select the best feasible one available, which may or may not be the optimal choice (Simon 1978, Williamson 1985, Williamson 1996a). Therefore, "'flawed' modes of economic organization for which no superior feasible mode can be described are, until something better comes along, winners nonetheless" (Williamson 1985, p. 448).

When a sourcing firm chooses a sourcing mode, it essentially is selecting the number and identity of suppliers who will provide the input. In this way, sourcing firms choose between having one or many suppliers, comparing the benefits of each choice. Similarly, the sourcing firm chooses the identity of its suppliers; the most fundamental identity choice is between an internal or external supplier. For the classic "make-or-buy" choice, the make option would involve one, internal supplier while the buy option would involve several, external suppliers. The next sections will use the sourcing criteria above to compare these two classic sourcing modes and concurrent sourcing.

Making the Input

The choice of making the focal input implies a sole, internal source for the input, where the input and corresponding downstream products are produced within a common firm. In this mode, the price the sourcing firm would pay for the input would be its internal production costs, which would be the primary direct economic consideration of this mode. These production costs will depend upon the volume of the input required, as well as its fit with other products already produced by the firm. Firms that require a high volume of the input may be able to achieve the minimum efficient scale in internal production, and thus could produce the input cost effectively. But, if the firm requires a relatively low volume, it may not achieve the minimum efficient scale nor the least cost. Moreover, since the firm will not be able to aggregate volume over several customers, it is likely that internal production would be considerably more expensive than the prices offered by outside suppliers. Also, the scope economies of internal production are likely to be lower than that of outside suppliers, since there will be only one type of production process involved, thus a lower number of potentially sharable inputs, as compared to several suppliers each using a different type of process. Production costs would also depend upon the match between the resources, capabilities, and knowledge of the firm and those required to produce the focal input (Penrose 1959,Wernerfelt 1984). Focal inputs that fit closely into the firm's constellation of knowledge and experience would be efficiently produced internally (Grant 1996, Conner and Prahalad 1996); conversely, inputs that do not match well with the firm's expertise would be relatively costly to make in-house.

Internal production will facilitate the sourcing firm's ability to evaluate the quality of the input. Making the input improves the firm's understanding since it gains a deeper and more tacit knowledge of the input's processes (Kogut and Zander 1992, Grant 1996). The firm will have knowledge of the raw materials and processes used and be able to determine the causes of any quality problems. Since they are part of a single firm, the downstream unit will be able to evaluate how the finished input compares to the efforts of the upstream producer. Internal suppliers may still slack on quality, but downstream units will be in a good position to know when this occurs. Sanctioning internal suppliers can be somewhat problematic, however. While the downstream unit can use the social sanctions inherent in the hierarchy of the firm, such as managerial control and compensation systems, the internal supplier knows there is little credible threat of switching suppliers, which can result in considerable shirking (Bradach and Eccles 1989, Hennart 1993).

Internal production should provide the sourcing firm with a smooth flow of product and information, due to the buying and supplying units being part of a common firm and thus sharing routines and systems. Communication should be better between two units of the same firm, as compared to between the sourcing firm and an external supplier, due to common history, language, communication channels, and routines (Arrow 1974, Nelson and Winter 1982). This ease of communication and common routines should reduce disputes over day-to-day issues, such as paperwork and volume fluctuations. The upstream and downstream units will have more knowledge of the other's product and paperwork flows and will be able to mutually adjust to benefit each other. The firm's coordinative structure and systems will ensure appropriate responses to unanticipated changes that are aligned with the best interests of the now-integrated firm (Williamson 1985). Coordination between the buying and producing units of the firm should be superior to that with outside suppliers since the buying unit is only dealing with one, rather than several suppliers, and the internal supplier operates under common authority. Dispute resolution and bargaining should be relatively harmonious when sourcing from an internal unit. Disputes can be settled by going through the hierarchical structure of the firm and by using the administrative systems in place for such issues (Barnard 1938, Williamson 1975). Bargaining should be minimal as compared to dealing with an outside supplier, since all gains will go to the common firm.

Internal production provides the sourcing firm with a stable supply relationship, rich in cooperation, but lacking high powered, market-based autonomous incentives. By being part of an integrated firm, the time horizon for the relationship between the producing and buying unit is long and open-ended, as compared to a contractual relationship with an outside firm, which typically have explicit ending dates. This arrangement should therefore promote stable exchange and a longer horizon for decision-making (Heide and Miner 1992). Cooperation is rewarded and supported by this sourcing mode. Firms will be more likely to invest in equipment, training, and other resources that are specifically related to the input and customized for the downstream demand unit. The firm can appropriate all the gains from these specialized investments, whereas an outside supplier would be subject to hold up from the sourcing firm since the supplier could not use this investment for any other purpose (Williamson 1975). In addition, the firm will have the incentive to maintain and improve these specific investments and use them as a basis for learning more about the input and its production process. By making these investments and producing the input internally, the firm will gain tacit knowledge only acquired from actually making the good. By producing the input, the knowledge becomes embedded in the firm's production process and may not depreciate as quickly (Darr, Argote et al. 1995). This learning by doing effect can greatly assist the firm and reduce its costs (Pisano 1994).

The firm's structure and administrative systems will provide socially based incentives and sanctions to influence personnel to work together toward a common goal. This will assist in cooperative and coordinative efforts. However, as compared to outside firms, the internal unit personnel do not directly receive the gains from productivity and other improvements. Thus, internal personnel may try to work in their individual self-interest, be more likely to slack, and not offer ways to reduce costs, particularly if these suggestions run counter to those presented by others within their unit. Firm compensation systems and promotional paths may reward compliance more than innovation, which could dull the incentives to improve processes and products. Opportunism is still present within the firm, which can also lead to slacking (Hennart 1993). Since the incentive of market competition is dulled, innovation and productivity improvements will be less likely and, when they occur, more incremental than when using an outside supplier. Skills of upstream and downstream units will be more similar than those between outside suppliers and the downstream unit. This means that any innovations made between units of a common firm will combine more similar components than innovations between an outside supplier and buyer, which would combine more diverse components and be more radical. In sum, sourcing firms that use internal receive both the positive and negative effects of social conformity and incentives.

Based upon the above, internal production can provide production cost advantages, if the input is related to other inputs already made by the firm. However, ceteris paribus, internal production costs are likely to be higher than those available from outside suppliers due to the latter's ability to aggregate demand, leverage a greater variety of scope economies, and offer competitive bids. Internal production provides moderately good quality monitoring properties, due to an increased ability to evaluate the input, but a reduced ability to sanction through switching suppliers. Internal production clearly excels at mitigating haggling and delivery issues, resolving disputes, and at providing coordinative incentives. But, internal production lacks high powered, market-based incentives that can motivate cost reductions and improvements spurred by competition.

Buying the Input

The choice of buying the focal input implies that the sourcing firm sources the input from one or more external suppliers. The usual assumption is that the sourcing firm can select from a relatively large number of suppliers for the input and typically sources from more than one. These suppliers will compete in the market for the input and the sourcing firm can use this competition to its advantage. It can ask the suppliers to bid on the business and select those that offer the best value. The outside suppliers' costs will depend upon their relative expertise and capabilities and, since they are all distinct firms, each will likely offer a somewhat different blend of price, delivery, quality, and other attributes for the sourcing firm to consider (Penrose 1959). This can be to the buyer's advantage, as the buyer can leverage one supplier against another to attempt to gain the best features at the lowest prices (Porter 1980). Since each individual outside supplier will produce the required input in a slightly different manner, depending upon firm-specific skills and equipment, the underlying indivisible inputs upon which the scope economies are based will be different for each supplier. This breadth of production processes and options will lead to greater scope economies. In addition to the competition of the market, an outside supplier could use the market to aggregate the sourcing firm's demand with those of other customers and gain scale economies. Thus, the competition, scope, and scale economy arguments support the standard assumption in transaction cost economics that outside suppliers will have lower production costs than internal suppliers (Williamson 1985).

Assuming some opportunistic potential of external suppliers, sourcing firms must monitor their inputs. Monitoring external suppliers will be more challenging than monitoring an internal supplier due to a greater information asymmetry between versus within firms. Sourcing firms can compare inputs from multiple suppliers as a way to evaluate the performance of each. Sourcing firms can also rely on third parties or internal inspection to ensure the quality of their inputs. However, monitoring performance of an outside supplier can be difficult in cases where the sourcing firm cannot determine the quality of the input by inspection (Akerlof 1970, Milgrom and Roberts 1992). While ease of supplier switching can be an effective sanctioning tool, the sourcing firm has to be able to determine when to switch based upon poor supplier performance.

Buying inputs from external suppliers will involve considerable effort in smoothing product and information flows, with a high likelihood of disputes. As the number of outside suppliers increases, coordinating among them will become more complicated. In addition, communication may be more difficult since each of these suppliers will have their own communication channels and systems (Arrow 1974). When a dispute arises, it may be tricky for the sourcing firm to resolve it since it must determine which suppliers are involved and coordinate the resolution among them. Dispute resolution between a sourcing firm and an external supplier is generally handled by referring to their initial contractual agreement and, if this is unsatisfactory, by going to court. Although the latter option is rarely taken since buyers and suppliers prefer to work things out informally, it is available in more extreme circumstances (Macaulay 1963). The sourcing firm does gain some bargaining strength by having multiple suppliers it can allocate volume among and credibly switch between, enabling the buyer to coerce the suppliers to surrender gains (Porter 1980). While bargaining power of the buyer increases as the number of suppliers increases, the accompanying coordination costs may mitigate the gains from this increased power.

The stability of the exchange relationship between outside suppliers and a sourcing firm will depend upon the incentives of the market. Since the suppliers will vie for the sourcing firm's business and will be able to appropriate all the gains from cost savings once the contract is settled, suppliers will be motivated to improve their processes and products. As long as the suppliers and the sourcing firm benefit from the relationship, it will continue. However, the understanding is that the relationship is only for a finite period of time, often explicitly mentioned in a contractual agreement.

Along with having a number of external suppliers, the sourcing firm can benefit from having suppliers that serve a variety of customers. The sourcing firm can directly and indirectly gain knowledge of their competitors and firms in other industries through these suppliers. This will provide the sourcing firm with more information about technological changes and may reduce its likelihood of being myopic in its view of the state of technology. Sourcing firms that are able to form closer relationships with outside suppliers will benefit from sharing knowledge with them, resulting in greater innovation for both firms due to their different, but complementary skills.

Although not necessarily adversarial, relationships with outside suppliers will not be as cooperative as those with internal suppliers. It will be more difficult to convince an outside supplier to make investments idiosyncratic to the sourcing firm. Outside suppliers benefit by leveraging their skills and equipment over several products and customers. Specific investments would tie the supplier to one customer, and would leave them vulnerable to the customer switching to another supplier or process. Similarly, in this situation, the customer would also be worried about the supplier holding it up for higher prices. Since both the customer and the supplier are concerned with the opportunism potential of each other and would desire to keep the benefits from the specialized asset for themselves, specific investments are less likely to occur between two independent exchange partners as compared to within a vertically integrated firm (Williamson 1985). Even if an independent supplier and buyer could initially come to terms over the specific asset, there would still be disputes over maintenance of the asset, how to deal with uncertainties that arise, and how to protect themselves from technological obsolescence. Given all of these difficulties, sourcing firms will find it difficult to convince an outside supplier to make investments specifically tied to their relationship and their input.

Based upon the above, external suppliers can provide lower production costs for the sourcing firm, due to their ability to aggregate demand, leverage scope economies, and offer competitive bids. Sourcing through external suppliers results in monitoring problems, due to the reduced ability to evaluate the input based upon the information asymmetry between the buying and supplying firms, although having multiple external suppliers does allow the sourcing firm to have an increased ability to sanction by switching suppliers. Sourcing through external suppliers leads to more haggling and delivery issues, due to increased coordination costs. External sourcing excels in providing high powered, market-based autonomous incentives that can motivate cost reductions and improvements spurred by competition, as well as a greater diversity of knowledge flows. However, external sourcing generally does not facilitate coordination between the buying and supplying firms due to a lack of coordinative incentives.

Hybrid Sourcing Modes

Making and buying, the two distinct sourcing modes described above, are often depicted to represent two ends of a continuum of sourcing choices. These two options are treated as polar opposites, completely different from each other (Williamson 1975). The prototypical sourcing option of making implies producing the input in close proximity with the downstream user, under a common management structure. However, the input could be made at a sister division's facility, distant from the downstream user, reporting to a different executive, and affected by market forces (Walker and Poppo 1991). Similarly, relationships with external suppliers can run the gamut from the prototypical arrangement of using short term, spot buys with many, varying suppliers to long-term agreements with few suppliers. While substantial variance exists in both the modes of making and buying, the decisive factor to the sourcing firm is how these modes compare on the production and exchange cost criteria. As discussed above, when comparing the two polar modes, internal sourcing in any of its variants should provide better quality, dispute resolution, and coordinative incentives, while external sourcing should provide lower production costs and higher powered, autonomous incentives.

Hybrid modes of sourcing attempt to combine the features of making and buying. These modes can be separated into two categories: intermediate and plural modes. Intermediate hybrids can be placed on the continuum of making vs. buying, but essentially are more similar to one pole than the other and can be categorized in this manner (Oxley 1997). Examples of intermediate hybrids include long-term supply agreements, licensing, alliances, and joint ventures. In contrast, plural modes involve concurrently using multiple modes, such as concurrently making and buying or franchising, in which a franchisor simultaneously owns and operates business outlets and has agreements with independent entities to own and operate others (Bradach and Eccles 1989). Dutta and colleagues provide the useful distinction between plural and intermediate modes by noting that in plural modes the "number of different forms employed remains the same (two) regardless of the proportion of sales through one or the other", while in an intermediate mode, only one mode is used and the placement along the make/buy continuum is significant (Dutta, Bergen et al. 1995). In other words, the most pertinent factor in describing an intermediate mode is the degree to which the mode approaches a polar form, while the most significant descriptor of a plural mode is the number and type of modes that a firm uses and how these modes are implemented.

Alliances have been one of the most studied intermediate hybrid forms and, while they could be used as a form of vertical integration to gain access to raw materials or distribution channels, this rarely occurs. Research indicates that less than 10% of alliances are vertically oriented (Mowery, Oxley et al. 1996). Alliances are a response to market failure, in which firms desire resources that are too tacit for transfer via a market interface and supply relationships (Capron and Mitchell 1999). Unlike supply relationships, alliances are often formed between competitors and initiated for a specific purpose or time period. It may be more difficult to find a suitable alliance partner, as compared to a supplier; past alliances, complementary resources, and network ties all enter into the choice (Gulati 1998). Alliances can be difficult to manage since partners must determine how knowledge will be transferred and the appropriate governance mode (Mowery, Oxley et al. 1996).

Although a multitude of intermediate hybrid sourcing options exists, the sourcing firm will only choose an option from its feasible set of alternatives. Many of the forms mentioned above, such as joint ventures or licensing, are infeasible for a sourcing firm, due to poor fit with the focal input, industry norms preventing the use of this mode, lack of available partners, or inexperience on the part of the sourcing firm. One intermediate hybrid mode, a variant of external sourcing, that is somewhat more common and feasible is the option to use only one external source in a long term, exclusive arrangement (Baker 1990). Sole sourcing with one external supplier may enable the sourcing firm to benefit from lower prices, since the external supplier would have all of the buyer's volume and could therefore take advantage of scale economies. This price advantage may also be supported by the sole source's expertise in the input. However, the sole external supplier would not be as likely to customize the input as would an internal supplier since it would not be as familiar with the firm's downstream processes or the firm's overall business. Also, by using a sole external supplier, the sourcing firm loses the power of a competitive market to drive down prices (Porter 1980).

Sole external sourcing offers some disadvantages and other advantages regarding the exchange criteria of quality monitoring, dispute resolution, and incentive stability. Monitoring a sole external source will be extremely problematic for the sourcing firm. The buyer does not have a deep understanding of the production process, since it does not make the input itself, and does not have other suppliers' inputs for comparison. This will lead the buyer to an inability to evaluate the quality of the sole supplier's product. In addition, the buyer will have not be able to use the threat of switching suppliers, since it has no other supplier. Dispute resolution should be less problematic with a sole external supplier as compared to using several external suppliers, since the sourcing firm only needs to coordinate and communicate with one firm. Less variation in the input will result, since it will only be sourced from one firm (Richardson 1993). Disputes can be resolved with less contention since the buyer and supplier will have more history, more opportunities to develop shared systems, and a longer relationship to maintain (Walker and Poppo 1991). However, sole external sourcing cannot replicate the reliability benefits of internal sourcing due to shared routines and systems (Nelson and Winter 1982). Sourcing within a common firm will provide better communication and will allow the use of administrative systems and structures for dispute resolution, which would not be available to an external supplier.

Sourcing from a sole external supplier suggests a potentially unstable incentive arrangement. Sole sourcing aims to emphasize the partnership and coordinative incentives between the buying and supplying firms. This should encourage long term investments, customized service, and reduce opportunism (Baker 1990, Richardson 1993). The buying and supplying firms may both invest in assets specific to each other, creating a mutual hostage relationship without vertical integration (Williamson 1985, Walker and Poppo 1991). However, the supplier is an external firm operating in its own self-interest. Thus, the supplier may choose to underinvest or make only those investments that it could use in other applications, perhaps in the future. If the market is thick and contestable, then the sourcing firm may have the option to switch to another supplier, in effect retaining its sanctioning ability. The converse may be equally true for the supplier, who would also have the ability to change to another customer. However, if the market is truly thin and few suppliers exist for the input, the sourcing firm would be better off either having multiple suppliers or internalizing production. One way to introduce a second source into a single external sourcing mode, especially in a thin market, would be to concurrently source the input.

The Japanese model of supply relations is a commonly used exemplar of sole sourcing in a manufacturing context. However, while Japanese buyers may use a single supplier for a component in a particular car model, they often use an alternate source for that same component in a different model or use a common supplier for multiple components, granting leverage to the buyer (Womack, Jones et al. 1990). Therefore, the market for these individual components is actually thicker and more contestable than it may appear. Moreover, Japanese buyers manage individual suppliers quite differently, with some resembling more adversarial, competitive relationships and others being more cooperative. Sourcing firms use external supply relationships to complement or substitute for internal development of skills, and also source internally to provide competition for suppliers and superior learning about strategic inputs (Lincoln, Ahmadjian et al. 1998).

In summary, hybrid sourcing modes can be classified as either intermediate or plural in form. Many intermediate modes, such as alliances, may be infeasible for the sourcing firm for various reasons. Other intermediate modes, such as long term supply agreements, are not sufficiently distinct from their related polar mode (e.g., buying) to merit their own set of discrete attributes and therefore the polar mode can be used as the comparative case. A relatively common intermediate mode, sole external sourcing, involves some of the same attributes of internal sourcing, such as higher production costs and greater monitoring difficulties, along with the dispute resolution problems of external sourcing. This mode may not be stable, due to conflicting autonomous and coordinative incentives. Thus, rather than an intermediate hybrid mode, perhaps a plural mode offers the sourcing firm a better mix of attributes. In a sourcing context, the prototypical plural mode would be to both make and buy, i.e., to concurrently source.

Concurrently Sourcing the Input

Concurrently making and buying an input can impart the benefits of both market competition and firm coordination, although it is costly to set up and complicated to manage. This plural governance mode employs both the price and authority control mechanisms, facilitating skill and information transfer between inside and outside sources. As Bradach and Eccles suggest, "Contracting is problematic without in-house experience, and the maladies associated with hierarchy are widely recognized. The remedy for these difficulties may be the simultaneous use of the two mechanisms, creating in essence competition between them" (Bradach and Eccles 1989). However, to institute concurrent sourcing, the firm must incur both the costs of securing capital, allocating plant and equipment capacity, staffing, and coordination that accompany internal production and the costs of finding, selecting, negotiating with, and maintaining external suppliers. Once both internal and external sources are in place, managing these simultaneously can be challenging due to the natural comparisons, suspicions, and shirking that can occur between them. These activities require quite distinct sets of routines and it can be difficult to gain synergies between them. The complementary and positive effects of this strategy involve an increased monitoring ability and the ability to balance autonomous and coordinative incentives.

As mentioned previously, sourcing firms will consider production and exchange cost criteria in determining which sourcing mode to use for an input. For concurrent sourcing, scale economies and expertise-related production costs will be between the costs associated with solely making and solely buying. The sourcing firm will neither gain from the full volume of a more specialized input from total internal production nor gain complete scale economies due to a generic good offered from external suppliers, particularly since the sourcing firm will be splitting its requirements between two or more suppliers. Moreover, since each firm will have a distinct set of resources and capabilities, the experience-related production costs will be a weighted average of the expertise of the internal and external suppliers (Penrose 1959). However, by concurrent sourcing the sourcing firm may be able to take advantage of greater scope economies. Scope economies will be greater if a wider variety of production processes are involved, since each will have its own set of indivisible, sharable inputs (Bailey and Friedlaender 1982). As compared to only using external suppliers, the addition of an internal supplier provides the sourcing firm with another variant of a production process, based upon a distinctly different set of inputs. While having some variation, the production processes of two external suppliers will be more similar than the production processes of an external vs. an internal supplier, since all external suppliers face more common market conditions and customer bases. Thus, by using both external and internal suppliers, the sourcing firm has access to more types of production processes and thus more sets of sharable inputs yielding greater scope economies.

Concurrent sourcing provides advantages in quality monitoring. By both producing internally and purchasing externally, the firm gains a unique and deeper understanding of the input. Firms that in-source develop a "parts evaluation capability" and better understand their inputs (Lincoln, Ahmadjian et al. 1998). Due to a more intimate knowledge of the input gained through internal production, the firm could identify potential troubling aspects of the input and credibly tell the external supplier how to fix them. At the same time, by having external suppliers, the sourcing firm has the ability to compare inputs provided by internal and external sources and benchmark one against the other, assuaging shirking by either (Hennart 1993). This competition improves the firm's monitoring ability by reducing the information asymmetries involved. The buyer will understand both its own production process and limitations as well as what its external suppliers can provide. Moreover, the sourcing firm has considerable sanctioning ability, since it can credibly threaten switch suppliers by either completely internalizing or outsourcing its requirements.

However, concurrent sourcing will be more problematic in terms of avoiding and resolving disputes. The buyer will have to learn to coordinate both with the internal supplier and external suppliers, each of whom will have different communication channels, information systems, and ordering routines (Arrow 1974, Nelson and Winter 1982). The downstream user of the input will potentially have the confusion and inconvenience of two different ordering and replenishment systems, depending upon whether the supplier is internal or external. This user may prefer one method to another, exacerbating the potential conflict between the sourcing firm and its suppliers. In addition, by supplementing internal production with outside suppliers, the downstream unit may have to use an input that is slightly less customized to their needs, possibly with more variation due to multiple suppliers. By dealing with two different sets of suppliers, confusion can develop in material and information flows, increasing the likelihood of misunderstandings and disputes. However, disputes will be resolved in different manners, depending upon the identity of the supplier, which affects the mechanisms that can be employed. Internal disputes will be settled through the administrative systems and structures of the firm, while disputes with external suppliers will be handled based upon the contracts in place. Essentially, the buyer could resolve a similar complaint in two very different ways, which can lead to contention by the other suppliers.

As compared to solely internal production, the sourcing firm that chooses to concurrently source will have to deal with more suppliers, which means it will have to divide the demand volume and bargain with at least two suppliers over how this is done and how to manage fluctuations in demand. This will take more time and be more contentious than dealing either with internal or external suppliers alone since both may be wary that the buying unit may manipulate its requirements to the benefit of one supplier over the other.

External suppliers, accustomed to peer-to-peer competition, may be threatened by now competing with a customer. External suppliers may assume that the buying unit will manipulate its requirements to the advantage of the internal supplier since they are part of a common firm. Conversely, the inside supplier, perhaps unaccustomed to market competition, may assume the buying unit would manipulate its requirements in the opposite direction to drive the inside supplier's costs down or otherwise use the external supplier as leverage. Thus, both the greater number and the distinct identities of the internal vs. external suppliers, will exacerbate dispute resolution costs.

Previous scholars have suggested that concurrent sourcing, or partial (tapered) integration, is beneficial for the sourcing firm since it can move requirements between internal and external suppliers, improving its bargaining power (Harrigan 1985, Oster 1994). However, this argument makes two critical assumptions: first, it assumes a competitive external supply market, with homogenous and numerous suppliers having few specific investments, such that production volumes can be seamlessly switched between them. This implies that the focal input is rather generic, which questions the logic as to why the sourcing firm would produce the input itself. Second, it assumes predictable, but perhaps fluctuating, end product demand volumes. If demand is not predictable, external suppliers will not know if the sourcing firm is providing it with true volume information or whether the firm is modifying these figures to suit its own interests. Both the firm and the supplier are potentially opportunistic, but the firm is the sole conduit by which external parties receive the final demand volume information. Thus, an opportunistic sourcing firm could manage the figures to better suit its internal operations. This will reduce the likelihood that external suppliers will continue to vie for this business and will make the firm unable to benefit from partial integration as in the traditional economic argument.

By concurrently sourcing, the firm experiences both autonomous and coordinative incentives. Their external suppliers will be predominantly motivated by market based, autonomous incentives while their internal suppliers will be motivated by hierarchically based, coordinative incentives. For this sourcing mode to be stable, the sourcing firm has to both satisfy and benefit from both types of incentives. Therefore, it must be in the outside supplier's best interest to remain in the exchange with the sourcing firm; this may be from the price it obtains or through the knowledge it gains from the buyer. One condition in which this could break down is if the input requires significant specific investments. In this case, the sourcing firm will have a difficult time convincing more than one supplier to make the specific investment, since it cannot be profitably redeployed outside this particular exchange. Moreover, internal sourcing is likely due to the difficulty of agreeing upon how to appropriate the gains from such an investment (Williamson 1975). Coordinative incentives which align the investments and gains from a specific asset and allow for further investments to maintain these will dominate over autonomous incentives that deter suppliers from making an idiosyncratic investment. Therefore, in such cases, concurrent sourcing will be unlikely.

Concurrent sourcing can allow the firm to innovate both to improve short term results, as motivated by market incentives, and to improve longer term prospects, as motivated by coordinative incentives. Concurrent sourcing increases a firm's technical sophistication and causes both internal and external suppliers to be more innovative (Wheelwright and Hayes 1985). Innovations comprise deviations from routine behavior and recombinations of existing routines and resources (Schumpeter 1934). By buying the input as well as making it, the knowledge surrounding it becomes less tacit, less contextually specific, and less ingrained in a particular functional area. Therefore, this knowledge is more likely to be recombined and used to form a new innovation (Galunic and Rodan 1998). In addition, firms can swap managerial and technical innovations between internal manufacturing units and suppliers, improving both (Bradach and Eccles 1989). The firm will gain both from the learning by doing of internal production and the vicarious learning from the outside suppliers who are connected by way of other customer relationships to the sourcing firm's competitors and also to other firm and industries that the sourcing firm is not directly related to. While perhaps strengthened by mutually specific investments, these investments are not required for a sourcing firm to benefit from gaining knowledge from external suppliers. Merely by having an exchange relationship, a sourcing firm can learn about the focal input and its related technologies as the external suppliers interpret them (von Hippel 1988).

By combining inside and outside expertise about an input, the firm's knowledge base becomes more diverse, potentially overcoming inertia (Sorensen and Stuart 1999). Firms can be at risk if they rely solely on internal knowledge and commit to one technology (Mitchell and Singh 1992). By ignoring suppliers' expertise, the firm could be "easily locked into narrow learning paths, and reduce their ability to gain access to radically new technological and market opportunities" (Tunisi and Zanfei 1998). However, by both making and buying, the firm can learn by doing and, through suppliers, even learn before doing (Pisano 1994). Having both internal capabilities and connectedness to outside firms maximizes the potential for innovation through "reciprocal interaction" (Cockburn and Henderson 1998). The firm will increase its stock of knowledge and become more attractive to other firms wishing to trade and gain knowledge (Powell, Koput et al. 1996). Through their external suppliers, the sourcing firm gains access to a breadth of contacts and knowledge.

Therefore, concurrent sourcing could be the best mode to allow for technological change, since it marries the deep tacit knowledge of internal production with the external knowledge sources of diverse outside suppliers, reducing the likelihood of myopia while also improving the firm's absorptive capacity. As Dosi asserts, "One needs to have substantial in-house capacity in order to recognize, evaluate, negotiate, and finally adapt the technology potentially available from others" (Dosi 1988). Also, innovation may require different governance modes depending upon the stage or type of innovation. At beginning inventive stages, external sources may be better; while at more final, adaptive stages, internal sources may be superior (Williamson 1975). Incremental changes may be best managed internally while more radical changes may be better handled externally (Nagarajan and Mitchell 1998). The firm benefits by having access to both.

Like other sourcing modes, the choice to concurrently source an input provides the sourcing firm with a distinct set of advantages and disadvantages. The sourcing firm will incur both the costs of setting up the bureaucratic structure of internal production as well as the search, negotiation, and contracting costs of external procurement. This mode will be more costly to manage, since the sourcing firm must be cognizant of and satisfy both the coordinative incentives of the firm's internal supplier and the autonomous incentives of the market's external suppliers. This sourcing mode will result in a moderate level of production costs, but will entail more haggling and disputes, since internal and external suppliers will view their relationship with the sourcing firm in distinctly different ways and have different expectations. However, the sourcing firm will be better at monitoring its suppliers due to both tacit understanding of the input and the benchmarks provided by outside suppliers. The ability to sanction poorly performing suppliers will be improved since they will more accurately know what sanctions may work the best and, ultimately, they will have the ability to either completely internalize or outsource their requirements. Also, sourcing firms will be more adept at evaluating and reacting to technological change since they will have both a better understanding of the input through their production processes and a reduced myopia concerning the technology due to their relationships with external suppliers and the myriad of indirect relationships with other outsiders that those suppliers bring to the sourcing firm.

Comparing the Sourcing Modes

Sourcing firms will compare the feasible sourcing modes using the criteria of production and exchange costs. Based upon arguments above, if an internal supplier has significant expertise, production costs can be the least for internal production. More typically, however, outside suppliers will provide the least production cost option, since they can both aggregate demand volume, gaining scale economies, and leverage different production processes, gaining scope economies. Concurrent sourcing may provide an advantage in scope economies, but not in either expertise or scale economies, since it combines both internal and external expertise and splits the volume among several suppliers. Therefore, this plural mode will provide a moderate level of production costs, somewhere between solely making and solely buying. Quality monitoring costs will be greatest when using only external suppliers, due to significant information asymmetries. Monitoring costs will be somewhat lower when producing internally, but using both internal and external sources will provide the best combination of evaluation and sanctioning ability, further reducing monitoring costs. Dispute resolution costs will be the greatest when concurrently sourcing, due to the firm's bargaining and coordinating with both a larger number of suppliers and suppliers' who have their own distinct identities and relationship to the sourcing firm, which affects their perception of the sourcing firm's motives and the mechanisms for settling disputes. Sourcing firms using all external suppliers will still face significant dispute resolution costs, as compared to using only one internal supplier. Internal production allows the use of fiat and other coordinative mechanisms, which will mitigate both the likelihood and the magnitude of disputes. Sourcing firms will benefit the most from autonomous incentives when using solely external suppliers since all these exchanges will be couched in the markets, whereas coordinative incentives will be best when the sourcing firm uses only internal production. Concurrent sourcing combines internal and external production and thus provides a moderate level of both coordinative and autonomous incentives.

In sum, concurrent sourcing excels in reducing monitoring costs, fails at mitigating dispute resolution costs, and provides a moderate level of production costs, autonomous, and coordinative incentives. The following table summarizes the above discussion of how each of the primary sourcing modes discussed above compare on the criteria a sourcing firm considers when sourcing (+ + indicates that the mode offers significant advantages on this criterion; + indicates that the mode offers some advantages on this criterion; - indicates that the mode offers significant disadvantages on this criterion).

Sourcing Consideration	**Make**	**Buy**	**Concurrently Source**
Production Costs	-	+ +	+
Quality monitoring costs	+	-	+ +
Dispute resolution costs	+ +	+	-
Incentives - Autonomous	-	+ +	+
Incentives – Coordinative	+ +	-	+

The arguments in this chapter, summarized in the above table, provide the basis for my four core propositions:

P1: Firms will concurrently source if no clear production cost advantage exists for either internal or external suppliers.

P2: Firms will concurrently source if quality monitoring is difficult.

P3: Firms will concurrently source if disputes are not likely.

P4: Firms will concurrently source if both autonomous and coordinative incentives are required.

The next chapter will present eight sets of hypotheses that elaborate on these propositions by determining how the attributes of the input, firm, supplier, and environment affect the sourcing criteria which, in turn, affect the choice to select concurrent sourcing as the preferred sourcing mode.

CHAPTER 3

HYPOTHESES

Based upon the framework in the last chapter, concurrent sourcing bestows distinctive benefits upon a sourcing firm. Concurrent sourcing provides the sourcing firm with superior quality monitoring ability, but is a poor sourcing mode if disputes are likely. This sourcing mode offers moderate production costs, between those of solely making or solely buying, and offers a modest level of both autonomous and coordinative incentives. This chapter will elaborate on input, environment, and firm attributes that would affect these sourcing criteria and thus either facilitate or prevent the sourcing firm from selecting concurrent sourcing as its sourcing mode for a focal input.

In selecting a sourcing mode, firms compare the production costs incurred in using internal production and outside suppliers. If this comparison is relatively indeterminate, with neither internal nor external suppliers enjoying significantly lower costs, the sourcing firm will be more likely to concurrently source the input. The differential in production costs can arise from expertise in producing the input, scale economies, or scope economies.

Typically, firms tend to produce items that are closely related to their experience base and resources. A clear production cost advantage for either the internal or an external supplier can arise if the input requires substantial expertise to produce it effectively. If production of the focal input requires a deep understanding of a unique technology or extensive experience using a certain process, it is likely that this knowledge will only be held and developed by a small number of firms. If the sourcing firm itself has this expertise, then it may choose to source internally (Argyres 1996). Conversely, if an outside supplier has this expertise, then the sourcing firm will source the input externally. Firms will compare their own expertise with that of its outside suppliers and base its sourcing decision upon this relative comparison. If either the firm or the outside supplier has considerably more expertise, then the firm will choose to in-source or outsource accordingly. If both the firm and the outside supplier have great expertise, the firm will choose to concurrently source in order to learn from the outside supplier. If neither the firm nor the outside supplier has considerable expertise, then the firm may again choose to concurrently source so they could pool their resources and learn from each other.

Some inputs require relatively little specialized knowledge to produce. For such inputs, product differentiation may also be minimal and no one supplier will enjoy significant cost advantages over another. Markets for these inputs will have low entry barriers and be very competitive, with many suppliers (Bain, 1962). Using these competitive or contestable input markets will offer sourcing firms lower costs, particularly if the input can be used by many firms and in several industries (Bailey and Friedlaender 1982, Pindyck and Rubenfeld 1995). Prior research suggests that outside supplier production cost advantages spurred by competitive markets will entice sourcing firms to buy the input (Walker and Weber 1984, Walker and Weber 1987). In this case, the expertise of the outside suppliers may involve how they are able to compete in such a market, typically by keeping their costs low. Using an internal supplier along with external suppliers in this situation will increase the sourcing firm's costs since it is likely the internal supplier will be less subject to market pressures (Williamson 1975). Therefore, concurrent sourcing would not be optimal. The above logic supports my first group of hypotheses:

Hypothesis 1a: *The greater the expertise of internal suppliers, the more likely the sourcing firm will make an input.*

Hypothesis 1b: *The greater the expertise of external suppliers, the more likely the sourcing firm will buy an input.*

Hypothesis 1c: *The smaller the difference between the expertise of internal and external suppliers, the more likely the sourcing firm will concurrently source an input.*

Scale economies of the input will also influence a firm's sourcing decision. Scale economies are based upon the technology of producing the input and arise when the marginal costs of producing an additional unit are less than the average costs (Pindyck and Rubenfeld 1985). Scale economies that arise from large, specialized investments can result in barriers to entry and thus reduce the number of competitors in a market (Bain 1962). Sourcing firms will consider their volume demand requirements relative to the volume required to produce cost effectively, the minimum efficient scale. If the minimum efficient scale is large relative to their requirements, they will prefer not to produce the input internally and it will be more efficient for outside suppliers to produce the input since these firms could aggregate demand volume over several customers. Therefore, sourcing firms will be better off procuring the input externally (Williamson 1975; Lyons 1995). If the minimum efficient scale is relatively close to the volume required by the sourcing firm, the sourcing firm may either make or buy the input but will not concurrent source since this would further split the available volume over which any supplier could spread its costs, thus rendering this sourcing strategy suboptimal (Hill 1994). This logic provides the basis for my next two hypotheses:

Hypothesis 2a: *The greater the input's production economies of scale relative to the volume demanded, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 2b: *The greater the input's production economies of scale relative to the volume demanded, the more likely the sourcing firm will buy the input.*

Savings due to scope economies that suppliers can obtain by producing the focal input along with its other products will also influence the sourcing firm's sourcing decision. It may be that outside or inside suppliers or both can offer the sourcing firm lower prices due to scope economies. Unlike scale economies, scope economies are not strictly driven by volume, but are reductions in overall production costs based upon fuller utilization of sharable inputs (Panzar and Willig 1981). These sharable inputs include specialized equipment and human capital, neither of which is sufficiently fungible to easily sell excess capacity in established markets, due to a lack of potential customers and information asymmetries (Teece 1982). The outside and inside supplier may use different production processes and thus each have a different type of excess sharable input that they wish to more fully utilize. For example, an outside supplier may have excess capacity on a particular machine while a sourcing firm has slack internal engineering resources, all of which could be better utilized by both of the firms producing the input. Alternatively, perhaps both the external and internal suppliers wish to more efficiently use a common input, such as skilled machinists or other experienced personnel. Again, if both firms make the focal input, they could reduce their costs of related items and thus overall total production costs.

Scope economies can be derived from either tangible or intangible production assets and can provide symmetric incentives for the external and internal suppliers to produce a particular good, resulting in lower production costs overall. As in the case of expertise, if production by internal suppliers generates significant scope economies and this is not the case for external suppliers we would expect to observe internal sourcing, i.e., making. When external suppliers can reap scope economies and internal suppliers cannot, buying would be the more efficient mode. In contrast to the case of production expertise, however, the sourcing firm will consider the absolute and the relative value of scope economies that can be derived from internal and external suppliers. If both internal and external suppliers can realize important scope economies, then concurrent sourcing should occur. Conversely, if scope economies are insignificant for both internal and external suppliers, this factor will not enter into the sourcing decision and other considerations will dominate. These arguments provide the basis for the following hypotheses.

Hypothesis 3a: *The greater the scope economies to the internal supplier from producing the focal input along with its other products, the more likely the sourcing firm will make the input.*

Hypothesis 3b: *The greater the scope economies to the external supplier from producing the focal input along with its other products, the more likely the sourcing firm will buy the input.*

Hypothesis 3c: *The greater the scope economies of both the internal and external suppliers from producing the focal input along with their respective products, the more likely the sourcing firm will concurrently source the input.*

Concurrently sourcing an input will improve the sourcing firm's ability to monitor quality. This ability will be most beneficial when the input's performance is ambiguous, meaning that it is difficult to determine ultimate performance of the input through simple inspection. This performance measurement problem can originate from several input attributes. Inputs that involve multiple components, technologies, and interactions will be more difficult to evaluate (Bensaou and Anderson 1999, Novak and Eppinger 2001). Inputs such as these will require a buyer to specify more features, adding to its quality monitoring burden. Moreover, the greater the uncertainty in the input's production process, the greater the uncertainty that the supplier will meet these specifications, further complicating the sourcing firm's quality evaluation procedure (Masten 1984, Anderson, Glenn et al. 2000).

When a sourcing firm cannot determine the performance of the input by observation because it does not know what went into the production of the input, the buyer has an information disadvantage (Alchian and Demsetz 1972, Barzel 1982, Anderson and Schmittlein 1984, Anderson 1988). This information asymmetry may be caused by a lack of understanding of the production process of the input, such as not knowing if inferior raw materials were substituted that could subsequently cause poor performance. Information problems also arise when the buyer does not have a transparent and complete understanding of how the input functions in its own downstream processes, perhaps due to interactions with other components in the buyer's production system (Bensaou and Anderson 1999). In such a case, buyers will not know if substituting a problematic input with one from another source will cure the downstream problem, complicating its ability to compare offerings from multiple suppliers. These complex inputs make specification more difficult, as well as enforcement of any specifications that are agreed upon. The ambiguity of performance will motivate the buyer to seek both the deeper understanding of the input's production processes and uses, which can be gained through internal production, and the breadth of approaches that external suppliers provide, along with their benchmarking benefits.

Empirically, performance ambiguity and dual forms of distribution (in-house and direct sales representatives) have been shown to be positively related (Dutta, Bergen et al. 1995); my work extends this research to dual forms of sourcing. Through concurrently making and buying, the sourcing firm will be able to reduce information asymmetries and have an increased ability to enforce quality requirements. If few information asymmetries exist and quality is easily measured, then sourcing firms will be more likely to purchase the input since they can easily evaluate it and compare it with other supplier's offerings. This will be the case for simple, more generic goods or for those with clearly defined standards or specifications, perhaps set by the industry or outside organizations. Restating these points, my next hypotheses follow:

Hypothesis 4a: *The greater the performance ambiguity of an input, the more likely the sourcing firm will concurrently source the input.*

Hypothesis 4b: *The lower the performance ambiguity of an input, the more likely the sourcing firm will buy the input.*

As mentioned in the previous chapter, concurrent sourcing can be difficult to manage when disputes are likely. A key driver of disputes is volume uncertainty, the degree to which the demand volume for the input is unpredictable. When volume is difficult to predict, coordination between the sourcing firm and its suppliers becomes more difficult and communication more intense. Fluctuating quantities and schedules will require substantially more communication between the buyer and the suppliers, increasing the likelihood for manipulation and misunderstandings.

The manipulation potential arises from a basic information asymmetry that exists between the sourcing firm and its suppliers. Since the sourcing firm is closer to the end user, it will get their volume requirements first and pass these figures onto their suppliers by allocating quantities to each. If suppliers can sell the input to other customers, then they may be somewhat sanguine about absorbing any volume uncertainty. Indeed, in cases where no specific assets exist and volumes are unpredictable, sourcing firms can use the market to absorb the unpredictability since external suppliers can fill their plants with demand from other customers or products when volumes from the sourcing firm fall. But, for inputs with some non-trivial amount of specificity, suppliers will push the sourcing firm for reliable data and volume commitments. For inputs with highly uncertain volumes, it will be difficult to determine whether the demand fluctuations were actually due to the end user's changing requirements or due to the sourcing firm's communication of those requirements to the suppliers. Since all the data involving volume requirements originates from the sourcing firm, suppliers may believe that the sourcing firm is manipulating end product demand requirements to its advantage. Thus, disputes are likely to arise.

These disputes will become even more charged if the sourcing firm uses both external and internal suppliers. First, the sourcing firm will have to communicate to and coordinate with a greater number of suppliers. More significantly, however, the internal supplier occupies a distinctly different position as being part of the same firm as the sourcing entity. This may lead external suppliers to suspect that the internal supplier is getting preferential treatment and information due to common ownership. Conversely, the internal supplier may believe outsiders are preferred, since the consequences for not resolving any dispute with an outside supplier are severe (e.g., going to court). Essentially, by sourcing both internally and externally, the sourcing firm uses two different mechanisms for handling disputes (e.g., using authority versus using market or court-based means). Thus, when a dispute does occur, it may be resolved through different channels depending upon the supplier's identity, with a likelihood of different outcomes. This can lead to still more disputes and haggling. Therefore, inputs that are unpredictable in volume, which would lead to disputes, are poor candidates for concurrent sourcing.

If volumes are unpredictable, the sourcing firm's mode choice will depend upon the degree of asset specificity. As mentioned above, if the input requires little specific investment on the part of a supplier and thus the supplier can easily change over any equipment to produce another good or can sell the input to many other customers, then outside suppliers will be willing to absorb any unpredictability due to volume fluctuations since these may offset fluctuations from other customers or they can fill their plant with other orders. If there is significant asset specificity, the sourcing firm will not be able to entice an outside supplier to invest, particularly since volume is uncertain, therefore it will be forced to produce the input internally and settle all disputes via the hierarchy of the firm. This logic provides the basis for my next set of hypotheses:

Hypothesis 5a: *The greater an input's volume uncertainty, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 5b: *The greater an input's volume uncertainty, the more likely the firm will make those inputs that involve highly specific assets and buy those inputs that involve little specific assets.*

Concurrent sourcing combines and balances both the high-powered autonomous incentives of the market and the coordinative incentives of the firm. Therefore, input, firm, and environment attributes that benefit from this combination will motivate the sourcing firm to concurrently source. Conversely, transaction attributes that result in one type of incentive dominating the other will prevent the sourcing firm from concurrent sourcing and motivate it toward solely making or solely buying.

Coordinated incentives dominate autonomous incentives in cases of high asset specificity, in which supplying an input requires non-redeployable investments that are idiosyncratic to the buyer/supplier dyad. These investments have a much lower (or no) value in another alternate use, but may significantly reduce production or other costs associated with supplying the input. Types of asset specificity include site (co-location of activities), physical (characteristics built into the asset), human (unique training or other dedication of personnel), dedicated (only used for that buyer/transaction), temporal (unique timeliness of the activity), or brand name capital (unique market -identifying features of the asset) (Williamson 1999). Transactions tied to highly specific assets will be prone to "lock-in", due to opportunistic partners who may take advantage of these investments. For example, if a supplier purchases a piece of equipment for a particular customer's products, the customer may threaten to move its business to another supplier, knowing that the initial supplier will make concessions to keep the business and not forgo the investment. Alternately, the supplier may reduce its costs by using the specialized equipment, but neglect to pass the savings along to the customer. Due to asset specificity, a "fundamental transformation" occurs; the market relationship morphs into a bilateral monopoly (Williamson 1985). Sourcing firms can avoid this bilateral monopoly problem by internally producing inputs requiring specific assets. In this way, the sourcing firm avoids sharing the savings generated by the specific investments with another firm and coordinates and controls the use of these assets. Asset specificity is the primary driver of the decision to make rather than buy and has empirically been shown to strongly correlate with this choice (see literature reviews in Rindfleisch and Heide 1997 or Crocker and Masten 1996).

In some cases, a sourcing firm may be able to entice an outside supplier to invest in specific assets, but this will only be possible if sufficient safeguards are in place. For example, a sourcing firm may use an external supplier to produce an input requiring a unique piece of equipment, but retain possession of the equipment, only allowing the supplier to use it in production. Scholars have termed this arrangement quasi-integration, since it enables the buyer to retain control of the asset without being completely vertically integrated (Monteverde and Teece 1982a). Alternatively, a sourcing firm may be able to source an input requiring specific investments from a sole external supplier if relational safeguards are in place, perhaps from a long history of exchange (Baker 1990, Dyer and Singh 1998). Note that in these situations, only one external supplier is involved, due to the large investment required in the specific asset. Similarly, when the sourcing firm internalizes production due to a specific asset, again a sole (internal) supplier results. Using only one supplier focuses the investment and coordination decisions, resulting in a specialized supplier and an easier to manage relationship. Since concurrent sourcing involves at least two suppliers (one internal and one external), this sourcing mode will be less amenable to conditions of high asset specificity.

In cases of highly specific assets, either internalization or significant relational safeguards will be used to subdue high-powered market incentives in favor of coordinated incentives and adaptation. Since concurrent sourcing involves both coordinative and autonomous incentives, it is unlikely that this sourcing mode will be preferred when specific assets are required. This forms the basis for my next hypothesis:

Hypothesis 6a: *The greater an input's asset specificity, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 6b: *The greater an input's asset specificity, the more likely the sourcing firm will make the input.*

As argued above, cases in which either autonomous or coordinative incentives dominate will not be amenable to concurrent sourcing. However, when both types of incentives are desired in combination, this sourcing mode may be preferred. One such case involves inputs whose technological future is uncertain. If the progress of technology is difficult to predict, sourcing firms will need to both gather a broad range of knowledge about the technology and have the capacity to understand, interpret, and act upon whatever changes occur. When the technology surrounding an input is immature, quickly changing, and diverse, firms will benefit by having a broad array of knowledge sources about the technology. In these situations, it will neither be clear from what source the newest developments will originate nor what the appropriate response to these developments may be. Also, if technology is rapidly changing, it will be unclear where the next improvement in the field will come from. Firms that have a greater number and more diverse connections to potential sources of technological gains will be more likely to be at the vanguard of the change. External suppliers can provide this breadth of technological options as they may have customers in other industries or otherwise have connections that the focal firm lacks.

But simply being connected to outside suppliers and exposed to new technologies will not be sufficient for the firm to benefit from them; the firm also needs to have the depth of knowledge to interpret and understand the new technology and determine how best to assimilate and act upon it. This attribute, absorptive capacity, is firm specific, path dependent and cumulative (Cohen and Levinthal 1990). By making an input internally, the firm gains experience with the input and develops the tacit knowledge required to produce it. This richer understanding of the input and its related technologies will provide the firm with the ability to recognize and implement technological advances. Internal production should also facilitate knowledge transfer between the firm and its outside suppliers since the dyadic absorptive capacity will increase due to the increased similarity of the firms' knowledge bases (Lane and Lubatkin 1998). This shared understanding provides a foundation upon which the firms can learn from each other (Tunisi and Zanfei 1998). By concurrently sourcing internally and externally, firms will have both a wider range of knowledge sources and adaptive responses.

In cases of technologically changing inputs, both the sourcing firm and its external suppliers will be motivated to formulate strategies to deal with an uncertain future. One strategy for firms to consider is the extent to which to invest in equipment and production processes that risk obsolescence. Any investments that are technologically specific will be undesirable and relatively less valuable due to their potentially shorter life span. Thus, sourcing firms will not want to produce inputs requiring such investments, but would rather procure them from outside suppliers (Balakrishnan and Wernerfelt 1986). But external suppliers face the same risky situation. Unless they can aggregate demand sufficiently and thus have enough volume to justify the investment, they will also be disinclined to invest in this type of equipment. This symmetric risk for both the buying and supplying firm may make it more likely that they will find sharing sourcing of the input an amenable solution. Both the buying and supplying firm will have some investments at risk, but it is likely that each firm will be able to invest less and will invest in an idiosyncratic manner due to their unique capabilities and past investments (Penrose 1959, Amit and Schoemaker 1993). Thus, they will each have access to a different, but similar, set of technological investments and in this manner can hedge and share the risks of obsolescence due to a technological change. They can also learn from each other and perhaps together influence the development of the technology to best suit their position.

Internal and external sourcing are synergistic activities in the face of technological change and uncertainty. They provide the sourcing firm with a wide array of sources of knowledge and a depth of understanding to evaluate and act upon the changes they encounter. By combining inside and outside expertise about an input, the firm's knowledge base becomes more diverse, potentially overcoming inertia and relying solely on one technological approach (Mitchell and Singh 1992, Sorensen and Stuart 1999). If firms cannot accurately predict the type of change forthcoming, having both types of sourcing available will improve the firm's likelihood to succeed by being "ambidextrous and able to deal with both suppliers and internal development groups in the face of technological change" (Afuah 2001). Since outside suppliers also face these changes, they, too, will want to be connected to the sourcing firm, making the incentives symmetric and concurrent sourcing stable. In cases of technological change, the high-powered, autonomous incentives of the market help to broaden the array of potential sources of knowledge about the technological change and weed out those that are the least viable. At the same time, the coordinative incentives of the firm assist in the evaluation of the changes and in implementing the activities the change requires. Given this balance of incentives and the fact that sourcing firms can benefit by having both types, concurrent sourcing will be the preferred sourcing strategy.

In contrast, if technology is stable, sourcing firms will be able to find capable external suppliers and source from them. If the technological future is easy to predict and the dominant science surrounding an input is clear, the sourcing firm will have little need to produce internally in order to understand how changes in technology will affect the input and its interaction in the firm's production process and coordinate these resulting decisions. Having multiple suppliers will not be necessary for gaining a breadth of streams of technological knowledge since all suppliers will be using a common process, but would be desirable for competitive pricing or product differentiation reasons. Moreover, technologically mature inputs will be relatively easy to specify and evaluate, facilitating external sourcing. Overall, in cases of predictable technology, external procurement will be most likely. My next set of hypotheses stems from this logic:

Hypothesis 7a*:* *The greater an input's technological uncertainty, the more likely the sourcing firm will concurrently source the input.*

Hypothesis 7b*:* *The lower an input's technological uncertainty, the more likely the sourcing firm will buy the input.*

Concurrently making and buying is more complicated to manage than solely making or solely buying due to the buyer having to manage two very different types of suppliers, internal and external. As compared to external suppliers which will be motivated by higher powered market-based incentives, internal suppliers will be more likely to be motivated to coordinate their actions with the buying unit, since both the internal supplier and buying unit are part of one common firm. Buyers that can develop and maintain cooperative relationships with suppliers will be more likely to successfully manage concurrent internal and external sourcing since these buyers can reduce the impact of asset specificity and volume uncertainty that block this sourcing strategy.

Supply management capability involves the skill of a firm to develop and maintain cooperative relationships with suppliers. Sourcing firms that can build a relational exchange with outside suppliers will gain competitive advantage based upon the improved coordination and knowledge gleaned from these relationships (Dyer and Singh 1998, Lorenzoni and Lipparini 1999). These relationships entail greater flexibility, assistance, and information exchange between the buyer and its suppliers, as well as greater monitoring by the buyer and an assumption by all that the relationship will continue (Heide and John 1990, Noordewier, John et al. 1990). Long standing relationships between buyers and suppliers will increase cooperation and coordination between them and will reduce the need for formal and legal enforcement of contracts (Heide and Miner 1992, Lyons 1996). In essence, sourcing firms with good supply management skills motivate outside suppliers to act as if part of the firm, reducing their opportunistic tendencies.

As mentioned above, in cases of significant asset specificity, sourcing firms may not be able to concurrently make and buy due to the potential for supplier opportunism. However, sourcing firms able to create cooperative, long term supply relationships can foster investments in assets specific to the parties. These mutual investments include learning how to work together effectively and customizing both products and logistical activities to match each other's operations (Williamson 1985). Relationship-specific assets, particularly in human capital, strengthen the bond between firms, lead to bilateral dependence, and reduce the likelihood of dissolution of the relationship (Levinthal and Fichman 1988). These investments can also facilitate cooperation and coordination between the firms, with shared operational control and blurred organizational boundaries. Shared control of these investments and social norms aid in stemming opportunism and sustaining the relationship (Williamson 1985). Therefore, supply management capability can mitigate the opportunistic potential of outside suppliers in cases of asset specificity and allow the sourcing firm to concurrent source internally and externally.

Sourcing firms with superior supply management skills will communicate more regularly with suppliers and exchange richer information. Between the buyer and supplier firms, communication routines will develop that will involve many modes of transmission between several different people in both firms. This will make it more difficult for the sourcing firm to manipulate information to its advantage, since the outside supplier will have access to several groups within the sourcing firm with which to corroborate the data. For example, if a supplier obtains volume requirements from the purchasing staff and questions these numbers, it can freely ask the buyer's engineering or production staff since it already has contacts with these areas. In this way, for sourcing firms with sufficient supply management skills, volume uncertainties will not pose as high a barrier to concurrent sourcing.

Conversely, firms with weak supply management skills will be more likely to produce internally. These firms have not developed methods of working with external suppliers to induce cooperation and flexibility and, as such, their supply relationships will tend to be more adversarial. They may prefer internal production since they can avoid conflict and better control supply flows through the firm's authority structure and induce cooperation structurally. In addition, sourcing firms with poor supply management skills may have difficulty in recruiting external suppliers, since their reputation of being poor customers may be disseminated throughout the supply base in the industry. This may leave internal production as the only viable sourcing alternative for the firm. Based upon these arguments, my final hypotheses follow:

Hypothesis 8a: *The greater the sourcing firm's supply management capability, the more likely that it will concurrently source an input.*

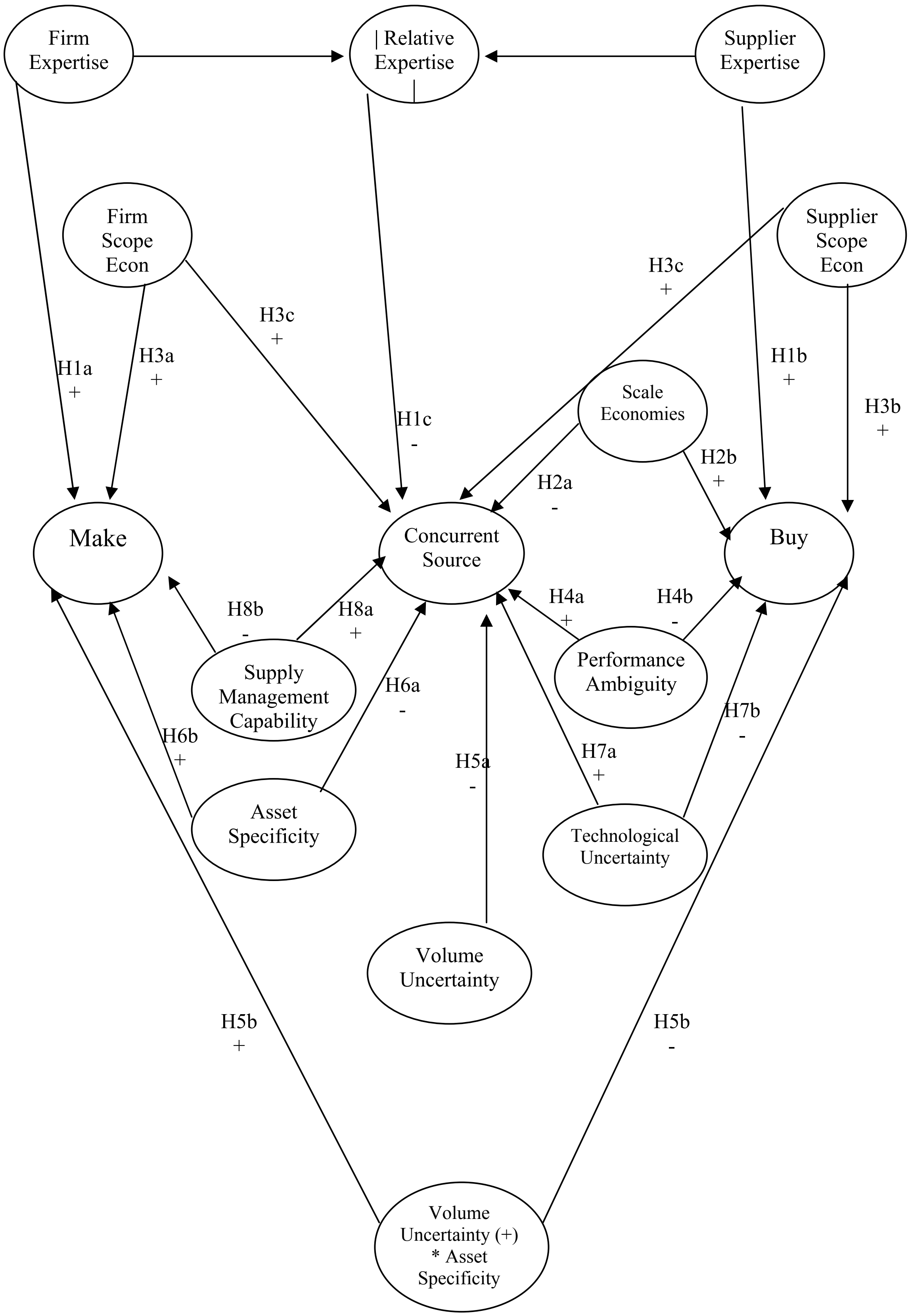
Hypothesis 8b: *The weaker the sourcing firm's supply management capability, the more likely that it will make an input.*

This chapter argued that sourcing firms will use concurrent sourcing in cases of dual scope economies, performance ambiguity, technological uncertainty, and superior supply management capabilities. If an internal or external production cost advantage, specific investment, or great volume uncertainty exists, concurrent sourcing is less likely. See Figure 1 for a graphical depiction of the concurrent sourcing hypotheses mentioned in this chapter and Table 1 for a summary of the propositions and hypotheses. The next chapter will discuss the empirical setting used to test these hypotheses, metal forming firms' sourcing decisions for production tooling and services.

Table 1: Propositions and Hypotheses

Proposition	Hypotheses supporting Concurrent Sourcing	Hypotheses against Concurrent Sourcing
P1: Firms will concurrently source if no clear production cost advantage exists for either internal or external suppliers.	H1c: The smaller the difference between the expertise of internal and external suppliers, the more likely the sourcing firm will concurrently source an input. H3c: The greater the scope economies of both the internal and external suppliers from producing the focal input along with their respective products, the more likely the sourcing firm will concurrently source the input.	H2a: The greater the input's production economies of scale relative to the volume demanded, the less likely the sourcing firm will concurrently source the input.
P2: Firms will concurrently source if quality monitoring is difficult.	H4a: The greater the performance ambiguity of an input, the more likely the sourcing firm will concurrently source the input.	
P3: Firms will concurrently source if disputes are not likely.		H5a: The greater an input's volume uncertainty, the less likely the sourcing firm will concurrently source the input.
P4: Firms will concurrently source if both autonomous and coordinative incentives are required.	H7a: The greater an input's technological uncertainty, the more likely the sourcing firm will concurrently source the input. H8a: The greater the sourcing firm's supply management capability, the more likely that it will concurrently source an input.	H6a: The greater an input's asset specificity, the less likely the sourcing firm will concurrently source the input.

Figure 1: Diagram of Hypotheses



CHAPTER 4

EMPIRICAL SETTING

This chapter discusses my research context, the production tooling and services sourcing choices of metal forming firms, and describes the applicability of this context to my core research question of when do firms concurrently source a particular input. An appropriate empirical context for investigating concurrent sourcing would include small, independent, numerous, homogenous firms whose production processes are relatively technologically mature. Moreover, inputs studied should include sufficient variance in sourcing modes, performance ambiguity, technological uncertainty, asset specificity and other key variables described in the previous chapter. These inputs need to be defined appropriately, neither too broad such that they cannot be considered a single sourcing choice nor too specific such that numerous firms could not identify them. This chapter discusses the above criteria for an appropriate context, describes the industry and inputs chosen, and summarizes the exploratory research conducted.

Industry Criteria

In selecting a suitable empirical setting in which to study concurrent sourcing, one must consider both the industrial context and the selection of focal inputs within that industry. First, an industry with small, independent firms is desirable as it rules out some alternate explanations for concurrent sourcing. Large, multi-unit firms may have more difficulty in switching between pure sourcing modes, from solely making to solely buying, which could result in concurrent sourcing due to inertia. Larger firms will also have more slack resources (Penrose 1959). Due to these additional resources, bigger firms could support concurrent sourcing even if it were not an optimal sourcing mode choice. Moreover, larger firms may be more likely to be unionized, which can restrict their activity (Argyres and Liebeskind 1999); labor contracts may result in these firms retaining internal production activity while simultaneously purchasing the same input.

Second, a desirable industry to investigate would be populated by firms that have relatively homogenous production processes, but some variance in organizational processes. By having similar production processes, these firms would share a common cost structure such that the magnitude of the input sourcing decisions would be comparable. Ideally, these firms would face common markets both for raw materials and for their end products, further standardizing their cost structures. Also, selecting appropriate focal inputs that are used and identifiable by all firms will only be possible if they have related production processes. At the same time, to investigate the importance of supply management capabilities on the decision to both make and buy, the firms studied must have some variance in organizational processes. Thus, selecting firms that vary in size and in their competitive approach would be preferable.

From a technology viewpoint, an appropriate empirical context would employ a relatively mature technology. This would assist in the commonality of production processes, as mentioned above. More importantly, a relatively mature technology would help control for the possibility that firms may internally produce an input based upon one generation of technology and outsource the same input, but based on a different generation of technology. For example, a firm may internally produce widgets based upon cutting-edge production technologies, but purchase from external sources widgets based on older production methods. My arguments from prior chapters suggest that these two widgets are not actually the same input, and thus not applicable to my key research question of concurrent sourcing. Thus, if one selects an industry whose technology is changing rapidly, it may be difficult to distinguish whether a firm that is concurrently sourcing is actually sourcing one or multiple inputs. A more technologically mature industry would simplify this issue.

A final criterion in selecting an appropriate context is feasibility. A feasible population would consist of several hundred firms, preferably all domestically located. This population size would provide a sufficient number of firms to gain a reasonable sample of respondents but not so large or complex as to be administratively cumbersome. Industry associations can assist in determining an appropriate population of firms to study. In addition, for a context to be feasible, a key respondents at each firm could be identified who could knowledgeably reply to inquiries about several different inputs and different aspects of these inputs. Smaller firms run by an identifiable general manager would be preferable in this regard. Another way to determine the feasibility of the population to be studied is to review past research. Since many procurement studies have focused on intermediate product markets in manufacturing contexts, this may be a fruitful area to continue to explore (Shelanski and Klein 1995, Rindfleisch and Heide 1997).

Input Criteria

For this research question, several inputs should be chosen to reflect the breadth of sourcing modes and variance over the theoretical variables. In order to best understand concurrent sourcing, one needs to explore inputs that are only made, only bought, and also those inputs that are both made and bought. This allows the researcher to distinguish between these three types of decisions. A recent study by Dutta and colleagues is one of the few empirical studies exploring plural, or concurrent, sourcing modes (Dutta, Bergen et al. 1995). They investigated when firms used both outside sales representatives and a direct sales force by surveying the outside representatives. However, based upon the design of this study, they only received data from two sourcing modes: solely buying (all outside reps) and concurrently making and buying (outside reps and direct sales). They suggested that "a more congenial context for such a study would be an industrial purchasing decision where buyers engage in buy-only, make-only, and make-plus-buy choices". In this dissertation, I use a variety of inputs to ensure observations from all three sourcing modes.

In addition to variance in sourcing mode, inputs should be chosen such that there is variance in the theoretical variables. In this way, the hypotheses of interest can be tested over a wider range of intensity levels of the variables. Thus, for my research, I selected inputs that varied in relative production cost advantages for the firm vs. outside suppliers, in scope economies for the firm and outside suppliers, in performance ambiguity, in volume uncertainty, in asset specificity, and in technological uncertainty.

However, while heterogeneity is required in the selection of inputs, homogeneity within each input category is needed. All the firms being questioned must understand what is meant by the input, identify that they use the input, and that they manage the sourcing decision of the input in a holistic fashion. As defined in chapter two, an input refers to an intermediate level of good or service that is used in the production process and converted by the firm into an output that is sold to its customers. Inputs, whether produced internally or purchased externally, share a common technology and are destined for the same function in downstream production. Inputs use similar raw materials, human skills, and physical equipment in their production processes. For downstream users of these inputs, no significant alteration in production routines need be made when switching between inputs procured from individual suppliers, be they external or internal. This input definition strives to operationalize and more precisely describe how sourcing managers make these decisions.

As with selection of the industrial context, the selection of inputs must represent a feasible set. This involves a reasonable number of inputs, between three and ten, to obtain variance in sourcing modes and constricts, but without putting an undue burden on respondents. Moreover, appropriate inputs will be frequently sourced so that respondents can recall the rationale for the decision. Finally, appropriate inputs will be those whose sourcing decision is significant, but not unduly high in value or significance. Extremely large purchases, such as a building or a major piece of production equipment, do not occur often and typically involve several people, perhaps at several locations, in the decision process. Since I intend to only have one respondent per firm, likely the general manager, to reply for all input questions, I must restrict my choice of inputs to those whose sourcing decision are made at the plant level.

Metal Stamping and Powder Metal Firms

As my research context, I chose two sectors of the metal fabrication industry: stamping firms and powder metal (PM) parts firms. These firms are relatively small, typically employing about 100 people in a single location. They share similar manufacturing processes, differ in some of their organizational processes, are based on relatively mature technologies, and will be feasible to study.

Several production processes exist to produce metal parts, including casting, forging, extrusion, rolling, drawing, stamping, and powder metallurgy. Casting is a high temperature process involving pouring melted metal into a die. Extrusion, forging, rolling, and drawing are conducted at room or higher temperatures and are considered to be bulk deformation processes, commonly used for fairly simple shapes, like beams, tubes, rods, plates, and wire (Groover 2002, Schey 2000). In contrast, both stamping and powder metallurgy are room-temperature processes used to produce intricately shaped parts, usually at high production volumes (thousands of parts per run).

Metal stamping, sometimes known as sheet metalworking or sheet metal pressing, is used to make a myriad of different types of products out of thin metal sheets, usually between 1/64" and ¼" thick. The raw material sheet can be in plate or coil form and can vary in width from under 1" to several feet. Narrow raw material stock is typically presented to the stamping press as a large continuous coil, while wider stock is presented in plate form (Groover 2002). The raw material is stamped using a die set, consisting of a female die and a male punch, placed into a mechanical or hydraulic press. Press forces can range from 10 to several thousand tons, depending upon the type and size of product required.

Stamping dies are categorized into three groups: simple dies that have one station and engage in one operation (e.g., bending, shearing, piercing, drawing, etc.) per press stroke; compound dies that have one station but engage in two operations per press stroke; and progressive dies which can consist of up to two dozen stations each engaging in one operation per press stroke. For large metal parts, such as automobile bodies or aircraft frames, simple dies and massive presses are generally used. If the parts require additional stamping operations, they may be transferred to a different press, either manually or via robots or other mechanical means. For smaller, complex parts made in high volumes from coil stock, progressive dies are most commonly used (Groover 2002, Schey 2000, Pollack 1987).

Production of powder metal parts begins with metal powder, typically iron based and about the consistency of fine sand. This powder is fed into presses that have dies shaped very close to the final part configuration. These dies typically only have cavities for one part, but if the parts are quite small, multiple parts may be pressed at once. Depending upon the size and complexity of the part, molding pressures can be between 20 to 500 tons. After molding, the parts are green and still quite fragile. Next, the parts are fed into a sintering furnace in which the metal particles bond together, with the final part approaching the strength and density of a stamped part made out of the same base material. Some parts are complete at this stage, while others may require impregnation to reduce porosity or heat treating to alter the physical properties. One of the major advantages of powder metal production over other metal forming methods is the lack of waste and the ability to form very complex shapes, such as multi-leveled gears, with no or very minor machining after the initial pressing operation. However, many powder metal parts still need some additional processing after sintering; these processes include grinding or lapping to improve surface finishes, machining features that cannot be directly molded into the part, such as tapped holes, and coating or plating the parts to protect against corrosion (German 1994).

Both powder metallurgy and metal stamping processes are used to make intricate, near-net shaped, customized, small (under 5 lb. and with a footprint of less than 1 square foot) ferrous-based (iron, steel, or stainless steel) parts. In both processes, the raw material (either coil stock or metal powder) is formed using intricately machined dies and mechanical presses ranging from 20-500 tons in force. While dies are designed such that the parts should need little additional machining, few parts are just "stamped and shipped" (Strasser 1971, German 1994). In most cases, firms perform (and/or subcontract out) subsequent operations such as heat treating, machining, surface finishing, plating, or assembly with other components. The end parts, such as gears, brackets, or spacers, are most commonly used in automotive, industrial, lawn/garden, and related applications (for part photos, see Figures 2 and 3).

Based on the above description, this context satisfies the criteria of small firms using relatively homogenous production processes. These firms also satisfy the criterion of have differing organizational processes, based primarily on the differences in their technologies. While both metal stamping and powder metallurgy are relatively mature technologies, both having been in widespread use for the last 50 years or more, powder metallurgy technology is a newer process whose applications continue to grow. For example, over the last 25 years, automotive applications, which represent 70% of PM parts in use, have grown from 15.5 lb to 38 lb per vehicle, with growth expected to reach 50 lb/vehicle in the next few years (White 2002, Kalpakjian and Schmid 2001). In some cases, PM parts are supplanting stamped and other traditionally formed parts due to less waste in raw material (3-5% in PM vs. 10-25% in stamping), relatively cheaper tooling, and the ability to form more intricate shapes without subsequent machining (Kalpakjian and Schmid 2001, German 1994). The PM process is more technologically complicated, involving sintering (metallurgical fusing of individual metal particles conducted at high temperatures in a controlled atmosphere in specially designed furnaces), potentially porous (and/or varying density) end products, and the ability to uniquely combine different metals, either in the powder state or via joining in sintering (German 1994). The technological differences and the expansion potential in the PM industry suggest that these firms place greater emphasis on technology development and therefore likely manage their suppliers differently than stamping firms, whose technology is more staid and growth less evident. These firm-level differences in supplier management are precisely the differences hypothesized to affect the ability of the firms to use concurrent sourcing.

Finally, this industrial context is feasible to be studied. It is a population that is moderate in size, with 86 PM firms and 433 metal stamping firms registered with their respective industry associations (the PMPA, Powder Metallurgy Parts Association, and the PMA, Precision Metalforming Association). These firms are relatively small and typically run by general managers who are involved in most significant decisions, including sourcing of key production equipment and services. These managers should be knowledgeable single respondents who can reliably reply to inquiries about sourcing practices. Most of these managers' names are listed on the respective web sites and printed directories of the industry associations, as are the firm names, addresses, phone numbers, and other relevant information. Contacts made with the industry associations have been cordial and fruitful.

Exploratory Research

In May 2002, I began exploratory interviews with metal stamping and PM firms. I conducted on-site interviews with eleven firms in Pennsylvania and Michigan, averaging two hours at each facility. These firms included five stampers, five PM firms, and one cold-heading firm (to better understand and subsequently rule out this type of firm), ranging in size from seven to over 1,000 employees. Interviews typically were hosted by the general managers of the firms and included plant tours and discussions with various production, engineering, and purchasing personnel. All those contacted were intrigued by my research and agreed to participate in later stages of survey pretesting. Many of the managers were deeply involved in their respective industry associations (Metal Powder Industry Federation/Powder Metallurgy Parts Assocation (MPIF/PMPA) and Precision Metalforming Association (PMA)).

It was through these interviews that five focal inputs of die design, die building, die maintenance, part machining, and part coating emerged. I discovered the multi-faceted nature of the die sourcing process, such that it actually consists of three activities - designing, building, and maintenance. I also gained an understanding of how dies are produced and learned that progressive dies are the most common and complex for these stamping firms. All the PM firms and most stamping firms use machining operations and all firms provided some coating or plating on their parts.

Significant variance in the sourcing mode was evident over these inputs. Dies were maintained in-house by nearly every firm, whereas surface coatings were outsourced by all firms. For the other inputs, however, the firms used a variety of sourcing modes, including concurrent sourcing. In addition to determining the focal inputs and their sourcing modes, I also used the exploratory interviews to better understand how these firms manage suppliers. All the firms tend to use a small number (one to three) of suppliers for die-related inputs, using more suppliers for the downstream operations, particularly surface coatings. Firms prefer local suppliers, citing the need to minimize transportation time, particularly for downstream operations. Several firms also have their own trucks to move product between their plants and those of their suppliers.

All of the firms were QS-9000 registered, such that they were required to evaluate suppliers, maintain records of supplier quality, and strive for 100% on-time delivery. If the firm's customer requires that it follow QS-9000 principles, it is more difficult for the firm to change suppliers since all its suppliers and processes must go through a lengthy qualification process (e.g., the Production Part Approval Process (PPAP)) (Smith 1996). Many firms used approved supplier lists, supplier surveys, and supplier scorecards and provided me with copies of some of these.

Considerable variance exists in the firms' approaches to protecting proprietary information and knowledge sharing. Some knowingly withhold information from suppliers and use and enforce confidentiality agreements. Others maintain there are "no secrets" in the industry and one shouldn't get "bent out of shape too much" over proprietary information because "word's good on the street" which suppliers are trustworthy. There also appeared to be different emphases on past supplier relationships. Some firms stressed prior experience with a supplier and doing favors for each other as a means of strengthening their ties, while others did not care at all about the past, but only "what you (the supplier) can do for me tomorrow". Die suppliers appeared to be particularly difficult to manage. Firms expressed distaste for the opportunism of die suppliers, who significantly increase prices (by $10,000 or more) and lengthen delivery times (by several weeks) when business is good. They also occasionally take part in the "kitchen remodeler trick" of increasing the price demanded when they are midway through completion of a die. Firms counter these actions by producing dies in-house and by not giving new business to the offenders. Firms need to have a fully equipped machine shop for die maintenance and strive to keep it full of work and their machinists busy.

Dies and Production Services

As mentioned above, I investigate sourcing mode choices for five different inputs: the design of progressive stamping dies (for PM firms, the term "conventional molding" everywhere replaced "progressive stamping"), the initial set of progressive stamping dies, the maintenance of progressive stamping dies, machining of final part details, and surface coating of end products. Some of these inputs are typically made internally, others are purchased from outside suppliers, and some are concurrently sourced. These inputs provide sufficient variance in relative production cost advantages, scope economies, volume uncertainty, technological uncertainty, asset specificity, and performance ambiguity. Each input category is relatively homogenous in terms of the materials and skills required to produce it. All of these inputs are sourced at least twice monthly by stamping and PM firms and these inputs are sufficiently important in terms of their impact on final products that general managers are involved in the sourcing process.

Dies for Stamping or Molding

Both metal stamping and PM firms use dies for the initial forming of their products. Costing from a $2,000 to nearly $100,000, these firms procure dies two to four times per month, with delivery ranging from one to sixteen weeks and progressive stamping dies generally being more expensive (SME 1994). These relatively high tooling and subsequent maintenance costs can be justified if volumes are sufficient and if the part will be produced for some time (Walsh 1994, Kalpakjian and Schmid 2001). Metal stamping firms use progressive stamping dies for high volume parts involving multiple operations. These dies are the most complicated and costly type of stamping dies, but are cheaper per piece to operate. With this type of die, firms can produce higher quality parts with less handling and labor (Walsh 1994, SME 1994). I focus on progressive dies as they are sufficiently complex relative to other types of dies, are most commonly used for intricate, small parts, and provide the best parallel comparison to molding dies used by PM firms, which are also quite complex (see Figures 4 and 5 for die drawings).

Die sets for progressively stamped or PM parts involve numerous interrelated components, including top and bottom die shoes, punches and dies, guideposts, bearings, bushings, springs, and guide pins. While some of these components are standard items typically sourced from tool and die supply houses (e.g., pins and bushings), the punches and dies are custom machined for the end product being produced (Walsh 1994). Typically attached to the large die shoes, the smaller punches or die pieces are cut from standard blocks, shaped, milled, drilled, turned, and/or ground to the precise shape required for producing the end parts. Increasingly, sophisticated, computer-controlled (CNC) milling machines and lathes are used to produce dies, as well as electric-discharge machining (EDM) centers. In the EDM process, a spark is run between two electrodes and excess material is “burned” off the die being machined. EDM equipment can produce finer details, eliminating the need for later grinding operations, and can be used over a wider range of raw materials. This method is more accurate and economical, with some experts claiming "no blanking die can be built as inexpensively with conventional techniques as it can with EDM" (SME 1994 p.313). However, this type of equipment represents a significant investment, costing upward of $100K, and requires skilled machinists to operate it (Kalpakjian and Schmid 2001). Therefore, both EDM and conventional machining methods are commonly used to make these types of dies (Walsh 1994).

Die design is a complex process, involving tool steel selection, raw material behavior and mechanics, press features, and planning for optimum productivity. Die designers can select from dozens of different tool steels and carbides, with differing hardness and wear resistance properties; material selection depends upon the die geometry, run size, machining method, and other factors (German 1994, Walsh 1994, Suchy 1998). In production, dies and the raw material being formed undergo compressive and tensile stresses; these must be understood and considered in designing the die (Walsh 1994). Press tonnage, stroke, bed size, and specific idiosyncrasies also must be taken into account (Suchy 1998). For PM dies, designers also need to consider the flow of the powder within the die cavity to ensure even density throughout the part, the effect of the powder's friction on the die walls, the shrinkage and swelling of the dies while in use, and the ability for smooth ejection of the finished part (German 1994). Progressive stamping die designers need to consider the stresses and springback of the material, how the material can be moved through the various stages of the die, and the optimal strip layout to minimize waste (Walsh 1994). Dies can also be flexibly designed, to produce different parts from the same die (by using replaceable punches), to produce more than one of the same part from a single die (e.g., a “4-up” design, resulting in 4 identical end parts for every one press stroke), or to produce mating parts from the same die (e.g., right and left hand parts) (SME 1994). Die designers must keep in mind the productivity of the dies, allowing for minimal down time, ease of maintenance, and replaceable parts. Designers typically use computer-assisted drawing (CAD) systems to develop the die drawings; these are then sometimes directly fed into other computerized EDM or other machining equipment, which can minimize errors (SME 1994). In sum, the design process is multi-faceted and, as Walsh suggests, “….die design and die making are complex arts as well as technologies that require considerable skill, knowledge, and practical experience” (Walsh 1994, p. 792).

In production, dies require regular maintenance activities, such as regrinding, realignment, and replacement of punches or other components. Typically, dies will be inspected and maintained as required after each production run or after a set number of press strokes (e.g., 100,000). Not all maintenance activity is predictable; occasionally, misfeeds in raw material, press crashes, defective products found downstream, or other events cause dies to be removed from production and remachined. Particularly in crises situations, dies must be quickly fixed and returned to production, since no end parts can be made while the die is out of service. Replacement die parts, or complete die sets, may also be required depending upon die usage and production volumes.

Die design, building, and maintenance are often sourced differently. While die maintenance is typically done in-house, the other die activities are typically concurrently sourced. Die design and building are complex processes, with high degrees of performance ambiguity. As one manager suggested, just because one sees a part, one doesn't necessarily know how to produce it since the key is "the magic of the tool - who designs it and how well it runs". Indeed, the performance of a die is not known until it is used in a "run off" at the producer's site and a subsequent trial at the buyer's site on the production press. If the die makes good finished parts, the die itself is considered to be acceptable. Die design requires specific skills (high human asset specificity) but work in this area appears to be fairly steady (low volume uncertainty). Predictability, or volume uncertainty, tends to be high for die maintenance, since crises cannot be forecasted but technological uncertainty appears to be low for this input, as conventional machining equipment can be used. Significant scope economies exist between die building, maintenance, and replacement parts as all of these inputs use similar machining equipment and skilled labor. From a relative production cost standpoint, replacement parts typically can be economically produced by either the firm or outside suppliers.

Production Services: Machining and Coating

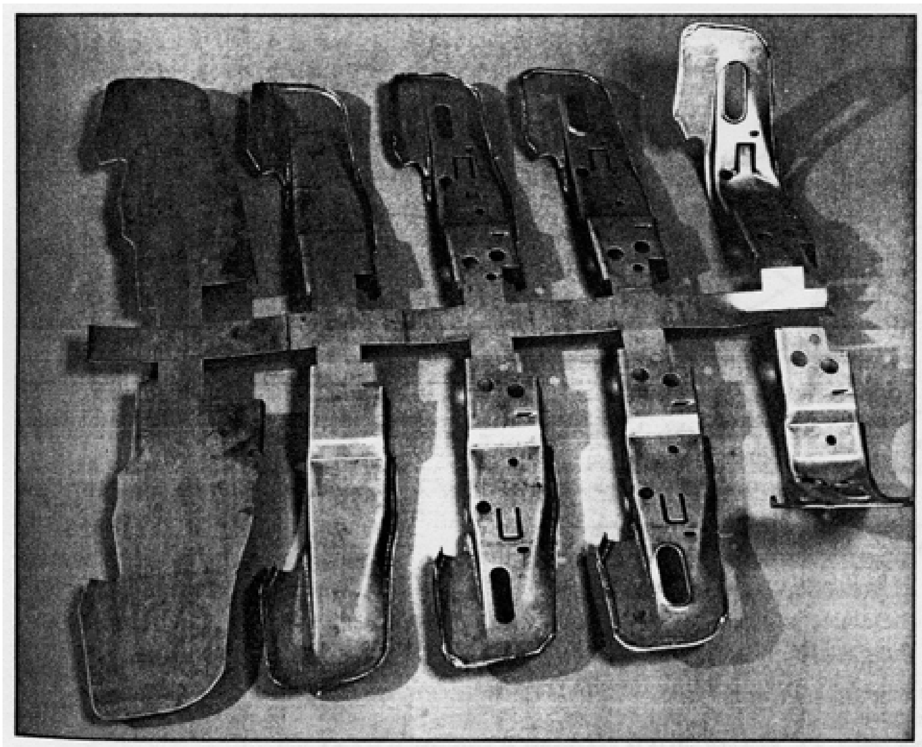
In addition to die-related inputs, I also investigate these firms' sourcing practices for downstream production services: machining of final part details and surface coating. Nearly all metal stamped and PM parts have additional operations after stamping or pressing. These include heat treatment, machining, cleaning, surface finishing, surface coating, joining, assembly, and/or inspection. Machining operations include drilling, tapping, boring, honing, milling, broaching, grinding, and lapping. Surface coating can be in the form of spraying, painting, dipping, glazing, or plating (Strasser 1971, German 1994). These operations are fairly homogenous between PM and stamping firms.

Firms use downstream machining operations when they cannot stamp or mold in the finished details required by their customers. It is fairly common to drill, tap, grind, or otherwise machine stamped or PM parts, with these operations being more prevalent in PM due to more constraints on geometries in this production method. PM firms are also more likely to concurrently source machining services, whereas stamping firms are more likely to use polar sourcing modes (either solely making or solely buying the service). More expertise may be required to machine PM parts, due to their porosity. As compared to other focal inputs, technology changes are more frequent in machining services, with it becoming increasingly computerized and automated.

Both stamped and PM parts are often plated or coated to protect parts from corrosion, to seal the surface, to provide a suitable mating surface for other components in an assembly, or to allow for a more pleasing cosmetic appearance. Common coating and plating types include zinc chromate (in yellow, green, or clear finishes), electrocoating (for a smooth, black finish), and vinyl dipping. All stamping and PM firms purchase coating and plating services, due primarily to the environmental issues that accompany this business and significant investments in equipment (plating lines, vats, racks, etc.). There appear to be significant scale economies in plating and coating, resulting in a relative production cost advantage for firms that focus solely in this area. Moreover, few opportunities for scope economies through leveraging a common piece of equipment or other sharable input exist since these operations are quite specialized. However, as compared to other inputs, surface coatings are fairly simple to specify, are relatively standardized, and performance is rather easily measured, based predominantly on appearance and corrosion testing (e.g., salt spray tests).

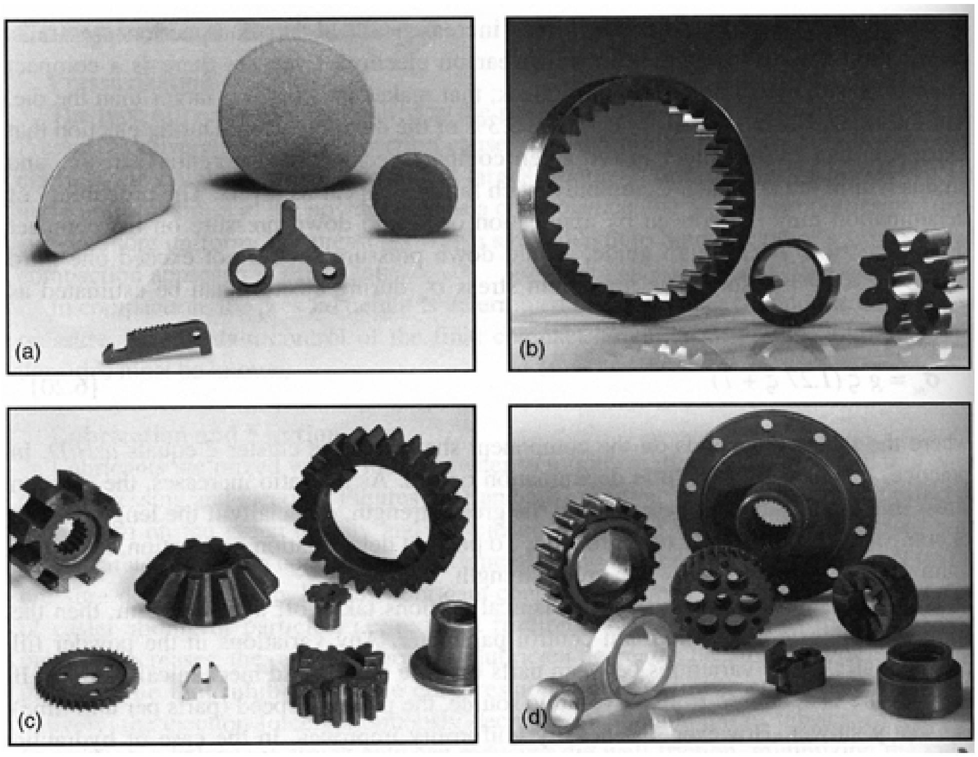
In sum, the metal forming industry and the above five production inputs represent a suitable context in which to study concurrent sourcing. The population of firms is reasonable in number (about 500 firms) and firms are small in size with general managers who can act as knowledgeable single respondents. This context provides variance in sourcing modes and in my theoretical variables while retaining sufficient homogeneity within the production processes and inputs. Although each of these firms makes hundreds of distinct parts and all the inputs are ultimately part-specific, each firm produces a fairly narrow range of part types. Therefore, the focal inputs should be relatively similar across the firm and managed as a uniform category. The next chapter describes how I surveyed these firms about their sourcing practices for these inputs and presents the initial analysis of the survey data.

Figure 2: A Progressively Stamped Part



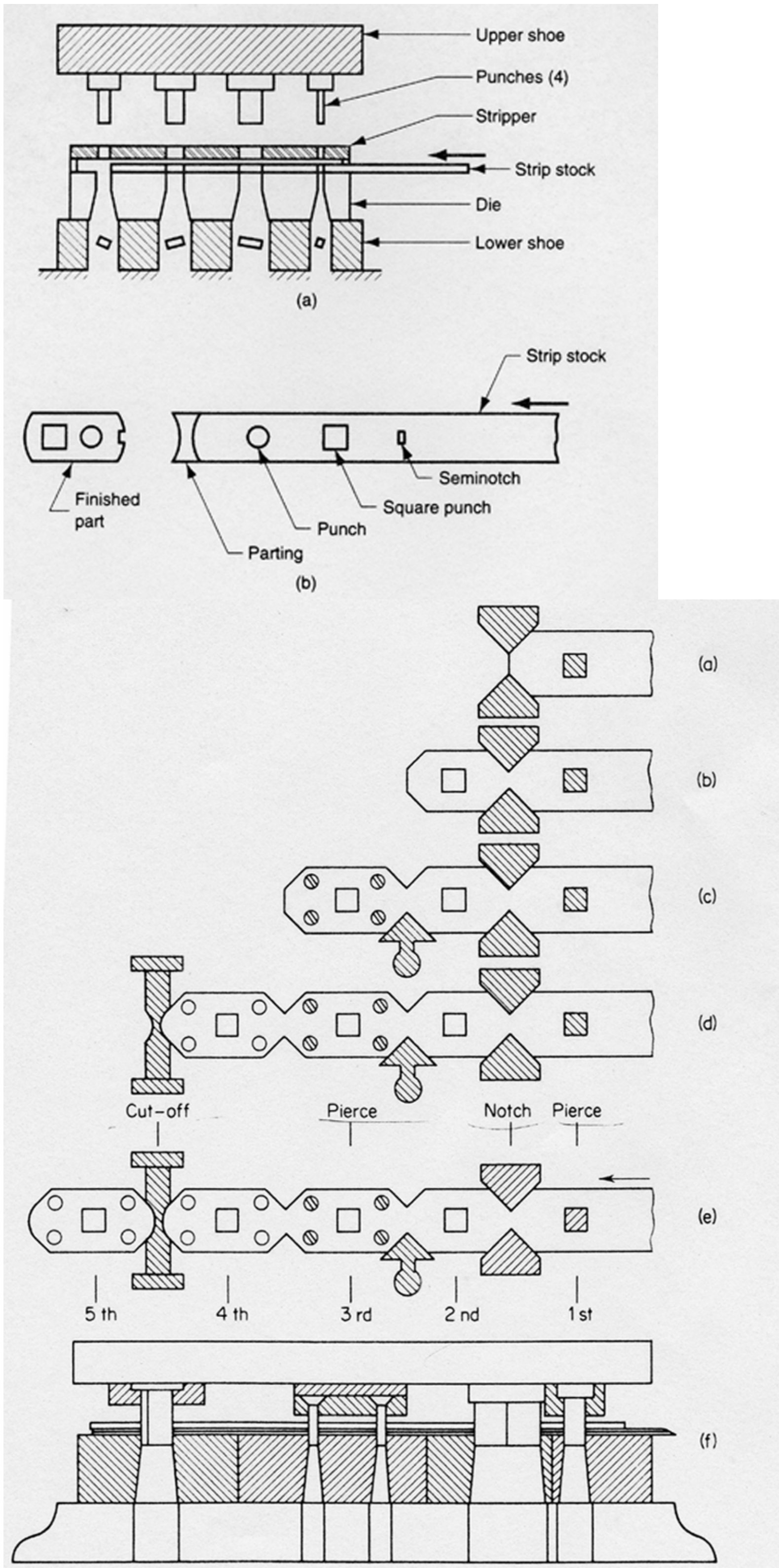
Source: Schey 2000

Figure 3: Powder Metal Parts



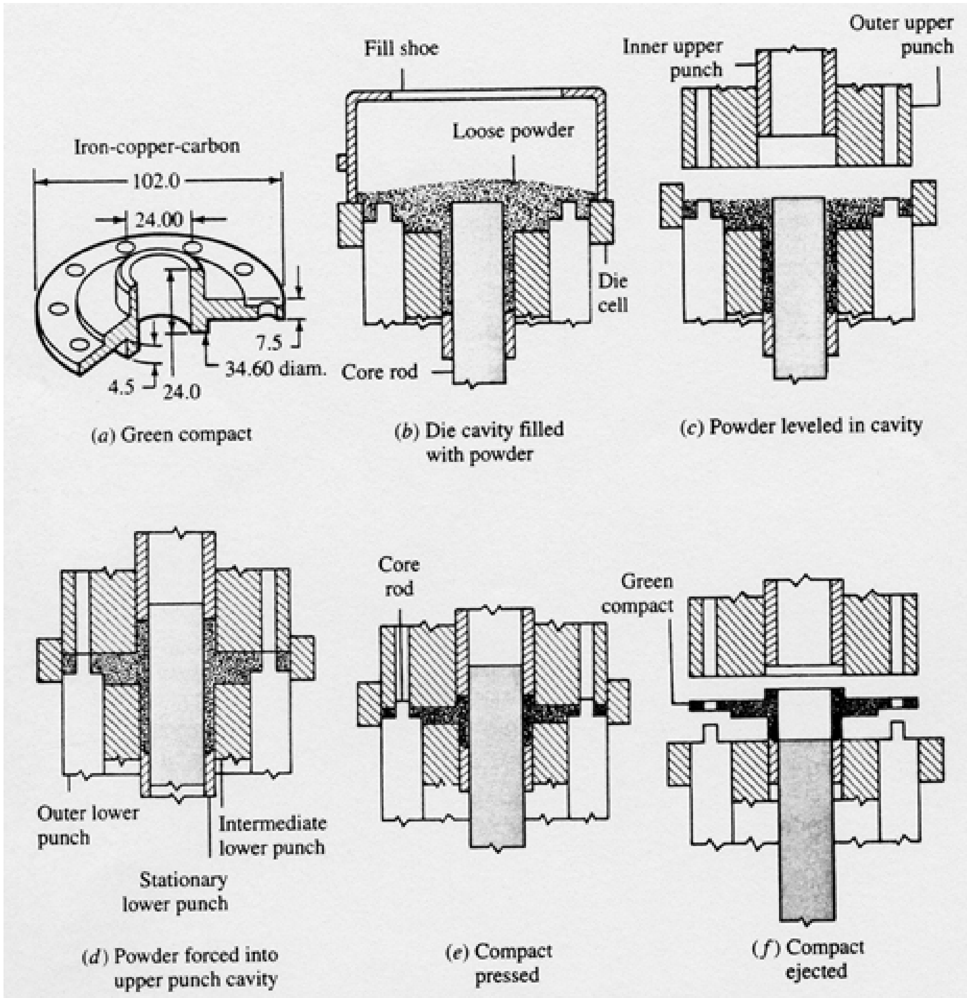
Source: German 1994

Figure 4: Schematic of a Progressive Stamping Die



Source: Groover 2002, Pollack 1987

Figure 5: Schematic of a Powder Metal Conventional Molding Die



Source: Schey 2000

CHAPTER 5

SURVEY DEVELOPMENT, ADMINISTRATION, AND DATA ANALYSIS

This chapter describes the creation and administration of the survey sent to metal forming firms to test the hypotheses regarding how they source die designs, dies themselves, die maintenance, machining, and surface coating services. This chapter emphasizes the connection of the survey to the independent variables of interest, while the next chapter connects these variables to the key dependent variables, primarily the sourcing mode. This chapter also discusses common survey issues, such as response bias, reliability, validity, and missing data. It also provides the methodology and results for the confirmatory factor analyses that statistically relate the survey items with the main independent variables.

Survey Development

Surveys, usually mailed questionnaires, are the most common method of investigating procurement choices (Shelanski and Klein 1995). This is likely because these choices and their antecedents are fine-grained organizational phenomena, unable to be directly observed in archival data, such as that found in standardized databases, annual reports, and other public records. In surveys, the researcher can directly create items that closely reflect their theoretical variables. In contrast, when using archival data, one must use proxies for these variables; these proxies rarely precisely represent the variables and can be "like wearing someone else's shoes" (Singleton, Straits et al. 1993, p. 368).

Surveys use a standardized instrument, such as a questionnaire, to gather data on a select set of variables over a relatively large sample and to allow subsequent statistical analysis of the relationships among these variables and can be used to either describe or explain causal relationships among variables (Babbie 1990). Surveys are appropriate if the data is most efficiently available from respondents' self reports and for a large, geographically dispersed population. This is the case for investigating procurement choices for metal forming firms, since their general managers would be appropriate respondents and these firms are dispersed throughout the US. I used a cross-sectional survey design, which provided me with a snapshot of these firms' procurement behaviors at a single point in time. Later, I may return to this population for follow up surveys, gaining longitudinal or panel data.

Variable Operationalization

Although theoretical concepts typically used in hypotheses have "no real meanings, no ultimate definitions", researchers can create data by ferreting out all the underlying dimensions of variables and constructing questionnaire items to match (Babbie 1990, p. 119). This is done by reviewing existing literature and developing of definitions based in prior work but fitting a specific research question. I also used the exploratory interviews described in the previous chapter to validate how the variables apply to concurrent sourcing in the metal forming context. This provided me with a shared understanding with respondents, increasing the likelihood that respondents will be willing and able to answer (Fowler 1995). To explore how other researchers measured my theoretical variables, I gathered items they created; some items I used directly, others I modified to fit my context. In some cases, I created new items, so that all the items fit both my variable definitions and my particular empirical context. Finally, I edited and culled my item list and formatted a questionnaire by grouping these items together in a logical manner.

When designing individual items, I aimed to make them simple, intelligible, and clear (Converse and Presser 1986). Most of the items are closed ended, seven-point Likert (true/untrue rather than the usual agree/disagree) scales, including a "Not Applicable" option. Using mainly closed-ended items like these should reduce respondent burden and increase their likelihood of finishing the survey (Fowler 1995). However, I did include two open-ended questions in case managers wanted to write at length about sourcing. For most of the main independent variables, I chose to use scales, incorporating several items to measure the concept. Most of these concepts are difficult to measure and somewhat multi-faceted, so having several items is appropriate. Also, any single can be unreliable, ambiguous, or confusing; by using a multi-item scale, items found to be poor indicators can be dropped at the data analysis stage (DeVellis 1991). I reverse scaled some items, to assure the validity of responses (Bagozzi 1994a). As for sequencing, I aimed to group similar items together for ease of comprehension (Edwards et al 1997). This resulted in four sections – sourcing choice and satisfaction; costs and expertise; technology, investments, and evaluation; and demand requirements. I kept the same sequence of items for each input type, slightly altering some items to better fit that input category. I put the firm-level items at the beginning and end of the questionnaire, to draw in respondents and put the potentially more threatening items (firm sales, total firm buy) at the end. I also used closed answer categories for these items to improve accuracy and reduce the likelihood of skipping these items (Fowler 1995). Finally, I attempted to make the opening question applicable to all, intriguing and non-threatening in order to draw in managers and motivate them to continue (Singleton, Straits et al. 1993).

The next sections discuss the process of variable operationalization for each major group of variables. All of the dependent variables are measured at the input level. Supplier management capability is measured at the firm level, but all other independent variables are measured at the input level. Controls are included at both the firm and input level. See the Appendix for a list of all items in the survey in question order and their related variables and item names (used in later analysis). Table 11 may also be helpful as it lists items ultimately used in later analysis by variable type.

Dependent variables

Sourcing mode choice: This variable reflects the sourcing firm's procurement choice for the focal input over the last year. I selected the time period of one year to understand the overall pattern of procurement choices for that input category, rather than for one particular item. For questions such as this that seek to understand respondent behavior, including a time period is essential (Fowler 1995). Other scholars have asked respondents to nominate particular inputs, rather than being given specific categories (e.g., Bottum 1992, Heriot and Kulkarni 2001). However, this may result in a type of self-selection bias such that respondents only mention the most recent, most important, or otherwise most memorable input. I avoided this issue by asking about choices over the entire category and by ensuring that all respondents actually do procure each category. The three sourcing mode choices of interest included all internal production, all external purchases, or a combination of both, the latter of which constitutes concurrent sourcing (making and buying). By "internal production", I mean that the input is sourced from within the same firm. The input may be produced within the same plant or produced in a sister division's facility that shares a corporate parent with the respondent's plant. I also inquired as to the number of outside suppliers, if the input is either entirely externally or if both made and bought. For inputs that are both made and bought, I inquired as to the percentage of the overall volume (unit) requirements that is internally produced and provide a range of response alternatives, since it is unlikely managers will be able to estimate this precisely. Therefore, I end up with two key dependent variables: sourcing mode (SMODE) and percentage made internally (PERMAKE). These items were located in section A of the survey.

Sourcing mode performance: While my theoretical model does not include performance outcomes, it may be useful to have this data for future research. Following other scholars, I defined performance as the sourcing firm's satisfaction over several aspects, including price, quality, delivery, communication, and cooperativeness of suppliers (Noordewier, John et al. 1990; Poppo and Zenger, 1998). The six items that measure performance will be combined into the PERF scale, another potential dependent variable. These items were located in section A of the survey.

Independent Variables related to Production Costs (Hypotheses 1-3)

Firm Expertise This variable reflects the extent to which the internal supplier, the firm, has relatively greater skills and capabilities for producing the focal input. These attributes result from a deep understanding of the technology related to the input and from experience in production. Some of these items were borrowed from prior work (Anderson 1985, Walker and Weber 1984, and Poppo and Zenger 1998). Six items were originally included to measure this variable, however two of them were ultimately reversed and moved to measure supplier expertise. These items have the prefix FEX and were in section B of the survey.

Supplier Expertise This variable reflects the extent to which the external supplier has relatively greater skills and capabilities for producing the focal input, again resulting from experience and understanding of the technology. Some of these items were borrowed from prior work (Anderson 1985, Walker and Weber 1984, Poppo and Zenger 1998, Stump and Heide 1996). I also included a market condition item here to reflect competition and contestability (e.g., the number of capable suppliers), but later moved it to the asset specificity section as a way to better measure market thinness directly. I also included in this variable an item to reflect the relative importance of the purchase. Six items were included to measure this variable and all have the prefix SUPEX and were in section B of the survey.

Scale Economies This variable reflects the volume required to product the input cost-effectively relative to the volume needs of the sourcing firm. There were two items measuring this variable, based on items from Walker and Weber (1984), Lyons (1995), and Poppo and Zenger (1998). Both of these items have the prefix SCALE and were in section B of the survey.

Firm Scope Economies This variable reflects the extent to which the firm can reduce its overall costs by producing the focal input along with its other products. This cost reduction is typically due to better utilization of a shared upstream production input or equipment. Two items were used to measure this variable, based on items from Dutta, et al (1995) and Anderson (1985) and have the prefix FSCOPE. These items were in section B of the survey.

Supplier Scope Economies This variable reflects the extent to which an external supplier could can reduce its overall costs by producing the focal input along with its other products. This cost reduction is typically due to better utilization of a shared upstream production input or equipment. In this case, it can also result from selling the buying firm more than one good. Two items were used to measure this variable, based on items from Dutta et al (1995), had the prefix SUSCOPE, and were in section B of the survey.

Independent Variables Related to Transaction Costs (Hypotheses 4-7)

Performance Ambiguity Similar to Masten's definition of complexity, this variable measures the degree of uncertainty in production outcomes and in the ultimate performance of the input (Masten 1984). I borrowed items measuring the transparency of the production process (Bottum 1992, Bensaou and Anderson 1999). I also included several items to directly measure problems in estimating performance, difficulties in comparing suppliers' offerings, and uncertainties in meeting specifications (Anderson and Weitz 1986, Bottum 1992, Anderson and Schmittlein 1984, Dutta, Bergen et al. 1995, Anderson, Glenn et al. 2000). In all, six items were included for this variable, all with the prefix "PA", and all located in section C of the survey.

<u>Volume Uncertainty</u> Following many other scholars, my definition of this variable involves the difficult in accurately predicting demand volumes of the focal input. This includes quantity fluctuations and changes in requirements (Anderson and Weitz 1986, Maltz 1994) and forecast accuracy (Anderson and Weitz 1986, John and Weitz 1988, Maltz 1994, Bensaou and Anderson 1999). There were eight items measuring this variable, all with the prefix VU and all found in section D of the survey.

<u>Asset Specificity</u> My definition of asset specificity is when an input requires non-redeployable investments that are idiosyncratic to the buyer/supplier dyad. This includes physical assets such as equipment (Masten 1984, Coles and Hesterly 1998, Bensaou and Anderson 1999), human assets such as engineering skills and production know-how (Anderson 1988, Maltz 1994, Masten 1984, Bensaou and Anderson 1999), and organizational assets that intertwine the sourcing firm and suppliers' systems such that switching costs are increased (Anderson and Schmittlein 1984, Heide and Weiss 1995, Poppo and Zenger 1998, Coles and Hesterly 1998, Bensaou and Anderson 1999). I used four items to measure this variable, all with the prefix AS and all found in section C of the survey.

Technological Uncertainty This variable refers to the difficulty in accurately predicting the progress of technology, including the rate of change (Heide and Weiss 1995), the likelihood of change (Walker and Weber 1984, Walker and Weber 1987, Bensaou and Anderson 1999), and the diversity of sources from which new technologies can emerge (Heide and Weiss 1995, Stump and Heide 1996, John and Weitz 1988, Bottum 1992). I used four items to measure this variable, all with the prefix TUN and all found in section C of the survey.

Independent Variable - Supply Management Capability (Hypotheses 8)

I define the supply management capability variable as the ability of the firm to develop and maintain cooperative relationships with suppliers. This includes communication, information exchange, and knowledge sharing (Noordewier, John et al. 1990, Dyer 1997); the length of the relationship (Noordewier, John et al. 1990,. Hoetker 2001); the size of the supply base; the connection of the supply management function to the rest of the firm; the use of supplier evaluation systems (Noordewier, John et al. 1990); responsiveness (Noordewier, John et al. 1990); and reputation (Dyer 1997). Supply management capability differs from the other independent variables since it is measured at the firm, rather than the input, level. I used 23 items to measure this variable, since it is multi-faceted and complex. I divided these 23 items into five groups, long term relationship management (five items with prefix LTR), sharing of information (five items with prefix SHARE), ability to evaluate the performance of suppliers (three items with prefix PEVAL and the type of quality system used), coordination ability (three items with prefix COORD and the number of people in purchasing), and communication (five items with prefix COMM). All of these items are found in sections I and II (the beginning firm sections) of the survey.

Control Variables – Firm Level

Firm size and age I included these variables as controls since larger and older firms may be more likely to vertically integrate (Perry 1989, Williamson 1985). They may also be more likely to have slack resources, such that concurrent sourcing may be more likely. I measure firm size by the number of employees, sales dollar volume, and purchasing dollar volume ("total buy"). I measured firm age by ascertaining the date of firm founding. These items are found in section VIII of the survey.

Customers and products: Automotive customers tend to be more demanding in terms of supplier management, requiring the metal forming firms to attentively manage their suppliers (Womack et al, 1990). To control for this affect on supplier management capability, I asked for the percentage of the firm's sales to the automotive industry. In addition, some products' technological differences may affect the sourcing mode chosen. Therefore, I measured the percentage of ferrous (iron, steel, and stainless steel) products as these are less technologically complex. I flagged powder metal firms, whose parts are more technologically complex than stamped parts. Part diversity may also affect sourcing practices; thus, I measure the number of active part numbers as a control variable. I also asked if the firm is unionized, as that may influence sourcing decisions. These items are found in section VIII of the survey.

Control Variables – Input Level

I included several items related to the inputs as controls. I included two measures of homogeneity of input, to control for the possibility that the input is not uniform and thus firms may buy one version of an input and make another, not truly concurrent sourcing as I have defined it. One item asked that directly ("all requirements are basically the same", ALLSAME) and the other attempted to separate sourcing modes by complexity (" we produce complex inputs in-house and outsource the rest", COMPLEXIN). These two items can be found in section B. I included an item to determine if the firm has additional market contact for this input, whether they make and sell the input (MKNSELL). This may confound the outside influences of suppliers with those of customers. I also included two items measuring stability of the sourcing mode (how long has it been used, HOWLONG; and whether a change is planned, PLANCHG). The three controls just mentioned are all in section A. I also control for the overall significance of the input, I included items measuring the frequency of deliveries ("when did you receive the last one", LASTDLY) and the volume of their requirements ("how many did you require in the most recent fiscal year", VOLUME). These two items are located in section D of the survey. In later analysis, I also included the type of input (design, build, maintain, machine, or coat) as a control variable.

Pretesting, Pilot Study, and Final Design

Prior to launching the survey, I conducted several waves of pretesting. Pretesting the questionnaire and the individual items provides the researcher with valuable feedback about the ultimate utility of the instrument. Specific questions should be pretested to determine sufficient variation in responses, to ensure the meaning is clearly understood, to gauge the difficulty of the task required to answer the question, and to verify that the question is interesting and salient. Pretesting the entire questionnaire allows the researcher to determine if the flow and order of the questions is appropriate, how long it will take respondents to complete the survey, and if respondents tend to lose interest or become fatigued, causing them to break off before completing the entire questionnaire. It also ensures that the survey has face validity, fits the context, and is in a language and format easily comprehended by respondents (Converse and Presser 1986, Fowler 1995).

I followed a four-stage pretest process. First, I asked my colleagues to review the questionnaire for their feedback. I then gained approval from the Internal Review Board; this approval was later extended and appended for the survey mailing itself and for subsequent data analysis and is valid through January 2004. As the second stage, in August 2002, I asked four managers to review the survey, focusing on selected items. I used cognitive interviewing techniques during this process in order to better understand what each of the items meant to them and ensure that this meaning is what is intended by the underlying variable. This developmental pretesting method involved probing questions and asking respondents to "think aloud" as they answer the items (Campanelli 1997). This stage resulted in including several control variables, including items to reflect the importance and variety of the inputs sourced, and in better constructing the machining section. Also, managers told me that they were motivated by the salience of the topic, its educational purpose, and the involvement of their industry associations. These were important items to later include in the cover letter to increase motivation among respondents. More significantly, they informed me that it was too burdensome for them to fill out and that some of the sections should be shortened. In one case, I observed a manager filling out the survey, proving that it was overlong and confusing in some sections. Based on this feedback, I edited and shortened the survey to five sections, one for each input (at one point, I had included sections for two other inputs, die replacement parts and surface finishing). My third stage involved evaluating the results from these developmental stages and revising the items accordingly. At this point, I also sent the survey to industry association executives for their feedback.

For the final pretesting stage, I sent the entire survey to five other managers from the initial exploratory interview group. This was a true pilot test or "polishing" pretest in which I attempted to replicate actual survey conditions as much as possible in terms of cover letters, mailing procedures, data entry and analysis (Babbie 1990). By conducting such a test I was able to better understand how the final rollout of the survey would proceed (Converse and Presser 1986, Fowler 1995). Based upon feedback from the pilot test, I made final but relatively minor revisions to the questionnaire. In all, I made ten significant revisions of the survey from its initial development (the version from the dissertation proposal in June 2002) through its final mailing.

My early pretests indicated that managers would prefer a mail survey to one conducted in person. I also chose to use a self-administered, mail survey since it was too lengthy to do by telephone or on-line. This form is easier to produce and administer and would be more common for most respondents to identify and complete (Edwards et al 1997). For the design of the survey booklet, I followed the advice of Dillman and created a booklet the size of a folded piece of legal-sized paper (7” wide x 8-1/2” long), which could be easily stuffed into standard envelopes (Dillman 2000). Two versions of the survey were constructed: one for stamping firms and another for powder metal firms. They were quite similar, except for the die terminology changed from “progressive stamping” to “conventional molding” for the PM firms and other minor wording differences. I chose to use different colored paper for the individual input sections (light blue for design, pink for build, yellow for maintenance, green for machining, and lavender for coating), with a white front and back cover for the firm-level items. I did this in order to help the survey stand out from other paperwork on a typical manager’s desk and to make the task appear somewhat less daunting (Dillman 2000). I also used a standard template in designing the survey, using bold-faced text for the questions, regular text for the response options, and italic text for the instructions within a question. I used visual cues like arrows and lines to divide sections to improve readability (Dillman 2000). I had the survey printed at the University Copy Center print shop for higher quality copies, their ability to print on colored paper, and to have it bound with a professional black tape binding (total cost to produce 1,000 surveys – 250 powder metal and 750 stamping - $1,417.50). The final printed version consisted of six sections, one for firm data and one each for the five inputs, and was 24 pages in length. A copy of the survey can be found in Appendix B.

Survey Administration

I obtained an initial list of stamping and powder metal firms from their respective industry associations. I assumed that the industry association members are representative of all progressive stamping and powder metal firms in the US population. Since these associations are quite active and are the sole such entities, this is a reasonable assumption. In cooperation with Bill Gaskin, president of the Precision Metalforming Association, and Jim Dale, director of marketing of the Metal Powder Industry Federation, I used their mailing lists as a starting sample frame of potential firms to contact. These lists were available on-line (for the stamping firms in the PMA) and in print (for the powder metal firms in the MPIF). This resulted in a beginning list of 509 firms, omitting all non-US firms but including Canadian ones (n=24), since they would be English speaking and would have common sourcing and end product markets with US firms.

I used each entry on the industry association roster as an independent "firm", assuming that they source independently even if it appeared that they had sister divisions doing similar work (e.g., Wrico Stamping has six stamping facilities within the US; but all are listed separately in the PMA roster). I took the separate entries as evidence that they are treated as a separate entity and thus make sourcing decisions autonomously. I believe this is valid; if each operation truly coordinated with a parent, they would not each have individual listings. Moreover, if coordination for sourcing was the norm, they would ultimately just return one survey. This was evident in my data. For several sister divisions, I sent multiple surveys but only one was returned (e.g., three surveys were sent to divisions of The Brown Corporation, but only one was returned). More often, I received replies from all or a subset of the sister divisions. For example, when I sent six surveys to divisions of Wrico Stamping, three of them did respond, supporting the assumption that they act independently; had they been coordinated, either all six, just one, or none of them would have replied.

The types of inputs I investigated are routinely sourced and quite specific to local plant conditions or a facility's product offerings (e.g., the dies must fit into those particular presses, the coating and machining needs depend upon the parts produced at that location, etc.), so using addressing each of these entities as an autonomous sourcing unit makes sense. This was confirmed by the data; there was little homogeneity among potential sister divisions as to which inputs they reported on, supporting the assumption of their independence regarding sourcing decisions. In the final dataset, about 10% of the firms (20 out of 193) and less than 10% of the inputs (78 out of 809) originated from units that appeared to have such sister divisions.

Between September 25 and October 11, 2002, I called the 509 firms to determine the correct contact person to whom to send the survey and to confirm that they did participate in progressive stamping or powder metallurgy part production. During this conversation, I verified their mailing addresses, obtained fax and email contact data, and confirmed that they were a free-standing entity, not a completely captive producer for a larger parent firm. The above follows Dillman's advice to determine the appropriate respondent and gather several means of contacting that person, paving the way to use a mixed mode design (Dillman 2000). Also, I attempted to determine the person who had the authority, capacity, and motive to respond because that person should be more likely to do so (Tomaskovic-Devey, Leiter et al. 1994). These calls were in lieu of prenotification letters, which are often recommended to increase response rate (Dillman, 2000). However, one of my pretesting managers indicated this type of letter would be considered “junk mail”, so I chose to only use the screening calls to notify respondents that the surveys would be forthcoming. These calls resulted in a viable mailing list of 453 firms.

Actions to Improve Response – Motivation and Multiple Contacts

In administering the survey, I took several actions to increase the potential response rate. Letters were customized by firm for a specific respondent and were distinct by industry. These letters attempted to motivate respondents with the salience of the topic being studied and the opportunity to assist a doctoral student at a major, well-known university. Such motivation is vital to increasing survey response (Edwards et al 1997; Dillman 2000). The relevant industry association executive and I co-signed each letter in ink. In some cases, the industry association executive also included hand-written notes (e.g., “Bob, I hope you can help out with this.”). Stickers with the industry association logos were affixed to the outside of the envelopes, which had the University of Michigan Business School logo and address. For the powder metal firms, Jim Dale also promoted participation in the survey by contacting all members by email. I also included a small incentive, a University of Michigan Business School window decal. Stamped, addressed return envelopes were included for ease of return. The return envelopes were coded with a firm identification number, so that the replies could be matched with the firm mailing list, in case the respondent declined to write in the name of his firm on the survey itself. Many of the procedures involved in assembling and mailing the survey involved tedious details, such as determining the type of envelope or postage to use, but these "mundane matters are vital to high quality scientific research" (Babbie 1990, p. 186).

On October 22, I mailed 453 surveys; 87 to powder metal firms and 366 to stamping firms. This initial mailing yielded 40 completed and usable surveys. Total costs for these mailings were $638 ($0.83 per survey to send plus $0.60 for the return envelope; Canadian mailings were slightly more expensive). On November 4, I then sent reminder messages by email, if I had a correct personal address, or otherwise by fax. This resulted in an additional 61 good surveys returned. On November 20, I sent a second wave of surveys out to 330 firms that still had not replied (costing $517); this resulted in 52 good surveys being returned. During the week of December 12, I made 275 follow up phone calls to solicit survey completion; this yielded 16 more completed surveys. Finally, on December 17, I sent out another 38 surveys ($52) to contacts that I had just spoken with by telephone and who indicated they needed a replacement copy. This last contact resulted in 24 usable surveys being returned. Throughout this period I also received a total of 25 other replies from firms, indicating that it was against company policy to fill out surveys, that their firm did not participate in progressive stamping or powder metal, or for some other reason they chose not to participate and therefore returned an unusable survey. See Appendix A for copies of the cover letters from each of the three mailings and for the text of the email/fax follow up message.

Overall, I made between two and six contacts with each of the 453 target firms, by phone, mail, and fax/electronic mail, resulting in 218 replies (48.1% total response rate), and 193 firms returning usable surveys, a 42.6% usable response rate. This response rate is significantly higher than 20% that is typical for firm surveys (Paxson et al 1995). These 193 surveys represented 809 usable inputs for subsequent analysis, satisfying sample size requirements for most techniques.

Assessing Potential Response Bias

The demographics for the respondent firms were rather unique as compared to those found in a typical organizational survey. Respondent firms were small (average size 2.45 on a 5 point scale, representing about 75 employees; 95% of the respondents had less than 500 employees), non-union (86%), and fairly old (average age: 44 years). Powder metal firms tended to be slightly larger and younger than the stamping firms. I also compared respondents to non-respondents by firm type and size, to check for any potential non-response bias (Armstrong and Overton, 1977, McEvily and Zaheer 1999). I mailed surveys to 453 firms, 87 of which were powder metal (19.2%); the proportion of powder metal firms in my set of usable respondents (21.2%) was not significantly different (p-value=0.281), indicating that neither type of firm was overrepresented in my dataset (Wonnacott and Wonnacott 1990).

In addition to firm type, I also checked the difference in firm size between respondents and non-respondents. I gathered employment figures for the non-responding firms from the PMA industry association directory or the Dun & Bradstreet Million Dollar Directory, and found data for 235 of the 260 non-responding firms. The average size for non-respondents was 2.22 on my five-point scale, significantly smaller than that of my respondents ($t = -2.11$, $p = 0.036$). However, this is likely due to the fact that more of the non-respondents were stamping firms, which typically are smaller in size. When I adjusted the data and looked at the stamping and powder metal non-respondents vs. respondents separately, I found no statistical difference (stamping firms: non-respondents' average = 2.15 vs. respondents' average = 2.36, $t = -1.76$, $p = 0.08$; powder metal firms: non-respondents' average = 2.62 vs. respondents' average = 2.80, $t = -0.71$, $p = 0.48$). Therefore, I am confident my respondents are similar to those firms that did not respond and my data does not suffer from non-response bias. My sample is based upon industry association listings that should represent the overall firm populations, making sample selection bias unlikely. I also used several control variables in the subsequent analysis, which should further reduce any potential hint of bias (Tomaskovic-Devey, Leiter et al. 1994).

Data Analysis and Scale Creation – Methods

This section will discuss the data entry, cleaning, and analysis activities that determined which items were ultimately used to represent the main variables. It also discusses the construction of the final datasets that eventually were used to investigate the relationships between the independent and dependent variables. This preparatory work was vital in understanding the data and gaining confidence that the survey truly measured the abstract concepts framed by the hypotheses.

Data Entry and Descriptive Statistics

The data was keyed directly off the surveys and entered into Microsoft Access software, using a form with validation rules set on the variables to limit mistakes upon entry (e.g., values had to be within the relevant range, between 1 and 9). Most of the survey items were scaled from 1 to 7; the value of 8 was used for a "not applicable" reply and 9 was used for blank or unanswered items. The items that would later need to be reversed included a suffix "orig" and all items for a common variable had a similar syntax (e.g., TUN1, TUN2, etc.). In this way, the raw data from the surveys is retained in Access tables in its original form. Inputs were only entered if the main dependent variable (sourcing mode) was filled out on the survey, with a final tally of 193 firm and 809 input records. Firm data was kept structurally separate from input data, with a firm identification number in the input dataset that linked the two sets. This separation was necessary since one of the main variables of interest, supplier management capability, was a firm-level variable, while most of the other variables (e.g., technological uncertainty) were at the input level. The data was then ported into SPSS, where some of the items were reversed in order for all items to be in the same direction for ease of later analysis. Further screening was conducted to remove out of range values and convert the 8/9 values to missing data values. Descriptive statistics were computed which assisted in catching data entry errors and determining the extent of missing data (see section below for additional details). The descriptive statistics basically support the assumptions of multivariate normality, which was necessary for subsequent statistical analysis. At this stage, five items were dropped due to extremely high or low means (VU7 and VU8), non-normality (number of people in purchasing) or severely missing data (SUPEX5 and the number of people who filled out survey). Note also that one item (PA5) originally should have been reversed in order to be aligned with the other items in its group but was this was inadvertently missed. Therefore, the actual item used (PA5R) is named as if it were reversed is actually in the correct orientation. Also, a few items have retained the suffix of “orig” since they were either found to have been mistakenly reversed (LTR3ORIG, LTR5ORIG) or ultimately moved to different scales (FEX5ORIG, FEX6ORIG). See Tables 2 – 6 for descriptive statistics of all items, grouped by variable type. See also Appendix C for a listing of survey items in order with their accompanying variable.

Reliability

The next stage of data analysis involved linking the individual items to the larger variables, or factors. In the sourcing model, all independent variables are latent, reflecting values or capabilities that are “intrinsically not measurable but related to measurable factors” (Kmenta 1997, p. 581). This implies that a measurement model must be formulated that connects the latent variables to the observed variables, the question items (Bollen 1989). As a first step in creating this measurement model, items were first verified for their reliability.

Reliability reflects repeatability, the “agreement between independent attempts to measure the same construct” (Bagozzi 1994b). Items high in reliability are highly correlated; for greater reliability, researchers should strive for a few, highly correlated items that precisely reflect the variable rather than a larger number of items that refer to issues peripheral to the variable. The standard measure of reliability is Cronbach's alpha (Cronbach 1951). Measured on a scale from 0 to 1, reliability for each item should be at least 0.50 for exploratory work and preferably over 0.70 for later stages of research (Nunnally 1967, Nunnally 1978).

The measure above assumes that the variables are unidimensional and that each item has the same relationship to each variable, meaning the same factor loadings. Different modeling methods, such as structural equation modeling, can overcome these assumptions and allow for items that have differential explanatory power by including the factor loadings, as well as item and item variances, in the computation of reliability (Bagozzi 1994b). A composite measure of reliability can be computed if the best relationship between the items and the variable is congeneric, meaning that each item has a different loading or weight associated with the variable (Fornell and Larcker 1981, Bagozzi 1994). This measure sums the squares of the loadings and divides this by this figure plus the variances. In following sections, I use whichever metric is appropriate for the measurement model chosen.

Factor Structure – Exploratory Factor Analysis (EFA)

While reliability analysis can assist in determining how items are related, it assumes a single factor structure. Exploratory factor analysis can further investigate this assumption and determine if it is valid or if multiple factors may exist (Tabachnick and Fidell, 1989). Based upon the correlations between the items, factors are extracted typically using the criteria of a minimum eigenvalue, the sum of the squared loadings of the items on that factor, equal to one. Additional insight can be gained from scree plots that graph the eigenvalues; the point in the plot at which the line becomes fairly horizontal indicates the number of factors that could reasonably be extracted (Kim and Mueller 1984). In EFA, all items are assumed to be related to all factors and the factors can be rotated to be orthogonal (e.g., varimax) or oblique (e.g., direct oblimin) in order to obtain a structure with higher loadings for the items (0.30 or better), ideally on each on a single factor (Pedhazur and Schmelkin 1991; Hair et al 1995).

Methods of extraction can be broadly classed into two types. First, principal components analysis, which reduces the data and extracts maximum total variance, is based upon formative indicators of a factor, such as in a typical index construction. In this type, the factors are essentially dependent variables that are fully explained by the independent linear indicators. In the usual illustration of factor models, this would mean arrows drawn from the indicator boxes toward the factor circles and no error variance on the indicators. Second and more typical, is common factor analysis that assumes reflective indicators are the dependent variables and that common factors explain a substantial amount of the variance and act as linear independent variables. The illustration of this type would be arrows drawn from the factor circles toward the indicator boxes, which would also have error variances (all uncorrelated) drawn into them. Extraction methods for this latter type of EFA include principal axis factoring or maximum likelihood estimation. (Kim and Mueller 1984, Pedhazur and Schmelkin 1991, Edwards and Bagozzi 2000). Minimum sample sizes for either type of EFA seem to be between 150 and 200 (Nunnally 1978; Pedhazur and Schmelkin 1991).

EFA complements later confirmatory factor analysis (CFA), particularly in cases where scales have not already been developed extensively and can be profitably used prior to CFA (Anderson and Gerbing 1988; Hurley et al 1997). In the following sections describing my data, I use the two-step approach of EFA then CFA to support my intuition based upon item intercorrelations that in some cases more than one factor may be underlying the theoretical variable. I follow Pedhazur and Smelkin's advice, that EFA is part of the process of determining construct validity and "meaningful application of (E)FA is unthinkable without theory" (Pedhazur and Smelkin, 1991, p. 591).

Factor Structure and Validity – Confirmatory Factor Analysis (CFA)

After conducting reliability computations and using EFA to get a sense of the number of factors that emerge from the data, confirmatory factor analysis (CFA) can then be used to flesh out the actual measurement model and support its validity. Reliability and validity reflect different properties of the question items, their repeatability and their accuracy. Items measuring the same latent variable should be highly reliable and valid. As a metric of replication, reliability provides an upper bound and a necessary but not sufficient condition for validity, the degree to which an item adequately represents the latent variable and measures what it is intended to measure (Bagozzi 1994a).

Determining the validity of an item is a matter of providing evidence and cannot be indisputably proven (Bagozzi, 1994a). Primary types of validity include criterion, content, and construct. Criterion validity refers to the predictive ability of an item, how well it relates to other items. Content validity reflects the consistency of the items and the degree to which they emanate from a common variable. This type of validity refers to the theoretical meaningfulness of the items, is based on reason and logic, and cannot be empirically determined. In practice, content validity is determined by theoretical arguments, sound survey construction, and pretesting.

Construct validity is empirically determined and reflects the extent to which the operationalizations of a variable, or factor, actually measure that variable. Computing construct validity involves calculating the convergent and discriminant validities. Convergent validity reflects the degree to which multiple items agree and discriminant validity refers to the degree to which items measuring different variables are actually different. Thus, if items all load significantly on a particular factor and are highly correlated and thus reliable, they display convergent validity; if two factors are not highly correlated with each other, they display discriminant validity (Anderson and Gerbing, 1988). Ideally for CFA, each item must only be tied to a single variable; if this is not the case, clear discriminant validity cannot be determined. Items that do not strongly relate to the latent variables or relate to several variables can be dropped. However, variables do not have to be unidimensional; a second order CFA can be conducted for variables having subcomponents (Bagozzi 1994b).

Convergent and discriminant validities can be tested by constructing a measurement model using CFA. The measurement model conducted using CFA tests the strength of the empirical relationships between the items and their latent variables and is a subset of structural equation modeling methods. This analysis assumes the items are reflective indicators of latent variables and the analyst selects which items load onto which factors, as compared to EFA where all items are assumed to load onto all factors. In a standard CFA, only loadings connecting items and their corresponding variables will be estimated; others will be set to zero. To avoid identification problems, at least three items of each variable are required (Bollen 1989). CFA can determine if any item correlations exist, how the variables are correlated, and error relationships. Typically, maximum likelihood estimation is used, comparing the sample and the theoretical covariance matrices to determine the best fitting parameters. Assuming there are p indicators (x) and m latent variables (ξ), the following matrix equation and table depict the CFA model:

Indicator (or item) equation: $x = \Lambda_x \xi + \delta$

Variance-Covariance of indicators: $\Sigma_x = \Lambda_x \Phi \Lambda_x' + \Theta_\delta$

Matrix	Dimension	Description	Covariance matrix	Dimension of covariance matrix
x	p x 1	Indicators of latent variables		
Λ_x	p x m	Loadings of indicators onto latent variables		
ξ	m x 1	Latent variables	Φ	m x m
δ	p x 1	Random errors for indicators of latent variables	θ_δ	p x p

Assumptions inherent in the measurement model include standardization of the latent variables ($E(\xi)=0$), the expected value of the error term is zero ($E(\delta)=0$), the number of indicators is greater than the number of latent variables ($p>m$), errors and latent variables are uncorrelated ($E(\xi,\delta')=0$, and both indicators and latent variables are distributed normally. To standardize the latent variables and set the scale variance, I set their variance equal to one (Bagozzi, 1994a).

The data appears to be reasonably multivariate normal, fitting that assumption. Sample size is also sufficient; for the firm-level measures, the sample size of 193 is greater 150 as suggested by Anderson and Gerbing (1988) and also fits the recommendation of having five or more observations per parameter as recommended by Bentler and Chou (1987). The input-level sample size of 809 records also fits these recommendations. All CFA analysis was done using the AMOS software, since it uses full information maximum likelihood techniques and thus can account for missing data (Arbuckle 1996).

Evaluating CFA models is a multi-stage process. First, one can check for significance of the loadings of the items on the factors and other parameters. Next, one can check the match of the sample covariance matrix with the population covariance matrix as a function of the parameters. If the difference is small, the fit is good and the p-value of the chi square statistic will be insignificant. However, this statistic is affected by sample size and is often significant when sample sizes are large or multivariate normality does not hold (Jöreskog and Sörbom, 1996). Hu and Bentler (1998) suggest that using chi-square tests alone may be too strong to be realistic and supplementary metrics should also be used. There is no dearth of alternatives; most CFA software packages provide a score or more of measures, a veritable alphabet soup of choices. As Hu and Bentler acknowledge, "applied researchers inevitably face a constant challenge in selecting appropriate fit indices among a large number of fit indices that have recently become available in many popular structural equation modeling programs" (Hu and Bentler, 1998).

I evaluate the models through six indices, following the advice of Pedazhur and Schmelkin who suggest that "exclusive reliance on one kind of index is unwise" (Pedazhur and Schmelkin, 1991 p 657) and the recommendations of Hu and Bentler (1998). First, I checked the chi-square statistic for the significance of the p-value. Second, I divided this figure by the degrees of freedom, a metric termed the discrepancy index. This figure should be small, preferably under 5 to support adequate model fit (Arbuckle and Wothke 1999). Third, I checked the root mean square error of approximation, RMSEA, which like the two other indices is an absolute measure of fit, but does not penalize for model complexity. Close fitting models have an RMSEA of less than 0.05; a value of 0.08 reflects a reasonable fit, and a figure of less than 0.10 suggests an adequate fit (Hu and Bentler 1998; Arbuckle and Worthe 1999). Since these three indices are all absolute in nature, I also chose some comparative fit indices. The fourth metric I used was the Tucker-Lewis index (TLI; also sometimes called the non-normed fit index or NNFI), which is between 0 and 1 with a value of 0.90 or better indicating close model fit (Bentler and Bonnet 1980). My fifth metric, the comparative fit index or CFI, is also known as the relative noncentrality index (RNI). This comparative index is similar to the TLI and likewise is bounded between 0 and 1 with a value of 0.90 or better indicating close model fit (Bentler and Bonnet 1980). All of the above measures can be calculated in cases of missing data. When I had complete data, I also checked the GFI, the goodness of fit index, which also is bounded by 0 and 1, again with a value of 0.90 or better being preferred (Jorsekog and Sorbom 1996, Bentler and Bonnet 1980).

The last stage of model evaluation involves comparing nested models using likelihood ratio tests of unrestricted versus restricted models. Using a chi-square difference test, if the more parsiminous or restricted model is not significantly different from the more complex one, the simpler model should be used (Bollen 1989). One standard restriction is to test the equality of the item loadings on the factor; if all loadings and error variances are equivalent, the model is said to be parallel; if the loadings are the same but the errors vary, the model is tau-equivalent; if both the loadings and the errors vary, the model is congeneric (Bollen 1989). The CFA loadings can be used both to confirm that the items do fit together within the same scale and also to calculate item weights to be used for composite scale measures, which I do in a later section of this chapter.

Data Analysis and Scale Creation - Results

The following section provides the details of the EFA and CFA data analysis. Following other scholars (Anderson and Gerbing 1988, Atuahene-Gima and Li 2002), I began with submodels for six scales – one for performance, two related to production costs (firm expertise and supplier expertise), one related to transaction costs (performance ambiguity), and two for supplier management capability (performance evaluation ability and relationship management skills). For these models, I checked that the items loaded sufficiently and tested the best loading pattern (e.g., tau vs. congeneric), as well as tested for unidimensionality of the factor, reliability of the scale, and overall model fit. Next, I grouped the scales into three larger models (production costs, transaction costs, and supplier management capability) that incorporated some scales that could not be analyzed independently due to identification issues originating from a small number of items (three or less) for that scale. My final analysis consisted of two main models: a model combining the production and transaction cost variables and the supplier management capability model mentioned above. I kept these models separate since the former reflects input-level characteristics while the latter reflects firm-level characteristics. All of these models were estimated in AMOS using full information maximum likelihood techniques, which can adjust parameter estimates to account for missing data. I also verified these models with the smaller complete dataset, giving me confidence in the resulting scales (Roth 1994).

Performance

To create this scale, I first noted that the correlations among the six items were reasonably high and the Cronbach's alpha indicating reliability was very good (0.88). Exploratory factor analysis clearly indicated one single factor. This was corroborated by confirmatory factor analysis that supported a one-factor, congeneric model for the six items as the best fitting (chi-square 59.3, 9 degrees of freedom, TLI 0.993, CFI 0.997, RMSEA 0.083). A model with all items equally weighted degraded the fit (chi square 140.1, 14 degrees of freedom, chi-square difference test $p<0.001$). For scale construction and subsequent analysis, only the 743 records for which I have complete data will be used since this scale represents one of the dependent variables.

Production Cost Variables

Firm Expertise

The survey contained six items measuring firm expertise related to the focal input and although these items were reasonably consistent (alpha = .69), the relationship between them became even stronger once two items were moved and reversed to fit on the supplier expertise scale. These two items measured the relative cost or quality level of the focal firm versus the supplier, rather than the firm's direct production or technical expertise related to the input. The remaining four items have a Cronbach's alpha of 0.78. When CFA was applied, a congeneric model fit better than than the tau-equivalent model (congeneric chi-square = 2.70, 2 degrees of freedom, p=0.26, chi-square/dof=1.348, TLI=0.999, CFI=1.00, RMSEA=0.02; chi-square of tau-equivalent model =102.05, 5 degrees of freedom, chi-square difference between the models p<.001). The resulting composite reliability was 0.81. I then attempted to combine the firm scope items with this variable, but the fit was poor (chi-square 131.63, 9 degrees of freedom), supporting the theoretical position that these are two distinct variables.

A two factor model was much better, with two items on the firm scope factor and four items on the firm expertise factor, with all items being congeneric (chi-square = 20.04, 8 degrees of freedom, p=0.01, chi-square/dof=2.51, CFI=0.999, RMSEA=0.043; if scope items were set as tau-equivalent, chi-square difference = 242.88, 2 degrees of freedom, p<0.001). Moreover, the two factors were clearly distinct. The above oblique model fit best and 1 was not in the confidence interval of the factors' covariance; a model fixing the covariance to 1 was inferior (chi square difference 111.59, 1 degree of freedom, $p<0.001$). The orthogonal model was not identified due to only having two items on the firm scope factor.

Supplier Expertise

The survey contained six items measuring supplier expertise, but one of these items fit better with the asset specificity variable as it measured the size of the market. Two other items were omitted, one had an unusually high mean and the other contained an implicit calculation and was vaguely worded. This left a total of five items -- three supplier expertise items and two items moved from the firm expertise scale as mentioned above. The Cronbach's alpha for these items was 0.49. When CFA was applied to these items, a congeneric model fit best (chi-square = 12.25, 5 degrees of freedom, p=0.03, chi-square/dof=2.451, TLI=0.996, CFI=0.999, RMSEA=0.042; if items were set as tau-equivalent, chi-square difference = 16.06, 4 degrees of freedom, p=0.003). The composite reliability for these items was 0.50. This marginal figure is likely due to the fact that two of the items compared the firm versus the supplier's abilities on price and quality while the other three items focused more on the technical skills of the supplier. Diverse items like this will reduce overall reliability, but a sensitivity analysis conducted by dropping individual items showed that reliability actually got worse if any of the items were dropped. Therefore, I chose to leave the scale of five items intact. The fit degraded when the item measuring supplier scope was added, indicating that this was indeed a separate variable (chi-square = 32.92, 9 degrees of freedom, p=.000, chi-square/dof=3.66, CFI=0.996, RMSEA=0.057). A two factor model could not be tested in this case, since only one item measured the scope variable.

Scale Economies

Originally, two survey items were included to measure the degree of scale economies of the input. However, due to unclear wording and a higher proportion of missing data, one item was dropped. The retained item is very similar to an item that had been used by Lyons 1995. Given that there is only one item for this variable, I could not analyze it alone using CFA, but rather analyzed it along with the other variables related to production costs.

Firm Scope Economies

Two survey items were included to measure the degree of scope economies that the firm gains from producing the focal input along with its other production items. These items were strongly correlated and had a Cronbach's alpha of 0.75. Given that there are only two items for this variable, I could not analyze it alone using CFA, but rather analyzed it along with the other variables related to production costs.

Supplier Scope Economies

Originally, two survey items were included to measure the degree of scope economies that suppliers gain through producing the focal input. However, due to a high proportion of missing data (27%), one item was dropped. The retained item is also worded similarly to one of the items measuring firm scope economies, so I felt confident that the correct item was being retained. Given that there is only one item for this variable, I could not analyze it alone using CFA, but rather analyzed it along with the other variables related to production costs.

Overall Production Cost Model

To test the factor structure of the constructs representing all the aspects of production cost, I included firm expertise (four items), supplier expertise (five items), supplier scope (one item), firm scope (two items), and scale economies (one item) in one model. I used a congeneric structure for all items and allowed the three variables for which I had multiple measures to be correlated. This model fit reasonably well (chi-square = 394.19, 64 degrees of freedom, $p<0.001$, chi-square/dof=6.16, TLI=0.973, CFI=0.981, RMSEA=0.080) and indicated that the factors were indeed distinct as all the covariances were significantly different from one. A fully orthogonal model could not be tested due to identification issues, but a model omitting the correlation between supplier expertise and firm scope fit worse than the more inclusive model (chi square difference 96.73, 1 degree of freedom, $p<0.001$).

From all of the above model comparisons, I conclude that production cost can be modeled as five separate factors: firm expertise (FEX), supplier expertise (SUPEX), firm scope economies (FSCOPE), supplier scope economies (SUSCOPE), and scale economies (SCALE). This model satisfies convergent validity as the respective items load significantly and have adequate reliabilities; it also satisfies the divergent validity criteria as the correlations among the factors are significantly less than one. A summary of the final subscales and model are presented in Table 7 and a graph is depicted in Figure 6.

Transaction Cost Variables

Performance Ambiguity

Six items were originally designed to measure performance ambiguity and were reasonably correlated and consistent (Cronbach's alpha=0.58) and exploratory factor analysis indicated that they all grouped onto one variable. This relatively low reliability may be due to the variety of items in the scale; two items refer to inspection, one to problem solving, one to descriptions, and the final one to equitably measuring and comparing suppliers against each other. However, reliability decreased if any of these items were dropped and, since each of these aspects is logically part of the overall construct of difficulty in measuring performance, I opted to keep them all in the scale. Subsequent confirmatory factor analysis showed an improved fit by omitting one item and by using a congeneric model (for the five item model: chi-square= 9.87, 5 degrees of freedom, p=0.08, chi-square/dof=1.974, TLI=0.998, CFI=0.99, RMSEA=0.035). A tau-equivalent model degraded the fit (chi-square= 53.35, 9 degrees of freedom, chi-square difference p<0.001).

Volume Uncertainty

Originally, eight items were included on the survey to measure volume uncertainty, however two items were dropped due to extremely high or low means and another was dropped due to double-barreled wording. The remaining five items were well correlated and had sufficient reliability (Cronbach's alpha = 0.63). However, exploratory factor analysis showed the presence of two factors. One factor, unpredictability of forecasts, involved two items with a reliability of 0.71 and the other factor, changes in requirements, involved three items with a reliability of 0.73. Subsequent CFA indicated that the five items did not fit well together (chi-square 258.14, 5 degrees of freedom, p<0.001), but the two factor model could not be tested alone due to identification issues (Bollen 1989).

Asset Specificity

Originally, four items were included on the survey to measure asset specificity. However, one of the original supplier expertise items (number of suppliers in the market) was found to fit better with these items. The original analyses of these five items indicated reasonable consistency (Cronbach's alpha=0.55) but exploratory factor analysis showed the presence of two factors. One factor, specialization of assets, involved two items with a reliability (Cronbach's alpha) of 0.60 and the other factor, market thinness, involved three items with a reliability of 0.61. Subsequent CFA indicated that the five items did not fit well together (chi-square 147.05, 5 degrees of freedom, p<0.001), but the two factor model could not be tested alone due to identification issues (Bollen 1989).

Technological Uncertainty

Four items were designed to measure technological uncertainty, but one of the items was not positively correlated with the other three and was missing considerably more data, resulting in three remaining items to measure this variable. These three items were consistent (Cronbach's alpha = 0.74). When confirmatory factor analysis was conducted on the original four item scale, the fourth item had a negative parameter estimate, not fitting well with the other three items and supporting its omission. CFA could not be performed on the three-item scale alone as it was perfectly identified (Bollen 1989).

Overall Transaction Cost Model

To test the overall factor structure of the variables representing all the aspects of transaction costs, I included performance ambiguity (five items), technological uncertainty (three items), asset specialization (two items), market thinness (three items), volume unpredictability (two items), and volume changeability (three items). I first used a congeneric structure for all items and included all 15 covariances, connecting all six of the above variables (chi-square 409.63, 120 degrees of freedom). I then altered the structure of the asset specialization and volume unpredictability variables to set them to be tau-equivalent; this ensured significance of all variance parameters and fit equally well to the first model (chi square 414.25, 122 degrees of freedom, chi-square difference $p= 0.10$). I then omitted the seven covariances between the variables that were not significant, resulting in a model with eight covariances, two variables measured as tau-equivalent, and four variables measured as congeneric. This final more parsimonious model fit the data well (chi-square= 420.67, 129 degrees of freedom, $p<0.001$, chi-square/dof=3.26, TLI=0.986, CFI=0.989, RMSEA=0.053) and was not significantly different than the original model (chi-square difference $p=0.27$) thus it should be used. This final model also indicated that the factors were indeed distinct as all the remaining covariances were significantly different from one. A fully orthogonal model was not an admissible solution, nor were other models in which any of the seven significant covariances mentioned above were set to zero.

From all of the above model comparisons, I conclude that transaction costs can be modeled as six separate factors: performance ambiguity (PA), technological uncertainty (TU), asset specialization (SPEC), market thinness (MTHIN), volume unpredictability (UNPRED), and volume changes in requirements (CHG). This model satisfies convergent validity as the respective items load significantly and have adequate reliabilities; it also satisfies divergent validity criteria as the correlations among the factors are significantly less than one. A summary of the final subscales and model are presented in Table 8 and pictorially in Figure 7.

Model Incorporating Production and Transaction Costs

I next constructed a model incorporating the two above models for production and transaction costs. My first model used the relationships between the individual variables as in the above models but included no relationships between any of the production cost variables and any of the transaction cost variables (chi-square 1679.97, 427 degrees of freedom). I then relaxed these restrictions, testing the supplier expertise, firm expertise, and firm scope variables individually against the six transaction cost variables. I also did this test in the reverse direction – first connecting all variables and then iteratively dropping covariances that were not significant. Ultimately, I found six significant relationships between production cost related variables and transaction cost related variables. The significant covariances were between supplier expertise and technological uncertainty, supplier expertise and volume changeability, firm expertise and performance ambiguity, firm expertise and asset specialization, firm scope and performance ambiguity, and between firm scope and asset specialization. However, in all cases, none of these relationships were significantly close to 1, thus divergent validity among all the variables can be supported. This model containing 17 covariances among the variables sufficiently fit the data (chi-square= 1521.642, 421 degrees of freedom, $p<0.001$, chi-square/dof=3.614, TLI=0.972, CFI=0.976, RMSEA=0.057). All parameter estimates were significant ($p<0.02$), supporting convergent validity, with all variables measured congenerically, with the exception of asset specialization and volume unpredictability that were measured as being tau-equivalent. Details of this model are provided in Table 9 and Figure 8.

Supply Management Capability

To create this independent variable scale, I first reversed the relevant items so that all items were aligned in the same direction and also adjusting the coding for missing data values. Next, I investigated the descriptive statistics and correlations among the 23 items related to this construct. I omitted two items based upon non-normality (LTR1 – overall opinion of suppliers) and significant missing data (# in purchasing). I then computed the reliability of the remaining items (initial Cronbach's alpha = .63), deleting individual items until the reliability could not be improved. This resulted in a remaining pool of 15 items, with a Cronbach's alpha of 0.73. However, exploratory factor analysis indicated that this was not a unidimensional construct; the items appeared to cluster into three groups: performance evaluation (PEVAL), sharing of information (SHARE), and relationship management (RELN). These three subscales have four, three, and eight items, with initial reliabilities as measured by alpha of 0.64, 0.56, and 0.50 respectively.

I then analyzed the data using confirmatory factor analysis, first looking at each scale and then the overall model for this larger construct. The PEVAL scale was shown to have a good fit and was best modeled as being congeneric on the PEVAL factor (chi-square = 1.941, 2 degrees of freedom, chi-square/dof= 0.971, p=0.38, TLI=1.00, CFI=1.00, RMSEA=0.00; chi-square of tau-equivalent model = 35.981, 5 degrees of freedom, chi-square difference p<0.001; chi-square of parallel model=109.186, 8 degrees of freedom, chi-square difference p<0.001). The loadings of all four items were significant and the reliability of this scale was 0.68, indicating that this scale has convergent validity. Note that the Cronbach's alpha formula assumes that the factor is unidimensional and items are tau equivalent; using that formula, the reliability for this scale was 0.64. I used a composite reliability formula that better captures the differential weighting of the items for the reliability figure above (Bagozzi 1994, Fornell and Larcker 1981).

I then looked at the RELN subscale using CFA, beginning with the eight items from the initial analysis. This model resulted in non-significant estimates for two of the items, so they were dropped from subsequent models. The resulting six item scale was shown to have a good fit and was best modeled as tau-equivalent (chi-square 29.022, 14 degrees of freedom, p=.01, chi-square/dof = 2.073, TLI=0.973, CFI=0.995, RMSEA = 0.075; congeneric chi-square 21.243, 9 degrees of freedom, chi-square difference test p=0.17; parallel chi-square 220.689, 19 degrees of freedom, chi-square difference test p<.001). The loadings for all six items were significant and the reliability of this scale (using Cronbach's alpha, which is appropriate given the tau-equivalency of the items) was 0.49, indicating that this scale has convergent marginal validity. As in the case of some of the other scales, this relatively low reliability is likely due to the variety of items included in the scale; two of the items refer to formal agreements, two to longevity of relationships, and two to robust communication patterns. I felt that all of these items were needed to best describe the concept of relationship management and, since reliability dropped if any one of them was omitted, I kept all of the six items together for this scale.

Due to only having three items, the SHARE subscale was perfectly identified so could not be analyzed separately (Bollen, 1989). The SHARE subscale had relatively low composite reliability (0.56), due to a small number of items with moderate correlations, all around 0.30. Had I either four measures with that correlation level or three measures with a higher correlation (0.40), the reliability would have been between 0.60 and 0.70 (Nunnally 1978). While I began with five items attempting to measure this variable, reliability was actually higher using just these three and got worse if any of the three were deleted. Therefore, I decided to stick with these three items for the SHARE scale.

I next analyzed all three subscales simultaneously. I first computed the completely congeneric and oblique (all factors correlated) model as a baseline (chi-square

116.16, 62 degrees of freedom, $p<0.01$, chi-square/dof=1.874, TLI=0.987, CFI=0.991, RMSEA=0.067). I then restricted the model with all measures tau-equivalent (chi square difference 53.18, 10 degrees of freedom, $p<0.001$), the relationship measures tau-equivalent (chi square difference 15.96, 5 degrees of freedom, $p=0.007$), the share measures tau equivalent (chi square difference 3.43, 2 degrees of freedom, $p=0.18$), and the share and relationship measures tau-equivalent (chi square difference 17.77, 7 degrees of freedom, $p=0.013$). Only restricting the share items to being tau equivalent improved the fit of the model (chi-square 119.58, 64 degrees of freedom, $p<0.001$, chi-square/dof=1.868, TLI=0.987, CFI=0.991, RMSEA=0.067). I then further restricted the model by constraining the share items to be parallel, having both the same loadings and the same error variances. This improved the fit of the model (chi-square 120.88, 66 degrees of freedom, $p<0.01$, chi-square/dof=1.831, TLI=0.988, CFI=0.991, RMSEA=0.066). I also tested this model against the congeneric model (chi-square difference: 4.72, 4 degrees of freedom, $p=0.317$) and the tau-equivalent model (chi-square difference: 1.29, 2 degrees of freedom, $p=0.52$) and found that the model with the share items being parallel but the other items being congeneric to be the best. Restricting the model also reduces the demands on the data since I am estimating 38 distinct parameters rather than 42 in the full congeneric model.

Once the measurement weightings for each scale were established, I next tested the factor structure of the model. I found that the three factors were distinct, with their correlations ranging from 0.48 to 0.58, but since 1 was not within the 95% confidence interval of these parameter estimates for the correlations, I can support the claim that these are indeed separate and distinct factors thus satisfying the criteria of discriminant validity (Bagozzi and Philips 1982; Anderson and Gerbing 1988). The chi-square difference between the orthogonal model (zero correlation among the factors) and the oblique model (some correlation among the factors) was 39.74 with 5 degrees of freedom ($p<0.001$) and the chi-square difference between the unidimensional model (perfect correlation of 1 between all factors) and the oblique model was 35.42 with 5 degrees of freedom ($p<0.001$). As a further test of unidimensionality following Anderson and Gerbing (1988), I tested the model loading all 13 items onto a single factor and this model was significantly worse than the three factor oblique model (chi-square difference: 25.60, 1 degrees of freedom, $p<0.001$). I also tested a second order factor model where SMC was directly and equally composed of the three sub-factors; however, this model was no better than the oblique, three factor model (chi-square difference: 40.55, 3 degrees of freedom, $p<0.001$) and its solution was only admissible if the lower level variances were standardized to one.

From all of the above model comparisons, I conclude that supply management capability can be modeled as three separate factors: performance evaluation, sharing, and relationship management. This model satisfies convergent validity as the respective items load significantly and the subscales have adequate reliabilities; this model also satisfies the divergent validity criteria as the correlations among the factors are significantly less than one. A summary of the final subscales and model are presented in Table 10 and pictorially in Figure 9.

Model Verification with Complete Data

Following Ross (1994), I retested the two final models above with a smaller datasets that included complete values for all relevant variables. These datasets had 180 records for the firm models (supplier management capability) and 343 for the input models (production and transaction costs). As in the above analysis, I first verified the submodels for the individual variables and then moved to the larger models to connect these variables. The overall supplier management capability model was replicated and fit well (chi-square 111.58, 66 degrees of freedom, $p<0.01$, chi-square/dof=1.69, TLI=0.788, CFI=0.821, GFI=0.90, RMSEA=0.066). The overall production and transaction cost model required manual inclusion for the variances of two items (VU2 and VU3) to ensure all item variances were positive and significant. Also, seven of the covariances originally modeled were omitted in this model due to lack of significance. This does not substantively change the model or its predictions since this supports the divergent validity among the factors. Moreover, all parameter estimates were significant. This omission resulted from data constraints since the number of parameters to be estimated (66) was high relative to the sample size. The overall model had a reasonable fit given the demands on the data and the complexity of the model (chi-square 1130.19, 430 degrees of freedom, $p<0.01$, chi-square/dof=2.63, TLI=0.667, CFI=0.692, GFI=0.83, RMSEA=0.069). Since these two main models, supplier management capability and overall production and transaction costs, were consistently supported by both the raw and the smaller datasets, I felt confident that scales could be constructed based upon their parameter estimates for the items' relationships to the variables of theoretical interest. See Figures 6, 7, 8, and 9 for graphical representations of all the main models tested.

Scale Construction

Once the CFA analysis had confirmed that the individual items loaded significantly on the different latent variables, I constructed aggregate or composite values to represent these variables. These composite values were used in subsequent analysis to relate these mostly independent variables with my dependent variables of interest, primarily sourcing mode. Scale composite values can be constructed in various ways, either by using factor score weights, simple averages, or by another calculation since no particular method is superior (Pedazhur and Schmelkin 1991; Nunnally 1978). Since some of my scales were shown by the CFA to be congeneric, with item loadings being non-uniform, I chose to use these loadings as a basis for weighting the items in my composite scale value and I used the most comprehensive models as the basis for these weights. My weights sum to 100%, therefore the composite scale figure will have the same scale range as the original items (typically 1 to 7).

Thirteen scales were constructed; one for the dependent variable performance; three for production cost-related variables of firm expertise, supplier expertise, and firm scope economies; six for the transaction-cost related variables of performance ambiguity, unpredictability of forecasts, changes in requirements, asset specialization, market thinness, and technological uncertainty; and three for the supply management capability variables of performance evaluation, sharing, and relationship management. All other dependent and independent variables and all controls were represented by single items rather than by a scale.

The performance scale consists of six items (composite reliability = 0.88): pricperf (scale weight: 12%), qualperf (16%), dlyperf (19%), commperf (17%) coopperf (17%) and overperf (19%). The firm expertise scale consists of four items (composite reliability = 0.81): fex1 (30%), fex2 (18%), fex3 (30%), and fex4 (22%). The supplier expertise scale consists of five items (composite reliability = 0.50): supex3 (16%), supex4 (27%), supex6 (20%), fex5orig (19%), and fex6orig (18%). The firm scope scale consists of two items (composite reliability = 0.77): fscope1 (46%) and fscope2 (54%). The performance ambiguity scale consists of five items (composite reliability = 0.58): pa1 (11%), pa3 (29%), pa4r (24%), pa5r (23%), and pa6 (13%). The scale representing unpredictability of forecasted volume consists of two items (composite reliability = 0.71): vu1 (50%) and vu4 (50%). The scale representing changes in volume and other requirements consists of three items (composite reliability = 0.75): vu2 (43%), vu3 (36%), and vu5 (21%). The asset specialization scale consists of two items (composite reliability = 0.61): as2 (50%) and as4 (50%). The market thinness scale consists of three items (composite reliability = 0.62): as1 (40%), as3 (27%), and supex1r (33 %). The technological uncertainty scale consists of three items (composite reliability= 0.76): tun1 (25%), tun2 (40%), and tun3 (35%). The performance evaluation scale consists of four items (composite reliability = 0.68): peval1 (33%), peval2 (19%), peval3 (35%), and qualcert (13%). The share scale consists of three items (composite reliability = 0.53): share2 (33%), share3 (33%), and share4 (33%). The relationship management scale consists of six items (composite reliability = 0.50): comm1 (18%), comm3 (22%), ltr2

(7%), ltr3orig (21%), ltr4 (8%), and ltr5orig (24%). See Table 11 for a summary of all the variables, scales, and items used.

Missing Data Issues

When constructing the scales and investigating the single items which are to represent my variables, I encountered some missing values in the original survey data. Missing data is common in social science surveys, where missing data amounts vary from 2% to well over 25% on the item level (Huisman 1999). Mail surveys can be especially prone to this problem (Edwards et al 1997). One needs to determine the extent and pattern of missing data and then determine a method of addressing this situation, since missing values can bias parameter estimates and decrease statistical power (Roth 1994).

A modest amount of missing elements were found in the data; 3,771 cells out of a possible 45,304 were null, or 8.3% overall. Note that I only count as missing any values for the independent variables or controls; if dependent variables are missing, I discard the entire case from that particular analysis. It did not appear that the data was missing as a result of a few bad cases or that there was any systematic pattern to the missingness, therefore one could assume the data was missing at random, or MAR (Little 1988, Allison 2002). With this assumption, one can ignore and not bother to model the mechanism generating the missingness since the parameters for the missing data process are unrelated to the parameters of interest. This condition is common for most "real world conditions" (Allison 2002).

There are several options for dealing with missing data. First, one can do nothing and only use complete observations for the analysis. This is the default for most statistical computer programs, which use listwise deletion (LD), essentially only incorporating fully complete observations into the analysis. Using this option does result in the best statistical properties of the estimates (unbiased, consistent, etc.) but one loses a considerable amount of data. In my dataset, I have about 340 fully complete records, so I would be losing well over half of my dataset if I used this method; losing this magnitude of data is not unusual if LD is used (Allison 2002). Pairwise deletion is a related method that only uses complete observations and leads to similarly lost data, although to a somewhat lesser degree and is ambiguous to implement (Allison 2002).

All other methods of dealing with missing data involve imputing values for all the missing values. Imputation can be grouped into two categories: deterministic and stochastic (Huisman 1999). Deterministic imputation involves estimating a single value for each missing value and can be roughly grouped into two types: naïve and modeled. Naïve imputation methods are predominantly based upon substituting a reasonable value, usually some form of mean, for the missing value. There are numerous ways to do mean substitution, including substituting the overall variable mean for the missing value, using related scale items for a particular case to estimate a missing scale value for that same case (scale substitution), using a form of case weighting on the overall mean to determine the missing value, using the most closely correlated item on a scale and substituting that case's value on the correlated item for the missing item, using a mean for the subgroup of the case, or doing predictive mean matching. Modeled imputation methods include regression models (conditional mean substitution) in which one uses other variables to predict the missing value, maximum likelihood models (including expectation maximumization, direct likelihood, and full-information maximum likelihood), dummy variable techniques, and hot deck imputation in which a score is "donated" from a similar case (this technique is nonparametric, while all the others are parametric) (Allison 2002). Stochastic imputation involves estimating several values for each missing value, such that one creates multiple datasets each with slightly different values added for the missing value. Some analysts suggest that this reduces bias considerably, gaining better estimates (Allison 2002). This method can be done using nonparametric methods (hot decks with a random component) or parametric methods (multiple regressions).

I took a three stage approach to my missing data situation and tried to heed the advice of Sande, who suggested that "even the simplest survey, properly run, is a complex operation and one does not want to increase the complexity any more than one has to" (Sande 1982). First, I used listwise deletion, or only the observed values, to determine which items could potentially group together as scales, computing the reliabilities and conducting exploratory factor analysis in SPSS that only incorporates complete cases. Using LD is a good first step and a conservative test of one's analysis, particularly for building scales and factors which can be artificially attenuated when using some of the techniques for imputation, particularly those based upon mean substitution (Hair et al 1995; Roth 1994).

Second, I used full-information maximum likelihood (FIML) methods for the CFA analysis, which is possible via the AMOS software (Arbuckle 1996; Arbuckle and Wothke 1999). Maximum likelihood does not fill in the missing values but provides estimates for these missing values that would be most probable, given the other observed values. This technique has "statistical properties that are about as good as we can reasonably hope to achieve" (Allison 2002), providing consistent, asymptotically efficient estimates and correcting standard errors and is preferred for structural equation and related linear modeling, like CFA (Allison 2002). By using this method, my scale construction incorporates as much data as possible, both from complete cases and cases that may be missing one or more items. Once my CFA analysis was complete using FIML, I reran the models using LD data and they were robust (see the above section for details).

Third, once I determined which items belonged to each of the scales, I addressed the missing value issue prior to calculating the composite scale values. In order to take advantage of the similarity of items across the scale within a case, I chose scale mean substitution when I had a majority of other scale item values for that case. This method is also termed proportionate or correlated item mean substitution, is often used in survey research, and has the advantage of retaining the overall range of the items (Edwards et al 1997; Husiman 1999). When I did not have a majority of items or when there was only one item to measure a variable, I used mean substitution based on the mean for that item within a particular subgroup. These subgroups were based on the type of firm and the type of item, resulting in ten distinct subgroups. Using this subgroup mean assumes that the observations within the subgroups are more similar than across the groups, which I believe is a more reasonable assumption and results in better imputation values than just using a simple overall mean from all observations. Since in many cases I had low correlations between the variables and less than 10% missing data, mean substitution should be an appropriate method and not significantly different or better than more exotic methods (Roth 1994, Edwards et al 1997). See Table 12 for more details regarding missing data amounts and imputation methods used for the independent and control variables.

Based upon the above imputation techniques, I created a dataset using Excel that included imputed values for the missing cells. I then transported the data into Stata for subsequent analysis with the dependent variables. I could not use structural equation modeling software (like AMOS) for my analysis since my key dependent variable, sourcing mode choice, was categorical and discrete, with the choices of make, buy, or make-and-buy. My final dataset contained 809 observations, each of which representing an input and its sourcing mode. I also retained a dataset with only the totally complete records (n=343) that I can use for verification of my later models. In the final dataset, I computed the aggregate scale scores based upon the weights in the above section. This dataset includes three dependent variables, sourcing mode (SMODE), percentage made in-house (PERMAKE), and performance (PERF); five independent variables related to production costs (FEX, SUPEX, SCALE1, FSCOPE, and SUSCOPE1); six independent variables related to transaction costs (PA, CHG, UNPRED, SPEC, MTHIN, and TUN); three independent variable scales for supplier management capability (RELN, SHARE, and PEVAL; six firm control variables (AGE, EMPEES, UNION, AUTOPER, FERPER, and PM); and 11 input control variables (HOWLONG, PLANCHG, VOLUME, LASTDLY, COMPLEXIN, ALLSAME, MKNSELL, DESIGN, BUILD, MAINT, and MACH). See Table 11 for a listing of these variables.

With this dataset complete and confidence in the scales, I then proceeded to analyzing the relationship between sourcing mode and attributes of the input, firm, and environment as represented by these independent and control variables. This analysis is presented in the next chapter.

Table 2: Descriptive Statistics – Dependent Variable Items

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
SMODE	Sourcing mode; 1=make, 2=buy, 3=MnB	809	1	3	2.082	0.827
PERMAKE	Scale of %make; 0=buy,1-6=MnB; 7=all make	805	0	7	3.583	2.925
PRICPERF	Price competitiveness/value	750	1	7	5.036	1.065
QUALPERF	Quality level / defect rates	752	1	7	5.358	1.048
DLYPERF	On-time shipments	750	1	7	5.189	1.234
COMMPERF	Communication and paperwork	751	1	7	5.300	1.076
COOPPERF	Cooperation and dispute resolution	750	1	7	5.512	1.037
OVERPERF	Overall sourcing experience	747	1	7	5.404	0.999

Table 3: Descriptive Statistics - Production Cost Variable Items

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
SCALE1	dem double, ave cost change a lot	769	1	7	3.481	1.706
SCALE2	qty too low to take advantage	749	1	7	3.850	1.936
FSCOPE1	by making, reduce overall prod costs	633	1	7	4.488	1.790
FSCOPE2	by making, better use equip/labor	623	1	7	4.159	1.877
SUSCOPE1	suppliers can reduce costs by making these	585	1	7	4.733	1.564
SUSCOPE2	we buy other products from supp	630	1	7	3.646	2.163
FEX1	engr staff can do	697	1	7	4.836	2.079
FEX2	we understand deep expertise	737	1	7	5.307	1.723
FEX3	we have done for years	712	1	7	5.292	2.314
FEX4	skills related to our other products	690	1	7	4.110	2.018
FEX5ORIG	vs supp, int higher in price	615	1	7	3.766	1.882
FEX6ORIG	vs supp, in lower in quality	619	1	7	2.889	1.770
SUPEX2	Small % of overall cost	778	1	7	4.213	1.711
SUPEX3	supp have prop knowledge	685	1	7	3.999	1.747
SUPEX4	rely on supp to help keep up with tech	702	1	7	4.407	1.878
SUPEX5	outside supp have EDM/CAD/CNC	526	1	7	6.405	1.009
SUPEX6	big diff btwn process we/supp use	614	1	7	3.094	1.816

Table 4: Descriptive Statistics - Transaction Cost Variable Items

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
PA1	hard to describe with dwgs	733	1	7	2.220	1.281
PA2	quality based on many factors	786	1	7	5.947	1.019
PA3	can't use simple inspec for down fn	769	1	7	3.282	1.509
PA4R	not sev forms inspec, metrics to evaluate	769	1	7	2.900	1.465
PA5R	when prob cannot determine cause	788	1	7	2.536	1.249
PA6	difficult to equitably measure one supp vs other	687	1	7	3.741	1.609
TUN1	processes/skills not mature	779	1	7	4.076	1.680
TUN2	major prod innov unlikely	760	1	7	4.549	1.483
TUN3	major process innov unlikely	758	1	7	4.646	1.473
TUN4	no one knows where next tech from	737	1	7	4.380	1.472
AS1	switching suppliers is not easy	704	1	7	4.389	1.779
AS2	requires major investments not used for other	757	1	7	4.165	1.776
AS3	skills not generic nor widely available	770	1	7	4.748	1.643
AS4	cannot easily modify equipment for other	728	1	7	3.765	1.799
SUPEX1R	Numerous capable suppliers do not exist	738	1	7	3.103	1.611
VU1	forecasts not accurate	756	1	7	3.729	1.605
VU2	frequently change features	755	1	7	3.837	1.674
VU3	frequently change timing	758	1	7	4.127	1.650
VU4	there are not predictable patterns	752	1	7	3.908	1.713
VU5	suppliers complain about unpred	660	1	7	3.059	1.547
VU6	suppliers accomod rev but with hassles	679	1	7	3.670	1.615
VU7	need to stay in contact w/ supp	678	1	7	5.642	1.335
VU8	supp don't get info direct from end custs	667	1	7	1.766	1.396

Table 5: Descriptive Statistics - Supply Management Capability Items

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
LTR1REAL	Overall opinion	188	1	5	4.101	0.650
LTR2	relationships last for years	191	3	7	6.047	0.860
LTR3ORIG	use formal, written contracts	190	1	7	5.095	1.846
LTR4	work thru difficulties vs. switch	192	2	7	5.417	1.020
LTR5ORIG	use confidentiality agreements	186	1	7	3.957	2.013
SHARE1	share proprietary info	183	1	7	4.213	1.736
SHARE2	engineers travel to suppliers	189	1	7	5.571	1.635
SHARE3	help suppliers improve processes	187	1	7	4.877	1.545
SHARE4	suppliers help us reduce costs, etc	191	2	7	4.874	1.554
SHARE5	Purch has engr, tech, mfg backgrd	189	1	7	4.392	1.875
PEVAL1	tell supp perf vs. other supp	188	1	7	4.702	1.742
PEVAL2	eval internal same as ext supp	180	1	7	5.233	1.721
PEVAL3	use formal scorecard for eval	185	1	7	4.730	2.096
QualCertOrig	Type of Qual cert held	192	0	4	1.927	1.056
COORD1	purch great at coord	184	1	7	4.707	1.561
COORD2	coord not necess easier in/out	184	1	7	3.092	1.539
COORD3	ship prod direct from supp to cust	188	1	7	2.628	1.709
INPURCH	How many people in purch	180	1	25	5.778	4.270
COMM1	immed inform if change in vol	189	1	7	5.317	1.518
COMM2	supp don't keep us in dark	191	1	7	4.398	1.507
COMM3	communicate daily	188	1	7	5.356	1.550
COMM4	comm in not necess easier in/out	186	1	7	3.505	1.525
COMM5	all supp contacts not ness thru pur	189	1	7	3.587	2.016

Table 6: Descriptive Statistics - Items Measuring Controls

Firm Controls

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
AGE	Calculated from year est	181	2	122	44.160	22.736
UNION	1=yes; 2=no	191	1	2	1.864	0.344
EMPEES	How many empees (1-5 scale)	191	1	5	2.455	1.099
SALES	Total annual sls (1-5 scale)	185	1	5	2.292	0.951
BUY	Total annual buy (1-7 scale)	164	1	6	2.537	0.854
AUTOPER	% sales $ to auto (1-6 scale)	188	1	6	3.346	1.874
FERPER	% sales $ ferrous=iron pts (1-6 scale)	190	1	6	4.974	1.319
ACTPTS	How many act pts (1-5 scale)	186	1	5	3.355	1.304
PM	firm type; 1 if PM, 0 if ST	193	0	1	0.212	0.410

Input Controls

Item Name	Abbreviated wording	N	Min	Max	Mean	Std. Dev
COMPLEXIN	do complex in and outsource others	626	1	7	3.371	2.207
ALLSAME	inputs are basically all the same	779	1	7	3.513	1.834
VOLUME	volume (on 5 point scale)	762	1	5	2.625	1.508
MKNSELL	make and sell (yes=1, 2=no, 3=not applic)	787	1	3	2.139	0.599
TYPE	input type (5 types)	809	1	5	2.944	1.434
LASTDLY	5 point scale, 1=within week to 5=over a year	759	1	5	1.543	0.921
HOWLONG	how long sourced this way - 3 pt - 1=short	699	1	4	2.672	0.554
PLANCHG	1=yes, 2=no	776	1	2	1.899	0.301

Table 7: Production Cost Model

	FEX	SUPEX	FSCOPE	SUSCOPE	SCALE
Items and loadings (standard errors in parentheses; all p<.001, unless indicated)	Fex1 1.794 (0.069) Fex2 1.036 (0.062) Fex3 1.863 (0.077) Fex4 1.237 (0.074)	Supex3 0.510 (0.078) Supex4 1.014 (0.083) Supex6 0.729 (0.085) Fex5orig 0.644 (0.088) Fex6orig 0.818 (0.082)	Fscope1 1.380 (0.072) Fscope2 1.605 (0.075)	N/A (one item)	N/A (one item)
Type	Congeneric	Congeneric	Congeneric	N/A	N/A
Reliability	0.81	0.50	0.77	N/A	N/A
Covariances (standard error in parentheses)	SUPEX -0.862 (0.040)	FSCOPE -0.637 (0.052)	FEX 0.728 (0.030)	N/A	N/A

<u>Overall model fit statistics</u>

	Model Statistics	Evaluation
Chi-square	394.19, 64 degrees of freedom, p<0.01	OK
Discrepancy index	6.16	OK
Tucker-Lewis Index (TLI)	0.973	Good
Comparative fit index (CFI)	0.981	Good
Root Mean Square Error of Approximation (RMSEA)	0.080 (0.072, 0.088)	Reasonable

Figure 6: Production Cost Model

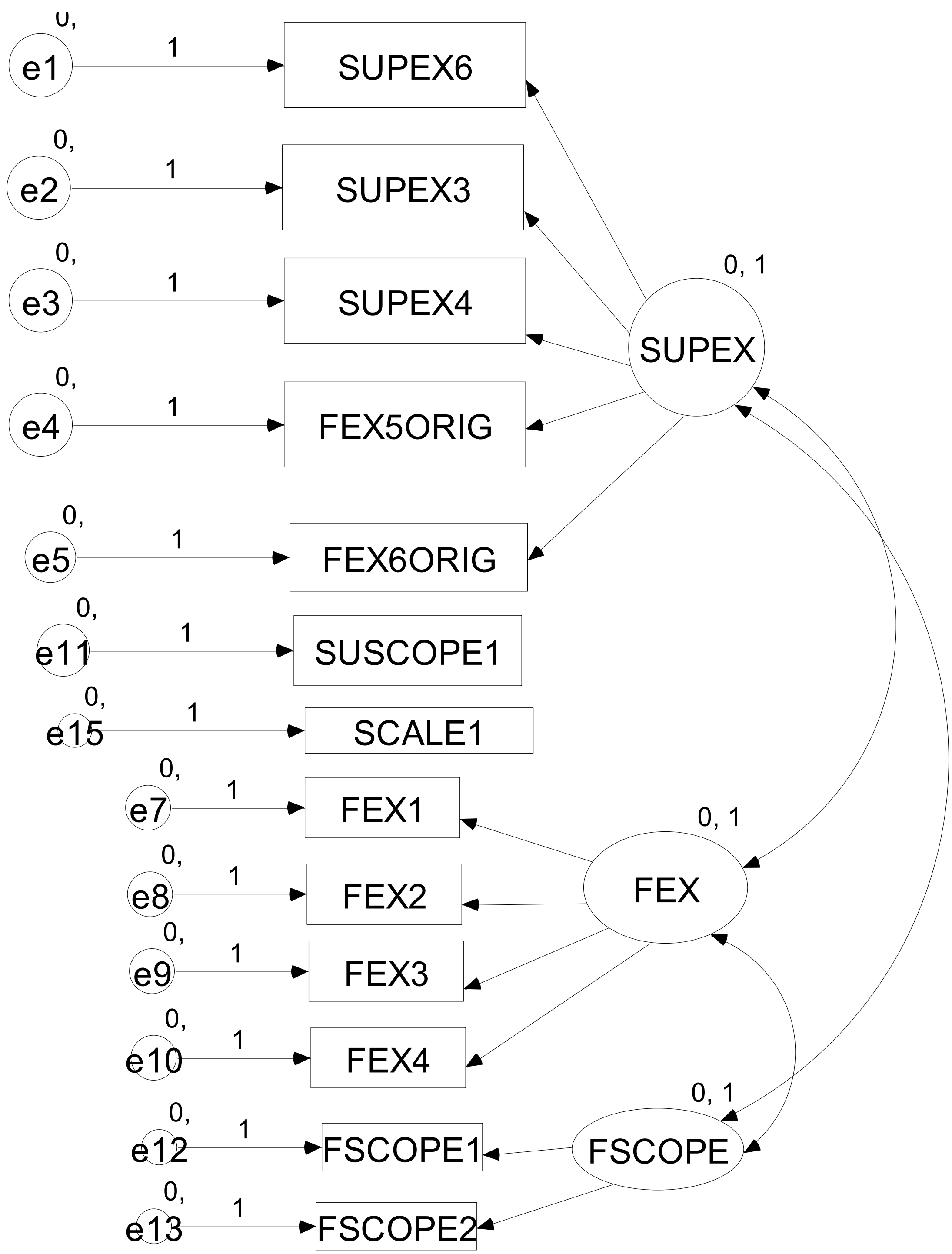


Table 8: Transaction Cost Model

	PA	TU	AS-SPEC	AS-MTHIN	VU-UNPRED	VU-CHG
Items and loadings (standard errors in parentheses; all p<.001, unless indicated)	PA1 0.383 (0.057) PA3 1.023 (0.065) PA4R 0.772 (0.062) PA5R 0.675 (0.053) PA6 0.480 (0.074)	TUN1 0.815 (0.062) TUN2 1.306 (0.057) TUN3 1.178 (0.056)	AS2 1.170 (0.055) AS4 1.170 (0.055)	AS1 1.173 (0.094) AS3 0.814 (0.076) SUPEX1R 0.974 (0.081)	VU1 1.229 (0.046) VU4 1.229 (0.046)	VU2 1.430 (0.073) VU3 1.232 (0.069) VU5 0.702 (0.064)
Type	Congeneric	Cong.	Tau	Cong.	Tau	Cong.
Reliability	0.58	0.76	0.61	0.62	0.71	0.75
Covariances (standard error in parentheses; all p<0.001 unless indicated)	SPEC 0.269 (0.054) MTHIN 0.123 (0.054) p=0.023 UNPRED 0.476 (0.046)	CHG 0.178 (0.043) UNPRED 0.105 (0.045) p=0.019	MTHIN 0.154 (0.060) p=0.010	CHG –0.164 (0.050) p=0.001	CHG 0.146 (0.045) p=0.001	

Overall model fit statistics

	Model Statistics	Evaluation
Chi-square	420.669, 129 degrees of freedom, p<.01	OK
Discrepancy index	3.261	Good
Tucker-Lewis Index (TLI)	0.986	Good
Comparative fit index (CFI)	0.989	Good
Root Mean Square Error of Approximation (RMSEA)	0.053 (0.047, 0.059)	Good

Figure 7: Transaction Cost Model

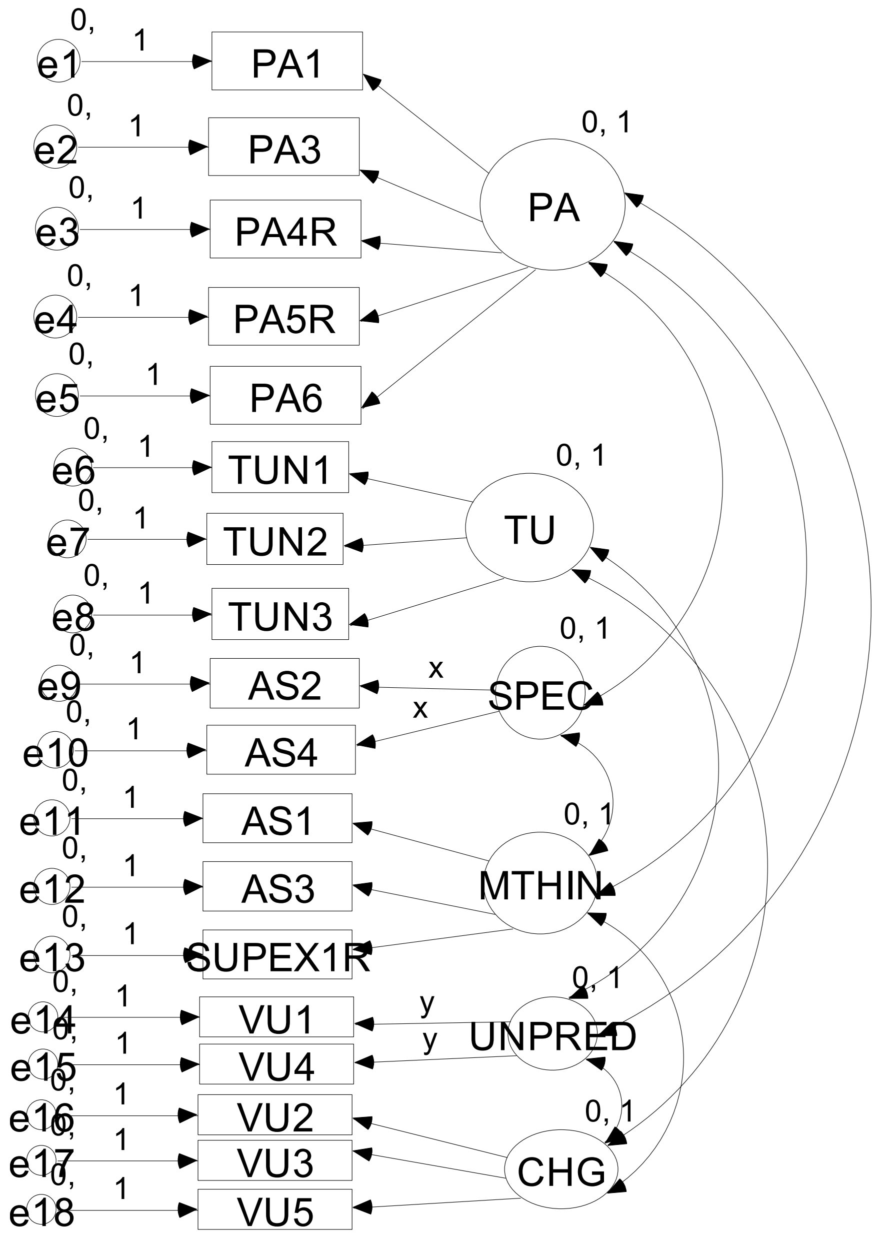


Table 9: Production and Transaction Cost Model

	FEX	SUPEX	FSCOPE	SUSCOPE	SCALE
Items and loadings (standard errors in parentheses; all p<.001, unless indicated)	Fex1 1.699 (0.066) Fex2 1.007 (0.061) Fex3 1.736 (0.075) Fex4 1.228 (0.072)	Supex3 0.583 (0.080) Supex4 0.998 (0.085) Supex6 0.730 (0.086) Fex5orig 0.718 (0.089) Fex6orig 0.685 (0.084)	Fscope1 1.349 (0.072) Fscope2 1.576 (0.075)	N/A (one item)	N/A (one item)
Type	Congeneric	Congeneric	Congeneric	N/A	N/A
Reliability	0.81	0.50	0.77	N/A	N/A
Covariances (standard error in parentheses)	SUPEX -0.717 (0.042) PA -0.332 (0.040) SPEC -0.476 (0.041)	FSCOPE -0.578 (0.053) TU 0.214 (0.050) CHG 0.199 (0.051)	FEX 0.710 (0.032) PA –0.114 (0.049) p=0.020 SPEC -0.233 (0.051)	N/A	N/A

Table 9 (contd): Production and Transaction Cost Model

	PA	TU	AS-SPEC	AS-MTHIN	VU-UNPRED	VU-CHG
Items and loadings (standard errors in parentheses; all p<.001, unless indicated)	PA1 0.364 (0.057) PA3 0.952 (0.063) PA4R 0.791 (0.061) PA5R 0.740 (0.052) PA6 0.450 (0.073)	TUN1 0.814 (0.062) TUN2 1.307 (0.056) TUN3 1.180 (0.056)	AS2 1.185 (0.055) AS4 1.185 (0.055)	AS1 1.178 (0.093) AS3 0.819 (0.076) SUPEX1R 0.965 (0.080)	VU1 1.231 (0.046) VU4 1.231 (0.046)	VU2 1.437 (0.072) VU3 1.226 (0.068) VU5 0.707 (0.064)
Type	Congeneric	Cong.	Tau	Cong.	Tau	Cong.
Reliability	0.58	0.76	0.61	0.62	0.71	0.75
Covariances (standard error in parentheses; all p<0.001 unless indicated)	SPEC 0.283 (0.054) MTHIN 0.123 (0.053) p=0.019 UNPRED 0.446 (0.046)	CHG 0.183 (0.043) UNPRED 0.114 (0.044) p=0.010	MTHIN 0.181 (0.055) p=0.001	CHG –0.160 (0.050) p=0.001	CHG 0.161 (0.044) p=0.001	

Overall model fit statistics

	Model Statistics	Evaluation
Chi-square	1521.642, 421 degrees of freedom, p<.01	OK
Discrepancy index	3.614	Good
Tucker-Lewis Index (TLI)	0.972	Good
Comparative fit index (CFI)	0.976	Good
Root Mean Square Error of Approximation (RMSEA)	0.057 (0.054, 0.060)	Good

Figure 8: Production and Transaction Cost Model

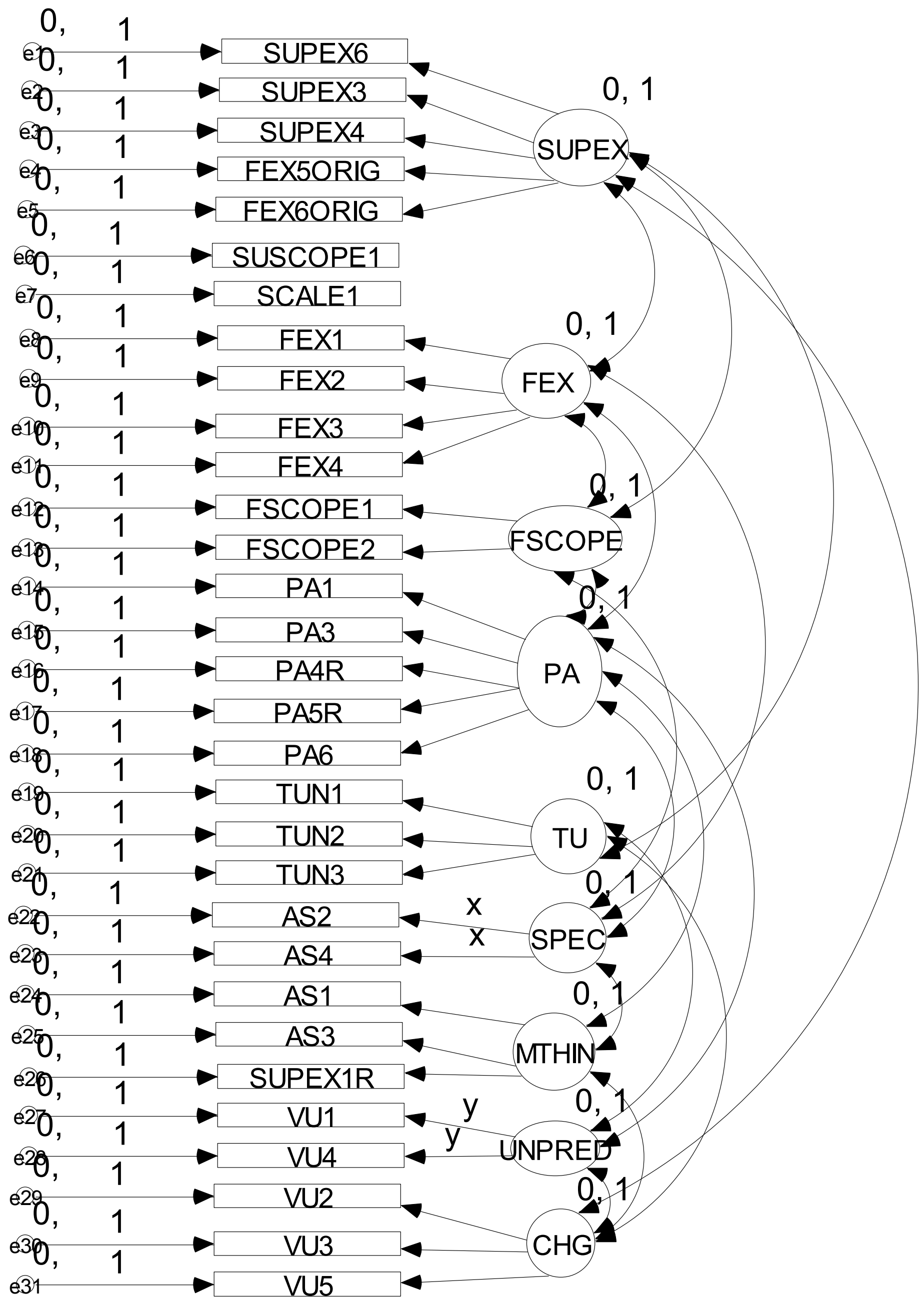


Table 10: Supply Management Capability Model

	PEVAL	SHARE	RELN
Items and loadings (standard errors in parentheses; all p<.001, unless indicated)	Peval1 1.302 (0.140) Peval2 0.732 (0.144) Peval3 1.363 (0.168) Qualcert 0.495 (0.085)	Share2 0.829 (0.084) Share3 0.829 (0.084) Share4 0.829 (0.084)	Ltr2 0.223 (0.080, p=0.004) Ltr3orig 0.717 (0.171) Ltr4 0.287 (0.094, p=0.002) Ltr5orig 0.802 (0.188) Comm1 0.625 (0.141) Comm3 0.751 (0.145)
Type	Congeneric	Parallel	Congeneric
Reliability	0.68	0.56	0.50
Covariances (standard error in parentheses)	SHARE 0.447 (0.107)	RELN 0.550 (0.125)	PEVAL 0.579 (0.103)

Overall model fit statistics

	Model Statistics	Evaluation
Chi-square	120.88, 66 degrees of freedom, p<.01	OK
Discrepancy index	1.831	Good
Tucker-Lewis Index (TLI)	0.988	Good
Comparative fit index (CFI)	0.991	Good
Root Mean Square Error of Approximation (RMSEA)	0.066 (0.047, 0.084)	Good

Figure 9: Supply Management Capability Model

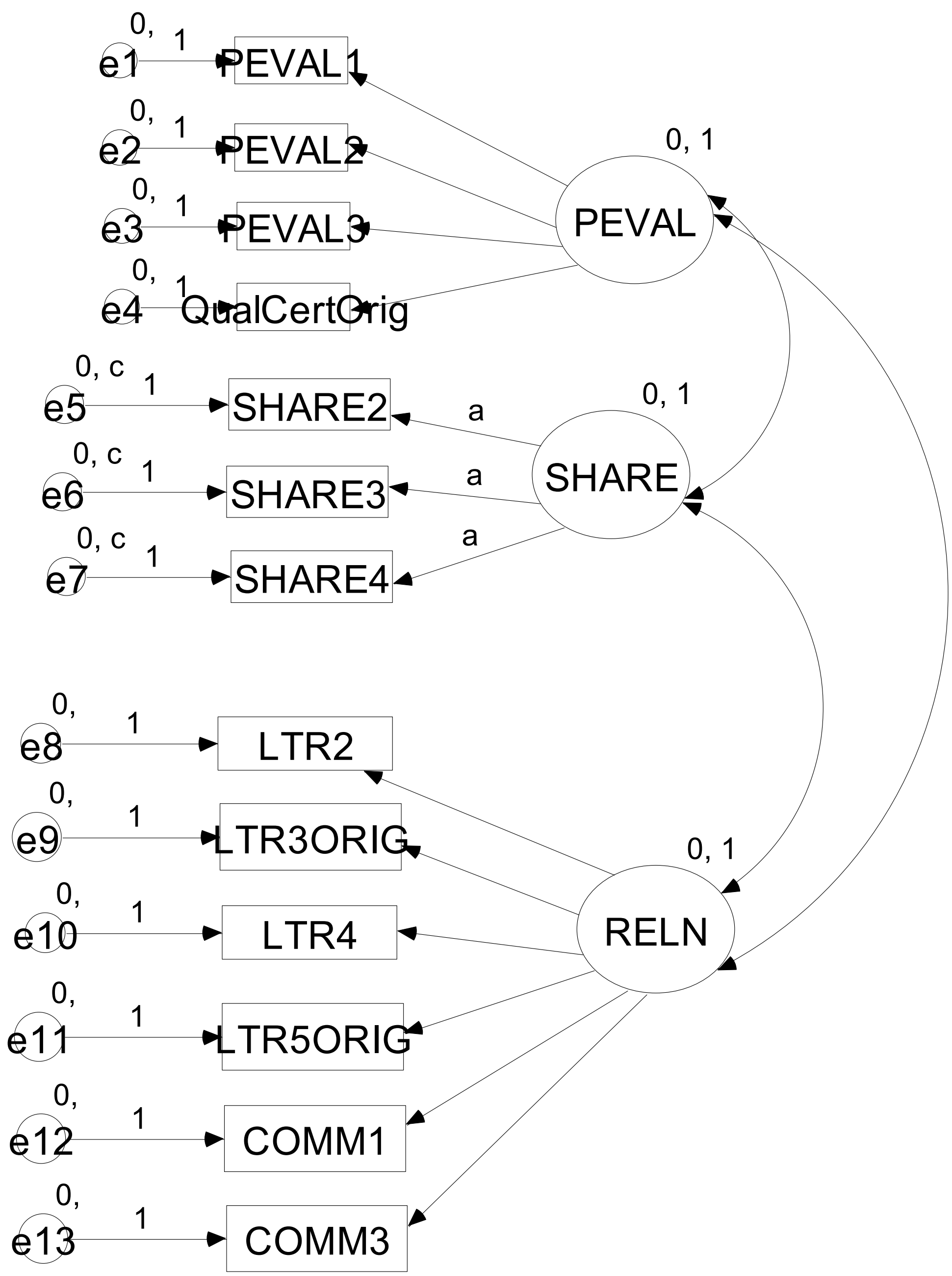


Table 11: List of Variables, Scales, and Items Used

Variable	Type	Scale	Item	Scale Wt	Q #	Rev ?	Word Snippet
Sourcing Mode	DV	SMODE	smode	100%	A1	0	Where did input come from?
	DV	PERMAKE	permake	100%	A1b	0	If make and buy, % make
Performance	DV	PERF	priceperf	17%	A6	0	Price
			qualperf	17%	A7	0	Quality
			dlyperf	17%	A8	0	On time
			commperf	17%	A9	0	Communication
			coopperf	17%	A10	0	Cooperation
			overperf	17%	A11	0	Overall
Firm Expertise	IV	FEX	fex1	30%	B11	0	Mfg staff can do
			fex2	18%	B12	0	Requires expertise, we have
			fex3	30%	B13	0	Have done for years
			fex4	22%	B14	0	Skills related to others
Supplier Expertise	IV	SUPEX	supex3	16%	B7	0	Leading suppliers prop know
			supex4	27%	B8	0	Suppliers help us keep up
			supex6	20%	B10	1	No difference in supp/our proc
			fex5orig	19%	B15	0	Internal higher price
			fex6orig	18%	B16	0	Internal lower quality
Scale Economies	IV	SCALE	scale1	100%	B1	1	Double demand, no cost chg
Firm Scope	IV	FSCOPE	fscope1	46%	B17	0	reduce costs of other prod
			fscope2	54%	B18	0	better use lbr/equip
Supplier Scope	IV	SUSCOPE	suscope1	100%	B19	0	reduce costs of other prod
Performance Ambiguity	IV	PA	pa1	11%	C9	1	Easily describe in drawings
			pa3	29%	C11	1	Simple inspection, predict fn
			pa4r	24%	C12	0	Several forms of inspection
			pa5r	23%	C13	1	Problem, can determine cause
			pa6	13%	C14	0	Can't equitably measure
Volume Uncertainty	IV	UNPRED	vu4	50%	D6	1	Predictable patterns
			vu1	50%	D3	1	Accurate forecasts
		CHG	vu2	43%	D4	0	Change features
			vu3	36%	D5	0	Change timing
			vu5	21%	D7	0	Suppliers complain
Asset Specificity	IV	SPEC	as2	50%	C6	0	Need major investments
			as4	50%	C8	1	Equipment easily modified
		MTHIN	as1	40%	C5	1	Switching supplierseasy
			as3	27%	C7	1	Skills generic/available
			supex1r	33%	B3	0	Numerous suppliers
Technological Uncertainty	IV	TUN	tun1	25%	C1	1	Mature processes/skills
			tun2	40%	C2	0	Major innov in product
			tun3	35%	C3	0	Major innov in process
Supplier Mgmt Capability	IV	PEVAL	peval1	33%	II 9	0	Advise supp performance
			peval2	19%	II 10	0	Evaluate in/out same

			peval3	35%	II 11	0	Use formal scorecard
			qualcert	13%	I 3	1	Quality certifications
		SHARE	share2	33%	II 5	1	Engr never travel
			share3	33%	II 6	0	Help suppliers improve
			share4	33%	II 7	1	Supp don't' help us
		RELN	ltr2	7%	II 1	0	Supp reln last for years
			ltr3orig	21%	II 2	0	Formal written contracts
			ltr4	8%	II 3	0	Work thru difficulties
			ltr5orig	24%	II 8	0	Use confid agreements
			comm1	18%	II 16	0	Tell supp if change in vol
			comm3	22%	II 18	0	Communicate daily
Firm Type	C	PM	pm			0	1 if PM; 0 if not
Firm Age	C	AGE	age		VIII 3	calc	What yr established
Firm Size	C	EMPEES	empees		VIII 1	0	Number of employees
Unionization	C	UNION	union		VIII 2	0	Majority hourly rep by union
Product Mix	C	AUTOPER	autoper		VIII 5	0	% automotive
		FERPER	ferper		VIII 6	0	% ferrous
Input type	C	DESIGN	type			0	1 if design; 0 if not
		BUILD					1 if build; 0 if not
		MAINT					1 if maint; 0 if not
		MACH					1 if mach; 0 if not
Stability	C	PLANCHG	planchg		A3	0	Plan to change
		HOWLONG	howlong		A2	0	How long this way
Purchase Importance	C	VOLUME	volume		D1	0	How many in last yr
		LASTDLY	lastdly		D2	0	When receive last one
Variety	C	ALLSAME	allsame		B4	0	All basically the same
		COMPLEXIN	complexi		B5	0	Make more complex
Make and sell	C	MKNSELL	mknsell		A4	0	If make, Sell to outsiders

Table 12: Summary of Missing Data

Variable	Type	# Items	# Total Cells	# Miss Cells	% Cells Missing	Affected Records	Imputation Method
PEVAL	IV	4	3,236	104	3.2%	77	Scale mean sub (57/77)
SHARE	IV	3	2,427	46	1.9%	40	Scale mean sub (38/40)
RELN	IV	6	4,854	80	1.6%	61	Scale mean sub (58/61)
SCALE1	IV	1	809	40	4.9%	40	Subgroup mean sub
FSCOPE	IV	2	1,618	362	22.4%	216	Scale mean sub (70/216)
SUSCOPE1	IV	1	809	224	27.7%	224	Subgroup mean sub
FEX	IV	4	3,236	400	12.4%	182	Scale mean sub (112/182)
SUPEX	IV	5	4,045	810	20.0%	315	Scale mean sub (146/315)
PA	IV	5	4,045	299	7.4%	166	Scale mean sub (142/166)
TU	IV	3	2,427	130	5.4%	55	Scale mean sub (8/55)
AS-SPEC	IV	2	1,618	133	8.2%	104	Scale mean sub (75/104)
AS-MTHIN	IV	3	2,427	215	8.9%	150	Scale mean sub (97/150)
VU-UNPRED	IV	2	1,618	110	6.8%	78	Scale mean sub (46/78)
VU-CHG	IV	3	2,427	254	10.5%	161	Scale mean sub (107/161)
AGE	Con	1	809	49	6.1%	49	Subgroup mean sub
EMPEES	Con	1	809	6	0.7%	6	Got values from Dun & Bradstreet
UNION	Con	1	809	8	1.0%	8	Subgroup mode sub
AUTOPER	Con	1	809	19	2.3%	19	Subgroup mean sub
FERPER	Con	1	809	7	0.9%	7	Subgroup mean sub
PLANCHG	Con	1	809	33	4.1%	33	Subgroup mean sub
HOWLONG	Con	1	809	110	13.6%	110	Subgroup mean sub
VOLUME	Con	1	809	47	5.8%	47	Subgroup mean sub
LASTDLY	Con	1	809	50	6.2%	50	Subgroup mean sub
ALLSAME	Con	1	809	30	3.7%	30	Subgroup mean sub
COMPLEXIN	Con	1	809	183	22.6%	183	Subgroup mean sub
MKNSELL	Con	1	809	22	2.7%	22	Subgroup mean sub
Total			45,304	3,771	**8.3% Overall missing data**		

CHAPTER 6

EMPIRICAL RESULTS

This chapter explores the relationships between the independent variables described in the previous chapter with the key dependent variable of sourcing mode choice, emphasizing concurrent sourcing. It describes the data, explains why a multinomial logit model was chosen and how this model was adjusted to fit the data, presents the model results and connects these results to the hypotheses, and discusses the robustness of the model.

Descriptive Analysis

My main dependent variable is sourcing mode (SMODE), a categorical dependent variable where the value 1 represents "make", 2 represents "buy", and 3 represents "concurrently source". I also created binary variables based upon the three different modes. For 805 of my 809 input observations, I also have the percentage of in-house production (PERMAKEP). I use 0% for the buy cases, 100% for the make cases, and for the concurrently sourced cases, I use a categorical value based on the respondent's selection of one of the following six response options: less than 10%, 11 to 25%, 26 to 49%, 50 to 75%, 75 to 90%, and over 90%.

I have three sets of independent variables: those related to production costs, to transaction costs, and to supplier management capability. The production cost variables are firm expertise (FEX), supplier expertise (SUPEX), scale economies (SCALE1), firm scope economies (FSCOPE), and supplier scope economies (SUSCOPE1). The transaction cost variables are performance ambiguity (PA), volume unpredictability (UNPRED), volume changeability (CHG), market thinness (MTHIN; one type of asset specificity), specific investment (SPEC; a second type of asset specificity), and technological uncertainty (TUN). The supplier management capability variables are performance evaluation ability (PEVAL), sharing of information (SHARE), and relationship management (RELN).

I use two sets of control variables. At the firm level, I use firm age (AGE) and size as measured by number of employees (EMPEES) since these may correspond to greater vertical integration (Perry, 1989). I also include unionization (UNION), since this can affect the firm's sourcing decision, and a binary variable for the type of firm (powder metal (PM) or stamping). I also gathered data on the firm's product mix (AUTOPER, the percentage of automotive products, and FERPER, the percentage of ferrous (iron-based) products), but did not include these variables in subsequent analysis as they were both correlated with firm size (0.33 and 0.19, respectively).

My other set of control variables measures input attributes. These include two items indicating the relative importance of the input: the volume required (VOLUME) and frequency, as indicated by the last receipt (LASTDLY). As these variables are highly correlated (0.54), I chose to use the volume measure for the empirical models reported. I included two items to measure the homogeneity of the input: ALLSAME indicates the extent to which the inputs required are "basically all the same" and COMPLEXIN reflects the extent to which the firm produces more complex inputs internally and outsources simpler ones. Due to the endogeneity of the complexity item with the sourcing mode chosen, I omitted it in the empirical models. Thus, the two remaining input controls are VOLUME and ALLSAME. In addition, I included the input type as four dummy control variables, DESIGN, MAINT, MACH, and COAT, with die building being the omitted input.

Although not included in the models estimating sourcing mode choice, I also gathered data on the stability of the sourcing mode choice. The variable of HOWLONG reflects how long the firm has sourced the input by the current mode and PLANCHG indicates if the firm plans to change its sourcing mode within the next two years. I also include an item indicating if the firm also makes and sells (MKNSELL) the particular input, to control for the potential outside influence of customers. Due to endogeneity concerns, I did not include any of these variables in the empirical models, but did use them for descriptive purposes to assist in understanding the mode choice selection and model results. Descriptive statistics and correlations of all of these variables can be found on Table 13 and Table 14. I also included reliability (alpha) figures for the scales; these figures are slightly higher than those from chapter 5 since they are based upon the fully imputed data.

Descriptive statistics provide an initial indication of the nature of the sourcing decision in this setting. Table 15 presents the distribution of each sourcing mode in the entire dataset and breaks these choices down by type of firm and by type of input. All three modes are present in the data, with concurrent sourcing, the mode of interest, being the most prevalent. The difference between powder metal and stamping firms' use of concurrent sourcing was slightly significant (p=0.085, two-tailed test), with powder metal firms doing so more often. The dominant mode difference was between the input types. While die design and building were sourced through all three modes, die maintenance and part machining were rarely bought and part coating was rarely made. Table 16 depicts the percentage of internal sourcing, with Figures 10 and 11 providing graphical representations of the data by firm and input type. Interestingly, this percentage is fairly evenly spaced for those inputs that are both made and bought. This indicates that firms select a percentage to produce internally as a decision variable, analogous to franchisors who select what proportion of outlets to operate internally (Lafontaine and Slade 2000; Lafontaine and Shaw 2003).

One potential issue with the sourcing mode of concurrent sourcing is its stability. Critics may assume that this mode of sourcing is transitory, used for a short time while moving between solely making and solely buying (Williamson 1985). With my data, I can test this assumption by comparing the longevity of each sourcing mode using the item that asks how long the firm has used this particular mode (HOWLONG). For inputs that were both made and bought, 60% had always been sourced in this way, as compared to 54% for inputs made and 70% for inputs bought. The difference between those always concurrently sourced and those always internally sourced was not significant (p=0.10, two tailed test). Moreover, I also ask whether firms plan to change their sourcing mode within the next two years (PLANCHG). For inputs that are both made and bought, 11.9% plan to change, as compared to 10.3% for inputs made and 8.0% for inputs bought. Again, the difference between those planning to change that are currently concurrently sourcing is not significantly different than those that are currently making (p=0.27, two tailed test). Thus, the data supports concurrent sourcing as a stable, equilibrium sourcing mode.

As a first step in the analysis to link the sourcing mode choice to the independent variables, I reviewed the means and standard deviations of these variables by sourcing mode, as depicted in Table 18. An inspection of this data indicates potential support for the hypotheses involving production cost variables. Firm expertise and firm scope economies were higher for those inputs that were made, while supplier expertise and supplier scope economies were higher for those inputs that were bought. Also, the mean for scale economies was higher for inputs that were bought. In all of these cases, the variable means for the concurrently sourced inputs were intermediate. There was little apparent difference between the means of most of the transaction cost variables, although the mean for technological uncertainty for concurrently sourced inputs was somewhat higher than that for made inputs. The supplier management capability variables displayed few differences between the means across sourcing modes. Firms in the sample that made appeared to be slightly older and larger than those that bought, and unionized firms concurrently sourced more often. Concurrently sourced inputs also appeared to be more similar than those made or bought.

Multinomial Logit Model

Given that I am investigating three distinct sourcing modes, a multinomial logit model is appropriate. The multinomial logit model estimates the odds of selecting one choice from among multiple, independent possibilities given a set of covariates (Long 1997, Greene 1997, Hosmer and Lemeshow 2000). This discrete choice model is a generalization of a standard dichotomous logit model, based on the assumption that the decision maker selects the option that provides the greatest benefit or utility (McFadden 1974, Agresti 1996, Kennedy 1998). The utility a firm gains from choosing a sourcing mode for a particular input, where the input is depicted by i and the mode type selected by m (1=make, 2=buy, and 3=concurrent source), can be shown as follows:

$$U_{im} = \beta'_m x_i + \varepsilon_{im}$$

Where β_m is the vector of coefficients to be estimated and x_i are the observed variables that affect the choice. Since I have three mode choices and one of these can be set as a base alternative (m=3), their probabilities can be depicted as follows:

$$P(m=1) = \exp(x\beta_1)/[1+\exp(x\beta_1)+\exp(x\beta_2)]$$

$$P(m=2) = \exp(x\beta_2)/[1+\exp(x\beta_1)+\exp(x\beta_2)]$$

$$P(m=3) = 1/[1+\exp(x\beta_1)+\exp(x\beta_2)]$$

In this model, each mode choice is compared to the others and is assumed to be distinct. This means that the assumption of the independence of irrelevant alternatives

(IIA) holds (e.g., the classic "red bus" vs. "blue bus" choice does not exist that would violate this assumption, see Long 1997), such that the mode choices are not close substitutes.

In the results section, I test this IIA assumption using three methods. First, I use a Wald test to check if the categories can be combined. If the categories could be combined such that the parameter estimates are the same for more than one of them, the categories would be indistinguishable and there would not be a clear choice between them (Long and Freese 2001). Next, I conduct a Hausman test that drops one of the outcome categories and checks if the estimated coefficients change; if they do not change, the chi-square test will not be significant, indicating that the outcomes are independent. Finally, I conduct a Small and Hsiao test on each model, which tests the likelihood ratios from subsamples of the data once a particular category is omitted. Again, if the ratios are similar and thus the probability is not significant, the IIA hypothesis is upheld. With my data, I occasionally got negative test statistics for the Hausman test, indicating that some asymptotic assumptions may not hold. This is not uncommon and is not proof that IIA has been violated (Long and Freese 2001).

When estimating using a multinomial logit model, problems can arise if the occurrence of one category is rare, relative to the others. This is termed a sparse cell count and can bias parameter estimates and increase standard errors (Agresti 1996). In my data, I have several instances where the distribution among the sourcing modes is unbalanced. For example, die maintenance is rarely bought (n=7 out of 164) and part coating is rarely made (n=3 out of 169), leading to fewer observations in these cells. To address this issue and smooth out the relative occurrence of each sourcing mode, I used a 90% cutoff for the mode choice. That is, I considered "make" to be producing 90+% of the input internally and "buy" to be sourcing 90+% externally. This also reduced my overall data slightly (n=805), since I did not have percentage figures for four inputs. It also reduced the number of inputs that were concurrently sourced, from about 39% (312/809) to about 28% (226/805). See Table 17 for details of the sourcing mode choice, using this cutoff.

In addition to addressing the uneven nature of the data, there are two conceptual reasons to use this adjustment. First, it addresses the possibility of one part or situation that is being outsourced or in-sourced which obscures the more typical mode of sourcing. Similarly, this cutoff corrects for respondent memory issues. A respondent may have thought that with all the many parts sourced, there must be at least one purchased on the outside, but could not specifically recall if that was indeed the case or the precise part or percentage. So, to be conservative, the respondent may have marked "make and buy", but indicated that less than 10% was outsourced. Second, this cutoff is more consistent with prior research, which typically uses a lower figure than 100% internal production to indicate a "make" choice (e.g., Monteverde and Teece 1982b used 80%).

The other issue arising with my data is the interdependence of observations. My dataset of 805 input choices comes from 193 firms, each of which provided data from one to five inputs. Therefore, it is likely that the within firm observations will share some similarities and thus not be independent. This clustering phenomenon is common in survey research (Hosmer and Lemeshow 2000, Agresti et al 2000). To address this issue in my estimation, I use robust (Huber/White/sandwich) standard errors adjusted for repeat observations by firm. This method alters the estimated standard errors and variance-covariance matrices, but not the estimated coefficients (Stata Corporation 1999). Other scholars have successfully used clustered errors with similarly structured data (e.g., Mizruchi and Stearns 2001).

Another data consideration is the nature of the dependent variable and its potential to be ordered. Rather than using a multinomial logit model, another estimation option is the ordered logit model, e.g., ordering the sourcing modes as buy, concurrent source, and make. This assumes that the ordering is consistent for all variables. Although such an ordering is inconsistent with the logic of my hypotheses, I nonetheless test for this ordering as a robustness check, by re-estimating the model using an ordered logit specification and comparing these results with those of the multinomial logit.

Model Specification

My model includes variables involving production costs, transaction costs, firm controls, and input controls. I included all of the production cost measures discussed above. For the transaction cost variables, I use one measure each for volume uncertainty (UNPRED – volume unpredictability) and for asset specificity (MTHIN – market thinness), due to inter-correlations. As a robustness test later in this chapter, I do verify the results of the model when using the other or both measures for these variables. In developing the model, I found that none of the supplier management capability variables significantly affected the sourcing mode, even if only these variables and controls were included in a model. Given this null finding and that some of these variables were correlated with other explanatory variables (e.g., performance evaluation and performance ambiguity), I chose to omit them in the final specification.

Based on the above, my multinomial logit model using clustered errors by firm for the 805 input observations is as follows, where a coefficient will be estimated for each individual variable:

SMODE90 (1 for make; 2 for buy; 3 for concurrently source) = β_0 +

$\boldsymbol{\beta_P}$ (Production Cost variables = FEX, SUPEX, SCALE1, FSCOPE, SUSCOPE1) +

$\boldsymbol{\beta_T}$ (Transaction Cost variables = PA, UNPRED, MTHIN, TUN) +

$\boldsymbol{\beta_F}$ (Firm Controls – AGE, EMPEES, UNION, PM) +

$\boldsymbol{\beta_I}$ (Input Controls – VOLUME, ALLSAME, DESIGN, MAINT, MACH, COAT)

Model Results and Comparison with Hypotheses

The model, shown on Table 19, was significant with very good explanatory power (Wald chi-square test p=0.000; Pseudo R-squared = 0.417; adjusted count R-squared = 0.550), predicting 71% of the sourcing mode choices correctly. The sourcing mode of concurrent sourcing was statistically distinct from that of make (p=0.000) and of buy (p=0.000). Both the Hausman and the Small-Hsaio tests confirmed the IIA assumption, further supporting the distinction between the three sourcing modes. As Figure 12 depicts, the three sourcing modes do not appear to be in a continuum, always ordered from make to concurrent source to buy. Rather, for some variables, concurrent sourcing is the most or least likely sourcing mode, supporting the logic of some of my hypotheses.

Most of the independent variables had explanatory power. Wald tests of the independent variables indicated that firm expertise (p=0.000), firm scope economies (p=0.000), supplier scope economies (p=0.000), performance ambiguity (p=0.094), market thinness (p=0.017), input sameness (p=0.069), volume (p=0.040), maintenance (p=0.000), and machining (p=0.001) coefficients were significant for the overall model. See Tables 20 and 21 for summary comparisons of the model and the hypotheses. The following sections will compare the results and the hypotheses in more detail.

Table 22 provides the results of the ordered logit model, using the same independent variables. Goodness of fit tests comparing the log-likelihood values of the two models indicated that the parallel regression assumption of the ordered logit was violated, thus the multinomial logit was the better model (Long 1997; Stata Corporation 1999). Testing the models as if they were nested provided evidence that the constraints of the ordered logit model were too severe, and the multinomial model was a better fit (chi-square difference tests of 43.384, 19 degrees of freedom, p=0.000). A visual comparison of the prediction of concurrent sourcing for the two models shown in Figure 13 also depicts an unrealistic truncation of the distribution, further supporting a rejection of the ordered model, in favor of the unordered one (Long and Freese 2001).

Evidence Regarding Production Cost Hypotheses

Hypothesis 1a: *The greater the expertise of internal suppliers, the more likely the sourcing firm will make an input.*

Hypothesis 1b: *The greater the expertise of external suppliers, the more likely the sourcing firm will buy an input.*

Hypothesis 1c: *The smaller the difference between the expertise of internal and external suppliers, the more likely the sourcing firm will concurrently source an input.*

Taken together, these hypotheses suggest a continuum of expertise regarding the input such that firms will make an input if their expertise is significantly greater, buy an input if outside suppliers have greater expertise, and concurrently source if the expertise is intermediate. The model as illustrated in Figure 12 supported all of these hypotheses. Concurrent sourcing, sourcing mode numbered 3, is in between modes 1 (make) and 2 (buy) for both the firm and supplier expertise variables.

However, there was quite an imbalance in the effects of firm versus outside supplier expertise. Firms having the skills required to produce the input are more than twice as likely to make versus buy it. The increased likelihood of firms with great expertise to make versus concurrently source the input is smaller, about 32% for each unit increase in the firm expertise scale. In all three pairs of decisions, stronger firm expertise pushed the firm toward greater in-sourcing and this effect was one of the strongest of all the variables included. In contrast, the effect of supplier expertise did not directly significantly affect the sourcing decision. It seems that even exceptionally skilled outside suppliers are not sufficiently enticing for the firm to completely outsource and it takes a great lack of internal expertise to move a firm to outsource entirely. Firms have better knowledge about their own skills than those of any outside firm and with this knowledge they may be better able to evaluate suppliers and predict their performance.

To investigate the third hypothesis, involving the relative comparison of firm versus supplier expertise, I increased and decreased these variables by one standard deviation from their means and compared the resulting sourcing mode probabilities to those at the mean levels. The hypothesis predicts that if the relative values of firm versus expertise are similar, firms would be more likely to concurrently source. Thus, if both were increased or decreased, concurrent sourcing should be more likely. But, if only one was changed, the likelihood of concurrent sourcing should not be affected; rather, firms will go toward the polar mode (make or buy) having greater expertise. The findings, shown in Table 23, agree with this prediction for increasing firm expertise, supplier expertise, or both. However, when decreasing firm expertise, firms are less likely to concurrently source, even if supplier expertise also is lower. This suggests that while the relative nature of expertise does exist, firms also need a certain amount of expertise to manage concurrent sourcing. Thus, there is partial support for the third hypothesis.

Hypothesis 2a: *The greater the input's production economies of scale relative to the volume demanded, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 2b: *The greater the input's production economies of scale relative to the volume demanded, the more likely the sourcing firm will buy the input.*

By looking at the coefficients for the scale item, it appears that effects of scale economies do not affect the sourcing decision. There may be two reasons for this. First, the item measuring scale economies may be difficult for respondents to answer since it requires them to make an implicit calculation ("if demand doubled, the average cost would change very little") (Fowler 1995). Second, the effects of scale economies may be coming through the volume variable instead. For managers, this may be a better measure as it more intuitively expresses the concept. Assuming no scale diseconomies and that some minimum efficient scale does exist over the volumes listed (1 to 200+ dies designed, built, or maintained and 10-100+ parts machined or coated), firms would be more likely to split the volume between multiple suppliers when those volumes were higher. This is what the model predicts; firms that require higher volumes of an input will be more likely to purchase the input from outside suppliers versus concurrent sourcing or making. Thus, the concept behind the above hypotheses is supported albeit with a different measure.

Hypothesis 3a: *The greater the scope economies to the internal supplier from producing the focal input along with its other products, the more likely the sourcing firm will make the input.*

Hypothesis 3b: *The greater the scope economies to the external supplier from producing the focal input along with its other products, the more likely the sourcing firm will buy the input.*

Hypothesis 3c: *The greater the scope economies of both the internal and external suppliers from producing the focal input along with their respective products, the more likely the sourcing firm will concurrently source the input.*

Much like the expertise variables, the model provides support for the continuum view, in which firms will make if they have a higher level of scope economies and buy if their outside suppliers have high scope economies. Unlike the expertise variables, both of the scope economy measures affected all three decisions with neither measure being inordinately stronger. This may be because scope economies are less influenced by perception and may be easier to observe and evaluate in outside suppliers. In making a sales pitch and justifying a low price, suppliers may emphasize how well the focal input fits the labor and equipment already in place for their other products. This claim may relatively easy to verify before actually purchasing goods, through knowledge of their other product lines and by obtaining equipment lists. In contrast, a supplier's proprietary expertise or technological acumen may only be apparent once the buying firm has made a purchase and is actually using the supplier's goods in its production process.

Unlike the expertise variables, the scope economy variables are more absolute rather than relative measures. As such, following the third hypothesis, firms will concurrently source if both the firm and the outside supplier will gain from scope economies. If the scope economy for both inside and outside suppliers is low, the likelihood of concurrent sourcing will not be affected. If the scope economies of either the inside or outside supplier is increased or decreased, the appropriate polar sourcing mode (make or buy) will change, but not the likelihood of concurrent sourcing. As above, to investigate this hypothesis, I increased and decreased these variables by one standard deviation from their means and compared the resulting sourcing mode probabilities to those at the mean levels. The findings, shown in Table 24, indicate that if scope economies are low for the firm, the outside supplier, or both, it does not affect the likelihood of concurrent sourcing; this supports the hypothesis. If only the firm's scope economy is increased, the likelihood of concurrent sourcing is not affected; this also supports the hypothesis. However, if the outside supplier has greater scope economies, the likelihood of concurrent sourcing decreases, counter to the hypothesis that suggested no effect. Moreover, if both the firm and the outside supplier have greater scope economies, the likelihood of concurrent sourcing does not change; this is also counter to the hypothesis that suggested an increase. Overall, these results suggest partial support for the third hypothesis.

Evidence Regarding Transaction Cost Hypotheses

Hypothesis 4a: *The greater the performance ambiguity of an input, the more likely the sourcing firm will concurrently source the input.*

Hypothesis 4b: *The lower the performance ambiguity of an input, the more likely the sourcing firm will buy the input.*

Contrary to these hypotheses, the model suggests that firms are more likely to make an input as performance ambiguity increases. The performance ambiguity variable positively affected the make versus concurrently source decision; this effect was strong and robust to model specification. It also positively but moderately affected the make versus buy decision. The explanation for these findings may be due to the types of inputs studied. These inputs are production services with relatively thin markets, particularly for die maintenance and parts machining. In these cases, it may be that if performance is somewhat difficult to determine, firms will not even consider using only outside suppliers, effectively choosing between the modes of making and concurrent sourcing.

This finding is consistent with a more nuanced version of Proposition 2 which states that concurrent sourcing will be more likely when quality is hard to monitor. The logic underlying this hypothesis is that having both internal and external streams of information about the input reduces the problems associated with monitoring quality. The firm can both better evaluate inputs through knowledge gained via internal production experience and have outside suppliers for benchmarking purposes. However, it may be that the costs of monitoring the quality of two different types of suppliers outweigh these benefits. Using concurrent sourcing which involves two different sets of sourcing routines may be too complex and confusing in the face of ambiguous inputs. The items measuring performance ambiguity involve attributes like an inability to describe in drawings, difficulty in inspection, and problems equitably measuring suppliers against each other. All of these indicate tacitness of the input, making it difficult to even characterize whether or not it meets the specifications of the buying firm. Indeed, it may be that the buying firm has no rigid specifications or may not even know precisely what it wants, but will "know it when they see it". These properties make intuitive sense when considering die maintenance, part machining, or die designs. The tacit nature of the specifications would make firms more likely to produce the input internally. Given the difficulty in characterization, it would be difficult to communicate to outside suppliers what is required and even more challenging to evaluate the offerings of multiple suppliers. Therefore, it is unlikely firms would want to use multiple suppliers, so would not want to concurrently source. The finding of higher performance ambiguity leading to making, both in the make vs. concurrent source and in the make vs. buy decision, provides evidence of the preference to single source these types of inputs.

Three other findings from the model support the idea that concurrent sourcing incurs both costs and benefits with respect to quality monitoring. First, more similar inputs were concurrently sourced rather than bought. Since they are more similar, it should be less costly and easier for the buying firm to compare the offerings of internal versus external suppliers. Second, unionized firms tended to use concurrent sourcing. For these firms, the benefit of having an outside source of cost and efficiency measures may help in monitoring the internal supplier's quality levels. Third, firms that concurrently source need sufficient internal expertise. This expertise should reduce information asymmetries and the firm's costs in understanding the inputs. Skilled firms will be better able to define inputs, communicate their requirements to outside suppliers, and then evaluate them more accurately. With sufficient expertise, firms can overcome the complexities and benefit from using both internal and external suppliers.

Hypothesis 5a: *The greater an input's volume uncertainty, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 5b: *The greater an input's volume uncertainty, the more likely the firm will make those inputs that involve highly specific assets and buy those inputs that involve little specific assets.*

The model did not show any effect of volume uncertainty in the sourcing decision. This null result was robust even when changing the nature of the uncertainty by changing the variables used (e.g, swapping out the volume unpredictability measure for the volume changeability measure). Indeed, even when both measures were included, no significance was found. A rationale for this null result may be that volume uncertainty does not play a role in the sourcing decision unless asset specificity is involved. To test this explanation, I ran the model including an interaction term between volume unpredictability and market thinness; results for this model are shown on Table 25. This interactive model does indicate that volume uncertainty alone would persuade firms to concurrently source versus making. However, when this uncertainty is coupled with thin markets, firms are more likely to internally produce. The volume uncertainty and the interactive terms were only significant in the make versus concurrent source choice; they did not affect either of the other two decisions. While this particular model does not offer better explanatory power than the base model (LR(40)=736.872; p-value for chi-square difference = 0.203) and some of its results do not conform to those already proven robust in the basic model (e.g., the asset specificity measure, market thinness, does not affect the make versus buy choice), the significance of these terms indicate that more investigation may be warranted to further explore this relationship.

Hypothesis 6a: *The greater an input's asset specificity, the less likely the sourcing firm will concurrently source the input.*

Hypothesis 6b: *The greater an input's asset specificity, the more likely the sourcing firm will make the input.*

These hypotheses assumed that in cases of highly specific assets, either internalization or significant relational safeguards would be used to subdue high-powered market incentives in favor of coordinated incentives and adaptation. The preferred sourcing mode in cases of high asset specificity would be internalization and then external sourcing with one or two suppliers with the appropriate safeguards such as long term contracts. Since concurrent sourcing involves both coordinative and autonomous incentives, it is unlikely that this sourcing mode will be preferred when specific assets are required. Model results do not support the first hypothesis, but strongly support the second.

The lack of support for the first hypothesis is likely due to the nature of the market and typical supply relationships for these inputs. In the survey, I asked those firms using outside suppliers how many suppliers they used and some details about the terms of their transaction (e.g., whether they used long term contracts or single purchase orders for each transaction). Firms tended to use few outside suppliers; 51% used four or fewer for focal inputs that were bought and 77% used four or fewer for inputs that were concurrently sourced, suggesting rather thin markets. While this may imply stronger relationships between buyers and suppliers, that was not reflected in their contracting behavior. Only 17% of the inputs that were sourced externally (either solely bought or concurrently sourced) were under a long-term contract agreement. One common form of relational safeguard, the sole source contract, was rare; among those firms using only external suppliers, only 4% of the inputs were covered by such an arrangement. Sole external sourcing was considerably more common among firms that concurrently sourced (11%).

In this context, other forms of relationships may reduce the problems associated with specific investments. In some cases, firms and their external suppliers may trade roles, with the suppliers becoming the customers. This relationship, making and selling, is fairly common with 13% of die building, 15% of die maintaining and 21% of parts machining firms indicating that they both make and sell. Twenty-seven firms make-and-sell as well as concurrently source, multiplying the possibility for interrelationships. Firms in this industry also tend to be geographically concentrated, which can lead to other forms of ties to entice specific investments. Typically, specific investments in this context are not highly expensive and customized pieces of equipment but rather strong relationships such as informally dedicating some capacity in the form of quick turnaround times to preferred customers. Concurrent sourcing may not necessarily be a deterrent for making these types of specific investments since they may be easier to reciprocate.

While the second hypothesis is supported, providing the normal result that higher asset specificity leads to internalization, a better understanding of why this occurs is revealed since the comparison is among three rather than two sourcing modes. In the normal dichotomous 'make-or-buy' set up, it is unclear if the 'make' choice is because the firm prefers internal production to gain additional control or rather wants to avoid buying to escape supplier opportunism. By including the concurrent sourcing option, it appears that in cases of higher asset specificity in this context, firms prefer to avoid buying.

Hypothesis 7a*: The greater an input's technological uncertainty, the more likely the sourcing firm will concurrently source the input.*

Hypothesis 7b*: The lower an input's technological uncertainty, the more likely the sourcing firm will buy the input.*

The model moderately supported the first hypothesis, indicating that inputs with greater technological uncertainty were somewhat more likely to be concurrently sourced versus made. This provides support for the benefits of having two different streams of knowledge entering the firm, particularly in cases of technological change and uncertainty. Firms that have sufficient expertise and knowledge gained through internal production in combination with more diverse knowledge and skills of external suppliers can benefit by using concurrent sourcing for such inputs. Given that this industry is not beset by radical technological change, this is a compelling result. As in the case of performance ambiguity, the results suggest some costs and benefits from gathering outside information. In the case of technological change, these benefits outweigh the costs so firms are more likely to look to outside suppliers. By also producing internally, the firm has the expertise to evaluate this information.

If technological change is minimal, it is unclear from the model whether firms will make or buy, indicating a lack of support for hypothesis 7b which suggests that firms will purchase inputs that are more technologically mature. This may be due to the relatively slow pace of technological change in this industry and the nature of the input markets involved. As mentioned earlier, the markets for these inputs are fairly thin so the usual assumption that competitive outside suppliers drive down prices due to optimizing production methods in times of stable technology may not hold. Also, the usual assumption is that once technology has matured, suppliers will make the necessary specific physical investments. However, these inputs do not require large, specific investments in technologically unique equipment, so again this logic may not be supported. Finally, there could be some interaction between the performance ambiguity of the input and technological change such that these two effects may cancel each other out. Further research may help in better understanding this result.

Evidence Regarding Supply Management Capability Hypotheses

Hypothesis 8a: *The greater the sourcing firm's supply management capability, the more likely that it will concurrently source an input.*

Hypothesis 8b: *The weaker the sourcing firm's supply management capability, the more likely that it will make an input.*

None of the three supply management capability variables, performance evaluation ability, sharing of information, or relationship management, were significant in any of the models leading up to the development of the final model. There are two possible explanations for this null result. First, the measures for these variables were not as reliable as some of the others, with alphas ranging from 0.528 to 0.604. There were a total of 23 items investigating this capability and, because it has not been extensively researched and is therefore not well understood, it may take additional work to develop robust and reliable measures. Second, it may be that these firm characteristics do not necessarily lead toward a particular mode of sourcing, but rather to superior sourcing performance regardless of the mode chosen. Since data was gathered on several different aspects of performance (cooperation, cost effectiveness, etc.), these variables can be analyzed in the future to determine how they relate.

Control Variables

The model presented intuitive results for most of the firm and input control variables. Older firms tended to make versus concurrently source, perhaps due to inertia if they had begun making the input and did not choose to add another mode of sourcing. Firm size did not affect the decision to concurrently source. Unionized firms were more likely to concurrently source, perhaps because having outside suppliers for comparison allows them to monitor and motivate their internal suppliers. Firm type (powder metal or stamping) did not appear to directly affect the sourcing decision. Higher volume inputs tended to be bought rather than concurrently sourced, probably for scale economy reasons (see hypotheses 2 above). Importantly, more similar inputs tended to be concurrently sourced rather than bought. This finding supports one of the key ideas presented throughout this dissertation that firms make and buy the *same* input.

Tests for Model Robustness

I explored the robustness of the model in three ways. First, I changed the measures of volume uncertainty and asset specificity to determine if the model changed if I had chosen differently or included all measures. Second, I investigated the potential for variable misspecification, creating models to include the supplier management capability variables and ran the model without the input dummy variables. Finally, I explored unobserved firm fixed effects.

First, I investigated using a different or both volume uncertainty measures. Rather than using unpredictability (UNPRED), I ran the model using the changeability (CHG) measure and the results did not change. Then, I ran the model using both measures; again the results did not change and a nested model test indicated that the model using only the UNPRED measure was superior (p-value of chi-square difference test: 0.7261). Similarly, I ran models using the other measure of asset specificity, specific investment (SPEC), and using both measures (SPEC and MTHIN). Again, the results did not change and the model with both measures was not significantly better than the main model (p-value of chi-square difference test: 0.0517). Next, I included all four measures of these variables. Once more, the results did not change and the nested test indicated the main model was superior (p-value of chi-square difference test: 0.1621).

Next, I considered other variables that could have been included or model misspecification. To the main model, I added the three supplier management capability variables. The performance evaluation variable marginally and positively affected the make versus concurrently source choice and the unpredictability variable became marginally significant, positively affecting the concurrently source versus buy choice. All of the other results remained the same as in the main model. The test of nested models indicated that this model was not significantly better than the main model (p-value of the chi-square difference test: 0.5248). I also dropped the input control variables from the model. In this case, the supplier expertise variable became marginally positively significant in the make versus the concurrent source choice. All of the other results were the same as the main model and a test of nested models indicated that the main model with the input controls was significantly superior (p-value of the chi-square difference test: 0.000).

The other robustness test involved the need to control for unobserved attributes of individual firms in affecting the sourcing mode choice. To investigate this possibility, I created a model with 192 dummy variables, one for each firm (less one that was omitted). Results of this model are shown on Table 26, with most of the results being the same as the main model. While this method overcomes the problem of unobserved firm-level characteristics, other econometric issues arise due to the small number of observations per firm – between one and five. This may lead to problems of perfect prediction, in cases of only one observation. There also can be cases of insufficient variance, if a particular firm only uses one sourcing mode across several inputs. These problems led to the inability to estimate coefficients for most of the firm dummy variables, potentially biasing the coefficients of the primary explanatory variables. Therefore, the better approach is to include control variables for firm demographic characteristics (age, type, and size) and to use firm-clustered errors to further control for the firm effects. This follows what other scholars have used in similar situations and the structure of my main model (Mizruchi and Stearns 2001).

In summary, four findings about concurrent sourcing arise from the empirical results. First, concurrent sourcing clearly does occur and is a stable sourcing mode. Second, production costs matter in the decision and this mode will be selected if neither the firm nor outside suppliers' costs are considerably lower. Third, the combination of two types of information and incentives from internal and external suppliers leads to both costs and benefits in terms of quality monitoring, protecting specific investments, and technological learning. These effects can be difficult to untangle and led to intriguing results. Finally, firm characteristics such as unionization do impact the sourcing decision, but it is not clear how a firm's ability to manage its suppliers affects the choice itself. The next and final chapter of this dissertation will provide a summary, suggest contributions, and provide extensions for future work.

Table 13: Descriptive Statistics – Variables Used in Models

Variable	Description	Min	Max	Mean	Std. Dev	Alpha
SMODE	Sourcing Mode (1=make 2=buy 3=make and buy)	1.0	3.0	2.082	0.827	
MNB	Make and buy (1) or not (0)	0.0	1.0	0.386	0.487	
MAKE	Make (1) or not (0)	0.0	1.0	0.304	0.460	
BUY	Buy (1) or not (0)	0.0	1.0	0.310	0.463	
PERMAKEP	Percentage of input made in-house	0.0	1.0	0.519	0.438	
PERF	Performance scale score	1.9	7.0	5.310	0.865	
FEX	Firm expertise scale score	1.0	7.0	4.722	1.742	0.839
SUPEX	Supplier expertise scale score	1.0	7.0	3.723	1.060	0.593
SCALE1	Economies of scale item	1.0	7.0	3.475	1.664	
FSCOPE	Firm scope scale score	1.0	7.0	4.214	1.572	0.805
SUSCOPE1	Supplier scope item	1.0	7.0	4.703	1.361	
PA	Performance ambiguity scale score	1.0	6.1	2.948	0.928	0.619
UNPRED	Volume unpredictability scale score	1.0	7.0	3.814	1.448	0.733
CHG	Volume changeability scale score	1.0	7.0	3.807	1.336	0.752
MTHIN	Market thinness (asset specificity) scale score	1.0	7.0	4.070	1.266	0.636
SPEC	Specific investment (asset specificity) scale score	1.0	7.0	4.009	1.524	0.658
TUN	Technological uncertainty scale score	1.0	7.0	4.464	1.232	0.743
PEVAL	Performance evaluation (supplier mgmt cap) scale	0.9	6.6	4.493	1.264	0.604
SHARE	Sharing information (supplier mgmt cap) scale	2.3	7.0	5.106	1.140	0.556
RELN	Relationship mgmt (supplier mgmt cap) scale	2.6	7.0	5.049	0.974	0.528
AGE	Age of the firm (in years)	2.0	122.0	43.7	22.0	
EMPEES	Number of employees (1-5 scale)	1.0	5.0	2.501	1.100	
UNION	Unionized (1) or not (0)	0.0	1.0	0.140	0.347	
AUTOPER	Percentage of products for auto applications (1-5)	1.0	6.0	3.449	1.833	
FERPER	Percentage of ferrous (iron) products (1-5 scale)	1.0	6.0	5.065	1.252	
PM	Powder metal (1) or not (0=stamping firm)	0.0	1.0	0.227	0.419	
PLANCHG	Plan to change sourcing mode (1) or not (0)	0.0	1.0	0.099	0.299	
HOWLONG	How long have used this sourcing mode (1-4 scale)	1.0	4.0	2.664	0.518	
VOLUME	Volume of input required (1-5 scale)	1.0	5.0	2.643	1.474	
LASTDLY	Last delivery received (1-5 scale; 1=most recent)	1.0	5.0	1.537	0.896	
ALLSAME	Inputs required are basically all the same (1-7 scale)	1.0	7.0	3.509	1.805	
COMPLEXI	Produce complex internally, outsource rest (1-7)	1.0	7.0	3.182	2.045	
MKNSELL	Make and sell this input (1) or not (0)	0.0	1.0	0.117	0.322	
TYPE	Input type (1=des 2=bld 3=maint 4=mach 5=coat)	1.0	5.0	2.944	1.434	

Note: n=809 for all variables except n=743 for PERF and n=805 for PERMAKEP

Table 14: Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	mnb	1																						
2	permakep	0.0701*	1																					
3	perf	-0.0351	0.0836*	1																				
4	fex	0.3224*	0.7030*	0.1496*	1																			
5	supex	-0.1689*	-0.4938*	-0.0935*	-0.5362*	1																		
6	scale1	0.0146	-0.0223	-0.1280*	-0.0317	0.0393	1																	
7	fscope	0.1210*	0.5139*	0.0443	0.5439*	-0.4013*	0.0092	1																
8	suscope1	-0.1188*	-0.3871*	0.0232	-0.3246*	0.3956*	0.0543	-0.1996*	1															
9	pa	-0.0577	0.0237	0.0119	-0.012	0.0625*	0.0204	0.0133	0.0661*	1														
10	unpred	0.0331	0.0118	0.0267	0.0013	-0.0317	0.0109	0.0416	-0.0013	0.2971*	1													
11	chg	-0.0158	-0.0418	-0.0289	-0.0131	0.1061*	0.0294	-0.0876*	0.0651*	-0.0023	0.1031*	1												
12	mthin	0.0022	0.0418	-0.0055	-0.0256	0.0098	-0.0144	0.0315	-0.0828*	0.0660*	0.0129	-0.0884*	1											
13	spec	-0.0551	-0.0735*	0.0749*	-0.1047*	0.1398*	-0.0565	-0.0684*	0.0587*	0.1353*	-0.0327	0.0468	0.0706*	1										
14	tun	0.0473	-0.0547	-0.0121	-0.0161	0.056	-0.039	-0.0391	-0.0077	-0.0166	0.0880*	0.1198*	0.0399	0.001	1									
15	peval	-0.001	0.0217	-0.0002	0.0095	-0.0503	0.0084	-0.0162	-0.0275	-0.1383*	-0.1842*	-0.041	0.0947*	0.0314	0.0844*	1								
16	share	0.0072	-0.0122	-0.0033	-0.0313	-0.0156	0.0501	0.0262	0.0295	-0.1748*	-0.1690*	-0.1458*	-0.0026	0.0044	0.0704*	0.2627*	1							
17	reln	0.0096	0.0115	-0.0197	0.0173	-0.0065	-0.0027	0.0263	0.019	-0.2374*	-0.2559*	-0.0176	0.0183	0.0428	0.0736*	0.3492*	0.2771*	1						
18	age	-0.0279	0.0996*	0.0676*	0.1037*	-0.0594*	0.0017	0.0125	0.0093	-0.0024	0.0062	0.0191	-0.0311	0.0345	0.0295	-0.0444	0.0769*	0.0882*	1					
19	empees	0.0273	0.0452	0.012	0.0549	-0.1051*	-0.0745*	0.0416	-0.0413	-0.1265*	-0.0926*	0.0973*	0.0609*	-0.0688*	0.0519	0.1885*	0.1372*	0.2227*	0.0522	1				
20	union	0.0544	-0.0235	-0.0039	0.0139	0.0477	-0.0054	0.0224	0.0572	0.0582*	0.0639*	0.0584*	-0.1337*	-0.0274	0.0373	-0.0705*	-0.0606*	-0.0065	0.1845*	0.0241	1			
21	pm	0.0487	-0.004	-0.0746*	0.0012	-0.0495	0.0276	0.0847*	-0.0078	0.0208	-0.0284	-0.1316*	-0.1241*	-0.0951*	-0.0374	-0.0252	0.0326	0.0033	-0.3223*	0.1633*	-0.1165*	1		
22	volume	-0.0788*	-0.0338	-0.0394	-0.0373	-0.0099	-0.0287	0.0496	0.0009	-0.0533	-0.1905*	0.0801*	-0.0003	0.1028*	-0.0436	-0.0084	0.0021	0.0081	0.0255	0.2796*	0.0159	0.0567	1	
23	allsame	0.0036	-0.0085	-0.0543	0.009	-0.0336	0.0261	-0.0411	-0.0233	0.0697*	-0.1797*	-0.0417	-0.1773*	-0.022	-0.1803*	-0.1078*	-0.1329*	-0.0142	-0.1207*	-0.0627*	-0.0513	-0.0038	0.0654*	1

Table 15: Sourcing Modes – Overall, By Firm, and By Input Type

	Make	Buy	Concurrent Source	Total
Overall	246 30.4%	251 31.0%	312 38.6%	809
By Firm Type				
Stamping	192 30.7%	200 32.0%	233 37.3%	625
Powder Metal	54 29.3%	51 27.7%	79 42.9%	184
By Input Type				
Die Design	62 36.3%	31 18.1%	78 45.6%	171
Die Build	36 20.8%	54 31.2%	83 48.0%	173
Die Maintenance	89 54.3%	7 4.3%	68 41.5%	164
Part Machining	56 42.4%	14 10.6%	62 47.0%	132
Part Coating	3 1.8%	145 85.8%	21 12.4%	169

Table 16: Percentage Produced Internally

	0%	< 10%	11 - 24%	25-49%	50-75%	76-90%	> 90%	100%
Overall	251	36	38	54	58	76	46	246
By Firm Type								
Stamping	200	26	29	32	48	60	35	192
Powder Metal	51	10	9	22	10	16	11	54
By Input Type								
Die Design	31	7	12	14	16	20	9	62
Die Build	54	15	16	16	14	15	7	36
Die Maintenance	7	5	3	8	10	19	21	89
Part Machining	14	5	5	12	15	18	6	56
Part Coating	145	4	2	4	3	4	3	3
Total	251	36	38	54	58	76	46	246

Figure 10: Percentage Produced Internally, by Firm Type

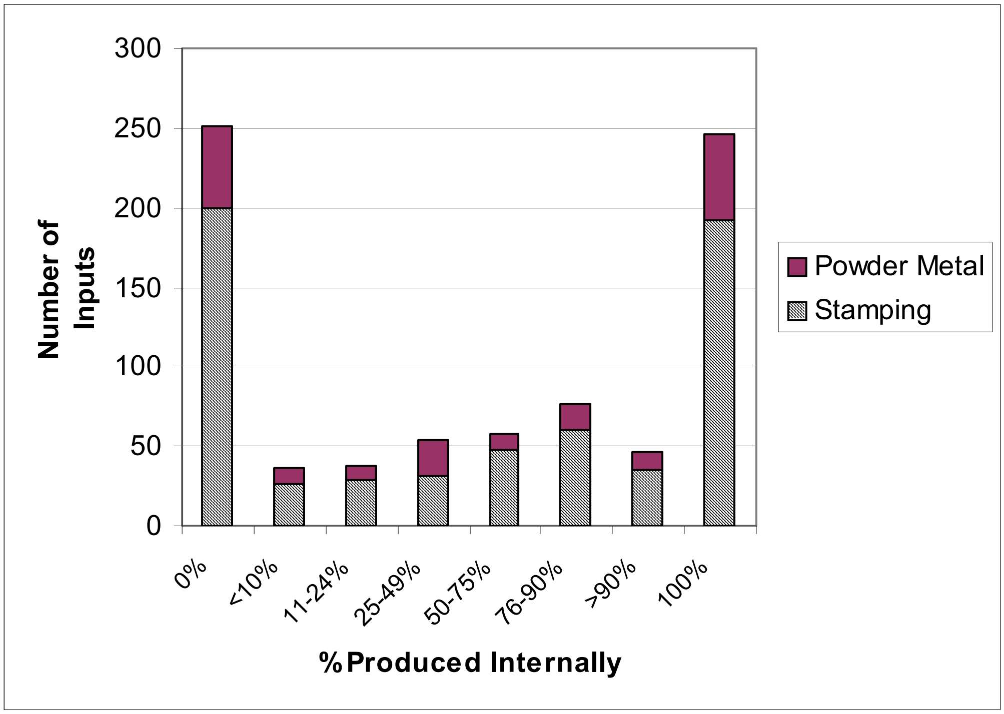


Figure 11: Percentage Produced Internally, by Input Type

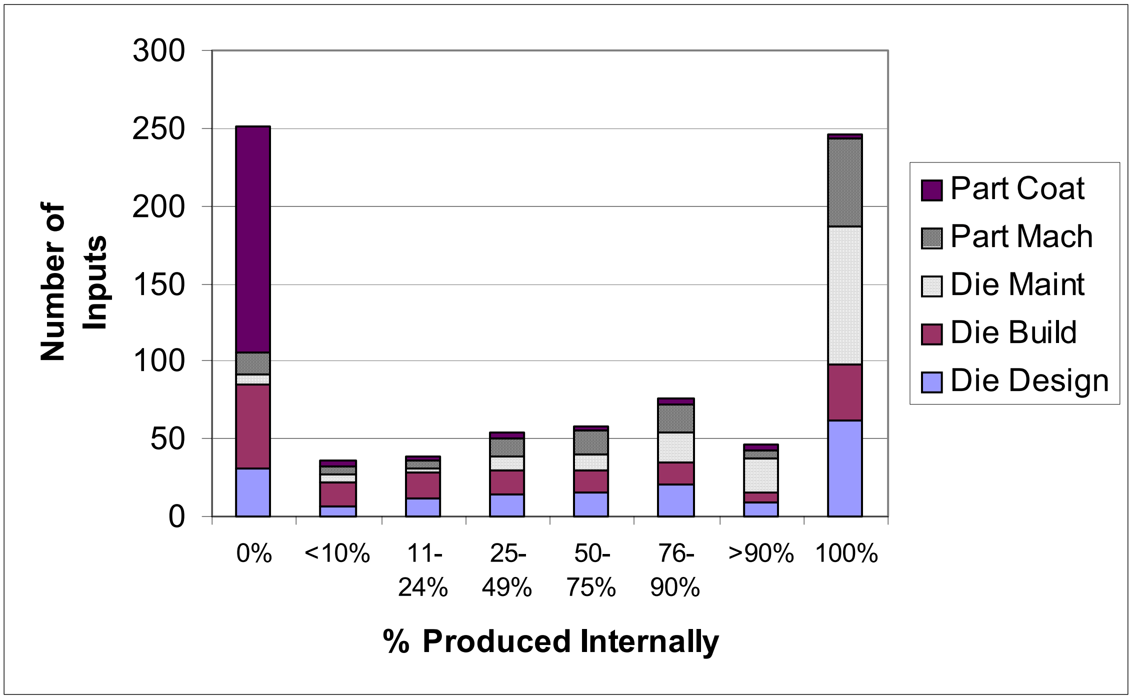


Table 17: Sourcing Modes – Overall, By Firm, and by Input Type with 90% Cutoff

	Make	Buy	Concurrent Source	Total
Overall	292 36.1%	287 35.5%	226 27.9%	805
By Firm Type				
Stamping	227 36.3%	226 36.2%	169 27.0%	622
Powder Metal	65 35.3%	61 33.2%	57 31.0%	183
By Input Type				
Die Design	71 41.5%	38 22.2%	62 36.3%	171
Die Build	43 24.9%	69 39.9%	61 35.3%	173
Die Maintenance	110 67.1%	12 7.3%	40 24.4%	162
Part Machining	62 47.0%	19 14.4%	50 37.9%	131
Part Coating	6 3.6%	149 88.2%	13 7.7%	168

Table 18: Descriptive Statistics of Independent Variables by Sourcing Mode (Means with Standard Deviations in Italics)

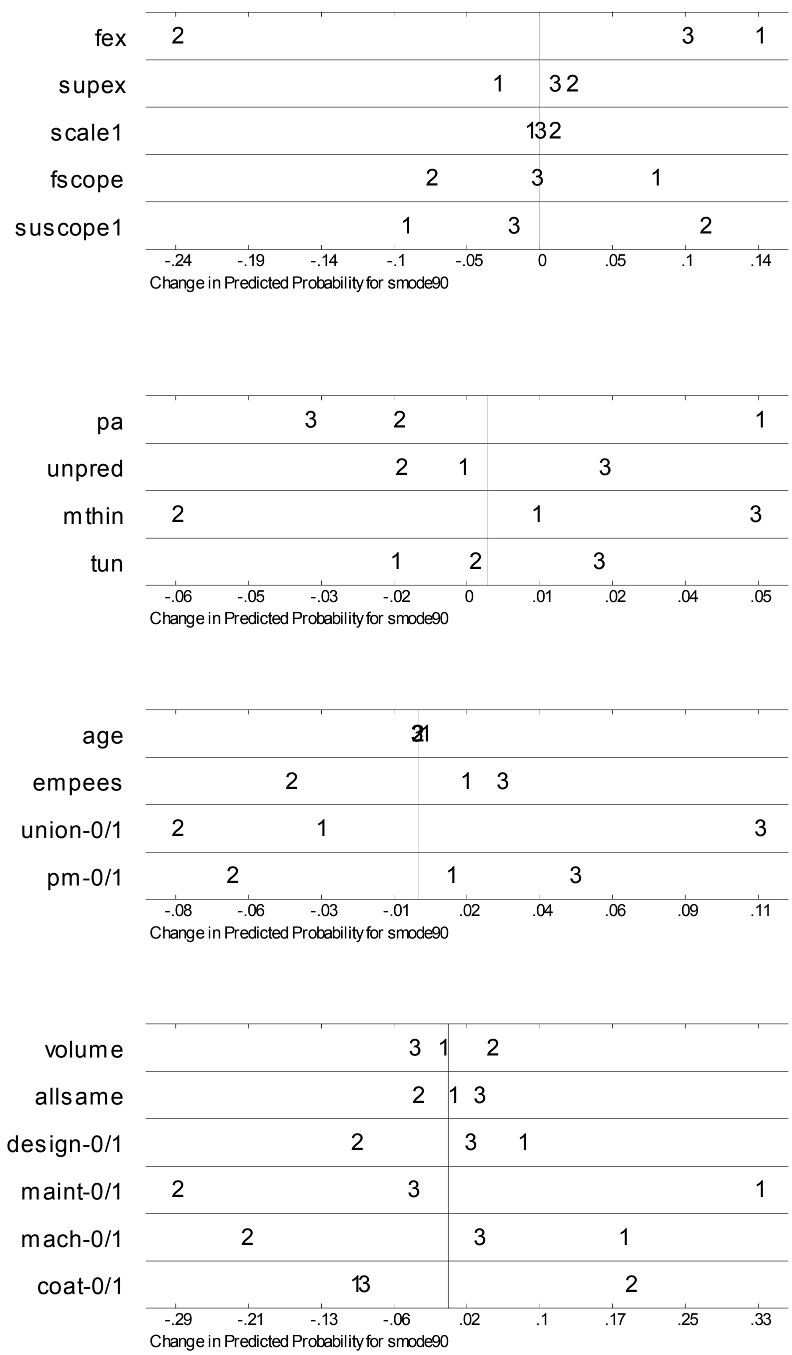
Variable	Make	Buy	Concurrent Source
Firm Expertise	5.855 *0.843*	2.985 *1.488*	5.472 *1.035*
Supplier Expertise	3.189 *0.947*	4.418 *0.952*	3.528 *0.830*
Scale Economies	3.406 *1.702*	3.568 *1.687*	3.444 *1.585*
Firm Scope Economies	5.052 *1.359*	3.194 *1.388*	4.419 *1.315*
Supplier Scope Economies	4.109 *1.325*	5.390 *1.104*	4.586 *1.319*
Performance Ambiguity	2.982 *0.975*	2.965 *0.901*	2.868 *0.894*
Volume Unpredictability	3.802 *1.487*	3.770 *1.420*	3.871 *1.439*
Volume Changeability	3.736 *1.407*	3.875 *1.298*	3.802 *1.300*
Market Thinness	4.105 *1.225*	3.998 *1.319*	4.130 *1.255*
Specific Investment	3.917 *1.500*	4.128 *1.623*	3.974 *1.413*
Technological Uncertainty	4.357 *1.286*	4.503 *1.220*	4.564 *1.168*
Performance Evaluation	4.557 *1.293*	4.454 *1.245*	4.459 *1.253*
Sharing of Information	5.112 *1.171*	5.105 *1.120*	5.103 *1.138*
Relationship Management	5.064 *1.006*	4.995 *0.961*	5.094 *0.955*
Firm Age	46.611 *22.707*	41.498 *20.539*	42.487 *22.166*
Firm Size (Employees)	2.575 *1.157*	2.394 *1.062*	2.549 *1.067*
Union	0.127 *0.333*	0.136 *0.343*	0.164 *0.371*
Powder Metal	0.223 *0.417*	0.213 *0.410*	0.252 *0.435*
Volume Required	2.678 *1.461*	2.788 *1.454*	2.436 *1.501*
All Inputs the Same	3.485 *1.841*	3.466 *1.825*	3.577 *1.741*
Design	0.243 *0.430*	0.132 *0.340*	0.274 *0.447*
Maintenance	0.377 *0.485*	0.042 *0.201*	0.177 *0.383*
Machining	0.212 *0.410*	0.066 *0.249*	0.221 *0.416*
Coating	0.021 *0.142*	0.519 *0.501*	0.058 *0.233*
N =	292	287	226

Table 19: Main Model: Production and Transaction Costs with Input Type Dummies

	Make vs. Concurrent	Buy vs. Concurrent	Make vs. Buy
Firm Expertise	0.278 **	-1.095 ***	1.373 ***
	0.110	*0.128*	*0.148*
Supplier Expertise	-0.119	0.053	-0.171
	0.142	*0.171*	*0.206*
Scale Economies	-0.023	0.034	-0.057
	0.066	*0.088*	*0.113*
Firm Scope Economies	0.266 ***	-0.253 **	0.520 ***
	0.081	*0.111*	*0.129*
Supplier Scope Economies	-0.265 ***	0.431 ***	-0.695 ***
	0.088	*0.119*	*0.131*
Performance Ambiguity	0.265 **	0.431	0.249 +
	0.123	*0.119*	*0.182*
Volume Unpredictability	-0.070	-0.115	0.045
	0.083	*0.105*	*0.109*
Market Thinness	-0.089	-0.344 ***	0.255 **
	0.094	*0.120*	*0.124*
Technological Uncertainty	-0.113 +	-0.060	-0.053
	0.082	*0.131*	*0.146*
Firm Age	0.009 *	0.000	0.009
	0.005	*0.007*	*0.008*
Firm Size (Employees)	-0.010	-0.218	0.207 +
	0.094	*0.133*	*0.147*
Union	-0.368 +	-0.567 +	0.210
	0.260	*0.390*	*0.448*
Powder Metal	-0.079	-0.356	0.277
	0.247	*0.367*	*0.409*
Volume Required	0.064	0.248 **	-0.184 *
	0.064	*0.099*	*0.105*
All Inputs the Same	-0.059	-0.193 **	0.134 +
	0.059	*0.086*	*0.092*
Design	0.199	-0.446 +	0.645 **
	0.205	*0.287*	*0.311*
Maintenance	0.989 ***	-1.511 ***	2.497 ***
	0.273	*0.566*	*0.556*
Machining	0.462 *	-1.158 ***	1.621 ***
	0.269	*0.387*	*0.422*
Coating	-0.160	0.805 *	-0.965 *
	0.530	*0.448*	*0.568*
Constant	-1.264	6.659 ***	-7.923 ***
	1.275	*1.670*	*0.176*
n	805	Log Like: -512 .363	
Wald Chi-squared	303.390	Prob>Chi 0.000	
Pseudo R-squared	0.417	Adj Count R2 0.550	
Wald test - combine modes	73.622; p=0.000	173.036; p=0.000	216.86; p=0.000
Hausman IIA: omit Make	7.426; p=0.995	omit Make & Buy:	1.823; p=1.00
Small-Hsiao IIA: omit Make	20.436; p=0.431	omit Make & Buy:	30.559; p=0.061

Note: +=p<0.10; *=p<0.05; **=p<0.025; ***=p<0.005 one tailed test
Robust (cluster) standard errors in italics, beneath the coefficients.

Figure 12: Changes in Sourcing Mode Probabilities per Standard Deviation



<u>Note</u>: On the above graphs, 1 indicates “make”, 2 indicates “buy” and 3 indicates “concurrent source”. In comparing above graphs, observe that each has a different scale on the x-axis.

Table 20: Predictions Versus Multinomial Logit Model Results

Independent Variable & Hypotheses	Ln (P(M) / P(CS))	Ln (P(B)/ P(CS))	Ln (P(M)/P(B))	Model Results
Sourcing firm expertise (H1a, c)	+	-	+	H1a: Strongly supported H1c: Partially Supported
Outside supplier expertise (H1b, c)	-	+	-	H1b: Not supported H1c: Partially Supported
Econ of scale (H2a, b)	?	+	-	H2a & H2b: Supported (through the volume measure)
Sourcing firm scope econ (H3a, c)	+	-	+	H3a: Strongly supported H3c: Partially supported
Outside supplier scope econ (H3 b, c)	-	+	-	H3b: Strongly supported H3c: Partially supported
Performance ambiguity (H4a, b)	?	-	+	H4a & H4b: Not supported; Moderate support for Make vs. Buy; Strong support for Make vs. Concurrent
Volume uncertainty (H5a, b)	+	+	?	H5a & H5b: Not supported (Variable had no effect)
Asset specificity (H6 a, b)	+	?	+	H6a: Not supported Strong support for Concurrent vs. Buy H6b: Strongly supported
Technological uncertainty (H7a, b)	?	-	+	H7a: Moderately support H7b: Not supported
Supply Mgmt Capability (H8 a, b)	-	?	-	H8a & H8b: Not supported (Variable had no effect)

Table 21: Propositions, Hypotheses, and Model Results for Concurrent Sourcing

Proposition	Hypotheses supporting Concurrent Sourcing	Hypotheses against Concurrent Sourcing
P1: Firms will concurrently source if no clear production cost advantage exists for either internal or external suppliers.	H1c: The smaller the difference between the expertise of internal and external suppliers, the more likely the sourcing firm will concurrently source an input. **Partially Supported** H3c: The greater the scope economies of both the internal and external suppliers from producing the focal input along with their respective products, the more likely the sourcing firm will concurrently source the input. **Partially Supported**	H2a: The greater the input's production economies of scale relative to the volume demanded, the less likely the sourcing firm will concurrently source the input. **Supported (volume measure)**
P2: Firms will concurrently source if quality monitoring is difficult.	H4a: The greater the performance ambiguity of an input, the more likely the sourcing firm will concurrently source the input. **Not supported**	
P3: Firms will concurrently source if disputes are not likely.		H5a: The greater an input's volume uncertainty, the less likely the sourcing firm will concurrently source the input. **Not supported**
P4: Firms will concurrently soruce if both autonomous and coordinative incentives are required.	H7a: The greater an input's technological uncertainty, the more likely the sourcing firm will concurrently source the input. **Supported** H8a: The greater the sourcing firm's supply management capability, the more likely that it will concurrently source an input. **Not supported**	H6a: The greater an input's asset specificity, the less likely the sourcing firm will concurrently source the input. **Not supported**

Table 22: Ordered Logit Model (where 1=Buy, 2=Concurrently Source, 3=Make)

Firm Expertise	0.848 *** *0.087*
Supplier Expertise	-0.179 + *0.123*
Scale Economies	-0.030 *0.066*
Firm Scope Economies	0.327 *** *0.069*
Supplier Scope Economies	-0.370 *** *0.076*
Performance Ambiguity	0.178 * *0.106*
Volume Unpredictability	-0.020 *0.065*
Market Thinness	0.058 *0.075*
Technological Uncertainty	-0.065 *0.077*
Firm Age	0.007 + *0.005*
Firm Size (Employees)	0.084 *0.083*
Union	-0.031 *0.248*
Powder Metal	0.102 *0.231*
Volume Required	-0.069 *0.057*
All Inputs the Same	0.041 *0.052*
Design	0.399 ** *0.173*
Maintenance	1.504 *** *0.242*
Machining	0.970 *** *0.237*
Coating	-0.798 ** *0.357*

n	805
Wald Chi-squared	447.54
Pseudo R-squared	0.396
Adjusted Count R-squared	0.513
Log Likelihood	690.297, 19 df

Figure 13: Comparing Ordered vs. Multinomial Logits

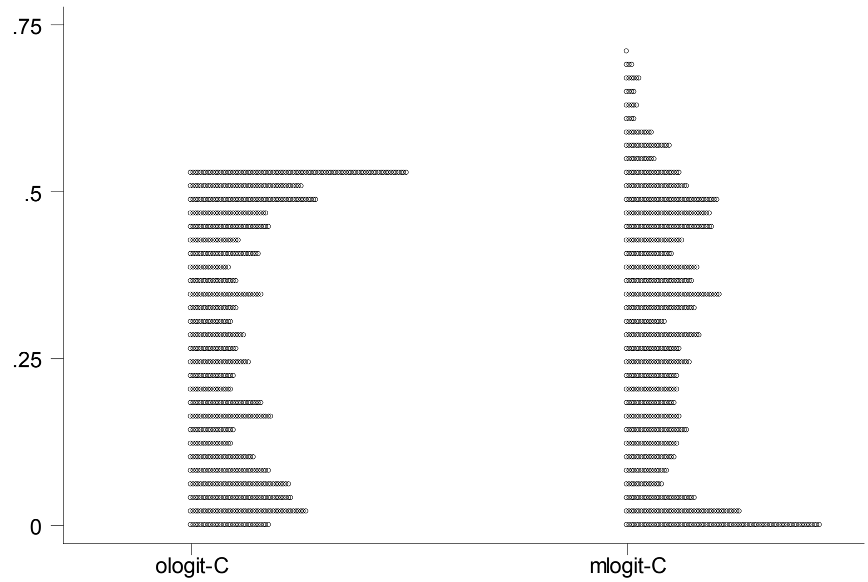


Table 23: Change in Sourcing Mode Likelihood:
Different Levels of Firm and Supplier Expertise

Probability of Sourcing Mode	Both at mean	Firm high	Supplier High	Both high	Firm low	Supplier low	Both low
P(Make)	0.290	**0.497**	0.261	**0.465**	**0.072**	0.321	**0.084**
p-value of change		*0.000*	*0.093*	*0.000*	*0.000*	*0.086*	*0.000*
P(Buy)	0.276	**0.044**	0.298	**0.049**	**0.753**	0.255	**0.735**
p-value of change		*0.000*	*0.171*	*0.000*	*0.000*	*0.168*	*0.000*
P(Concurrent)	0.434	0.459	0.442	**0.486**	**0.175**	0.424	**0.181**
p-value of change		*0.154*	*0.373*	*0.017*	*0.000*	*0.341*	*0.000*

Note: "High" indicates mean plus one standard deviation; "low" indicates mean minus one standard deviation. Bold values are statistically significantly different than the "both at mean" column.

Table 24: Change in Sourcing Mode Likelihood:
Different Levels of Firm and Supplier Scope Economies

Probability of Sourcing Mode	Both at mean	Firm high	Supplier High	Both high	Firm low	Supplier low	Both Low
P(Make)	0.290	**0.416**	**0.179**	0.287	**0.184**	**0.414**	0.292
p-value of change		*0.000*	*0.000*	*0.444*	*0.000*	*0.000*	*0.465*
P(Buy)	0.276	**0.175**	**0.438**	0.310	**0.397**	**0.153**	0.245
p-value of change		*0.000*	*0.000*	*0.071*	*0.000*	*0.000*	*0.075*
P(Concurrent)	0.434	0.409	**0.383**	0.404	0.419	0.432	0.117
p-value of change		*0.158*	*0.019*	*0.110*	*0.270*	*0.477*	*0.000*

Note: "High" indicates mean plus one standard deviation; "low" indicates mean minus one standard deviation. Bold values are statistically significantly different than the "both at mean" column.

Table 25: Model with Volume Uncertainty and Asset Specificity Interaction

	Make vs. Concurrent	Buy vs. Concurrent	Make vs. Buy
Firm Expertise	0.281 **	-1.094 ***	1.375 ***
	0.110	*0.128*	*0.148*
Supplier Expertise	-0.120	0.053	-0.173
	0.142	*0.172*	*0.206*
Scale Economies	-0.018	0.034	-0.052
	0.066	*0.088*	*0.114*
Firm Scope Economies	0.269 ***	-0.254 **	0.522 ***
	0.082	*0.111*	*0.129*
Supplier Scope Economies	-0.263 ***	0.431 ***	-0.694 ***
	0.089	*0.119*	*0.132*
Performance Ambiguity	0.277 **	0.017	0.261 +
	0.125	*0.158*	*0.183*
Volume Unpredictability	-0.420 **	-0.142	-0.277
	0.209	*0.328*	*0.351*
Market Thinness	-0.432 **	-0.367	-0.065
	0.215	*0.332*	*0.358*
Technological Uncertainty	-0.123 +	-0.064	-0.059
	0.080	*0.131*	*0.145*
Volume Unpredictability * Market Thinness	0.087 *	0.004	0.083
	0.047	*0.077*	*0.084*
Firm Age	0.009 **	0.000	0.009
	0.004	*0.007*	*0.008*
Firm Size (Employees)	-0.004	-0.218 *	0.213 +
	0.095	*0.131*	*0.144*
Union	-0.368 +	-0.566 +	0.198
	0.262	*0.393*	*0.449*
Powder Metal	-0.074	-0.347	0.272
	0.248	*0.370*	*0.410*
Volume Required	0.066	0.246 **	-0.180 *
	0.064	*0.101*	*0.107*
All Inputs the Same	-0.058 +	-0.194 **	0.136 +
	0.059	*0.086*	*0.091*
Constant	0.043	6.807 ***	-6.763 ***
	1.442	*2.077*	*2.180*
N	805		
Log Likelihood	-510.77		
Wald Chi-squared	306.82		
Prob>Chi-squared	0.000		
Pseudo R-squared	0.419		
Adjusted Count R-squared	0.563		
Wald test - combine modes	74.915; p=0.000	177.003; p=0.000	218.30; p=0.000
Hausman IIA: omit Make	7.30; p=0.99	omit Make & Buy:	-2.668; p= ----
Small-Hsiao IIA: omit Make	29.548; p=0.101	omit Buy:	19.67; p=0.542

Notes: +=p<0.10; *=p<0.05; **=p<0.025; ***=p<0.005 one tailed test. Robust (cluster) standard errors in italics, beneath the coefficients. Due to space constraints, input dummy variables are not displayed in the table above; however, their effects are statistically the same as in the base model.

Table 26: Model Including Firm Dummy Variables

	Make vs. Concurrent	Buy vs. Concurrent	Make vs. Buy
Firm Expertise	0.497 *	-2.329 ***	2.826 ***
	0.256	*0.409*	*0.433*
Supplier Expertise	-0.596 *	-0.185	-0.411
	0.305	*0.526*	*0.553*
Scale Economies	-0.024	0.094	-0.118
	0.144	*0.235*	*0.244*
Firm Scope Economies	0.167	-1.043 ***	1.209 ***
	0.197	*0.302*	*0.328*
Supplier Scope Economies	-0.361 *	0.860 **	-1.221 ***
	0.197	*0.348*	*0.376*
Performance Ambiguity	0.694 ***	-0.144	0.839 **
	0.232	*0.391*	*0.405*
Volume Unpredictability	-0.223 +	-0.190	-0.033
	0.149	*0.244*	*0.264*
Market Thinness	0.208	-0.435 +	0.643 **
	0.169	*0.268*	*0.288*
Technological Uncertainty	-0.313 *	-0.106	-0.207
	0.176	*0.286*	*0.297*
Volume Required	-0.033	-0.002	-0.031
	0.133	*0.217*	*0.231*
All Inputs the Same	-0.135	-0.232 +	0.097
	0.134	*0.180*	*0.198*
Design	1.374 **	-2.062 ***	3.436 ***
	0.545	*0.749*	*0.850*
Maintenance	3.106 ***	-3.955 ***	7.061 ***
	0.591	*1.090*	*1.173*
Machining	1.497 ***	-4.120 ***	5.618 ***
	0.570	*1.052*	*1.116*
Coating	-0.078	0.724	-0.803
	1.037	*1.000*	*1.227*
N	805		
Log Likelihood	-194.52		
Wald Chi-squared	1369.37		
Prob>Chi-squared	0.000		
Pseudo R-squared	0.779		
Adjusted Count R-squared	0.834		
Wald test - combine modes	70.53; p=1.000	67.895; p=1.000	864.3; p=0.000
Hausman IIA: omit Make	0.00; p=1.00	omit Make & Buy:	0.00; p=1.00

Note: Due to space constraints, the individual firm coefficients (n=192) are not presented.

CHAPTER 7

CONCLUSION

This dissertation explores the question of when firms would concurrently source, both making and buying a particular input. By combining a resource-based and transaction cost approach, I identified conditions that lead firms to choose among the three primary sourcing modes: making, buying, and concurrent sourcing. Empirical analysis using survey methods in the metal forming industry confirmed the existence and stability of concurrent sourcing. I found that firms were more likely to concurrently source if their production costs were similar to those of their suppliers by having sufficient expertise and moderate scope economies from both internal and external suppliers. They also concurrently source in cases of high technological uncertainty, indicating the benefit of learning from both internal and external suppliers. Concurrent sourcing was also more evident if performance ambiguity was low, markets were thin, inputs were similar, and firms were unionized, suggesting quality monitoring advantages. These findings do not support the traditional argument that volume uncertainty motivates firms to choose this mode, but rather support the view that knowledge motivates firms to concurrently source.

Contributions

Other scholars have argued that firms concurrently source to gain knowledge about inputs and their related processes. My research supports this position. Firms will concurrently source inputs which face technological changes since firms can benefit from combining the deep understanding gained from making the input with a broader stream of knowledge coming from outside suppliers. Unionized firms are also more likely to concurrently source; in this case, firms benefit from the knowledge of labor costs and practices of their outside suppliers that they can potentially leverage in motivating their internal suppliers.

Another orthodox perspective about sourcing is that it is a continuum, with making at one end and buying at the other. In this view, concurrent sourcing would be in between, somehow combining the costs and benefits of both internal and external suppliers. My research supported this view in terms of expertise and scope economies. Firms will concurrently source if neither they nor their suppliers have considerably greater expertise and if both can gain scope economies from producing the input. Production costs will motivate firms to concurrently source when there is no clear advantage to completely insourcing or outsourcing the input.

However, my research proposes that this continuum view does not extend to transaction costs. Concurrent sourcing is not a middle ground between the two polar sourcing modes when it comes to performance ambiguity. As the difficulties of evaluating an input increase, having two different types of suppliers becomes too complex to manage. For these types of inputs, firms will tend to insource and then use only outside suppliers, rather than concurrently source. In my context, higher levels of asset specificity also drove firms to concurrently source, rather than solely to make. This suggests that asset specificity is not a uniform concept, particularly when markets are thin and the primary form of investment is in relationships rather than physical assets.

A further traditional view on concurrent sourcing that my research did not support was the hedging against uncertainty argument. While prior work posits that firms will strive to keep their own production at full capacity and only use outside suppliers as an overflow, I did not find evidence of this. My findings suggest that volume uncertainties alone do not affect the sourcing decision. Nor did I find evidence supporting the common argument that firms produce more customized inputs internally and outsource more generic ones. Rather, firms concurrently source more homogenous inputs.

Several novel considerations arise from this work. First, it depicts how we can deepen our understanding of “make-or-buy” decisions by also including the concurrent sourcing choice. By including this option, we can determine if firms are moving toward or away from one of the polar choices. Second, it emphasizes the role of firm expertise in sourcing decisions, especially when outside suppliers are also involved. Firms need to have sufficient input knowledge to manage the more complex relationship of concurrent sourcing. Third, while other scholars have shown that diverse types of supply arrangements, such as relational governance and formal contracts, can be complements my research goes a step further and posits that internal and external sourcing can also be synergistic activities (Poppo and Zenger, 2002).

In addition to the above-mentioned theoretical contributions, this dissertation also provides guidance to practitioners making sourcing decisions. First, managers should recognize that they do have three sourcing options: solely making, solely buying, and concurrent sourcing. In their decisions, they need to consider the relative production costs of internal versus external suppliers. Concurrent sourcing would only be recommended if these costs are comparable. While it may be enticing to have an outside supplier to use as leverage against internal suppliers, perhaps especially in a unionized firm, they should realize there are costs that accompany managing two sets of very different suppliers. For some inputs, particularly those that are difficult to evaluate, these costs may not outweigh the benefits. However, for other inputs, such as those that the firm understands well, that are relatively similar, and where technology is immature, concurrent sourcing may be the best approach. Managers need to take a holistic view, incorporating firm, input, supplier, and environmental attributes into their decisions.

Extensions

Several extensions of this research are possible to both build on its findings and unravel some of the unanswered questions. One could investigate the performance implications of choosing concurrent sourcing. Both the resource-based view and transaction cost economics assume that firms typically select the most efficient mode. If governance form matters, then we would expect misaligned sourcing transactions to have negative performance implications. But, since performance is multidimensional, including price, delivery, quality, communication, and other criteria, a mode superior in all of these areas may not exist. It would be informative to connect some of these specific performance measures with mode choice, firm characteristics, and input attributes. Furthermore, while supplier management capability does not affect the sourcing mode chosen, it may play a role in performance. It is intuitively plausible that firms have different skills in managing suppliers but research remains to be conducted to empirically tie these skills to measures and results.

This dissertation provides evidence that concurrent sourcing exists as an equilibrium mode, but questions remain as to how it arises and evolves. Do firms begin with making and move to concurrent sourcing, or begin with buying and then move to both? As with the sourcing choice itself, we would expect that some combination of input, firm, and environmental factors drive this evolution. One also wonders how and whether this mode changes over time. While it does not appear in my data, some firms may ultimately move toward a polar mode. Another question to ponder is whether the percentage of inside versus outside sourcing in a manufacturing context is stable or changes over time.

Using both internal and external suppliers involves managing different forms of supply relationships. The focus of this work was on the buying firm, but including the external supplier's perspective could add another layer to the explanation. Understanding the incentives motivating them to stay in a relationship with a competitor who is also a customer would be fascinating and has been largely unexplored in the theory. During the course of this research, some data was gathered on firms that both make and sell the same input. It is intriguing that firms can simultaneously be producers, suppliers, and customers for the same class of input. There is sparse theoretical or empirical work involving how a particular firm originates, maintains, and alters its myriad of interfirm relationships and how these relationships interact. Clearly, this is an area worth further study.

The findings of this research suggest tradeoffs that firms confront in choosing concurrent sourcing, particularly with regard to managing knowledge and information flows. While there are costs of understanding and evaluating inputs originating from multiple distinct suppliers, there are also benefits in learning that arise. More work needs to be done to understand more precisely the origin of these costs and benefits and their differential impact on the sourcing decision. Connected to this is the affect of volume uncertainty on sourcing. While much of the theory and many empirical findings suggest its importance, it did not arise as a significant factor in the decisions that I studied. This is puzzling and provides an opportunity for additional exploration.

While this dissertation explored a simple question, it underscores the complexity of firm choices. Even in fairly routine decisions, firms combine factors of item characteristics, their own skills, other firms' expertise and potential opportunistic tendencies, and environmental attributes to ultimately make a sensible choice. We are fortunate in our field to have such richness to contemplate, investigate, and explain. I believe this research regarding firms' decisions to concurrently source adds to our overall understanding of firm behavior. I hope it also inspires new ideas for future exploration.

APPENDICES

Appendix A: Cover Letters and Follow Up Messages

October 21, 2002
(Prefix) (FirstName) (LastName)
(Firm Name)
(Address)
(City), (State) (Zip)

Dear (Prefix) (LastName):
As a PhD student at the University of Michigan, I am writing to ask for your help with my doctoral dissertation research, which investigates sourcing decisions in the powder metal industry.

This research, supported by the University of Michigan and with assistance from the Metal Powder Industries Federation, examines how PM firms procure conventional molding dies, die-related services, and downstream operations. As a former purchasing manager at Windfall (now Metaldyne) and a CPM, I know the importance of sourcing decisions to a firm's bottom line. By understanding the best practices for sourcing these items critical to your production process, this work can help firms like yours improve operating processes, make better sourcing decisions, work more effectively with suppliers, and enhance profitability.

To participate in this research, please fill out the enclosed survey. The survey has two white sections, with firm-related questions, and five colored sections, with questions specific to distinct items. Below is a summary of the survey sections:

White – front page	Supplier relationships
Blue	Designs for conventional molding dies
Pink	Building of conventional molding dies
Yellow	Maintenance of conventional molding dies
Green	Machining operations
Purple	Surface coating or plating operations
White – back page	General firm data

If you don't use one of these items, just make the appropriate mark on the first question on that page and continue with the next set of colored pages. Completing the survey should take approximately 45-60 minutes. Participation is entirely voluntary and **your responses will be kept confidential**. Any questions that you prefer not to answer may be skipped. If you do not wish to complete the survey, please return it with a brief note in the enclosed stamped envelope. If at all possible, please return this survey by **November 15, 2002**.

If you would like a summary of the research results, simply check the box on the last white page of the survey and it will be mailed to you.

If you have any questions about the survey or comments regarding this research, please call me at 734-647-9598 or contact me via email at annepa@umich.edu. Thank you very much for helping with this important research project.

Sincerely,

Anne Parmigiani	James Dale
Doctoral Candidate, Corporate Strategy	Director, Marketing and Technology
University of Michigan Business School	Metal Powder Industries Federation

PS: Enjoy the enclosed UM window decal to brighten up your office.

University
of
Michigan
Business
School

The University of Michigan Business School
701 Tappan Street
Ann Arbor, MI 48109

Fax Message For: (Prefix) (FirstName) (LastName)
(FirmName) (City), (State)
(FaxNumber)

Dear (Prefix) (LastName):

About two weeks ago, a multi-colored survey from the University of Michigan was mailed to you. This survey asks questions about how your firm sources production tooling and services.

If you have already completed the survey and it is on its way to Ann Arbor, please accept my sincere thanks. If not, please take some time this week to fill it out and return it to me – preferably by next Friday, November 15. I appreciate your help.

This survey, supported by the University of Michigan, will provide data for use in my PhD dissertation; it is not for marketing or any other purposes. Your reply and the identity of your firm will be kept strictly confidential. A summary of the research results will be provided to those who submit a survey.

Only through responses of managers like you can we understand how and why metal forming firms source these items that are so critical to downstream production. Through this research, I hope to be able to provide recommendations to help metal forming firms improve operating processes, make better sourcing decisions, work more effectively with suppliers, and enhance profitability.

If you did not receive a survey or if it was misplaced, please reply to my email address above, fax to 734-468-0125, or call 734-647-9598 and another one will be put in the mail to you today.

Thanks again for your attention and help with this research. I'm looking forward to receiving your completed survey in the mail very soon!

Regards,
Anne Parmigiani

November 20, 2002
(Prefix) (FirstName) (LastName)
(Firm Name)
(Address)
(City), (State) (Zip)

Dear (Prefix) (LastName):
As a PhD student at the University of Michigan, this is my second request for your help with my doctoral dissertation research, which investigates sourcing decisions in the powder metal industry.

This research, supported by the University of Michigan and with assistance from the Metal Powder Industries Federation, examines how PM firms procure conventional molding dies, die-related services, and downstream operations. As a former purchasing manager at Windfall (now Metaldyne) and a CPM, I know the importance of sourcing decisions to a firm's bottom line. By understanding the best practices for sourcing these items critical to your production process, this work can help firms like yours improve operating processes, make better sourcing decisions, work more effectively with suppliers, and enhance profitability.

To participate in this research, please fill out the enclosed survey. The survey has two white sections, with firm-related questions, and five colored sections, with questions specific to distinct items. Below is a summary of the survey sections:

White – front page	Supplier relationships
Blue	Designs for conventional molding dies
Pink	Building of conventional molding dies
Yellow	Maintenance of conventional molding dies
Green	Machining operations
Purple	Surface coating or plating operations
White – back page	General firm data

If you don't use one of these items, just make the appropriate mark on the first question on that page and continue with the next set of colored pages. Completing the survey should take approximately 45-60 minutes. Participation is entirely voluntary and **<u>your responses will be kept confidential</u>**. Any questions that you prefer not to answer may be skipped. If you do not wish to complete the survey, please return it with a brief note in the enclosed stamped envelope. If at all possible, please return this survey by **<u>December 6, 2002</u>**.

If you would like a summary of the research results, simply check the box on the last white page of the survey and it will be mailed to you.

If you have any questions about the survey or comments regarding this research, please call me at 734-647-9598 or contact me via email at annepa@umich.edu. Thank you very much for helping with this important research project.
Sincerely,

Anne Parmigiani	James Dale
Doctoral Candidate, Corporate Strategy	Director, Marketing and Technology
University of Michigan Business School	Metal Powder Industries Federation

PS: If our letters have crossed in the mail and your completed survey is already on its way to Ann Arbor, then Thanks! If not, please make my holiday season joyful by sending in a completed survey – I'd really appreciate it.

December 17, 2002
(Prefix) (FirstName) (LastName)
(Firm Name)
(Address)
(City), (State) (Zip)

Dear (Prefix) (LastName):
As a PhD student at the University of Michigan, this is a request for your help with my doctoral dissertation research, which investigates sourcing decisions in the powder metal industry.

This research, supported by the University of Michigan and with assistance from the Metal Powder Industries Federation, examines how PM firms procure conventional molding dies, die-related services, and downstream operations. As a former purchasing manager at Windfall (now Metaldyne) and a CPM, I know the importance of sourcing decisions to a firm's bottom line. By understanding the best practices for sourcing these items critical to your production process, this work can help firms like yours improve operating processes, make better sourcing decisions, work more effectively with suppliers, and enhance profitability.

To participate in this research, please fill out the enclosed survey. The survey has two white sections, with firm-related questions, and five colored sections, with questions specific to distinct items. Below is a summary of the survey sections:

White – front page	Supplier relationships
Blue	Designs for conventional molding dies
Pink	Building of conventional molding dies
Yellow	Maintenance of conventional molding dies
Green	Machining operations
Purple	Surface coating or plating operations
White – back page	General firm data

If you don't use one of these items, just make the appropriate mark on the first question on that page and continue with the next set of colored pages. Completing the survey should take approximately
45-60 minutes. Participation is entirely voluntary and **<u>your responses will be kept confidential</u>**. Any questions that you prefer not to answer may be skipped. If you do not wish to complete the survey, please return it with a brief note in the enclosed stamped envelope. If at all possible, please return this survey by **<u>December 31, 2002</u>**.

If you would like a summary of the research results, simply check the box on the last white page of the survey and it will be mailed to you.

If you have any questions about the survey or comments regarding this research, please call me at 734-763-5293 or contact me via email at annepa@umich.edu. Thank you very much for helping with this important research project.

Sincerely,
Anne Parmigiani
Doctoral Candidate, Corporate Strategy
University of Michigan Business School

PS: It was nice talking with you on the phone the other day and thanks for agreeing to take the time to complete the survey. Have a wonderful holiday season!

Appendix B: Copy of the Survey

Sourcing Practices of Stamping Firms for Production Tooling & Services

I. Supplier Relationships: Please answer these general questions about your firm's relationships with its suppliers. Interpret the term "firm" as a complete legal entity, including all wholly owned subsidiaries, sister divisions, production locations, and corporate parent headquarters. Except where indicated, "supplier" should be interpreted as a separate firm, external to your own. Please mark **(X)** in the box to indicate the appropriate answer for each question.

1. **Overall, what is your opinion of the majority of suppliers who provide your firm with tooling and production services?**
   - ☐ Great; we work well together.
   - ☐ Good; we have mostly good days and a few bad days.
   - ☐ Neutral; dealing with them is just part of doing business.
   - ☐ Irritating; they are a necessary evil and a hassle to work with.
   - ☐ Infuriating; I wish we would just make everything ourselves so we don't have to deal with them.

2. **How many people work in purchasing and closely related functions in your firm (logistics, receiving, supplier development, etc.)? __________________**

3. **What quality certifications does your firm hold (*please mark all that apply*)?**
   - ☐ ISO/TS16949
   - ☐ QS-9000
   - ☐ ISO 900x
   - ☐ Other (please specify) ____________________
   - ☐ None

4. **What types of computer-aided equipment does your firm use (*please mark all those that apply)*?**
   - ☐ EDM (wire or ram)
   - ☐ CNC machining equipment (lathes, mills, etc.)
   - ☐ CAD for designing drawings
   - ☐ We don't use any of these
   - ☐ I don't know

II. Supply Management For the next statements, please **circle** the appropriate response on the following scale ranging from "1" indicating totally untrue to "7" indicating totally true. If you do not know or if the item does not apply to your firm, select NA.

How true are the following statements?	Totally Untrue → Totally True
1. Our supplier relationships last for years.	1 2 3 4 5 6 7 NA
2. We use formal, written contracts whenever possible.	1 2 3 4 5 6 7 NA
3. We will always work through difficulties with a supplier rather than switch to a new one.	1 2 3 4 5 6 7 NA
4. We routinely share proprietary information with suppliers.	1 2 3 4 5 6 7 NA
5. Our engineers never travel to our supplier's plants.	1 2 3 4 5 6 7 NA
6. We frequently help our suppliers improve their processes by providing them with technical, engineering, quality, or other assistance.	1 2 3 4 5 6 7 NA
7. Our suppliers do not help us in reducing costs and overall problem solving.	1 2 3 4 5 6 7 NA
8. We regularly use confidentiality agreements with our suppliers.	1 2 3 4 5 6 7 NA
9. We advise suppliers of their performance in relation to that of other suppliers.	1 2 3 4 5 6 7 NA
10. We evaluate our internal production using the same criteria and strictness as our suppliers.	1 2 3 4 5 6 7 NA
11. We have a formal, written scorecard that we always use to evaluate our suppliers.	1 2 3 4 5 6 7 NA
12. People in purchasing have engineering, technical, or manufacturing backgrounds.	1 2 3 4 5 6 7 NA
13. The purchasing group is great at coordinating the efforts of several departments.	1 2 3 4 5 6 7 NA
14. Coordination is significantly easier when we produce internally than when we use an external supplier.	1 2 3 4 5 6 7 NA
15. We routinely ship products directly to our end customers from our suppliers' sites.	1 2 3 4 5 6 7 NA
16. We immediately inform our suppliers whenever there's a change in volume requirements.	1 2 3 4 5 6 7 NA
17. Our suppliers keep us in the dark about potential problems in meeting our needs.	1 2 3 4 5 6 7 NA
18. We communicate daily with major suppliers.	1 2 3 4 5 6 7 NA
19. Communicating internally is much easier than with most of our suppliers.	1 2 3 4 5 6 7 NA
20. All supplier contacts go through purchasing.	1 2 3 4 5 6 7 NA

III. DESIGN OF PROGRESSIVE STAMPING DIES

This **blue** section will ask you questions about **the design of progressive stamping dies.** In places, the word "design" will be used as an abbreviation for this input. Please only consider the design itself, not the physical dies.

A. Sourcing Choice and Satisfaction: Please answer the following questions about how you source the design of progressive stamping dies. Please mark **(X)** the box corresponding to the appropriate response.

1. **For the past fiscal year, where did all of the designs for progressive stamping dies come from?**
   - ☐ All done internally (either within your plant or from a division with which your firm shares a common corporate parent)

   - ☐ All purchased from external suppliers
     - *(i) If you marked this response, how many suppliers did you use?*
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7

   - ☐ Both done internally and purchased from external suppliers
     - *(i.) If you marked this response, what % of your requirements did you design internally (please mark one)?*
       - ☐ 0-10% ☐ 26-49% ☐ 75-90%
       - ☐ 11-25% ☐ 50-74% ☐ Over 90%
     - *(ii) How many external suppliers did you use*?
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7

   - ☐ Don't use die designs (please skip to the **pink** section) →

2. **How long have you sourced die designs as indicated above in Question 1?**
   - ☐ Always, for as long as we've used them.
   - ☐ For the last several years.
   - ☐ Only for the last year or so.
   - ☐ I don't know.
3. **Do you plan on changing the way you source die designs within the next two years?**
   - ☐ Yes (If so, how? ____)
   - ☐ No
4. **If you design internally, do you ever sell designs to competitors or other outside firms?**
   - ☐ Yes – we sometimes sell to outside firms.
   - ☐ No – we produce only for our own use and don't sell to outside firms.
   - ☐ Not applicable – we only use external suppliers for die designs.

5. **If you use external suppliers for designs, which best describes your transactions?**
   - ☐ Long term, rarely modified contracts for multiple designs
   - ☐ Long term, frequently modified contracts for multiple designs
   - ☐ Written purchase orders for each design
   - ☐ Verbal purchase orders for each design
   - ☐ Some combination of these or Other (Please explain______________________)
   - ☐ Not applicable – we design all of our progressive dies internally

Please rate how you source the design of progressive stamping dies along the following dimensions on the following scale ranging from 1 = absolutely terrible to 7 = absolutely terrific. If you only design internally, rate the performance of your internal unit. If you use multiple suppliers, use a summary rating based on your allocation of business to each.

Our current sources' performance on …is…	**Absolutely Terrible → Absolutely Terrific**
2. Price competitiveness and value	1 2 3 4 5 6 7
3. Quality level / defect rates	1 2 3 4 5 6 7
4. On-time shipments	1 2 3 4 5 6 7
5. Communication and paperwork	1 2 3 4 5 6 7
6. Cooperation and dispute resolution	1 2 3 4 5 6 7
7. Overall sourcing experience	1 2 3 4 5 6 7

B. Costs and Expertise: For each statement, please **circle** the appropriate numerical response on the following scale ranging from "1" indicating totally untrue to "7" indicating totally true. If you don't know or the question does not apply, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. If demand for designs doubled, the average cost per design would change very little.	1 2 3 4 5 6 7 NA
2. Our quantity requirements for designs are much too low to take advantage of the cheapest, high volume production methods.	1 2 3 4 5 6 7 NA
3. Numerous capable design suppliers exist in the market.	1 2 3 4 5 6 7 NA
4. The die designs we require are basically all the same.	1 2 3 4 5 6 7 NA
5. We do complex designs in-house and outsource the others.	1 2 3 4 5 6 7 NA
6. Die designs represent a very small percentage of the overall production cost of the final product.	1 2 3 4 5 6 7 NA
7. The leading die design suppliers have proprietary knowledge that gives them an advantage over other firms.	1 2 3 4 5 6 7 NA
8. We rely on our suppliers to help us keep up with the die design technology.	1 2 3 4 5 6 7 NA
9. Our external suppliers have CAD capability.	1 2 3 4 5 6 7 NA
10. There is little difference between the process we would use to make designs and that used by a supplier.	1 2 3 4 5 6 7 NA
11. Our engineering staff can/could easily create our designs.	1 2 3 4 5 6 7 NA
12. Creating die designs requires a deep expertise that our firm understands.	1 2 3 4 5 6 7 NA
13. We have internally created die designs for years.	1 2 3 4 5 6 7 NA
14. The skills to make designs are closely related to those that we use to make other similar products.	1 2 3 4 5 6 7 NA
15. As compared to suppliers, our internal production of designs is/would be higher in price.	1 2 3 4 5 6 7 NA
16. As compared to suppliers, our internal production of designs is/would be lower in quality.	1 2 3 4 5 6 7 NA
17. By making our own designs, we do/could reduce our overall production costs of other products.	1 2 3 4 5 6 7 NA

18. We do/could better utilize our labor and equipment by making designs in addition to our other products.	1 2 3 4 5 6 7 NA
19. By making designs for us, our suppliers can reduce their overall costs since they can make better use of their labor and equipment.	1 2 3 4 5 6 7 NA
20. In addition to designs, we buy other items or services from these same suppliers.	1 2 3 4 5 6 7 NA

C. Technology, Investments, and Evaluation: For each statement, please **circle** the appropriate numerical response on the scale ranging from "1" = totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. The processes and skills required to create designs are mature and unlikely to change in the future.	1 2 3 4 5 6 7 NA
2. Major innovations in die features to be designed are very likely within the next few years.	1 2 3 4 5 6 7 NA
3. Major innovations in die design software or hardware are very likely within the next few years.	1 2 3 4 5 6 7 NA
4. No one really knows where the next technological advance for designs will come from.	1 2 3 4 5 6 7 NA
5. Switching design suppliers would be quick and easy to do.	1 2 3 4 5 6 7 NA
6. Designing dies requires major investments that cannot be used for other products.	1 2 3 4 5 6 7 NA
7. The skills needed to create die designs are generic and widely available.	1 2 3 4 5 6 7 NA **Untrue** →
8. Any equipment or software used for making our designs can easily be modified to make other products.	1 2 3 4 5 6 7 NA
9. We can easily describe designs to our suppliers through printed/electronic descriptions and/or drawings.	1 2 3 4 5 6 7 NA
10. The quality of the design is based upon many different factors.	1 2 3 4 5 6 7 NA
11. Through a simple inspection, we can predict how well the design will function in our downstream production processes.	1 2 3 4 5 6 7 NA
12. We use several forms of inspection and several different metrics to evaluate design quality.	1 2 3 4 5 6 7 NA
13. When there is a problem with a design, we usually can determine its cause.	1 2 3 4 5 6 7 NA
14. It is difficult to equitably measure one supplier's design versus another supplier's.	1 2 3 4 5 6 7 NA

D. Demand Requirements For each question, please mark **(X)** the appropriate box or **circle** the appropriate response on the scale from “1”= totally untrue to “7”= totally true. If the question does not apply to your firm, select NA.

1. **Approximately how many designs for progressive stamping dies did you require in the most recent fiscal year?**

   ☐ 1-25 ☐ 51-100 ☐ Over 200
   ☐ 26-50 ☐ 101-200 ☐ I don’t know.

2. **When did you receive your last die design?**

   ☐ Within the last week ☐ Within the last quarter ☐ Over a year ago.
   ☐ Within the last month ☐ Within the last year ☐ I don’t know.

How true are the following statements?	**Totally Untrue → Totally True**
3. Our forecasts for die designs are very accurate.	1 2 3 4 5 6 7 NA
4. We frequently change the features on orders.	1 2 3 4 5 6 7 NA
5. We frequently change the timing on orders.	1 2 3 4 5 6 7 NA
6. There are predictable patterns to our requirements.	1 2 3 4 5 6 7 NA
7. Our suppliers frequently complain about the unpredictability of the requirements for die designs.	1 2 3 4 5 6 7 NA
8. Our suppliers accommodate revisions with no hassles or extra charges.	1 2 3 4 5 6 7 NA
9. We need to stay in close contact with our suppliers to keep them updated on the changes in our requirements.	1 2 3 4 5 6 7 NA
10. Our suppliers receive demand information directly from our end customers.	1 2 3 4 5 6 7 NA

IV. BUILDING OF PROGRESSIVE STAMPING DIES

This **pink** section will ask you questions about **the building of progressive stamping dies.** In places, the word "die" will be used as an abbreviation for this input.

A. Sourcing Choice and Satisfaction: Please answer the following questions about how you source progressive stamping dies. Please mark **(X)** the box corresponding to the appropriate response.

1. **For the past fiscal year, where did all your progressive stamping dies come from?**
   - ☐ All made internally (either within your plant or from a division with which your firm shares a common corporate parent)
   - ☐ All purchased from external suppliers
     - *(i) If you marked this response, how many suppliers did you use?*
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7
   - ☐ Both made internally and purchased from external suppliers
     - *(i.) If you marked this response, what % of your requirements did you make internally (please mark one)?*
       - ☐ 0-10% ☐ 26-49% ☐ 75-90%
       - ☐ 11-25% ☐ 50-74% ☐ Over 90%
     - *(ii) How many external suppliers did you use***?**
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7
   - ☐ Don't use progressive dies (please skip to the **yellow** section) →
2. **How long have you sourced progressive dies as indicated above in Question 1?**
   - ☐ Always, for as long as we've used them.
   - ☐ For the last several years.
   - ☐ Only for the last year or so.
   - ☐ I don't know.
3. **Do you plan on changing the way you source dies within the next two years?**
   - ☐ Yes (If so, how? ____)
   - ☐ No
4. **If you make dies internally, do you ever sell them to competitors or other outside firms?**
   - ☐ Yes – we sometimes sell to outside firms.
   - ☐ No – we produce only for our own use and don't sell to outside firms.
   - ☐ Not applicable – we only use external suppliers for dies.

5. **If you use external suppliers for dies, which best describes your transactions?**
   - ☐ Long term, rarely modified contracts for multiple dies
   - ☐ Long term, frequently modified contracts for multiple dies
   - ☐ Written purchase orders for each die
   - ☐ Verbal purchase orders for each die
   - ☐ Some combination of these or Other (Please explain____________________)
   - ☐ Not applicable – we produce all of our progressive dies internally

Please rate how you source progressive stamping dies along the following dimensions on the following scale ranging from 1 = absolutely terrible to 7 = absolutely terrific. If you only produce internally, rate the performance of your internal unit. If you use multiple suppliers, use a summary rating based on your allocation of business to each.

Our current sources' performance on …is…	**Absolutely Terrible → Absolutely Terrific**
6. Price competitiveness and value	1 2 3 4 5 6 7
7. Quality level / defect rates	1 2 3 4 5 6 7
8. On-time shipments	1 2 3 4 5 6 7
9. Communication and paperwork	1 2 3 4 5 6 7
10. Cooperation and dispute resolution	1 2 3 4 5 6 7
11. Overall sourcing experience	1 2 3 4 5 6 7

B. Costs and Expertise: For each statement, please **circle** the appropriate numerical response on the following scale ranging from "1" indicating totally untrue to "7" indicating totally true. If you don't know or the question does not apply, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. If demand for dies doubled, the average cost per die would change very little.	1 2 3 4 5 6 7 NA
2. Our quantity requirements for dies are much too low to take advantage of the cheapest, high volume production methods.	1 2 3 4 5 6 7 NA
3. There are numerous capable die suppliers in the market.	1 2 3 4 5 6 7 NA
4. The dies we require are all basically the same.	1 2 3 4 5 6 7 NA
5. We make complex dies in-house and outsource the others.	1 2 3 4 5 6 7 NA
6. Dies represent a very small percentage of the overall production cost of the final product.	1 2 3 4 5 6 7 NA
7. The leading die suppliers have proprietary knowledge that gives them an advantage over other firms.	1 2 3 4 5 6 7 NA
8. We rely on our suppliers to help us keep up with die technology.	1 2 3 4 5 6 7 NA
9. Our external suppliers have EDM capability.	1 2 3 4 5 6 7 NA
10. There is little difference between the process we would use to make dies and that used by a supplier.	1 2 3 4 5 6 7 NA
11. Our manufacturing staff can/could easily produce dies.	1 2 3 4 5 6 7 NA
12. Making dies requires a deep expertise that our firm understands.	1 2 3 4 5 6 7 NA
13. We have internally produced dies for years.	1 2 3 4 5 6 7 NA
14. The skills to make dies are closely related to those that we use to make other similar products.	1 2 3 4 5 6 7 NA
15. As compared to suppliers, our internal production of dies is/would be higher in price.	1 2 3 4 5 6 7 NA
16. As compared to suppliers, our internal production of dies is/would be lower in quality.	1 2 3 4 5 6 7 NA
17. By making our own dies, we do/could reduce our overall production costs of other products.	1 2 3 4 5 6 7 NA
18. We do/could better utilize our labor and equipment by making dies in addition to our other products.	1 2 3 4 5 6 7 NA

19. By making dies for us, our suppliers can reduce their overall production costs since they can make better use of their labor and equipment.	1 2 3 4 5 6 7 NA
20. In addition to dies, we buy other items or services from these same suppliers.	1 2 3 4 5 6 7 NA

C. Technology, Investments, and Evaluation: For each statement, please **circle** the appropriate numerical response on the scale ranging from "1" = totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. The processes and skills required to create dies are mature and unlikely to change in the future.	1 2 3 4 5 6 7 NA
2. Major die innovations are very likely within the next few years.	1 2 3 4 5 6 7 NA
3. Major innovations in how dies are produced are very likely within the next few years.	1 2 3 4 5 6 7 NA
4. No one really knows where the next technological advance for dies will come from.	1 2 3 4 5 6 7 NA
5. Switching die suppliers would be quick and easy to do.	1 2 3 4 5 6 7 NA
6. Die production requires major investments that cannot be used for other products.	1 2 3 4 5 6 7 NA
7. The skills needed to produce dies are generic and widely available.	1 2 3 4 5 6 7 NA **Untrue →**
8. Any equipment or tooling used for making our dies can easily be modified to make other, similar products.	1 2 3 4 5 6 7 NA
9. We can easily describe dies to our suppliers through printed/electronic descriptions and/or drawings.	1 2 3 4 5 6 7 NA
10. Die quality is based upon many different factors.	1 2 3 4 5 6 7 NA
11. Through a simple inspection, we can predict how well the die will function in our downstream production processes.	1 2 3 4 5 6 7 NA
12. We use several forms of inspection and several different metrics to evaluate die quality.	1 2 3 4 5 6 7 NA
13. When there is a problem with a die, we usually can determine its cause.	1 2 3 4 5 6 7 NA
14. It is difficult to equitably measure one supplier's die versus another supplier's.	1 2 3 4 5 6 7 NA

D. Demand Requirements The next set of questions and statements refer to the demand requirements for progressive dies. For each question, please mark **(X)** the appropriate box or **circle** the appropriate response on the scale from “1”= totally untrue to “7”= totally true. If the question does not apply to your firm, select NA.

1. **Approximately how many progressive stamping dies did you require in the most recent fiscal year?**
   ☐ 1-25 ☐ 51-100 ☐ Over 200
   ☐ 26-50 ☐ 101-200 ☐ I don’t know.

2. **When did you receive your last die?**
   ☐ Within the last week ☐ Within the last quarter ☐ Over a year ago.
   ☐ Within the last month ☐ Within the last year ☐ I don’t know.

How true are the following statements?	**Totally Untrue** ⟶ **Totally True**
3. Our forecasts for dies are very accurate.	1 2 3 4 5 6 7 NA
4. We frequently change the features on orders.	1 2 3 4 5 6 7 NA
5. We frequently change the timing on orders.	1 2 3 4 5 6 7 NA
6. There are predictable patterns to our requirements.	1 2 3 4 5 6 7 NA
7. Our suppliers frequently complain about the unpredictability of the requirements for dies.	1 2 3 4 5 6 7 NA
8. Our suppliers accommodate revisions with no hassles or extra charges.	1 2 3 4 5 6 7 NA
9. We need to stay in close contact with our suppliers to keep them updated on the changes in our requirements.	1 2 3 4 5 6 7 NA
10. Our suppliers receive demand information directly from our end customers.	1 2 3 4 5 6 7 NA

V. MAINTENANCE OF PROGRESSIVE STAMPING DIES

This **yellow** section will ask you questions about **the maintenance of progressive stamping dies**, including regrinding, repair, troubleshooting, and other related activities. In places, the word "maintenance" will be used as an abbreviation for this input.

A. Sourcing Choice and Satisfaction: Please answer the following questions about how you maintain progressive stamping dies. Please mark **(X)** the box corresponding to the appropriate response.

1. **How would you describe your maintenance of progressive stamping dies within the past fiscal year?**
   - ☐ All maintained internally (either within your plant or from a division with which your firm shares a common corporate parent)

   - ☐ All maintained by external suppliers
     - → *(i) If you marked this response, how many suppliers did you use?*
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7

   - ☐ Both maintained internally and by external suppliers
     - → *(i.) If you marked this response, what % of maintenance did you conduct internally (please mark one)?*
       - ☐ 0-10% ☐ 26-49% ☐ 75-90%
       - ☐ 11-25% ☐ 50-74% ☐ Over 90%
     - *(ii) How many external suppliers did you use*?
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7

   - ☐ Don't require die maintenance (please skip to the **green** section) →
2. **How long have you sourced die maintenance as indicated above in Question 1?**
   - ☐ Always, for as long as we've used them.
   - ☐ For the last several years.
   - ☐ Only for the last year or so.
   - ☐ I don't know.
3. **Do you plan on changing the way you source maintenance within the next two years?**
   - ☐ Yes (If so, how? ____)
   - ☐ No
4. **If you maintain dies internally, do you ever also maintain dies for competitors or other outside firms?**
   - ☐ Yes – we sometimes maintain dies for outside firms.
   - ☐ No – we maintain only our own dies and don't sell this service to outside firms.
   - ☐ Not applicable – we only use external suppliers for die maintenance.

5. **If you use external suppliers for maintenance, which best describes your transactions?**
   - ☐ Long term, rarely modified contracts for multiple maintenance tasks
   - ☐ Long term, frequently modified contracts for multiple maintenance tasks
   - ☐ Written purchase orders for each maintenance task
   - ☐ Verbal purchase orders for each maintenance task
   - ☐ Some combination of these or Other (Please explain ______________________)
   - ☐ Not applicable – we maintain all of our progressive dies internally

Please rate how you source progressive die maintenance along the following dimensions on the following scale ranging from <u>1 = absolutely terrible to 7 = absolutely terrific</u>. If you only maintain internally, rate the performance of your internal unit. If you use multiple suppliers, use a summary rating based on your allocation of business to each.

Our current sources' performance on …is…	**Absolutely Terrible → Absolutely Terrific**
6. Price competitiveness and value	1 2 3 4 5 6 7
7. Quality level / defect rates	1 2 3 4 5 6 7
8. On-time shipments	1 2 3 4 5 6 7
9. Communication and paperwork	1 2 3 4 5 6 7
10. Cooperation and dispute resolution	1 2 3 4 5 6 7
11. Overall sourcing experience	1 2 3 4 5 6 7

<u>B. Costs and Expertise</u>: For each statement, please **circle** the appropriate numerical response on the following scale ranging from <u>"1" indicating totally untrue to "7" indicating totally true</u>. If you don't know or the question does not apply, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. If demand for die maintenance doubled, the average cost per maintenance activity would change very little.	1 2 3 4 5 6 7 NA
2. Our quantity requirements for die maintenance are much too low to take advantage of the cheapest, high volume production methods.	1 2 3 4 5 6 7 NA
3. Many capable maintenance suppliers exist in the market.	1 2 3 4 5 6 7 NA
4. The maintenance tasks we need are all basically the same.	1 2 3 4 5 6 7 NA
5. We do more complex maintenance tasks in-house.	1 2 3 4 5 6 7 NA
6. Die maintenance represents a very small percentage of the overall production cost of the final product.	1 2 3 4 5 6 7 NA
7. The leading die maintenance suppliers have proprietary knowledge that gives them an advantage over other firms.	1 2 3 4 5 6 7 NA
8. We rely on our suppliers to help us keep up with die maintenance technology.	1 2 3 4 5 6 7 NA
9. Our external suppliers have EDM capability.	1 2 3 4 5 6 7 NA
10. There is little difference between the process we would use to maintain dies and that used by a supplier.	1 2 3 4 5 6 7 NA
11. Our manufacturing staff can/could easily maintain dies.	1 2 3 4 5 6 7 NA
12. Maintaining dies requires a deep expertise that our firm understands.	1 2 3 4 5 6 7 NA
13. We have internally maintained dies for years.	1 2 3 4 5 6 7 NA
14. The skills to maintain dies are closely related to those that we use to make other similar products.	1 2 3 4 5 6 7 NA
15. As compared to suppliers, our internal maintenance of dies is/would be higher in price.	1 2 3 4 5 6 7 NA
16. As compared to suppliers, our internal maintenance of dies is/would be lower in quality.	1 2 3 4 5 6 7 NA
17. By maintaining our own dies, we do/could reduce our overall production costs of other products.	1 2 3 4 5 6 7 NA
18. We do/could better utilize our labor and equipment by	1 2 3 4 5 6 7 NA

maintaining dies in addition to our other products.	
19. By maintaining dies for us, our suppliers can reduce their overall production costs since they can make better use of their labor and equipment.	1 2 3 4 5 6 7 NA
20. In addition to die maintenance, we buy other items or services from these same suppliers.	1 2 3 4 5 6 7 NA

C. Technology, Investments, and Evaluation: For each statement, please **circle** the appropriate numerical response on the scale ranging from "1" = totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. The processes and skills required to maintain dies are mature and unlikely to change in the future.	1 2 3 4 5 6 7 NA
2. Major innovations in how dies are maintained are very likely within the next few years.	1 2 3 4 5 6 7 NA
3. Major innovations in the equipment used for die maintenance are very likely within the next few years.	1 2 3 4 5 6 7 NA
4. No one really knows where the next technological advance for die maintenance will come from.	1 2 3 4 5 6 7 NA
5. Switching die maintenance suppliers would be quick and easy to do.	1 2 3 4 5 6 7 NA
6. Die maintenance requires major investments that cannot be used for other products.	1 2 3 4 5 6 7 NA
7. The skills needed to maintain dies are generic and widely available.	1 2 3 4 5 6 7 NA Untrue →
8. Any equipment or tooling used for maintaining our dies can easily be modified to make other, similar products.	1 2 3 4 5 6 7 NA
9. We can easily describe our die maintenance needs to our suppliers through printed descriptions and/or drawings.	1 2 3 4 5 6 7 NA
10. The quality of die maintenance is based upon many different factors.	1 2 3 4 5 6 7 NA
11. Through a simple inspection, we can predict how well a newly maintained die will function in our downstream production processes.	1 2 3 4 5 6 7 NA
12. We use several forms of inspection and several different metrics to evaluate the quality of die maintenance.	1 2 3 4 5 6 7 NA
13. When there is a problem with die maintenance, we usually can determine its cause.	1 2 3 4 5 6 7 NA
14. It is difficult to equitably measure one supplier's die maintenance versus another supplier's.	1 2 3 4 5 6 7 NA

D. Demand Requirements The next set of questions and statements refer to the demand requirements for progressive die maintenance. For each question, please mark **(X)** the appropriate box or **circle** the appropriate response on the scale from "1"= totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

1. Approximately how many progressive stamping dies required maintenance in the most recent fiscal year?

☐ 1-25 ☐ 51-100 ☐ Over 200
☐ 26-50 ☐ 101-200 ☐ I don't know.

2. When did you last maintain a progressive die?

☐ Within the last week ☐ Within the last quarter ☐ Over a year ago.
☐ Within the last month ☐ Within the last year ☐ I don't know.

How true are the following statements?	**Totally Untrue → Totally True**
3. Our forecasts for die maintenance are very accurate.	1 2 3 4 5 6 7 NA
4. We frequently change the features on orders.	1 2 3 4 5 6 7 NA
5. We frequently change the timing on orders.	1 2 3 4 5 6 7 NA
6. There are predictable patterns to our requirements.	1 2 3 4 5 6 7 NA
7. Our suppliers frequently complain about the unpredictability of die maintenance.	1 2 3 4 5 6 7 NA
8. Our suppliers accommodate revisions with no hassles or extra charges.	1 2 3 4 5 6 7 NA
9. We need to stay in close contact with our suppliers to keep them updated on the changes in our requirements.	1 2 3 4 5 6 7 NA
10. Our suppliers receive demand information directly from our end customers.	1 2 3 4 5 6 7 NA

VI. MACHINING OPERATIONS

This **green** section will ask you questions about **machining.** Most firms conduct some type of machining operations on their parts to add features that cannot be stamped in.

Which one of these machining operations does your firm most often require?

- ☐ Adding holes by drilling or boring (and/or tapping this hole)
- ☐ Improving the finish by grinding, lapping, or honing
- ☐ Adding grooves or other features by milling or broaching
- ☐ Turning, threading, or other lathe operations
- ☐ Other (Please specify_____________________________________)
- ☐ None of these – we use no machining operations after stamping

If you checked "None", please skip to the **purple** section ⟶

Please consider only this most common operation for the next 4 pages. Wherever the word "machining" is used, please substitute the above operation.

A. Sourcing Choice and Satisfaction: Please answer **(X)** the following questions.

1. **For the past fiscal year, which best describes this most common machining operation?**
   - ☐ All machined internally (either within your plant or from a sister division)
   - ☐ All machined by external suppliers
     - *(i) If you marked this response, how many suppliers did you use?*
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7
   - ☐ Both machined internally and by external suppliers
     - *(i.) If you marked this response, what % of your requirements did you machine internally (please mark one)?*
       - ☐ 0-10% ☐ 26-49% ☐ 75-90%
       - ☐ 11-25% ☐ 50-74% ☐ Over 90%
     - *(ii) How many external suppliers did you use*?
       - ☐ 1 ☐ 5-7
       - ☐ 2-4 ☐ More than 7
2. **How long have you sourced machining as indicated above in Question 1?**
   - ☐ Always, for as long as we've required it.
   - ☐ For the last several years.
   - ☐ Only for the last year or so.
   - ☐ I don't know.
3. **Do you plan on changing the way you source machining within the next two years?**
   - ☐ Yes (If so, how? ____)
   - ☐ No
4. **If you machine internally, do you ever also machine parts for other outside firms?**
   - ☐ Yes – we sometimes machine parts for outside firms.
   - ☐ No – we machine only our own parts and don't sell this service to outside firms.
   - ☐ Not applicable – we purchase all our machining services from external suppliers.
5. **If you use external suppliers for machining, which best describes your transactions?**
   - ☐ Long term, rarely modified contracts for multiple shipments or parts
   - ☐ Long term, frequently modified contracts for multiple shipments or parts
   - ☐ Written purchase orders for each part shipment
   - ☐ Verbal purchase orders for each part shipment
   - ☐ Some combination of these or Other (Please explain _____________________)
   - ☐ Not applicable – we do all our machining internally

Please rate how you source machining along the following dimensions on the scale ranging from <u>1 = absolutely terrible to 7 = absolutely terrific</u>. If you only machine internally, rate the performance of your internal unit. If you use multiple suppliers, use a summary rating based on your allocation of business to each.

Our current sources' performance on …is…	**Absolutely Terrible → Absolutely Terrific**
6. Price competitiveness and value	1 2 3 4 5 6 7
7. Quality level / defect rates	1 2 3 4 5 6 7
8. On-time shipments	1 2 3 4 5 6 7
9. Communication and paperwork	1 2 3 4 5 6 7
10. Cooperation and dispute resolution	1 2 3 4 5 6 7
11. Overall sourcing experience	1 2 3 4 5 6 7

<u>B. Costs and Expertise</u>: For each statement, please **circle** the appropriate numerical response on the following scale ranging from <u>"1" indicating totally untrue to "7" indicating totally true</u>. If you don't know or the question does not apply, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. If demand for machining doubled, the average machining cost per part would change very little.	1 2 3 4 5 6 7 NA
2. Our quantity requirements for machining are much too low to take advantage of the cheapest, high volume production methods.	1 2 3 4 5 6 7 NA
3. Many capable machining suppliers exist in the market.	1 2 3 4 5 6 7 NA
4. The machining tasks we require are all basically the same.	1 2 3 4 5 6 7 NA
5. We machine more complex part features in-house.	1 2 3 4 5 6 7 NA
6. Machining represents a very small percentage of the overall production cost of the final product.	1 2 3 4 5 6 7 NA
7. The leading machining suppliers have proprietary knowledge that gives them an advantage over other firms.	1 2 3 4 5 6 7 NA
8. We rely on our suppliers to help us keep up with machining technology.	1 2 3 4 5 6 7 NA
9. Our external suppliers have CNC capability.	1 2 3 4 5 6 7 NA
10. There is little difference between the process we would use to machine parts and that used by a supplier.	1 2 3 4 5 6 7 NA
11. Our manufacturing staff can/could easily do machining.	1 2 3 4 5 6 7 NA
12. Machining requires a deep expertise that our firm understands.	1 2 3 4 5 6 7 NA
13. We have internally machined parts for years.	1 2 3 4 5 6 7 NA
14. The skills to machine parts are closely related to those that we use to make other similar products/services.	1 2 3 4 5 6 7 NA
15. As compared to suppliers, our internal machining is/would be higher in price.	1 2 3 4 5 6 7 NA
16. As compared to suppliers, our internal machining is/would be lower in quality.	1 2 3 4 5 6 7 NA
17. By machining our own parts, we do/could reduce our overall production costs of other products.	1 2 3 4 5 6 7 NA
18. We do/could better utilize our labor and equipment by	1 2 3 4 5 6 7 NA

machining parts in addition to producing other items.	
19. By machining parts for us, our suppliers can reduce their overall production costs since they can make better use of their labor and equipment.	1 2 3 4 5 6 7 NA
20. In addition to machining services, we buy other items or services from these same suppliers.	1 2 3 4 5 6 7 NA

C. Technology, Investments, and Evaluation: For each statement, please **circle** the appropriate numerical response on the scale ranging from "1" = totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. The processes and skills required for machining are mature and unlikely to change in the future.	1 2 3 4 5 6 7 NA
2. Major innovations in features to be machined are very likely within the next few years.	1 2 3 4 5 6 7 NA
3. Major innovations in machining equipment are very likely within the next few years.	1 2 3 4 5 6 7 NA
4. No one really knows where the next technological advance for machining will come from.	1 2 3 4 5 6 7 NA
5. Switching machining suppliers would be quick and easy to do.	1 2 3 4 5 6 7 NA
6. Machining requires major investments that cannot be used for other products.	1 2 3 4 5 6 7 NA
7. The skills needed to machine parts are generic and widely available.	1 2 3 4 5 6 7 NA **Untrue** →
8. Any equipment or tooling used for machining can easily be modified for other, similar products or operations.	1 2 3 4 5 6 7 NA
9. We can easily describe our machining needs to our suppliers through printed descriptions and/or drawings.	1 2 3 4 5 6 7 NA
10. The quality of machining is based upon many different factors.	1 2 3 4 5 6 7 NA
11. Through a simple inspection, we can predict how well a machined part will function in downstream production processes.	1 2 3 4 5 6 7 NA
12. We use several forms of inspection and several different metrics to evaluate the quality of machining.	1 2 3 4 5 6 7 NA
13. When there is a problem with machining, we usually can determine its cause.	1 2 3 4 5 6 7 NA
14. It is difficult to equitably measure one supplier's machining versus another supplier's.	1 2 3 4 5 6 7 NA

D. Demand Requirements For each question, please mark **(X)** the appropriate box or **circle** the appropriate response on the scale from "1"= totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

1. About how many part numbers required machining in the most recent fiscal year?

☐ 1-10	☐ 26-50	☐ Over 100
☐ 11-25	☐ 51-100	☐ I don't know.

2. When did you last machine or have a supplier machine parts?

☐ Within the last week	☐ Within the last quarter	☐ Over a year ago.
☐ Within the last month	☐ Within the last year	☐ I don't know.

How true are the following statements?	**Totally Untrue → Totally True**
3. Our forecasts for machining are very accurate.	1 2 3 4 5 6 7 NA
4. We frequently change the quantities on orders.	1 2 3 4 5 6 7 NA
5. We frequently change the timing on orders.	1 2 3 4 5 6 7 NA
6. There are predictable patterns to our requirements.	1 2 3 4 5 6 7 NA
7. Our suppliers frequently complain about the unpredictability of machining requirements.	1 2 3 4 5 6 7 NA
8. Our suppliers accommodate quantity fluctuations with no hassles or extra charges.	1 2 3 4 5 6 7 NA
9. We need to stay in close contact with our suppliers to keep them updated on the changes in our quantity requirements.	1 2 3 4 5 6 7 NA
10. Our suppliers receive demand information directly from our end customers.	1 2 3 4 5 6 7 NA

VII. SURFACE COATING/PLATING OPERATIONS

This **purple** section will ask you questions about **surface coating or plating of your parts.** This would include operations such as zinc plating, powder coating, or otherwise adding a protective/decorative coating to parts. In places, "coat" will be used as an abbreviation.

A. Sourcing Choice and Satisfaction: Please answer the following questions about how you source the surface coating of your parts. Please mark **(X)** the box corresponding to the appropriate response.

1. For the past fiscal year, which best describes how you surface coated your parts?

☐ All done internally (either within your plant or from a division with which your firm shares a common corporate parent)

☐ All purchased from external suppliers

→ *(i) If you marked this response, how many suppliers did you use?*

☐ 1 ☐ 5-7

☐ 2-4 ☐ More than 7

☐ Both done internally and purchased from external suppliers

→ *(i.) If you marked this response, what % of your requirements did you coat internally (please mark one)?*

☐ 0-10% ☐ 26-49% ☐ 75-90%

☐ 11-25% ☐ 50-74% ☐ Over 90%

(ii) How many external suppliers did you use?

☐ 1 ☐ 5-7

☐ 2-4 ☐ More than 7

☐ Don't use surface coating operations (please skip to the final **white** section) →

2. How long have you sourced surface coating as indicated above in Question 1?

☐ Always, for as long as we've required it.

☐ For the last several years.

☐ Only for the last year or so.

☐ I don't know.

3. Do you plan on changing the way you source surface coating within the next two years?

☐ Yes (If so, how? ____)

☐ No

4. If you surface coat internally, do you ever sell this service to competitors or other outside firms?

☐ Yes – we sometimes sell to outside firms.

☐ No – we coat only for our own use and don't sell this service to outside firms.

☐ Not applicable – we outsource all our surface coating to external suppliers.

5. If you use external suppliers for coating, which best describes your transactions?

☐ Long term, rarely modified contracts for multiple shipments or parts

☐ Long term, frequently modified contracts for multiple shipments or parts

☐ Written purchase orders for each part shipment

☐ Verbal purchase orders for each part shipment

☐ Some combination of these or Other (Please explain ______________________)

☐ Not applicable – we coat all our parts in-house

Please rate how you source surface coating along the following dimensions on the following scale ranging from 1 = absolutely terrible to 7 = absolutely terrific. If you only coat internally, rate the performance of your internal unit. If you use multiple suppliers, use a summary rating based on your allocation of business to each.

Our current sources' performance on …is…	**Absolutely Terrible → Absolutely Terrific**
6. Price competitiveness and value	1 2 3 4 5 6 7
7. Quality level / defect rates	1 2 3 4 5 6 7
8. On-time shipments	1 2 3 4 5 6 7
9. Communication and paperwork	1 2 3 4 5 6 7
10. Cooperation and dispute resolution	1 2 3 4 5 6 7
11. Overall sourcing experience	1 2 3 4 5 6 7

B. Costs and Expertise: For each statement, please **circle** the appropriate numerical response on the following scale ranging from "1" indicating totally untrue to "7" indicating totally true. If you don't know or the question does not apply, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. If demand for surface coating doubled, the average cost to coat each part would change very little.	1 2 3 4 5 6 7 NA
2. Our quantity requirements for surface coating are much too low to take advantage of the cheapest, high volume production methods.	1 2 3 4 5 6 7 NA
3. Numerous capable coating suppliers exist in the market.	1 2 3 4 5 6 7 NA
4. The surface coatings we require are all basically the same.	1 2 3 4 5 6 7 NA
5. We do more complex coating operations in-house.	1 2 3 4 5 6 7 NA
6. Surface coating represents a very small percentage of the overall production cost of the final product.	1 2 3 4 5 6 7 NA
7. The leading coating suppliers have proprietary knowledge that gives them an advantage over other firms.	1 2 3 4 5 6 7 NA
8. We rely on our suppliers to help us keep up with surface coating technology.	1 2 3 4 5 6 7 NA **Untrue** →
9. There is little difference between the process we would use for surface coating and that used by a supplier.	1 2 3 4 5 6 7 NA
10. Our manufacturing staff can/could easily coat our parts.	1 2 3 4 5 6 7 NA
11. Surface coating requires a deep expertise that our firm understands.	1 2 3 4 5 6 7 NA
12. We have internally surface coated parts for years.	1 2 3 4 5 6 7 NA
13. The skills for surface coating are closely related to those that we use to make other similar products.	1 2 3 4 5 6 7 NA
14. As compared to suppliers, our internal surface coating of parts is/would be higher in price.	1 2 3 4 5 6 7 NA
15. As compared to suppliers, our internal surface coating of parts is/would be lower in quality.	1 2 3 4 5 6 7 NA
16. By surface coating our own parts, we do/could reduce our overall production costs of other products.	1 2 3 4 5 6 7 NA
17. We do/could better utilize our labor and equipment by coating parts in addition to making our other products.	1 2 3 4 5 6 7 NA

18. By surface coating parts for us, our suppliers can reduce their overall production costs since they can make better use of their labor and equipment.	1 2 3 4 5 6 7 NA
19. In addition to surface coating services, we buy other items or services from these same suppliers.	1 2 3 4 5 6 7 NA

<u>C. Technology, Investments, and Evaluation</u>: For each statement, please **circle** the appropriate numerical response on the scale ranging from "1" = <u>totally untrue to "7"= totally true.</u> If the question does not apply to your firm, select NA.

How true are the following statements?	**Totally Untrue → Totally True**
1. The processes and skills required to surface coat parts are mature and unlikely to change in the future.	1 2 3 4 5 6 7 NA
2. Major innovations in surface coatings are very likely within the next few years.	1 2 3 4 5 6 7 NA
3. Major innovations in surface coating equipment are very likely within the next few years.	1 2 3 4 5 6 7 NA
4. No one really knows where the next technological advance for surface coating will come from.	1 2 3 4 5 6 7 NA
5. Switching coating suppliers would be quick and easy to do.	1 2 3 4 5 6 7 NA
6. Surface coating parts requires major investments that cannot be used for other products.	1 2 3 4 5 6 7 NA
7. The skills needed to surface coat are generic and widely available.	1 2 3 4 5 6 7 NA **Untrue →**
8. Any equipment or tooling used for our surface coatings can easily be modified for other, similar operations.	1 2 3 4 5 6 7 NA
9. We can easily describe our coating needs to our suppliers through printed/electronic descriptions and/or drawings.	1 2 3 4 5 6 7 NA
10. The quality of surface coating is based upon many different factors.	1 2 3 4 5 6 7 NA
11. Through a simple inspection, we can predict how well a coated part will function in downstream production processes.	1 2 3 4 5 6 7 NA
12. We use several forms of inspection and several different metrics to evaluate the quality of surface coating.	1 2 3 4 5 6 7 NA
13. When there is a problem with surface coating, we usually can determine its cause.	1 2 3 4 5 6 7 NA
14. It is difficult to equitably measure one supplier's surface coating versus another supplier's.	1 2 3 4 5 6 7 NA

D. Demand Requirements For each question, please mark **(X)** the appropriate box or **circle** the appropriate response on the scale from "1"= totally untrue to "7"= totally true. If the question does not apply to your firm, select NA.

1. About how many part numbers required surface coating in the most recent fiscal year?

☐ 1-10 ☐ 26-50 ☐ Over 100
☐ 11-25 ☐ 51-100 ☐ I don't know.

2. When did you last surface coat or have a supplier coat parts?

☐ Within the last week ☐ Within the last quarter ☐ Over a year ago.
☐ Within the last month ☐ Within the last year ☐ I don't know.

How true are the following statements?	**Totally Untrue → Totally True**
3. Our forecasts for surface coating are very accurate.	1 2 3 4 5 6 7 NA
4. We frequently change the quantities on orders.	1 2 3 4 5 6 7 NA
5. We frequently change the timing on orders.	1 2 3 4 5 6 7 NA
6. There are predictable patterns to our requirements.	1 2 3 4 5 6 7 NA
7. Our suppliers frequently complain about the unpredictability of the requirements for coating.	1 2 3 4 5 6 7 NA
8. Our suppliers accommodate quantity fluctuations with no hassles or extra charges.	1 2 3 4 5 6 7 NA
9. We need to stay in close contact with our suppliers to keep them updated on the changes in our quantity requirements.	1 2 3 4 5 6 7 NA
10. Our suppliers receive demand information directly from our end customers.	1 2 3 4 5 6 7 NA

VIII. Firm Data: Please answer the following general questions about your firm.

1. **How many employees work for your firm?**
   ☐ 1- 49 ☐ 100-249 ☐ 500 or more
   ☐ 50-99 ☐ 250-499 ☐ I don't know

1. **Are the majority of your firm's hourly employees represented by a union?**
   ☐ Yes (Which one (if known)? __________________________)
   ☐ No

2. **In what year was your firm established?** _________

3. **In what month does your fiscal year begin?** _____________

4. **Based on sales dollars, what percentage of your products were used in automotive applications in your most recent fiscal year?**
   ☐ 0-10% ☐ 26-50% ☐ 76-90%
   ☐ 11-25% ☐ 51-75% ☐ Over 90%

5. **Based on sales dollars, what percentage of products your firm produced in the most recent fiscal year were ferrous-based (iron, steel, or stainless steel)?**
   ☐ 0-10% ☐ 26-50% ☐ 76-90%
   ☐ 11-25% ☐ 51-75% ☐ Over 90%

6. **How many active part numbers does your firm currently have?**
   ☐ 1-100 ☐ 201-500 ☐ Over 1000
   ☐ 101-200 ☐ 501-1000 ☐ I don't know

7. **Approximately what is the total annual sales volume for your firm (please use US $ and your most recent fiscal year)?**
   ☐ Under $US 5 million ☐ $US 51-100 million
   ☐ $US 6-20 million ☐ $US 101-500 million
   ☐ $US 21-50 million ☐ Over $US 500 million

8. **Approximately what is the "total annual buy" for your firm (in US $, how much did your firm spend in the most recent fiscal year on all raw materials, equipment, components, supplies, and other resources needed for production, not including labor)?**
   ☐ Under $US 1 million ☐ $US 50-100 million
   ☐ $US 1-5 million ☐ $US 101-500 million
   ☐ $US 6-20 million ☐ Over $US 500 million
   ☐ $US 21-50 million ☐ I don't know

Your Name _________________________ Firm Name __________________________

Your Title __________________________ Date __________________________

Including yourself, how many people participated in filling out this survey? ________

If you like, please use the space below for any general comments you may have about sourcing production equipment and services.

If you have any general comments or suggestions regarding this survey, please jot them down in the space below.

If you would like a summary of the results of this survey, please mark this box: ☐

Thank you so much for your participation.
Please look over this booklet to make sure no pages were missed.
Return this survey in the envelope provided.

If you have any additional questions or comments, please contact:

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Appendix C: Survey Items, in Order, with Related Variables

Variable	Q#	Rev?	Word Snippet	Level	Item Name
Supplier Mgmt Capability	I 1	0	Overall opinion	Firm	LTR1
Supplier Mgmt Capability	I 2	0	# people in purchasing	Firm	INPURCH
Supplier Mgmt Capability	I 3	1	Quality certifications	Firm	QUALCERTORIG
Supplier Mgmt Capability	I3b	0	Quality certifications - desc	Firm	QUALDESC
Firm Expertise	I 4a	0	Have tech equipment - EDM	Firm	EDM
Firm Expertise	I4b	0	Have tech equipment - CNC	Firm	CNC
Firm Expertise	I4c	0	Have tech equipment - CAD	Firm	CAD
Supplier Mgmt Capability	II 1	0	Supp reln last for years	Firm	LTR2
Supplier Mgmt Capability	II 2	0	Formal written contracts	Firm	LTR3ORIG
Supplier Mgmt Capability	II 3	0	Work thru difficulties	Firm	LTR4
Supplier Mgmt Capability	II 4	0	Share prop info	Firm	SHARE1
Supplier Mgmt Capability	II 5	1	Engr never travel	Firm	SHARE2ORIG
Supplier Mgmt Capability	II 6	0	Help suppliers improve	Firm	SHARE3
Supplier Mgmt Capability	II 7	1	Supp don’t' help us	Firm	SHARE4ORIG
Supplier Mgmt Capability	II 8	0	Use confid agreements	Firm	LTR5ORIG
Supplier Mgmt Capability	II 9	0	Advise supp performance	Firm	PEVAL1
Supplier Mgmt Capability	II 10	0	Evaluate in/out same	Firm	PEVAL2
Supplier Mgmt Capability	II 11	0	Use formal scorecard	Firm	PEVAL3
Supplier Mgmt Capability	II 12	0	Purch have engr/mfg back	Firm	SHARE5
Supplier Mgmt Capability	II 13	0	Purch good at coord	Firm	COORD1
Supplier Mgmt Capability	II 14	1	Coord easier in vs out	Firm	COORD2ORIG
Supplier Mgmt Capability	II 15	0	Ship prod to cust from supp	Firm	COORD3
Supplier Mgmt Capability	II 16	0	Tell supp if change in vol	Firm	COMM1
Supplier Mgmt Capability	II 17	1	Supp don't tell us prob	Firm	COMM2ORIG
Supplier Mgmt Capability	II 18	0	Communicate daily	Firm	COMM3
Supplier Mgmt Capability	II 19	1	Comm in easier than out	Firm	COMM4ORIG
Supplier Mgmt Capability	II 20	1	Supp contacts thru purch	Firm	COMM5ORIG
Input ID		0		Input	INPUTID
Firm ID		0	To connect inputs and firms	Input	FIRMID
Input type		0		Input	TYPE
Machining Operation		0	Type of machine operation	Input	MACHOP
Machining Operation		0	Textual description of mach op	Input	MACHOPDESC
Sourcing Mode	A1	0	Where did input come from?	Input	SMODE
Sourcing Mode	A1b	0	If make and buy, % make	Input	PERMAKE
Sourcing Mode	A1a	0	If buy, how many suppliers	Input	NOSUPP
Sourcing Mode	A2	0	How long this way	Input	HOWLONGORIG
Sourcing Mode	A3	0	Plan to change	Input	PLANCHG
Sourcing Mode	A3b		Text - how to change	Input	HOWCHG
Make and sell	A4	0	If make, Sell to outsiders	Input	MKNSELL
Sourcing Mode	A5	0	Contract, PO, Other	Input	TRANTYPE
Sourcing Mode	A5b		Text - how do transactions	Input	TRANDESC
Performance	A6	0	Price	Input	PRICPERF
Performance	A7	0	Quality	Input	QUALPERF
Performance	A8	0	On time	Input	DLYPERF

Performance	A9	0	Communication	Input	COMMPERF
Performance	A10	0	Cooperation	Input	COOPPERF
Performance	A11	0	Overall	Input	OVERPERF
Scale	B1	1	Double demand, no cost chg	Input	SCALE1ORIG
Scale	B2	0	Qty too low for cheap prodn	Input	SCALE2
Asset Specificity	B3	0	Numerous suppliers	Input	SUPEX1
Product Mix	B4	0	All basically the same	Input	ALLSAME
Product Mix	B5	0	Make more complex	Input	COMPLEXIN
Supplier Expertise	B6	0	Small % of overall cost	Input	SUPEX2
Supplier Expertise	B7	0	Leading suppliers prop know	Input	SUPEX3
Supplier Expertise	B8	0	Suppliers help us keep up	Input	SUPEX4
Supplier Expertise	B9	0	Suppliers have tech equip	Input	SUPEX5
Supplier Expertise	B10	1	No difference in supp/our proc	Input	SUPEX6ORIG
Firm Expertise	B11	0	Mfg staff can do	Input	FEX1
Firm Expertise	B12	0	Requires expertise, we have	Input	FEX2
Firm Expertise	B13	0	Have done for years	Input	FEX3
Firm Expertise	B14	0	Skills related to others	Input	FEX4
Supplier Expertise	B15	0	Internal higher price	Input	FEX5ORIG
Supplier Expertise	B16	0	Internal lower quality	Input	FEX6ORIG
Firm Scope	B17	0	reduce costs of other prod	Input	FSCOPE1
Firm Scope	B18	0	better use lbr/equip	Input	FSCOPE2
Supplier Scope	B19	0	reduce costs of other prod	Input	SUSCOPE1
Supplier Scope	B20	0	buy other items from supp	Input	SUSCOPE2
Technological Uncertainty	C1	1	Mature processes/skills	Input	TUN1ORIG
Technological Uncertainty	C2	0	Major innov in product	Input	TUN2
Technological Uncertainty	C3	0	Major innov in process	Input	TUN3
Technological Uncertainty	C4	0	No one knows tech advance	Input	TUN4
Asset Specificity	C5	1	Switching supplierseasy	Input	AS1ORIG
Asset Specificity	C6	0	Need major investments	Input	AS2
Asset Specificity	C7	1	Skills generic/available	Input	AS3ORIG
Asset Specificity	C8	1	Equipment easily modified	Input	AS4ORIG
Performance Ambiguity	C9	1	Easily describe in drawings	Input	PA1ORIG
Performance Ambiguity	C10	0	Quality based on many factors	Input	PA2
Performance Ambiguity	C11	1	Simple inspection, predict fn	Input	PA3ORIG
Performance Ambiguity	C12	0	Several forms of inspection	Input	PA4
Performance Ambiguity	C13	1	Problem, can determine cause	Input	PA5
Performance Ambiguity	C14	0	Can't equitably measure	Input	PA6
Volume	D1	0	How many in last yr	Input	VOLUME
Volume	D2	0	When receive last one	Input	LASTDLY
Volume Uncertainty	D3	1	Accurate forecasts	Input	VU1ORIG
Volume Uncertainty	D4	0	Change features	Input	VU2
Volume Uncertainty	D5	0	Change timing	Input	VU3
Volume Uncertainty	D6	1	Predictable patterns	Input	VU4ORIG
Volume Uncertainty	D7	0	Suppliers complain	Input	VU5
Volume Uncertainty	D8	1	Accommodate w/o charge	Input	VU6ORIG
Volume Uncertainty	D9	0	Stay in contact-update	Input	VU7
Volume Uncertainty	D10	1	Supp get demand direct	Input	VU8

Indicate that input's good to use		0	good to use input or not?	Input	OKTOUSE
Firm Size	VIII 1	0	Number of employees	Firm	EMPEES
Unionization	VIII 2	0	Majority hourly rep by union	Firm	UNION
Unionization	VIII 3	0	Majority hourly rep by union	Firm	UNIONNAME
Firm Age	VIII 3	N/A	What yr established	Firm	YEAREST
Firm fiscal month	VIII3	0	Fiscal month	Firm	FISCALMO
Product Mix	VIII 5	0	% automotive	Firm	AUTOPER
Product Mix	VIII 6	0	% ferrous	Firm	FERPER
Product Mix	VIII 7	0	# active parts	Firm	ACTPTS
Firm Size	VIII 8	0	Annual sales volume	Firm	SALES
Firm Size	VIII 9	0	Annual total buy	Firm	BUIY
Name of person who filled out	VIII	0	Survey name	Firm	SURVEYNAME
Title of person who filled out	VIII	0	Survey contact title	Firm	SURVEYTITLE
Date survey filled out	VIII	0	Survey date	Firm	SURVEYDATE
Number of people who filled out	VIII	0	How m any people filled out	Firm	NOFILL
comments	VIII	0	Comments on sourcing	Firm	SOURCECOMM
comments	VIII	0	Comments on survey	Firm	SURVEYCOMM
Want results or not	VIII	0	Want results?	Firm	WANTRES
Firm Type		0		Firm	TYPE (M List)

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