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# Implications of uncertainty on firm outsourcing decisions

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**Abstract.** Outsourcing inherently considers what activity needs to reside within a given firm. The difficulty of exchanges between firms in the face of uncertainty affects where work on developing and producing new products is performed. Theory is developed and explored using a case study that explains firm sourcing decisions as a response to uncertainty within the context of industry structure and related transaction costs. Viewing outsourcing broadly results in a better delineation of outsourcing options. Implications for management research and practice are identified.

**Keywords:** Outsourcing, innovation, firm boundaries, uncertainty, transaction cost economics, industrial organization economics



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of any single firm to have all the resources needed to sustain competitive advantage [64], driving firms to adopt multiple organizational forms. Markets complement organizations, and outsourcing decisions shape firm boundaries. The goal of the present research is to identify and evaluate factors driving sourcing decisions for firms facing innovative pressures.

Research needs to examine the decisions behind organizing innovative activity [38,65], as extant research tends to focus primarily on hierarchy or market transactions [24], or a single “hybrid” classification [41,74]. Existing classifications typically do not fully capture or distinguish between the underlying variety of intermediate organizational forms that combine aspects of both hierarchies and markets – reality relies somewhere between these extremes. For example, firm sourcing decisions include mergers and acquisitions, joint ventures, preferred suppliers, and market competition [9,74]. Further, simultaneous pressures to innovate and reduce costs drive managers to continually adapt or adjust firm boundaries [28].

The premise of the current research is that uncertainty influences firm outsourcing, or decisions on where work is performed. Propositions are developed combining transaction cost economics [14,72] and industrial organization economics [55], as an initial point of departure. The linking of these different theories in the selection of firm boundaries both broadens and extends each theory and represents an important contribution. The propositions focus on firm behavior and performance beginning with alliances (Proposition 1),

## 1. Introduction

Managers cannot ignore outsourcing as they decide how and where work will be performed. A broad view of outsourcing, involving the integration of activity both internal and external to a firm into its overall operations, guides the current research. Selection of a firm’s boundaries represents a critical strategic decision [6]; this is particularly true for firms facing innovative demands that require allocating scarce resources between clear current needs and ambiguous future-oriented needs [32]. Rapid change limits the ability

\*The views expressed in this research are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

and then continuing with acquisition activity (Propositions 2a through 2c), contractual relationships (Propositions 3a and 3b), and market competition (Propositions 4a and 4b). The propositions are then explored using a case study before concluding with a discussion of implications for management research and practice.

## 2. Theoretical background

Theoretical perspectives from economics, strategy, and sociology outline different motivations for intermediate organizational forms. Research suggests that intermediate organizational forms have their own rationale, but a unifying purpose for their use remains to be identified [9]. A possible explanation for this is that the context of sourcing decisions is a critical variable [34] that may influence selection of organizational forms. For example, transaction cost economics has been criticized in situations where technology considerations predominate [22], and findings suggest that intermediate organizational forms, such as joint ventures, are more common in technology intensive industries [34].

Uncertainty may serve as a contextual factor that drives managers to select different organizational forms. In an environment with innovative pressures, managers may seek to both minimize costs (e.g., transaction cost economics, see Coase [14]; Williamson [72]) and maximize revenue (e.g., industrial organization, see Kogut [34]; Porter [55]). In other words, uncertainty will drive managers to satisfice by primarily focusing either on costs or revenue in an attempt to achieve higher financial performance.

### 2.1. Transaction costs

Transaction cost economics inherently addresses the comparison of feasible organizational forms [75], and holds that managers choose the least costly method of organizing [67]. Market exchange is generally considered more efficient than internalizing transactions, as it allows parties of a transaction to be competitively selected and drives the most efficient pricing for buyers and suppliers. However, Oliver Williamson [72] suggests that market failure precludes market exchange and drives internalization of exchanges within a firm. Williamson originally outlined five situations that involve market failure:

- *Bounded Rationality*, human beings tend to search for adequate and not optimum solutions,
- *Uncertainty/Complexity*, conditions without readily discernable patterns or manageable number of interactions that would facilitate decision making,
- *Information Impactedness*, information asymmetry involving situations where one party is better informed than the other making contractual arrangements difficult or expensive to verify,
- *Opportunism*, power imbalances that allow one party of a contractual relationship to pursue self-interests, and/or
- *Small Numbers*, reduction in business choices resulting from limited quantities of either buyers or suppliers [72, pp. 39–40].

Later, a sixth market failure involving *asset specificity*, or a condition created from recurring transactions that creates progressively stronger bilateral relationships, was identified [73].

As Coase [14] observed, it is unlikely that firms would exist without uncertainty and that, when price information is difficult to obtain, transactions internal to a firm will be cheaper than market transactions. Specifically, uncertainty escalates commitment costs for firms, contributing to intermediate organizational forms [23]. While not unique to innovative industries, bounded rationality is more likely to exist in innovative industries where uncertainty makes optimization difficult, if not impossible. For example, under conditions of frequent technology change early product designs may serve as market experiments [32].

Uncertainty also heightens information asymmetry as firms hold differentiated information, contributing to the difficulty of appraising and selling innovative resources [76]. Uncertainty can also lead to asset specificity as collaborating firms make specific resource investments that can compound information asymmetry. Further, the market for technology resources can also exhibit small numbers, as patents or other impediments limit alternatives for potential suppliers. Intermediate organizational forms incorporate safeguards against opportunism [23] that can minimize cost in the face of uncertainty.

### 2.2. Industrial organization

In regard to making an organizational sourcing decision, industrial organization economics research focuses on industry analysis and market positioning that balances speed and cost of entry into a market [65]. Industrial organization recognizes that no firm, or strategy, can remain static [30] and that changes in a firm's

external environment will necessitate changes in firm boundaries. Selection of a market position is a concern in innovative industries, as technology investments can act as an entry barrier, as firms achieve economies of scale and accumulate patents [63]. Additionally, intermediate organizational forms offer multiple competitive positioning advantages. For example, advantages of intermediate organizational forms include: accessing resources faster than internal development [35], offering a means of accessing complementary resources from other organizations [19], deterring or preempting rival firms [23,35], exposing a firm to new ideas, and learning about the level of technology held by competitors [42].

Under conditions of high uncertainty, early investments can be viewed as real options [65]. Applying real options logic or reasoning [45] to firm investment decisions helps explain why firms delay under conditions of uncertainty [48]. Real option reasoning allows firms to avoid locking in on uncertain technology by allocating resources among alternatives until one technology is clearly superior. Assuming an option to invest persists, it is rational for firms to wait until uncertainty is reduced [18] and the value of the underlying option is less ambiguous.

### 2.3. Summary

Uncertainty will influence management decisions on firm boundary selection due to difficulty in exchanging innovative resources [23]. From a transaction cost perspective, firms will expand until the cost of internal organization equals the cost of market exchange [67]. From a standpoint of industrial organization, extending a firm's boundaries to include market transactions enhances revenue by spreading risk [38], monitoring the technology of competitors [42], and co-opting potential competition [7]. Propositions relating to the impact of uncertainty on firm sourcing decisions are developed in the following section.

## 3. Technology change and organizing for innovation

The diffusion of innovations in social systems is well documented [44], but the organization of innovative activity is less well understood [24,38,65]. The current premise is that *uncertainty*, inversely proportional to the S-curve describing technology diffusion, drives firm sourcing decisions (see Fig. 1). Uncer-

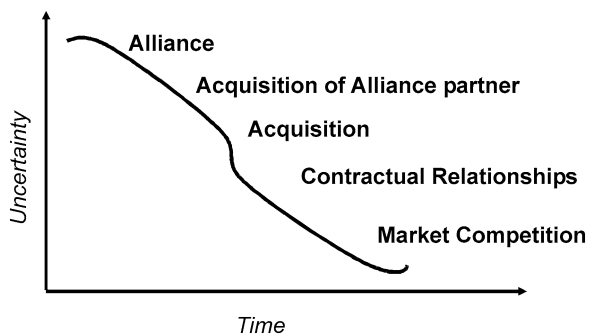


Fig. 1. Uncertainty and firm sourcing decisions.

tainty impacts investment decisions [50] and technology change creates uncertainty by impacting the competitive dynamics for firms [4]. Anderson and Tushman [4] outline a three-stage model of industry-level technological change that relates to different levels of uncertainty:

- (1) High uncertainty when a discontinuity alters how market needs are met,
- (2) Moderate uncertainty surrounding the inflection point or emergence of a dominant design that establishes core product features, and
- (3) Low uncertainty when the focus shifts to incremental improvements of a product technology's efficiency or performance.

Propositions for firm sourcing decisions related to Fig. 1 are developed in the following subsections.

### 3.1. Alliance

Alliances under high uncertainty involve collaboration between firms that can take multiple forms and serve multiple purposes. Collaboration between firms is more likely in changing environments [37], as a means of managing risk [23] and mitigating vulnerable strategic positions [21]. Collaboration offers firms the benefit of timely entry, as the persistence of options is uncertain [1]. The value associated with executing an option or making a larger investment will increase once uncertainty is resolved [50], if the option to invest persists [18] and represents a desired outcome. Firms that fail to take advantage of investment opportunities risk being locked out [27] suggesting that firms, when faced with uncertainty, often make a portfolio of investments to maintain options. Still, the benefits of maintaining long-term relationships may exhibit diminishing returns, so organizations tend to have no more partners than necessary [17].

In an environment of high uncertainty, alliances may be preferred to acquiring external resources [6] and can represent the initiation of an option when investments exhibit path dependence [36]. Intermediate organizational forms, such as joint ventures and alliances, under conditions of high uncertainty are better suited for dealing with asymmetric information and difficulty in valuing complementary resources than acquisitions [5]. For example, information asymmetry problems that make investing in another firm difficult are mitigated in joint ventures that align agency interests and reduce information asymmetry [38]. Additionally, intermediate organizational forms, such as joint ventures that combine diverse firm resources [41], contribute to learning [5] that can reduce uncertainty. Further, alliances typically involve less strategic and financial commitment, and will be viewed as less risky than other options, when uncertainty is high. Therefore, the following relationship is proposed:

**Proposition 1.** *Under conditions of high uncertainty, firms will enter into alliances to lower individual firm risk in accessing needed resources.*

### 3.2. Acquisition activity

Alliances may also contribute to acquisition activity between collaborating firms, and provide partner firms an advantage relative to outside buyers. Alliances and joint ventures allow firms to learn more about their partners and underlying resources, which contributes to reduced information asymmetry surrounding the value of resources in both firms. Over time, recurring transactions can also contribute to situations where one firm becomes dependent on a partner in a joint venture or alliance [39].

Firm investments can lead to asset specificity between alliance partners and create friction [56], if uncertainty that contributed to the selection of an intermediate organizational form is also reduced or initial contractual arrangements are later deemed unfair. For example, the emergence of a technology standard, or dominant design [4], reduces uncertainty and can act to clarify relative partner firm strengths and weaknesses [32], and can expose contractual relationships to breakdowns [55].

Alliances may serve as a precursor to an acquisition as information shared between firms reduces uncertainty [23] that contributes to better valuation of resources [35]. Reduced uncertainty that leads to breakdowns can help explain alliance instability [36], and

observations that half of all alliances fail [19]. While internalization of resources within a single firm between alliance partners is not inevitable, information shared as part of an alliance can contribute to internalizing problematic transactions through an acquisition. Therefore, the following relationship is proposed:

**Proposition 2a.** *Learning as a result of alliances reduces uncertainty and contributes to firms acquiring partner firms or joint ventures.*

If moderate levels of uncertainty allow satisfactory valuation of resources, firms may employ acquisitions to bring resources under a hierarchy to further reduce uncertainty [29]. In innovative industries where response times are important, acquisitions of required resources will more likely occur, once a resource need is apparent [12]. Acquisitions typically offer lower cost of entry and exposure to superior resources [10]. Additionally, acquisitions represent a method for sustaining or increasing innovative output [2]. Further, other alternatives may be precluded due to market breakdowns, such as patent protection [55] or opportunistic partners [23]. Still, internalization of transactions into a single firm will not ordinarily occur unless it results in lower transaction costs [38].

Lower transaction costs from internalization are more likely when exchanges involve uneven bargaining positions [26]. Uneven bargaining positions can exist in innovative industries, if a small number of firms own a given technology or a firm's patent protects critical technology. As the value of needed resources becomes clear and external resource dependence exists, critical or problematic exchanges will often be internalized within a firm through an acquisition [54]. This result comes from acquisitions offering greater control over and faster access to resources [32]. Therefore, the following relationship is proposed:

**Proposition 2b.** *Under moderate uncertainty and few sources of supply, firms will complete acquisitions to lower costs.*

### 3.3. Contractual relationships

Contractual relationships (i.e., licensing, supplier agreements, and so on) represent distinct outsourcing options. For example, licensing is different from joint ventures as licenses typically simply transfer patent rights, while joint ventures transfer both patent rights and tacit knowledge [26]. Contractual relationships in-

volve transactions designed to gain access to resources external to a firm, and their appeal rests on the recognition that a single firm cannot innovate as well as a combination of firms [42]. Contractual relationships drive participating firms to make relationship-specific resource investments that may contribute to increased opportunism [6]. However, the threat of market competition can reduce transaction costs in the presence of specific assets [7].

Firms may seek preferred suppliers for critical parts in conditions where some uncertainty remains and multiple suppliers exist to maintain the threat of competition. If a single supplier is used, the threat of competition can help limit the market power of a sole source to help keep costs competitive [15]. Identifying preferred suppliers can offer the benefits of increased quality and reduced risk in integrating subsystems—conditions that further reduce uncertainty. Additional circumstances may contribute to the use of contractual relationships.

Market structure may encourage the use of contractual relationships. For example, antitrust concerns surrounding levels of competition can lead to legal agreements that require firms to license critical technology [55]. This has the effect of lowering the costs associated with technology transfer by setting more favorable terms than may result from a court settlement or decision [31]. Further, contractual relationships may simply be needed to allow independent joint ventures to share technology with participating firms. For example, a joint venture with complementary patents needed for a product may have to pool them into a license to its parent firms [61]. These situations are referred to as cross-licensing or sharing licenses between participating firms, and it can provide participating firms efficient access to needed technology without incurring reverse engineering costs [3].

Firms may also pursue contractual relationships for strategic purposes, such as faster response times [16], or avoiding expenses required to successfully market a product [32]. For example, managers may choose to have independent components manufactured by reliable suppliers when they are focused on developing other resources [11]. Even if a single supplier is used, the threat of competition can help limit the market power of a sole source to help keep resource costs competitive [15]. Additionally, the use of contractual relationships may facilitate the continued development of a firm's resource base by exposing a firm to superior information [56]. Therefore, the following is proposed:

**Proposition 3a.** *Under conditions of low to moderate uncertainty, firms use contractual relationships to lower the cost of accessing resources.*

Contractual relationships exhibit potential hazards. If not managed properly, contractual relationships have recognized disadvantages. For example, a disadvantage of licensing relates to developing competitors, when managers improperly identify potential competitors [55]. Sharing information with competitors may be unavoidable. For example, antitrust concerns may lead firms to license core knowledge or be required for a joint venture to share technology with participating firms [31]. Increased competition from licensing can stimulate innovation and expand markets [32], and may place further innovative pressure on firms to use contractual relationships for accessing external knowledge. However, managed effectively the benefits of contractual relationships outweigh potential risks.

Contractual relationships represent a strategy managers can use to increase the profits of their firms. While providing other firms access to knowledge, contractual relationships can provide a technology leader additional profit from their stock of knowledge [55]. For example, IBM during 2000 received \$1.7B in revenues from licensing that enjoyed a 98 percent profit margin [32]. Licensing also represents a strategy to help establish a technology standard [55,64], or method of avoiding expenses required to successfully market a product on their own [32], such as the cost of establishing a brand. Therefore, the following relationship is proposed:

**Proposition 3b.** *Though sharing core knowledge involves risks, firms use contractual relationships to supply knowledge resources as a means of increasing revenue.*

### 3.4. Market competition

Competition drives firms to choose efficient sourcing options, and, in conditions with low uncertainty and multiple suppliers, market competition is likely to offer the lowest transaction costs. The trend of shifting work that used to be performed internally to external suppliers is facilitated by improved cost allocation and measurement [77]. Firms, where possible, can minimize costs by taking advantage of competitive markets at different points in their value chain through outsourcing. Simply establishing a reputation of switching

Table 1  
Budget driven changes in F/A-22 procurement quantities [46]

Year	Quantity	Related event
1986	750	Initial Air Force requirement to replace F-15 aircraft
1993	442	Congressional budget cuts delay F/A-22 development and anticipated production quantities
1997	339	Congress caps F/A-22 production budget

between suppliers may contribute to a firm obtaining lower price offers.

Under conditions of low uncertainty, using suppliers as part of a firm's pursuit of innovation can also contribute to innovation success [49]. This comes from outsourcing allowing each firm to focus on what they do best. Even if contractual relationships involve higher transaction costs, it may be effectively pursued for strategic purposes. Finally, research recognizes that integration of resources, even from market exchanges, can result in competitive advantage [42]. Therefore, the following relationship is proposed:

**Proposition 4a.** *Under conditions of low uncertainty, established firms will use competitive sourcing to lower costs.*

Outsourcing depends on the distribution of relevant capabilities in an industry [40]. The process of shifting work from large, established firms with large overhead costs to a network of generally smaller suppliers helps to build a supporting infrastructure. A supporting infrastructure is also required for developing new technology that is critical to economic development and competitive advantage [70]. Small firms serving as suppliers tend to spot emerging technologies faster and are less likely to be deterred by the uncertain growth prospects than the established firms they support [32]. The development of an industry infrastructure may be conducive to the development of alternate technologies that can either complement existing technology or result in the next discontinuity that may substitute for existing product technology.

While established firms have incentives to develop complementary technology to a given technology, their suppliers have the additional incentive to develop potential technology substitutes. For example, once uncertainty is reduced and competition increasingly focuses on price, the primary source of profit will shift to other parts of the value chain [13]. Therefore, firms acting as suppliers have competitive motives to both develop new technology to gain competitive advantage by moving into other parts of the value chain. Therefore, the following relationship is proposed:

**Proposition 4b.** *The suppliers to established firms are more likely to develop alternate technologies that result in a technological discontinuity.*

#### 4. Case study

A case study following Eisenhardt's [20] methodology allowed outlining instances of where a firm's organizational form changed over time. This facilitated an examination of whether uncertainty helps explain the selection of different firm boundaries. Specifically, changes to Lockheed Martin's involvement with other firms during development and production of F/A-22 aircraft are examined. Information on Lockheed Martin organizational forms for F/A-22 aircraft development and production was gathered from interviews with Lockheed Martin executives and public sources.<sup>1</sup> Although the military aircraft industry is used to outline the impact of uncertainty, summarized relationships should persist across firms in industries where innovation is product oriented [55].

As the F/A-22 program has progressed, Lockheed Martin has experienced continued pressure to lower costs that have contributed to an increase in outsourcing that is consistent with the US economy as a whole. For example, during the 1960s aircraft firms performed approximately 45 percent of work in house [25] compared to Lockheed Martin performing 25 percent of the work internally on the F/A-22. Pressure to lower costs is further driven by budget constraints that limit the number of aircraft that can be procured. Table 1 shows how budget decisions have impacted F/A-22 procurement quantities. Additionally, in 1999, a House of Representatives vote to eliminate funding for the F/A-22 program due to rising program costs would have effectively cancelled the program had it passed [51]. The result of these actions has been continued pressure to lower costs that placed a growing emphasis on outsourcing.

<sup>1</sup>The author was allowed access to Lockheed Martin executives and subcontract management practices.

#### 4.1. Background

Lockheed Martin was a niche firm in the 1970s that appeared to have lost its ability to develop fighter aircraft with its last successful design, the F-104, dating to the early 1950s [43]. To regain competitiveness, Lockheed Martin developed stealth technology using corporate funds from principles published by a Soviet radar expert with the HAVE BLUE prototype, in 1976 [43]. The successful prototype resulted in a 1978 production decision that resulted in the US Air Force buying 59 Lockheed Martin F-117A stealth fighters [52]. The development and production of stealth aircraft positioned the firm for the next fighter competition. Lockheed Martin joined the competition to develop the next generation stealth aircraft, in 1985, after the Air Force awarded seven firms initial concept definition contracts to replace the F-15 Eagle [68].

The Air Force invited two contractor teams, in 1987, to build prototype aircraft as part of a competitive fly-off. A partnership of Lockheed Martin, General Dynamics and Boeing represented one team, and Northrop and McDonnell Douglas represented the other team [71]. In 1991, the Lockheed Martin led team won the competitive fly-off with their YF-22 design emphasizing stealth and speed [59]. The aircraft was subsequently renamed the F/A-22 Raptor, and the following subsections describe the changing organizational forms Lockheed Martin used in managing the Raptor's development and production.

#### 4.2. Alliance

Lockheed Martin leveraged its stealth technology to access additional resources from partner firms Boeing and General Dynamics to ensure its F/A-22 design was the most competitive. Designing and producing fighter aircraft requires capabilities above general aerospace manufacturing with increased technological demands for materials, avionics, engines, and systems integration that push the limits of design and engineering knowledge. Boeing offered considerable experience with integrating avionics systems and composite materials [43], and General Dynamics provided crucial fly-by-wire technology, plus fighter aircraft production experience with literally thousands of the F-16 aircraft produced.

The alliance of Lockheed Martin with Boeing and General Dynamics occurred before the competitive fly-off, and allowed each firm to share the risk of design-

ing and producing a prototype.<sup>2</sup> Delivering YF-22 prototypes for the competitive fly-off involved significant uncertainty, and each firm brought specific expertise that resulted in improved chances of success than each firm would have enjoyed competing separately. Sharing the level of commitment needed to deliver a prototype lowered the overall level of uncertainty each participating firm faced, and drew upon individual firm strengths. Lockheed Martin's choice of an alliance at the beginning of F/A-22 development, when uncertainty and risk was high, is consistent with Proposition 1.

#### 4.3. Acquisition

After winning the design competition, in 1991, the F/A-22 program began development with a focus on testing to establish a stable, cost effective design. Winning the competitive fly-off and the process of building YF-22 prototypes required learning about integrating complementary technologies, such as composites, radar-absorbing materials and fly-by-wire flight control systems. An outcome of this learning was reduced uncertainty that contributed to a change in the original partnering relationship.

Lockheed Martin acquired General Dynamics' aircraft division for \$1.52 billion, in 1993 [69]. The transaction internalized General Dynamics' F-16 aircraft production and its 32.5 percent share of the F/A-22 contract. The acquisition of General Dynamics internalized F/A-22 aircraft mid-fuselage assembly and fly-by-wire technology. The acquisition of an alliance partner, after experience contributed to reduced uncertainty, to internalize scarce resources is consistent with Propositions 2a and 2b.

#### 4.4. Contractual relationships

Lockheed Martin performs competitive analysis to identify key suppliers for F/A-22 subsystems that receive long-term contracts. The analysis considers the cost and complexity of competition, and key subsystems are subcontracted on a "sole source" basis. An implication of Lockheed Martin selecting the most competitive suppliers on major subsystems is that it develops an infrastructure of supporting firms that provide capabilities that complement F/A-22 aircraft per-

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<sup>2</sup>The terms of the alliance split the profits from collaboration with Lockheed Martin receiving 35 percent of the profits, and Boeing and General Dynamics each receiving 32.5 percent of the profits.



formance. Lockheed Martin then integrates internally and externally produced hardware and software into fully assembled F/A-22 aircraft.

By selecting the most competitive suppliers on major subsystems for F/A-22 aircraft development and production, Lockheed Martin maintains a market for technology. For example, Northrop Grumman completes roughly ten percent of F/A-22 aircraft billable materials under subcontracts to both Lockheed Martin and Boeing. This is true even though Northrop Grumman lost the original competition to the F/A-22 aircraft design and the company continues to compete with both Lockheed Martin and Boeing for defense contracts. An explanation for this behavior comes from von Hippel [66] in that knowledge sharing is common in the aerospace industry with the exception of when government contracts are being awarded. These practices are consistent with Proposition 3a and 3b that firms share and access knowledge resources to lower cost and increase revenue respectively.

#### 4.5. *Market competition*

Lockheed Martin's corporate policy on "make or buy" decisions involves the application of competitive principles in order to make "best value" decisions for customers, and does not provide preferential treatment to Lockheed Martin business units. As a result, Lockheed Martin performs less work internally on the F/A-22 program than is generally assumed. For example, based on billable material, Lockheed Martin only performs about 25 percent of the work on F/A-22 aircraft. Consistent with transaction cost theory, Lockheed Martin uses competition for general material (e.g., sheet metal, machined parts, and electro-mechanical hardware) that involve less uncertainty/complexity and where multiple suppliers exist. More than 17 percent of billable materials for F/A-22 production are competed on an on-going basis.

Lockheed Martin also takes innovative approaches to ensuring competition, where appropriate. For example, Lockheed Martin has embraced electronic commerce to ensure competed work is awarded at the lowest possible cost through improved information flow. Although skepticism about applying electronic commerce to the aerospace industry have been voiced [46], Lockheed Martin, in a single transaction involving an online reverse auction, saved over \$2.2 million in material costs. Using an electronic marketplace contributes to reduced prices through competitive forces and is consistent with Propositions 4a.

#### 4.6. *Summary*

Changing levels of uncertainty impact how firms are organized. The experience of Lockheed Martin with F/A-22 aircraft development and production demonstrates that under high uncertainty firms are likely to collaborate to lower risk. However, decreased uncertainty and maturing technology build pressures for firms to consolidate [32]. An added pressure that potentially contributes to observed acquisition activity involves learning and the need to internalize key resources within a single firm. As uncertainty continues to decline and more work is outsourced, a supporting infrastructure for an industry develops. For example, over 1000 suppliers in 40+ states contribute to the F/A-22 aircraft program suppliers making with significant contributions to F/A-22 development and production at lower costs.

Firms acting as suppliers to industry incumbents may be more likely to develop alternate technology that challenges established products and firms, as a means of appropriating an increased share of revenues. The emergence of unmanned aircraft may represent a potential technological discontinuity and substitute for manned aircraft. Vigorous competition from unmanned aircraft is expected to transform the leadership of the aircraft industry with new entrants competing for future unmanned aircraft development projects [8] and, if it comes to pass, will represent an outcome consistent with Proposition 4b.

### 5. **Discussion**

Integrating transaction cost economics with industrial organization economics offers insight into firm outsourcing decisions by demonstrating that firm boundaries evolve as uncertainty fluctuates. The combined competitive pressures of lowering costs and maximizing revenues have contributed to firms managing uncertainty and sharing risk by performing less work internally, resulting in lower organization costs. The primary contribution of the current research is recognizing that outsourcing involves multiple options that inherently consider what activities need to reside within a firm.

Firm sourcing decisions are depicted as being driven by varying levels of uncertainty. In industries facing innovative pressures, intermediate organizational forms allow managers to select firm boundaries that balance the risk of selecting a losing design against the risks

of obsolescence and opportunism. Significantly, research suggests that deviating from optimal organizational forms can impact a firm's technological performance [40]. The developed propositions are supported in an exploratory case study, and they have implications for management research and practice.

### 5.1. *Research implications*

Management research needs to recognize that traditional firm boundaries continue to blur as firms perform less work internally. Although progress has been made Lei and Hitt's [39] observation that outsourcing deserves increased scrutiny remains valid. The propositions developed and explored here represent an obvious starting point for continued research on firm boundaries. Viewing the current propositions as a whole shows that firm sourcing decisions change as technology and industry conditions co-evolve, helping to explain potentially contradictory observations in existing research. An implication is that there is a need for longitudinal research to help account for changes in firm sourcing decisions. By relating firm sourcing decisions to a response to changing uncertainty, the current paper may also inform management research examining management behavior and firm evolution.

Finally, the creation of a supporting infrastructure through outsourcing may begin to explain the source of technology discontinuities. Existing research has primarily examined the diffusion of technology and its impacts, while forces that explain the origins of innovations remain largely unexamined. There is a clear need to better understand the source of innovations, if only because of the sweeping changes that follow in their wake. The current research suggests that the firms and the industries they operate in that are most effected by technology innovations may ultimately contribute to what Schumpeter [60] called creative destruction.

### 5.2. *Implications for practice*

The preceding observations also suggest implications for managers. The need to adapt innovation mode selection requires that a firm's managers recognize that there are several viable methods for dealing with uncertainty and that they should avoid specializing only in alliances, acquisitions or market transactions. To remain competitive, a firm will need to be proficient in multiple sourcing methods to adapt as an industry's technology changes and matures. Used effectively, outsourcing can facilitate manager efforts to fo-

cus a firm on developing and maintaining competitive core competencies. For example, there is the potential to leverage and potentially learn from external relationships created by extending firm boundaries. Further, managers may consider entering multiple relationships with external partners as a means to decrease opportunism – firms are less likely to renege when the possibility of sanctions on another relationship exists [3]. Managers may also need to demonstrate a willingness to switch suppliers as a method of signaling to external partners that they need to offer competitive pricing. Finally, the current treatment of innovation suggests that it is less random than is generally assumed and provides managers actionable knowledge.

### 5.3. *Limitations*

The application of the current propositions in future research will need to consider at least two qualifications. First, as indicated prior to Proposition 2a, the relationships described are not inevitable. The range of sourcing options is limited only by the imagination of the managers. A contribution of the current paper is not simply treating outsourcing as a homogeneous practice. Second, the arguments rely on the assumptions that firms face uncertainty along with cost pressures to lower costs and increase revenues that force managers to continually adapt or adjust firm boundaries. The degree that this assumption holds across different industries will limit the application of the current propositions; however, it is likely that the industries where this assumption holds will drive economic growth [58].

### 5.4. *Conclusion*

Even with recognized limitations, the present research offers clear contributions to current knowledge. Managers consider uncertainty in adapting firm boundaries to keep their firm competitive. Developed propositions integrate different theoretical perspectives to provide a more complete view of firm sourcing decisions. Specifically, the delineation of the impact of uncertainty on firm outsourcing decisions represents a potentially important contribution to the continued development of both management research and practice. In closing, the relationships developed and explored here with a case study represent promising areas for additional research.

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