HOW INTRA-FIRM AND INTER-FIRM EXPERTISE AFFECT THE SOURCING
DECISIONS OF TECHNOLOGICALLY INTERDEPENDENT COMPONENTS

ANNE PARMIGIANI
Lundquist College of Business, University of Oregon
Eugene, OR 97403

WILL MITCHELL
Duke University, The Fuqua School of Business

Theories of the firm traditionally posit that firms determine their boundaries by selecting sourcing modes for individual goods and services, choosing whether to make or buy a particular component with little attention to complementarities among multiple components (e.g., Coase, 1937; Williamson, 1975). In practice, firms typically need to make joint sourcing decisions for some components rather than treat them independently (Teece, 1982) due to complementarities that stem from interrelated business activities such as shared production equipment and technological interdependence (Helfat & Raubitschek, 2000; Panzar & Willig, 1981; Santos & Eisenhardt, 2005). Arguments that neglect such interdependencies by treating sourcing decisions for complementary components atomistically are likely to misinterpret firms’ boundary choices and, in turn, misconstrue key aspects of business strategy.

A growing body of research has begun to consider how complementarity among physical goods and/or business processes influences firm boundaries, initially focusing on the make versus buy dichotomy and more recently considering concurrent sourcing as a combined sourcing option. In perhaps the most formal treatment, Milgrom and Roberts (1990: 181) define complementarity in terms of the joint returns from carrying out different activities. In their terms, activities involving different items are complements if doing more of one activity increases the returns from doing more of another activity. Related work has considered complementarity in terms of economies of scope that create opportunities for cost savings in production and governance activities (Panzar & Willig, 1981; Teece, 1982, 1986; Helfat & Eisenhardt, 2004), as well as technological interdependencies that create opportunities to share design and production activities (Arrow, 1975; Helfat & Raubitschek, 2000; Kogut & Zander, 1992). The conventional conclusion concerning firm boundaries in this literature is that firms have strong incentives to vertically integrate sets of complementary components to reduce production costs, protect specialized assets, and draw on tacit interrelated skills to create goods and services.

Conventional arguments may underestimate the benefits of outsourcing at least some activities within a complementary system. Milgrom and Roberts (1990: 526) conclude that outsourcing complementary components to suppliers creates flexibility in the face of the supply and demand uncertainties that are common in interrelated systems of business activities, quite often overwhelming the tendency toward internalization. Brusoni and Prencipe (2001) and Prencipe, Davies, and Hobday (2003) highlight the growth of modularity in product markets and suggest that firms can benefit by acting as system integrators, by coordinating outsourced production activities of multiple suppliers. Yet, pure outsourcing of complementary components would be highly risky due to the loss of control to outsiders and the elimination of a key source of knowledge, learning by doing (Nonaka, 1994; Pisano, 1994). Thus, there is a tension between traditional vertical integration arguments and recent insights about the benefits of outsourcing complementary components.
Concurrent sourcing presents as an alternative to the traditional make versus buy boundary dichotomy and can resolve this tension. Concurrent sourcing occurs when firms both make and buy some of their requirements for a particular component (Cassiman & Veuglers, 2006; Gulati & Puranam, 2006; He & Nickerson, 2006; Heide, 2003; Parmigiani, 2007). We argue that firm and supplier expertise shape the incentives to undertake concurrent sourcing of sets of complementary components. Firms will be more likely to concurrently source complementary components rather than independent components in order to help utilize fungible resources and take advantage of learning opportunities. We draw on the capabilities literature to argue that both interfirm and intrafirm expertise relating to a set of complementary components increase firms’ incentives to concurrently source the components, rather than vertically integrate. In this view, firms’ knowledge boundaries influence their production boundaries (Brusoni, Prencipe, & Pavitt, 2001; Takeishi, 2002). We test the predictions using a sample of joint sourcing decisions for die design, die construction, and end-part machining services of 110 North American metal stamping and powder metal firms in 2002. Die design and die construction involve substantial complementarity due to technological interdependence and economies of scope, while die design and end part machining are largely independent.

BACKGROUND AND PREDICTIONS

Complementarity involving two or more components can originate from economies of scope and/or technological interdependence. Economies of scope arise when firms can reduce overall production costs by coordinating multiple activities jointly (Helfat & Eisenhardt, 2004; Panzar & Willig, 1981; Teece, 1982), resulting in more efficient utilization of fungible upstream resources, such as capital, labor, reputation, and managerial expertise. Technological interdependence produces complementarities when a firm’s ability to modify or create new goods and services requires knowledge of multiple aspects of design, production, and/or distribution across two or more components. Technological complementarity can arise when changes in the design of one component require changes in another component (Dosi, 1988). Such design complementarities can result from a pooled knowledge base, from sequential operations, and/or from the reciprocal nature of the production process (Thompson, 1967). Similarly, technological complementarity can result from the need for integrative knowledge in complex business activities (Brusoni & Prencipe, 2001; Helfat & Raubitschek, 2000). For both scope complementarity and technological complementarity, the key implication for boundary choices is that firms benefit by coordinating the activities needed to produce two or more components of an end-product and/or process within a business system.

We expect concurrent sourcing to be more prevalent for sets of complementary components than for sets of independent components. Independent components will not enjoy benefits of cost reductions due to scope economies from shared upstream assets. While complementary components use these shared upstream assets, they may not use them in the same amounts or at the same rate, which may result in capacity constraints leading to outsourcing of some portion of the firm’s requirements. There may also be complementarities in contracting (Novak & Stern, 2004) such that firms would prefer to use the same type of sourcing mode for complementary components.

Technological complementarities will also motivate firms to concurrently source related components more often than independent components. The incentives to concurrently source arise from information needs to respond to technological change and from learning opportunities. Such needs and opportunities are more important for interdependent than independent
components since independent components are derived from different knowledge bases, such that there will be little information spillover or learning effects between them. For complementary components, firms need information about current technological changes that affect multiple components. They must understand what changes are occurring, which components are impacted, and how these changes affect the relationship between the components (Brusoni & Prencipe, 2001; Kogut & Zander, 1992; Pisano, 1994). Through concurrent sourcing, firms gain a wider range of information about relevant changes than if they relied solely on internal production. Concurrent sourcing reduces the information asymmetry between the firm and its suppliers, enabling it to compare and benchmark internal versus external suppliers and thus reduce slacking (Heide, 2003; Oster, 1994). In addition to incorporating suppliers’ knowledge in a firm’s current products, concurrent sourcing creates opportunities to learn from suppliers, thereby creating a stronger base for future internal activities. This logic provides the basis for the first hypothesis:

Hypothesis 1. Firms are more likely to concurrently source complementary components than independent components.

Interfirm expertise encompasses the skills of a firm and its suppliers relevant to a particular component and/or set of components. We use the term “combined interfirm expertise” to refer to the aggregate set of skills that the firms and its suppliers can bring to bear in designing, producing, and marketing a set of components. Substantial combined interfirm expertise is present when both the firm and one or more potential suppliers each possess a high degree of relevant expertise for a set of components.

Substantial levels of combined interfirm expertise typically involve some degree of skill specialization, with the buyer having a greater understanding of some aspects of the components and a supplier knowing more about other aspects. As a result, two or more strong firms each bring differentiated value to a product, which creates an incentive to both make and buy. When combined interfirm expertise for a set of complementary components is sufficiently strong, a firm may elect to use concurrent sourcing – thereby giving up some degree of economies of scale – in order to gain access to the flexibility and specialized skills of a partner, rather than vertically integrating to take advantage only of its own skills. In addition, the presence of skill specialization across strong firms creates a learning incentive for concurrent sourcing complementary components. That is, a firm will often benefit from buying components from a highly-skilled supplier to learn from that supplier. Such learning opportunities will be most productive when the firm itself also has strong relevant expertise, because their internal skills create an absorptive capacity that enables knowledge transfer (Cohen & Levinthal, 1990). Thus,

Hypothesis 2: The greater the combined interfirm expertise of a firm and its potential suppliers for complementary components, the more likely the firm will concurrently source the components rather than vertically integrate.

We next consider the impact of intrafirm expertise, which is the focal firm’s skill relevant to a set of complementary components. The seemingly intuitive traditional expectation is that greater intrafirm expertise will lead firms to vertically integrate complementary components to leverage their strong internal skills and resources. Firms tend to accumulate tangible and intangible resources that can be used throughout a family of related products (Helfat & Raubitschek, 2000; Nelson & Winter, 1982).
Contrary to the intuitive expectation, an intriguing counterpoint from the modularity literature suggests that complementary components can be successfully outsourced if they are well defined with clearly described interfaces (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996). Some firms can outsource many of their activities but retaining expertise in the underlying technologies (Brusoni & Prencipe, 2000; Prencipe, Davies, & Hobday 2003). The benefits of outsourcing include both flexibility in the face of uncertainty (Milgrom & Roberts, 1990, 1995) and opportunities to learn from external partners (von Hippel, 1988). This implies that a firm’s production boundaries do not define their knowledge boundaries, which may be considerably broader (Brusoni, et al., 2001). But, firms must preserve internal knowledge to understand the interrelationships between components and technologies that may change at different rates. As Pavitt (2003: 86) argues, “Firms specializing in systems integration will need to maintain competencies in related manufacture, components, and subsystems”.

This argument suggests limits to complete outsourcing, since some degree of tacit knowledge will only be gained through internal production. Concurrent sourcing provides a resolution to this dilemma of requiring deep component knowledge but also preserving flexibility. Firms need not produce their full requirements for the set of complementary components in order to obtain deep component knowledge and sufficient absorptive capacity to source effectively (Adelman, 1949; Cohen & Levinthal, 1990; Oster, 1994; Parmigiani, 2007). This suggests an overlap in production and knowledge boundaries. When components are complementary, the sourcing decisions for the two components become intermingled such that concurrent sourcing of one will lead to that same mode being chosen for the other. This results in both technological and organizational complexity. The payoff of this difficult to manage mode is a richer understanding of the set of components and the underlying body of technical knowledge. This logic leads to our final hypothesis:

**Hypothesis 3**: The greater the intrafirm expertise for complementary components, the more likely the firm will concurrently source the components rather than vertically integrate.

**DATA, METHODS AND RESULTS**

We studied sourcing decisions of North American metal forming firms. Following exploratory interviews, we created a mail survey to collect data on the sourcing decisions of several production-related inputs, including die design, die building, and end-part machining. After obtaining mailing lists from industry associations and making screening calls to identify the best respondent, we sent the survey to 453 firms in Fall 2002. We obtained a 43% usable response rate, which is significantly higher than 20% rate that is common for firm surveys (Paxson, Dillman, & Tarnai, 1995). No indication of non-response bias or sample selection bias was apparent in the data (Armstrong & Overton, 1977, Tomaskovic-Devey, Leiter, & Thompson, 1994). Die design and die construction provided a pair of complementary components and, for comparison, die design and end part machining provided a pair of independent components. Die design and die construction are technologically interdependent (primarily sequential interdependence, in Thompson’s (1967) terms, with die design preceding die construction) and also enjoy scope economies. By contrast, die design and end part machining involve different kinds of expertise, have little or no work flow interdependencies, and create few economies of scope. After culling cases that did not include sourcing choices for all three inputs, the data include 110 firms’ joint sourcing decisions for the complementary and independent components.
The dependent variable was the joint sourcing decision. With were three options for each component (make, buy, concurrent), the joint sourcing decision for a pair of components has nine combinations. For simplicity and econometric parsimony, we focus on four of the combinations: concurrently sourcing both components (concurrent/concurrent), making both components (make/make), buying both components (buy/buy), and using some combination (mixed mode). Our key hypotheses compare the first and second options: concurrent/concurrent versus make/make. Our main independent variables were based on component-level firm expertise measures, which involved four to five item scales; some from prior work and others original (Noordewier, John, & Nevin, 1990; Walker & Weber, 1984). We measured intrafirm expertise by multiplying the firm component expertise scores for the two components, and then denoted combined interfirm expertise by multiplying the firm and supplier component expertise scores for the two components. Control variables included supplier component expertise, intrasupplier expertise for the pair of components, asset specificity, performance uncertainty, volume requirements, scale economies, firm and supplier scope economies for the components, firm size, age, unionization, and type (powder metal or stamping).

To test our first hypothesis, we constructed summary tables of sourcing choices. We then compared the results of the complementary pair of components (die designs and construction) with those from the independent pair of components (die designs and end part machining). Supporting hypothesis 1, firms were more likely to concurrently source complementary components (25/110 cases = 23%) than independent components (16/110 = 15%), with moderate statistical significance (p=0.06).

For hypotheses 2 and 3, we created multinomial logit models for the pair of complementary components using the four categories. A multinomial logit model is appropriate because we have independent choice categories (Maddala, 1983). While the models provide six comparisons between the four modes, we focus on the comparison between concurrently sourcing both components versus making both components. Our model fit the data quite well, with a pseudo R-squared value of 0.47. Consistent with hypothesis 2, greater combined interfirm expertise contributes to concurrent sourcing, at moderately significant level (p < 0.10). Our results strongly support Hypothesis 3, as greater intrafirm expertise leads to more use of concurrent sourcing of the pair of complementary components rather than producing the components internally (p<0.05). We also ran the model using the sourcing choices of independent components as the dependent variable, finding that neither combined interfirm expertise nor intrafirm expertise had a significant effect.

**DISCUSSION**

This paper is among the first to investigate how firms source complementary components, adding to economic and capability-based theories of the firm that typically only consider sourcing decisions of individual items. In particular, our finding that firms concurrently source these sets of components resolves the tension between the traditional view that firms will vertically integrate to coordinate technical interfaces and gain scope economies (Arrow, 1975; Panzar & Willig, 1981) with the emerging view that firms will outsource these components to obtain flexibility (Brusoni, et al., 2001; Sanchez & Mahoney, 1996). Concurrent sourcing provides a unique solution to the coordination versus flexibility dilemma as it allows for both activities, but also requires both knowledgeable suppliers and a substantial degree of expertise about the components. This finding provides insight to the distinction between a firm’s production and knowledge boundaries, and the need for overlap between these boundaries.
Knowledge appears to be the key driver toward concurrent sourcing of complementary components. In particular, combined interfirm expertise leads firms toward this sourcing mode because they can benefit from their suppliers’ understanding of the components. Whether suppliers have highly specialized or somewhat redundant skills, firms benefit from the broad and diverse knowledge acquired through supply relationships, because this augments knowledge that the firm obtains through internal production and provides the firm with a greater degree of absorptive capacity. Thus, firms that enjoy a high degree of combined interfirm expertise related to a set of complementary components benefit from concurrently sourcing rather than producing these goods entirely internally.

Perhaps our most intriguing finding is that firms with a considerable degree of expertise that spans the complementary components will tend to concurrently source rather than vertically integrate. This is in contrast with traditional economic and capability perspectives, which argue that skilled firms should internalize production of related components to gain scope economies and better coordinate technical change. Instead, our results are more aligned with the modularity and systems integration literatures, which posit that firms can outsource if they retain sufficient understanding of the technology to do so effectively. Brusoni, et al. (2001: 597), for instance, note that a firm’s knowledge and production boundaries are not equivalent – that firms “know more than they make”. In parallel, we suggest that firms often need to make in order to know, but can outsource some of their requirements if they have an underlying expertise in the base technology. Thus, there may be a virtuous cycle between producing to increase the understanding of the components which enables the firm to partially outsource, thereby learning more from their suppliers, further augmenting their knowledge base enabling them to produce more effectively. In this way, concurrent sourcing of complementary components can be a stable, on-going sourcing strategy. Thus, we bridge the gap between the traditional and modularity arguments by suggesting that firms often do not need to unilaterally make or buy a set of components, but instead can do both.

This work suggests several further studies. We look forward to studies that explore how firms source the myriad of products they require, how firms manage these associated relationships, and how the knowledge and production boundaries of the firm evolve.

REFERENCES AVAILABLE FROM THE AUTHORS