

# Organizational Constraints to Adaptation: Intrafirm Asymmetry in the Locus of Coordination

Vikas A. Aggarwal

INSEAD, 77305 Fontainebleau, France, vikas.aggarwal@insead.edu

Brian Wu

Ross School of Business, University of Michigan, Ann Arbor, Michigan 48109, wux@umich.edu

We assemble a panel data set of firms in the U.S. defense industry between 1996 and 2006 to examine the drivers of heterogeneous incumbent firm adaptation following the industry-wide demand shock of September 11, 2001. This shock entailed not only an increase in aggregate demand but, more importantly, a shift in the relative attractiveness of individual product areas, resulting in the need for firms to reshuffle their product portfolios in response to changing demand conditions. The exogenous nature of the shock allows us to empirically identify the effect of preshock interdependence structures on postshock adaptation outcomes. We find that the locus of coordination inside a firm can explain differential postshock adaptation performance: because interdependencies spanning organizational boundaries are more difficult to manage than those contained within such boundaries, coordination across product areas creates greater adaptation challenges compared with coordination within product areas. We further investigate the moderating effects of product complementarity and organizational grouping, finding results consistent with our hypothesized mechanisms. As one of the first studies to empirically link a firm’s locus of coordination with its adaptation performance, this study contributes to our understanding of the role of interdependence and organization design in dynamic environments.

*Keywords:* demand shock; coordination; adaptation; organization design; interdependence; dynamic environments; defense industry

*History:* Published online in *Articles in Advance* October 28, 2014.

## Introduction

A prominent conversation in the organizations literature involves the issue of firm adaptation to environmental change. Change can stem from factors such as the development and evolution of new technologies, legislative decisions, and social trends (e.g., Christensen 1997, Adner and Levinthal 2001, McGahan 2004, Madsen and Walker 2007), and it can often have significant organizational implications. As the large body of prior literature on this topic suggests, competitive advantage can be created and destroyed as a consequence of a firm’s fitness with respect to its external environment (e.g., Tushman and Anderson 1986, Benner 2007, Sosa 2011), with entry, maturity, and displacement playing out in a pattern common to many industry settings (Schumpeter 1934).

In the face of external change, why do some incumbents thrive where others falter? To answer this question, it may be helpful to start by understanding the nature of the change itself. Although we know quite a bit about the implications of technology-driven change, with a large body of prior work examining such “supply-side” technology shifts (Tushman and Anderson 1986, Henderson and Clark 1990), the role of the “demand side” has only relatively recently begun to be addressed (Adner and Levinthal 2001, Chatterji and Fabrizio 2012, Ye et al. 2012). Recognizing that demand-side change can be a

frequent and common source of environmental turbulence, Tripas (2008) introduces the idea of “customer preference discontinuities,” which represent rapid and significant change in the attributes over which customers make purchase decisions. Although such discontinuities can necessitate broadscale corporate transformation (Agarwal and Helfat 2009), there has been little work to date explaining differential firm success in adapting to such change. We aim to fill this gap by examining the sources of heterogeneous firm-level adaptation performance in response to such a demand shock.

We anchor our discussion of differential adaptation performance in the context of a firm’s preshock organization design, building on prior literature (e.g., Lawrence and Lorsch 1967) that suggests that the design and configuration of a firm’s activities can help explain how the firm can meet the needs of a changing environment. Structures for processing information and for coordinating activities developed prior to the shock would need to be adapted after the shock, with these structures becoming impediments in the new environment (e.g., Leonard-Barton 1992, Argyres 1995, Rajagopalan and Spreitzer 1997, Nickerson and Silverman 2003, Birkinshaw and Lingblad 2005, Lenox et al. 2006). We build on the idea that an organization’s structure mirrors (or maps to) its tasks (technology), with the two being aligned in equilibrium

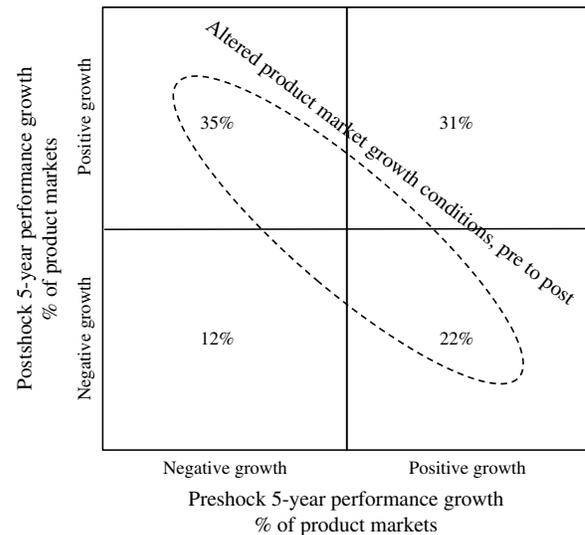
prior to the shock (e.g., Sanchez and Mahoney 1996, Sosa et al. 2004, Colfer and Baldwin 2010).<sup>1</sup> This follows from Henderson and Clark’s (1990) notion that architectural knowledge is embedded in the “channels, filters and strategies” of the firm. As Baldwin and Clark (2000, p. 56) note, “There is a close and powerful connection between the task structure and the internal organization of an enterprise”; the mapping (between tasks and people and work processes), “once established, may be both deep and irreversible, because it is often both tacit and complex.”

We hypothesize that the nature of an organization’s interdependence structures and its associated coordination needs can explain differences in its postshock adaptation performance.<sup>2</sup> Because we focus on activities within the boundaries of the firm, we are naturally concerned with coordination needs stemming from the firm’s production-related activities. We conceptualize two different patterns of coordination to this end: *interproduct coordination*, which stems from the need to bundle together multiple products to serve a common customer and hence entails interdependencies *across* different modules of product-related activities; and *intraproduct coordination*, which stems from the need to customize products for the needs of multiple customers and hence entails interdependencies *within* different modules of product-related activities. This distinction between bundling and customization is what we refer to as the *locus of coordination* within the firm. In the context of a demand-side shock, where the firm must reshuffle its portfolio of products in response to changing relative demand conditions (Helfat and Eisenhardt 2004, Levinthal and Wu 2010), these two forms of coordination can have differing effects, with interactions crossing the boundaries of changing modules being more difficult to manage than interactions contained within such modules, in line with Simon’s (1969) notion of decomposability.<sup>3</sup>

We test our theory using the U.S. defense industry in the years 1996–2006 as our empirical context. The terrorist attacks of September 11, 2001 represented a significant industry-wide shock, shifting the industry’s focus away from the Cold War mind-set of the prior decades to a new security and counterterrorism orientation. Total demand increased significantly after 2001; the relative attractiveness of different product markets also shifted suddenly and significantly. Figure 1 illustrates the *reshuffling of product areas* that is an important characteristic of the shock: 57% of product areas in the defense industry experienced a major change in the level of demand, defined as a switch from positive to negative five-year growth rates before versus after the shock, or vice versa.

Because of the sudden nature of this shock, there was no underlying scientific or technological change that occurred as a direct result. Thus, the production processes for any given product did not fundamentally change as an immediate consequence of the shock, a feature that has

**Figure 1 Nature of the Shock: Product Area Growth Rates, Before and After 2001**



implications for our theory development.<sup>4</sup> In addition, the unexpected nature of the shock allows us to empirically isolate the effect of preshock organizational structure on postshock adaptation outcomes without the confounding effects that would occur if managers could operate with foreknowledge of the new demand environment.

We thus use this industry, which experienced a demand-side shock at the midpoint of our sample time period, to understand heterogeneity in firms’ adaptation performance. We observe the full universe of defense contracts from 1996 through 2006, assembling a panel data set of more than 20,000 firms. These firms share the common feature of contracting with the U.S. defense department while at the same time operating in a diverse set of product areas. We develop and test hypotheses that relate a firm’s preshock patterns of interdependence to postshock outcomes, finding empirical support for our theoretical arguments. Although higher levels of preshock interproduct coordination lead to lower postshock adaptation performance, we do not find any such results when a firm’s preshock organization design includes higher levels of intraproduct coordination. We further examine our results in light of two key moderators meant to test the boundary conditions of our theorized mechanisms: product complementarity and organizational grouping. Our results show that the negative effects of interproduct coordination are enhanced when the firm’s products have a greater number of underlying interactions (i.e., higher product complementarity) and are mitigated when interdependencies are grouped by organizational unit. Together, our findings point to the importance of understanding a firm’s locus of coordination in explaining differential adaptation to industry change.

As one of the first large-sample empirical studies to examine firm adaptation in the face of demand-driven

environmental change, our study complements prior work that focuses more specifically on technology-driven change. By recognizing the heterogeneity and dynamics of demand patterns, often masked by the increase in postshock aggregate demand, we are able to identify the origins of adaptation challenges for firms in such settings. We also contribute to work on organization design by introducing the link to external environmental change. Our findings point to a “survivor’s paradox,” in which the tight fit among activities necessary for firms to survive an industry downturn (in our case, the post-Cold War environment) made it difficult for firms to adapt when the industry turned around (post-2001). The concept of a firm’s locus of coordination is important in that it points to the need to move beyond a focus on the aggregate level of within-firm interdependence. Only by identifying where inside the firm the shock hits can we understand the impact of the shock on the firm’s adaptation performance. Our empirical setting supports our theory development by offering a natural experiment that allows us to separate organizational structure from performance, a task that would be difficult to accomplish if managers were able to choose their preshock structure in anticipation of the state of the postshock environment.

### The Locus of Coordination

Following an unexpected industry shock, firms face the challenge of adapting to a new set of external conditions. Their differential adaptation performance, we argue, is a function of the postshock coordination challenges they face, which arise from differing patterns of within-firm interdependence. To motivate this idea, first consider Figure 2: here, we illustrate the point that two firms, equivalent with respect to the set of products they produce and the customers they sell to, can be very different in their interdependencies. In the left panel, for example, each product is sold to a distinct customer; an alternative approach (the right panel) is to sell each product to each of the firm’s customers, increasing the aggregate level of within-firm interdependence.

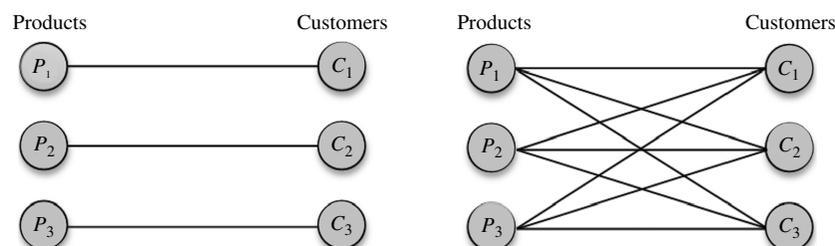
In this paper we seek to expand our understanding of within-firm interdependence by decomposing the *loci* where the associated coordination challenges occur. We illustrate this idea in Figure 3, where we depict two

different patterns: interproduct coordination, a situation of product bundling in which interdependencies occur *across* different product modules; and intraproduct coordination, a situation of product customization in which interdependencies occur *within* different product modules. We focus on these two (polar opposite) patterns because together they can be used to represent any arbitrary pattern of organization of a firm’s production links with its customers.

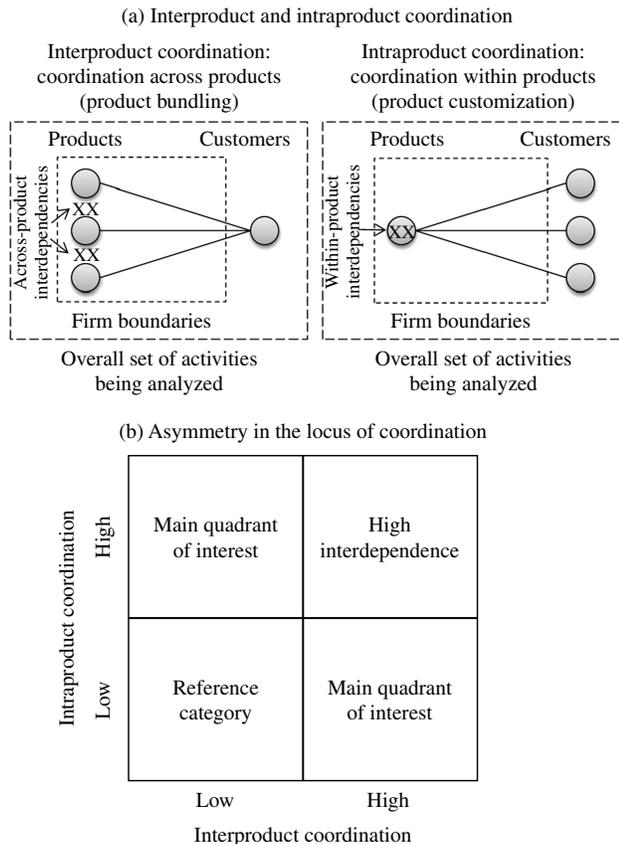
We recognize that product-oriented activities are at the core of what the firm does, and we thus take a product-oriented approach in analyzing the firm’s interdependencies. At the most basic level, a firm’s core activities involve making products, with customers carrying out the activity of using these products. We recognize though that there are customer-facing activities that can exist inside firm boundaries; indeed, the distinction between upstream (product) and downstream (commercialization) activities is one with deep roots in prior literature (Abernathy and Clark 1985, Teece 1986, Mitchell 1989, Tripsas 1997), with recent studies examining issues such as customer coupling, invention versus commercialization activities, and technology- versus application-specific capabilities (Danneels 2003, Lee 2009, Sosa 2009). We can think about customer-focused activities such as sales and marketing as *complementary* to a firm’s core activities of production (e.g., Teece 1986). This does not downplay their importance; rather, it highlights the idea that their main purpose is to support the commercialization of a firm’s products by serving as a conduit for information between a firm’s product activity modules (those activities that produce the goods demanded by customers) and the customers themselves. The results of a series of qualitative interviews we conducted with managers in defense-related firms confirm our view that customer-facing within-firm activities primarily serve as the interface between products and customers and are typically managed by standardized systems and processes.<sup>5</sup> Understanding the role of such activities allows us to appropriately characterize the nature of the coordination challenges associated with the two interdependence patterns we study, an issue we turn to next.

Figure 3 further illustrates the sources of interdependence associated with the two patterns we study. We can think of the production modules in this figure as a set

Figure 2 Product–Customer Linkages



**Figure 3** Alternate Patterns of Within-Firm Interdependence: Interproduct and Intraproduct Coordination



of modular and self-contained activities specific to a particular product (Baldwin and Clark 2000, Schilling and Steensma 2001, Ethiraj 2007), with interdependencies occurring both within and across different such modules. The notion of interdependence is rooted in classic studies of organizations (e.g., Simon 1962, Thompson 1967, Galbraith 1977), with the idea being that “the value generated from performing each [task] is different when the other task is performed versus when it is not” (Puranam et al. 2012, p. 421). Such interdependence leads to the need for coordination and for structures to facilitate that coordination (e.g., Tushman and Nadler 1978, Sosa et al. 2004). We are concerned specifically with interdependencies *across* or *within* different product modules, and we term the associated coordination challenges “interproduct coordination” and “intraproduct coordination”; the distinction between the two is what we refer to as the *locus of coordination*.

### Interproduct Coordination

On the left side of Figure 3, panel (a), we illustrate the case of interproduct coordination, in which multiple products are sold to a common customer. In such a situation, there are likely to be across-product interdependencies that are generated by the need for products to work together

as a system to serve a single customer’s needs (Teece 1982, Helfat and Eisenhardt 2004). Interdependencies in such a picture would likely arise, for example, from the need to design components so that they can interface with one another and be bundled together for a single customer. Although such interdependencies may have helped achieve synergies prior to the shock, they are likely to require reciprocal linkages across production activities (Thompson 1967, Hill and Hoskisson 1987), which may hinder adaptation following an industry shock. In general, the bulk of the coordination effort is borne by the firm’s product areas in such a picture, with efforts *across* product areas necessary to ensure effective alignment and response to external change.

Note that the extent of such across-product interdependencies is likely to be a function of factors such as the underlying “interdependence intensity” of the products themselves (an issue we turn to in more detail later in our discussion of product complementarity and organizational grouping). However, our baseline expectation is that this pattern of links creates the need for interproduct coordination. Moreover, a key assumption we make here is that if two product areas share a common customer, they are, simply, *more likely* to coordinate than if they do not; we leave it for future research equipped with more detailed information to examine more granular changes in interdependence. Accordingly, we draw a (binary) distinction based on the sharing of customers, which we expect would be correlated with the degree of required across-product coordination.

### Intraproduct Coordination

On the right side of Figure 3, panel (a), we illustrate the case of intraproduct coordination, in which a single product is sold to multiple customers. In contrast to the previous example, there are no across-product interdependencies generated as a consequence of this pattern; rather, the interdependencies are *within* a given set of product activities: the need to organize a firm’s activities for a particular product to serve multiple customers results in greater interdependence among the activities of the firm needed to tailor the product for multiple applications. As noted previously, when there are multiple sales teams associated with each individual customer, it may be the case that some customer-facing activities inside the firm could also be interdependent with one another. Although such interdependencies may indeed exist, our series of qualitative interviews suggests that their effects are likely to be minimal: when individual sales and marketing teams are assigned to particular customers, they generally function as autonomous entities, segmented for example by criteria such as geography and operating in such a way that their main activities involve relaying information back and forth between a firm’s production areas and the firm’s external customers. In the case of multiple sales teams, the need to coordinate is

generally limited to activities such as sharing information on sales leads. The customization itself, which consists of heavily production-oriented activities, is pursued by the firm's product areas. In the case of a single product being sold to multiple customers, then, the interdependencies necessary to customize the product for multiple customers would be contained within a particular module of product activities; hence the term "intraproduct" coordination.

### Asymmetry in Postshock Performance

Variation in the postshock adaptation consequences associated with different patterns of interdependence stems from the particular coordination challenges each represents. Simon's (1969) classic parable of *Tempus* and *Hora* provides a motivating illustration: two watchmakers, each producing watches of 1,000 parts, varied substantially in their degree of success. Whereas *Tempus* constructed his watches in such a way that anytime he was interrupted the entire watch fell to pieces, *Hora* designed his watches using subassemblies of 10 parts each, allowing the effects of any interruption to be contained and to affect only a particular subassembly. The beneficial effects associated with such near-decomposability of the task interaction structure help frame our story of the postshock consequences of different coordination structures: an organization's performance in coping with changing external conditions will be facilitated when the interdependencies affected by the shock are contained within modular units.

To build on this idea, and to understand more clearly the mechanisms underlying a firm's differential postshock performance, we draw on a knowledge and information processing view of the firm. The patterns we have described relate to the "input, processing, output, and direct support tasks" of the firm (Mintzberg 1979, p. 19), with the need to coordinate arising as a consequence. Processing information is central to the coordination effort (e.g., Thompson 1967, Galbraith 1977, Tushman and Nadler 1978), involving the need to ensure alignment in the predictive knowledge that interdependent actors have for one another (Puranam et al. 2012). The resulting coordination structures involve design trade-offs aimed at minimizing coordination costs and reducing uncertainty, and macro-structural decisions such as grouping together modules and linking together differentiated units (e.g., Nadler and Tushman 1997). Such structures can be both formal and informal (Nickerson and Zenger 2002, Gulati and Puranam 2009), consisting of tacit and codified communication channels, information filters, and problem-solving strategies (Henderson and Clark 1990).

In equilibrium, we would expect such organizational structures to map to the interdependencies associated with the firm's tasks (Baldwin and Clark 2000, Sosa et al. 2004). The consequence of this is that changing external conditions will then create the need for possible adjustments (e.g., Gulati et al. 2005) as misalignment

vis-à-vis the new environment imposes costs on the organization (e.g., Rawley 2010, Zhou 2011). The new postshock conditions impel the organization to ensure effective coordination of knowledge and information, with the central question being whether the change (preshock to postshock) in the nature of uncertainty faced by the organization, which Galbraith (1977, pp. 36–37) refers to as the "difference between the amount of information required to perform the task and the amount of information already possessed by the organization," can be managed by the organization's existing structures (which were set up to mirror the preshock task environment).

Making changes to coordination patterns can be difficult in the short run: Mintzberg (1979, p. 68) notes that "as conditions change, . . . organizational needs change, but changing the structure inevitably means interfering with established patterns of behavior." Nickerson and Zenger (2002, p. 553) echo this point, noting that "there is a lag between the implementation of a new formal structure and the realization of the new structure's steady-state functionality." An organization's capacity to change is, moreover, likely to be static in the short run, corresponding to organizational needs at that point in time (Puranam et al. 2009, Levinthal and Wu 2010); such limited slack would thus constrain organizations in the short run from using routines and capabilities developed prior to the shock as a source of change (Teece et al. 1997, Feldman and Pentland 2003). The inertial component of organizational structure would thus likely be the primary effect following a sudden demand shock (e.g., Henderson and Clark 1990, Leonard-Barton 1992, Ghemawat and Levinthal 2008). Consequently, to evaluate the effects of a shock, we must focus on the intervening period between the occurrence of the shock and the point at which the organization returns to equilibrium. This period involves an adjustment process (e.g., Helfat and Eisenhardt 2004) during which the different loci of coordination can have varying performance consequences as the organization responds to the changes in demand.

### Postshock Adaptation with Interproduct Coordination

What implications does an industry demand shock have for postshock adaptation in the interproduct coordination case? Recall that this particular case of coordination is akin to product bundling, in which the firm engages multiple distinct product areas to serve a single customer. Synergies across product markets (e.g., via economies of scope) are likely to be a key driver for such an organizational form (Hill and Hoskisson 1987, Rawley 2010, Zhou 2011, Kumar 2013); realizing the associated benefits involves multiple product areas working in concert with one another across a range of activities such as shared procurement, joint marketing, and distribution. Because a demand shock involves changes in multiple markets, however, the interdependencies *cross* organizational modules; in the context of a demand shock, this would likely

reduce the decomposability of the system, making coordinated activity more difficult. Cross-module activities are likely to involve sharing information flows across multiple product modules, involving both formal and informal mechanisms used to coordinate cross-product module efforts. Fundamental to such coordinated activity is the goal of ensuring that agents associated with the differing (but linked via a common customer) product areas have some degree of “common ground” and “predictive knowledge” (Srikanth and Puranam 2011, Puranam et al. 2012), with the organization therefore tasked with the effort of ensuring that such knowledge alignment is reestablished following the external shock.

Because a demand-side shock involves heterogeneous changes across different product markets (demand for certain products increases, whereas demand for others decreases), a likely result is that the firm will have to reshuffle its product portfolio in response to changing opportunity costs across product markets (Helfat and Eisenhardt 2004, Levinthal and Wu 2010). Ensuring the continued alignment of predictive knowledge across product areas can then pose challenges for the organization’s existing structures of coordination, as multiple product areas adapt to their individual demand situations. Individual product areas may find themselves at odds with one another, with a reduced ability to both predict and understand the actions of their counterparts. For example, an agent within the organization associated with a particular product area that needs to increase raw material procurement in response to expanded market demand may be at odds with those (previously aligned) agents that now have differing objectives. In such cases, coordination costs may be significantly increased from their preshock levels in response to the need to realign knowledge in an effort to maintain a shared understanding across product areas and, more generally, to reduce the frictions that occur at the interface of multiple sets of product activities.

### Comparison with Intraproduct Coordination

We can compare the interproduct coordination case with the intraproduct situation, in which interdependencies exist within a particular product area. In the latter pattern activities are likely to be tightly connected and contained within distinct product modules, with reciprocal interdependencies dedicated to a particular product likely to be grouped together (Thompson 1967). The intraproduct coordination case is likely to be more decomposable than the interproduct coordination case where different products are bundled together, as the interdependencies do not cross product boundaries, but rather are contained within them. A demand shock would likely result in a uniform impact to a grouped set of activities already tightly organized within a localized organizational structure. Since there is no underlying scientific or technological change as an immediate result of a sudden demand shock, such a

situation would not require breaking apart the production process of any given product, and the frictions characterizing interdependencies across products are not likely to be present in the case of intraproduct coordination. Although common knowledge and a shared understanding would still be necessary among the multiple interacting components, the effects of the shock would be uniform across the activities *within* a given product module, and preshock coordination structures would be sufficient to manage the resulting postshock information flows.

Although it may be the case that there are multiple customer-facing activities within the firm, each possibly dedicated to one or more customers, any such interdependencies are likely to be negligible relative to the product-related interdependencies: a customer team (or an individual) learning about new product demands or specifications would likely relay this information to the production team, requesting the relevant adjustments. The production team would then respond accordingly, conducting the customization work. Thus, because the role of the customer-facing activities is to pass information from customers to the production modules, and since there is ultimately a single production module in question, any relevant coordination efforts are likely to be taken on within the product-related module itself.

### Summary and Main Hypotheses

To summarize our discussion thus far from the current and previous sections, when different products need to work together as a system to serve a single customer, a demand shock will introduce incremental costs of coordination to the system. These costs arise not only from the need for any given product in the system to adapt to changing levels of demand but also, more significantly, from changes to the *other* products to which it is linked. Such changes will result in cross-product interdependencies that are likely to stress the existing organizational structures used to manage the flow of information and tasks within the organization. Interproduct coordination, where interdependencies cross product modules, is therefore less decomposable than intraproduct coordination, where interdependencies are contained within product modules and where postshock coordination challenges are likely to be negligible. In the context of an industry demand shock, therefore, we hypothesize that whereas coordination overall will impede adaptation, the locus of coordination within the organization (interproduct versus intraproduct coordination) will drive these effects.

**HYPOTHESIS 1A (H1A).** *A higher level of product-related coordination needs will reduce a firm’s adaptation performance following a demand shock.*

**HYPOTHESIS 1B (H1B).** *The negative effect of product-related coordination on adaptation performance (H1A) will arise from interproduct coordination rather than from intraproduct coordination.*

## Complementarity and Grouping

Our discussion thus far suggests that firms with higher interproduct coordination are more likely to face adaptation challenges because greater frictions are created at the interface of multiple interacting products; such effects are likely to play a reduced role in the case of intraproduct coordination where the effects are contained within product modules. We elaborate on two key aspects of the mechanisms linking preshock coordination and postshock adaptation, and we develop two associated moderating hypotheses. These two hypotheses stem from the following observations: first, even if two products are bundled, the extent of the associated interproduct interdependencies (i.e., the interdependence intensity) can vary; and second, the structure of the firm may be such that there are fewer internal boundaries across products, thereby reducing the cross-product effects associated with interproduct coordination.

These aspects of our hypothesized mechanisms lead us to develop two boundary conditions for our arguments, the first related to product complementarity and the second related to grouping within the organization. These factors allow us to further test the central mechanisms around which we theorize. Our approach of examining the interaction effects of these two moderating factors follows in the spirit of methodological approaches utilized in prior studies (e.g., Rajan and Zingales 1998, Dushnitsky and Shaver 2009). If we find that the negative effect of interproduct coordination is strengthened when underlying products are more complementary but mitigated when the organization's activities are grouped together, this would further support our theory that the tight preshock coupling across multiple product areas leads to difficulties in postshock incumbent adaptation.

### Product Complementarity

The extent of interdependencies among different product areas is likely to vary as a function of the nature of the interacting product areas. The idea underlying complementarity is that individual activities can be supermodular when working in conjunction with one another (Milgrom and Roberts 1990), and therefore that adaptation in the choices associated with one product area can influence the returns associated with another (Levinthal 2000). This idea reflects the extent to which individual activities are interdependent because of the need for jointly coordinated effort. It is important to note the distinction between the main effect of coordination (stemming from patterns of interdependence) and the moderator we examine, product complementarity. Whereas the former represents a set of organizational choices made by the firm, the latter represents the underlying nature of the products themselves. For instance, although two products can be complementary to each other by nature, the firm can choose whether to serve both of them to the same customer (thereby creating a need for interproduct coordination). The main

effect of interproduct coordination is thus a function of the *existence* of interdependence across products, and the degree of complementarity influences the *strength* of such interdependence.

Thus, greater product complementarity increases the intensity of interdependence across products as a consequence of the need to coordinate activities such as procurement, marketing, and distribution prior to the shock. We would expect that higher levels of complementarity would make it more difficult to adjust interproduct coordination structures following a shock because of the higher cross-product interdependence intensity, creating greater impediments in the postshock adaptation process. On the other hand, firms with products that are less complementary, and therefore relatively modular with respect to one another (Baldwin and Clark 2000), would be less likely to be affected by a demand shock via the information flows-based mechanism we have discussed. Indeed, such interactions across multiple product areas may require minimal levels of coordination: e.g., when two products are by nature independent of one another, even if by chance they are sold together, the need for the firm to coordinate across these product areas is likely to be minimal. Thus, we would expect that greater complementarity would manifest itself by exacerbating the negative effects of interproduct coordination in the presence of a demand shock.

*HYPOTHESIS 2 (H2). Higher levels of product complementarity within an organization will increase the degree to which interproduct coordination impedes postshock adaptation performance.*

### Organizational Grouping

Organizational grouping, on the other hand, reflects a possible avenue for reducing the negative effects of interproduct coordination: to the degree that there are fewer organizational boundaries across interacting product areas, the effects associated with cross-product interdependencies may be mitigated. Grouping is a core activity in the literature on organization design (e.g., Khandwalla 1977, Nadler and Tushman 1997, Rivkin and Siggelkow 2003). Stemming from Thompson's (1967) observation that reciprocal interdependencies are likely to be contained within modular units, this design feature enables interconnected sets of activities to exist within a distinct organizational structure, facilitating the flow of information across such activities. Such a structure is likely to be beneficial when information needs change in a postshock environment.

In situations following a demand shock, particularly where it is not perfectly clear how demand conditions will shift and how firms should restructure their interdependencies, grouping can thus create a common forum to facilitate communication, information exchange, and conflict resolution (e.g., Nadler and Tushman 1997). Individual managers in charge of different product areas

can more easily make complex decisions together by establishing and adjusting working flows and routines. By contrast, if different individual managers reside in different groups or organizational units, they may be less able to efficiently coordinate with those in another group with different routines and procedures. As a consequence, a firm's broader portfolio of product markets may be less amenable to reconfiguration, as each individual product area has its own individual representations and interpretations of the new demand environment. Subsuming multiple such product areas within a broader organizational grouping can mitigate the postshock challenges associated with cross-product interdependencies.

The extent to which an organization is organized into multiple divisions serves as a potential proxy for such grouping: higher divisional scope occurs when a greater number of the firm's activities are contained within a single unit. We would expect that such cases of greater organizational grouping would mitigate the effects of interproduct coordination. It should be noted that we are concerned with the interaction effect between grouping and interdependence, rather than the main effect of grouping. The main effect of grouping itself can be a double-edged sword: although grouping makes coordination easier within group boundaries, it can also cause organizational diseconomies of scope (Nadler and Tushman 1997). Because of these two opposing forces, whether the main effect of grouping is positive is an empirical question. Our main focus is on the interaction effect, which isolates the specific mechanism through which grouping mitigates the negative consequences of interproduct coordination.

**HYPOTHESIS 3 (H3).** *Higher levels of organizational grouping within an organization will reduce the degree to which interproduct coordination impedes postshock adaptation performance.*

## Methods and Results

### Industry and Sample

Our aim in this paper is to understand the impact of heterogeneous forms of preshock within-firm interdependence on the differential levels of firm success in adapting to a sudden industry shock. We contrast the case of interproduct coordination (product bundling) with intraproduct coordination (product customization), suggesting that the former is less decomposable than the latter as a result of interdependencies crossing product modules, which leads to greater difficulties in adaptation under changing industry demand conditions. The events of September 11, 2001 resulted in a significant demand shock to the defense industry: not only did total demand increase, but more importantly, there was a change in the nature of preferences with respect to individual product areas (e.g., with some fast-growing markets growing more

slowly after the shock and some slow-growing markets growing more quickly, as Figure 1 illustrates). Although there was no change in the nature of technologies and products themselves as an immediate result of the shock, the magnitude and composition of demand did change, resulting in the need for firms to reshuffle their product portfolios in response to the new external conditions.

In the pre-2001 period, the U.S. defense industry was broadly in a consolidation and contraction phase, transitioning away from the Cold War mind-set of the prior decades (e.g., Dial and Murphy 1995, Anand and Singh 1997, Goyal et al. 2002). The events of September 2001 caused a significant reset in the industry's focus: the Afghanistan and Iraq wars had their genesis in this event, pushing to the forefront of consideration those products and technologies that would be a better fit with the new security and counterterrorism orientation of the post-2001 environment.<sup>6</sup> The shock had heterogeneous effects on firms: while there was an aggregate increase in demand, a large portion of the post-2001 value was captured by industry entrants, with the declining incumbent share characterized by significant performance heterogeneity among individual firms. The exogenous nature of the shock made it impossible for firms to anticipate, offering the beneficial empirical feature of allowing us to separate preshock decisions around organizational structure from the nature of the postshock environment.

The data used in our analysis consist of the full universe of procurement contracts filed with the U.S. Department of Defense between 1996 and 2006. Each contract has attached to it several pieces of information, including the date granted, dollar amount, and the particular product and customer codes associated with the contract. Our definition of products draws on the product service classification codes used by the federal government, which contain 2,071 categories covering a wide spectrum of products (e.g., aircraft landing gear components, intelligence studies, office supplies, fiber optic devices, submarines), and our definition of customers utilizes the fact that there are 1,440 contracting offices (e.g., the U.S. Property and Fiscal Office for Virginia, the U.S. Naval Academy) ultimately responsible for granting a contract to a given firm serving this industry. The exogenous nature of the shock, the existence of variation in products and customers, and the heterogeneity among industry participants in the locus of coordination (i.e., there is no "correct" model of organizing ties between products and customers) make this industry context desirable for testing our theory.

To create our data set, we track the ultimate firm parent, grouping contracts together at the firm-year level and defining the years 1996–2000 as the preshock period and the years 2002–2006 as the postshock period. We create our sample as follows: first, we identify each unique firm that received a contract between 1996 and 2000. Since we are interested in *incumbent* effects, we include only firms that were granted at least one contract

in this preshock period. To appropriately interpret our measures of interdependence, we restrict the sample to firms that were granted (in the preshock period) more than one product for more than one customer. We correct for acquisition activity of firms by dropping firms acquired prior to 2001 and dropping postacquisition firm-years for acquisition events from 2002 through 2006. We observe firms in our sample for a five-year period prior to the shock and a five-year period after the shock; we consider a firm to have exited, and hence censor its observations, if it has not received a new contract for a continuous five-year period. The resulting 10-year sample (we exclude 2001) gives us over 185,000 firm-year observations across approximately 20,000 firms.

### Identification Strategy

We use a fixed-effects ordinary least squares (OLS) specification to examine within-firm performance change around the 2001 shock. To do so, we construct interaction terms of our covariates with the post-2001 dummy variable. The model we estimate is thus

$$\ln y_{it} = \beta_0 + \beta_1 D_t + \beta_2 D_t \mathbf{x}_i + f_i + \theta_{it}.$$

In this equation,  $y_{it}$  represents the performance of firm  $i$  during time period  $t$ , where  $t$  ranges across the entire period of the sample, pre- and postshock;  $D_t$  is a binary variable taking the value of 1 in time periods after 2001 (postshock) and 0 in time periods before 2001 (preshock). We use the term  $\mathbf{x}_i$  to denote a vector of firm portfolio characteristics *prior to the shock*. The core construct we seek to identify is the interaction between  $D_t$  and  $\mathbf{x}_i$ . The dependent variable is the log transformation of a firm's yearly performance; thus, the interaction term captures the percentage change in performance for the same firm before and after the shock (Greene 2002). We are not concerned, therefore, with the average impact of the shock on the average firm but instead with identifying how different preshock firm characteristics influence *within-firm* performance changes in a postshock versus preshock environment. As an example, if  $x_i$  is a binary variable representing high versus low (preshock) interdependence,  $\beta_2$  would capture within-firm performance differences in a post- versus preshock environment between a high- versus low-interdependence firm (this example is for illustration only; we discuss the interdependence variables used in our analyses in more detail below).

We note several points in regard to our model specification. First, preshock portfolio characteristics,  $\mathbf{x}_i$ , which include both the main coordination variables and the control variables, are measured by pooling contracts over the preshock five-year period. For example, to calculate a preshock count of customers, we pool all contracts in the five-year period of 1996–2000 and count the number of unique customers associated with these contracts. This design ensures that the preshock characteristics represent a stock immediately before 2001. Pooling over the

five-year period, as opposed to using an individual year, ensures that preshock portfolio characteristics do not suffer from year-to-year random fluctuations, consistent with our theory examining stable preshock structures for information processing and coordination, i.e., patterns that are stable and aligned with preshock market conditions (Mintzberg 1979, Henderson and Clark 1990, Baldwin and Clark 2000).

Second, note that we could face the issue of regressing past values on future ones if we were examining the main effect of  $x_i$  using a regular OLS specification because the dependent variable could take on the value in a given year before 2001 (e.g., 1997), whereas the preshock portfolio characteristics are constructed based on all five years before 2001. This is not, however, an issue in the fixed-effects model we estimate: because firm fixed effects ( $f_i$ ) are included, and since  $\mathbf{x}_i$  is time invariant, the main effect of  $\mathbf{x}_i$  is dropped. By contrast, our core construct, the interaction between  $D_t$  and  $\mathbf{x}_i$ , is time varying (the postshock dummy  $D_t$  is time varying, changing from 0 to 1) and can thus be identified by the fixed-effects model. The interaction between  $D_t$  and  $\mathbf{x}_i$  captures how a firm's preshock organizational characteristics affect its postshock adaptation performance, with its preshock performance working merely as a benchmark to ensure postshock performance growth is on the same scale and comparable across firms. This method, examining how a firm's characteristics at period  $T$  (the pre-2001 five-year period) affect a firm's performance change from  $T$  to  $T + 1$  (the post-2001 five-year period), is commonly employed in the literature (Greene 2002, Greve and Goldeng 2004).

Finally, note that we focus on the percentage change (as explained above, by using the semi-log model with the log of annual contract dollars as the dependent variable), not the absolute level of change, in contract dollars, to capture adaptation performance in the short run immediately after the shock. When a major industry shock occurs, incumbent firms may begin to lose market share yet maintain a higher absolute sales level initially (Christensen and Bower 1996). Only if new entrants are able to further invade the incumbent's market share may incumbents eventually experience an absolute sales decline in the long run. Thus, percentage change is an appropriate measure for the theoretical construct of postshock adaptation performance in the short run.

To mitigate unobserved firm-level heterogeneity, we make within-firm inferences by using fixed-effects specifications for time-invariant firm-level factors and controlling for time-varying factors that we believe affect adaptation performance. We base our identification strategy on the assumption that the shock was unexpected. Had firms anticipated the occurrence of the shock ( $D_t$ ), they might have configured the interdependence of their preshock portfolio ( $\mathbf{x}_i$ ) with the intention of maximizing adaptation performance, leading to a simultaneity bias that cannot be

eliminated by firm fixed effects alone. Our setting facilitates our design choice: the September 11 tragedy was unexpected (and thus an exogenous shock), allowing us to isolate the effect of preshock interdependence structure on postshock adaptation outcomes.<sup>7</sup>

### Variable Construction

*Postshock Adaptation.* As explained earlier in the Identification Strategy section, we use as our dependent variable the logged value of *total contract dollars* in each year, which offers the interpretation of a percent change in output, consistent with our theoretical objectives to examine firms' adaptation performance as a consequence of an external shock.

*Inter- and Intraproduct Coordination.* As we describe more fully in our up-front theoretical development, and as illustrated in Figure 3, we develop the constructs of interproduct coordination and intraproduct coordination, which enable us to measure a firm's locus of coordination. We utilize the fact that each defense contract granted to a firm has attached to it one of 2,071 product market codes and one of 1,440 contracting office codes. Each firm can have multiple associated contracts; consistent with our theoretical discussion around patterns of within-firm interdependence, we define a link between a product and customer as existing between a product area  $X$  and a customer  $Y$  of a particular firm when a contract granted to the firm shows the firm selling product  $X$  to customer  $Y$ . The variable *interproduct coordination* is measured by calculating, for each product the firm sells in the five-year preshock period, the number of other products to which the focal product is connected via a common customer. The *interproduct coordination* variable is then the average of this value across all products of the firm. The variable *intraproduct coordination* is measured by counting the number of customers to which each product of the firm is connected in the five-year preshock period, then averaging across all products of the firm. Thus, these two measures give us preshock measures of inter- and intraproduct coordination at the firm level. Although our main theoretical concern is the mean level of these measures within the firm, we also control for the distribution of these values across all products of the firm by including in our specifications the Herfindahl indices of the two product-related coordination measures, *interproduct Herfindahl* and *intraproduct Herfindahl*.<sup>8</sup>

As illustrated in Figure 3, panel (b), we construct a matrix that contains four different categories of inter- and intraproduct coordination: the four quadrants arise from the firm being higher versus lower than the median on either of the two dimensions. The use of the categorical versions of our measures is consistent with our theoretical development in which we focus on the comparison of two different categories.<sup>9</sup> We use three of these variables across the range of our specifications (the fourth should be

interpreted as the baseline category): *high inter- and high intraproduct coordination*, *high inter- and low intraproduct coordination*, and *low inter- and high intraproduct coordination*. Our main theoretical concern is with the lower right and upper left quadrants, in which the firm is high on one dimension and low on the other. These two quadrants represent, respectively, the *main effects* of interproduct coordination and intraproduct coordination; comparing the two allows us to understand the implications of having an interproduct versus intraproduct locus of coordination.<sup>10</sup>

*Complementarity and Grouping.* To investigate the mechanisms underlying our results, we utilize two moderating variables: *product complementarity*, which measures the degree of overlap between the inputs and outputs (based on Standard Industrial Classification (SIC) codes)<sup>11</sup> of a firm's products, following Fan and Lang (2000), and *organizational grouping*, which represents the degree of scope for each firm unit, preshock, measured as the inverse of the number of distinct organizational units within the firm. The *product complementarity* measure is, in essence, a proxy for the level of underlying interactions between a firm's products, and as such, we would expect (per Hypothesis 2) that the main results of *interproduct coordination* would be strengthened when there is greater product complementarity. The *organizational grouping* measure proxies for the extent to which an organization's activities are contained within a distinct organizational subunit. We would expect (per Hypothesis 3) that the main results of *interproduct coordination* would be weakened when there is greater *organizational grouping*.

We construct the *product complementarity* measure via a two-stage process, following Fan and Lang (2000). In the first stage, we construct a measure for the degree of complementarity between each pair of SIC codes as follows: first, for each SIC we form a vector whose elements are the percentage of inputs arising from each intermediate SIC other than the two focal SICs being examined. We then calculate the correlation between the elements of each of these two vectors, representing the similarity of inputs between the two focal SICs. We repeat the same process for outputs and use as the value of complementarity the average of the input and output correlations we constructed. In the second stage, we then calculate the value of complementarity at the firm level. In our data, a firm's product portfolio can be characterized by a set of underlying SICs, since each contract is associated with an SIC code. We form all possible unique pairs of these SIC codes, then assign to each pair the degree of complementarity between each pair calculated in the first stage. We then take the average of the complementarity value between each pair to obtain a value at the firm level.

To construct the *organizational grouping* variable, we utilize the fact that each firm has one or more distinct

subunits under which contracts can be granted. We use the inverse number of such distinct organizational units as our measure of grouping, which facilitates the interpretation of our interaction term as a measure of the degree of interdependence per organizational unit, consistent with our theoretical objectives.

*Scale and Scope Controls.* We utilize a set of firm-level variables that enables us to control for the possible effects of scale and scope on postshock adaptation. The *preshock size* variable is an average of the total yearly defense contract dollars in the five-year preshock period (a measure of firm size), and the *preshock product count* and *preshock customer count* variables respectively represent the total number of distinct product areas and customers for which the firm received contracts during the five-year preshock period; these variables serve as a proxy for firm scope, as well as for the total potential interactions between products and customers.<sup>12</sup>

*Industry-Level Controls.* Another set of control variables relates to the underlying industry-level values of inter- and intraproduct coordination. It may be the case, for example, that postshock performance is driven largely by the industry the firm is in, especially when industry segments have a particular coordination profile. To control for this possibility, we include measures for the average level of inter- and intraproduct coordination at the industry level. Because “industry” can be defined across one of two possible dimensions in our study (i.e., positioning in a particular product area or customer area), we define these controls across both dimensions for completeness. The four variables, *industry interproduct coordination (product)*, *industry intraproduct coordination (product)*, *industry interproduct coordination (customer)*, and *industry intraproduct coordination (customer)*, thus represent the average inter- or intraproduct coordination in the preshock period for all firms in the industry with contracts in the focal firm’s own product or customer areas (weighted by total dollars in those areas).

*Firm Positioning Controls.* A final dimension to control for relates to the positioning of the firm in its industry segments. A firm’s postshock adaptation outcomes may be further driven by the growth characteristics of the markets it is in. Including measures for preshock versus postshock industry positioning enables us to control for these factors. We construct variables that describe the preshock and postshock positioning of the firm, measured based on its underlying preshock product markets. To do so, we first construct, for each of these markets, measures of the pre-2001 and post-2001 five-year industry growth rates (i.e., the percentage growth in total contract dollars for each product market). For the preshock versus postshock period, we then weight the respective product market growth rates by the firm’s own preshock dollars granted in each of the product markets. Finally, we construct

measures of positioning changes from *high-to-high*, *high-to-low*, and *low-to-high* (with *low-to-low* thus being the reference category) by determining whether the preshock versus postshock dollar-weighted growth rates at the aggregate firm level are above or below their median value.

Table 1 summarizes the measures we use in the analysis. Table 2 provides means and standard deviations, along with a pairwise correlation matrix of our independent variables.

### Empirical Results

We begin our analysis with Table 3, which shows firm fixed-effects OLS estimates of the natural log of *total contract dollars*. The independent variables are organized in the order listed in Table 2, with the three main coordination variables at the top, followed by the controls. As noted previously, all preshock organizational characteristics are interacted with the *post-2001* dummy to identify their effects in the postshock period.<sup>13</sup> Model (3-1) includes the *post-2001* dummy, along with the control for *preshock size*. The results hold across all four specifications in this table and show that although there is an overall positive effect of the 2001 shock, larger firms have smaller percentage gains in the postshock period. In model (3-2) we add our core set of variables, and in model (3-3), we add the firm-level controls for scope. The coefficients on the three coordination variables should be interpreted as relative to the *low inter- and low intraproduct coordination* case. The results in models (3-2) and (3-3) are consistent with the results in model (3-4), which adds the other controls. Taking these three variables together, model (3-4) provides support for Hypothesis 1A, which suggests that a higher level of product-related coordination needs will reduce postshock adaptation performance: the sum of the three coordination variables is negative and statistically significant ( $F$ -statistic = 25.22,  $p$ -value = 0.001).

Turning next to the individual coordination variables, recall (from Figure 3, panel (b)) that we seek to compare the “asymmetric” quadrants, where inter- and intraproduct coordination are different in magnitude, as a test of Hypothesis 1B. Examining the coefficient of *high inter- and low intraproduct coordination*, we find that its estimate is consistently negative across the range of our specifications. By contrast, we do not find evidence of such a negative effect on *low inter- and high intraproduct coordination*, which is nearly zero. The difference between these two coefficients in model (3-4) is statistically significant ( $F$ -statistic = 14.38,  $p$ -value = 0.001). These results support Hypothesis 1B, suggesting that the high interproduct coordination effects are driving the negative effects of postshock performance growth. The magnitude of these effects is worth noting: in the full specification (3-4), the *high inter- and low intraproduct coordination* case decreases within-firm postshock adaptation performance by 57.6% relative to the *low inter- and*

**Table 1** Definitions of Measures

	Definition
Dependent variable	
<i>Total contract dollars</i>	Total dollar value of defense contracts granted to firm in the firm-year
Independent variables: Interproduct and intraproduct coordination	
<i>High inter- and high intraproduct coordination</i>	Interproduct coordination and intraproduct coordination are both above their respective median values (see Figure 3, panel (b))
<i>High inter- and low intraproduct coordination</i>	Interproduct coordination is above and intraproduct coordination is below its respective median value (see Figure 3, panel (b))
<i>Low inter- and high intraproduct coordination</i>	Interproduct coordination is below and intraproduct coordination is above its respective median value (see Figure 3, panel (b))
Independent variables: Moderating characteristics	
<i>Product complementarity</i>	Degree of overlap in the input and output markets of a firm's products, preshock, based on SIC codes, following Fan and Lang (2000)
<i>Organizational grouping</i>	Degree of scope for each firm unit, preshock, measured as the inverse of the number of distinct organizational units within the firm
Independent variables: Controls	
<i>Post-2001</i>	Dummy for years post-2001
<i>Preshock size</i>	Average yearly defense contract dollars in the preshock period
<i>Preshock product count</i>	Total number of distinct product areas in the preshock period
<i>Preshock customer count</i>	Total number of distinct customer areas in the preshock period
<i>Industry interproduct coordination (product)</i>	Average interproduct coordination in the preshock period for firms with contracts in the focal firm's product areas
<i>Industry intraproduct coordination (product)</i>	Average intraproduct coordination in the preshock period for firms with contracts in the focal firm's product areas
<i>Industry interproduct coordination (customer)</i>	Average interproduct coordination in the preshock period for firms with contracts in the focal firm's customer areas
<i>Industry intraproduct coordination (customer)</i>	Average intraproduct coordination in the preshock period for firms with contracts in the focal firm's customer areas
<i>Positioning change, high to high</i>	Dummy for firms moving from high-growth markets preshock to high-growth markets postshock
<i>Positioning change, high to low</i>	Dummy for firms moving from high-growth markets preshock to low-growth markets postshock
<i>Positioning change, low to high</i>	Dummy for firms moving from low-growth markets preshock to high-growth markets postshock
<i>Interproduct Herfindahl</i>	Herfindahl index of the distribution of interproduct coordination within the firm
<i>Intraproduct Herfindahl</i>	Herfindahl index of the distribution of intraproduct coordination within the firm

*low intraproduct coordination* case, whereas the effect of the *low inter- and high intraproduct coordination* case is negligible. It might also be noted that the *high inter- and high intraproduct coordination* variable is negative, but with a smaller magnitude than the *high inter- and low intraproduct coordination* variable. The difference, however, is not statistically significant ( $F$ -statistic = 1.09,  $p$ -value = 0.2965). Although we do not theorize specifically about the individual effect of *high inter- and high intraproduct coordination* (which involves an interaction between the two types of interdependence), this finding is broadly consistent with our main results, where the negative effect on postshock performance is primarily driven by *interproduct coordination*.

Several of the significant control variables are worth mentioning: the positive coefficients on *preshock product count*, *interproduct Herfindahl*, and *intraproduct Herfindahl* suggest that greater product variety facilitates postshock adaptation, and a less dispersed distribution of either interproduct coordination or intraproduct coordination across different products can likewise facilitate postshock adaptation. Several industry-related control variables are

also significantly positive, suggesting that industry effects are over and above firm effects. Finally, the positioning variables are positive, addressing the issue of “luck” with respect to a firm’s positioning by controlling for the firm simply being present in the “right” industries at the right time.

We turn next to Table 4, where we use *product complementarity* and *organizational grouping* as moderators to investigate the mechanisms and boundary conditions associated with *interproduct coordination*, per Hypotheses 2 and 3. We organize the explanatory variables in this table similarly to Table 3 (containing all of the same variables as in model (3-4)) except that we include the two moderators, along with their interactions with *high inter- and low intraproduct coordination* and *low inter- and high intraproduct coordination*. We examine the effects of *product complementarity* and *organizational grouping* separately in models (4-1) and (4-2), respectively; we then include both sets of moderators in the full specification (4-3) to test robustness.

We focus on model (4-3) in our discussion, as the estimates associated with the moderating variables are

**Table 2 Summary Statistics and Correlations**

(A) Means and standard deviations																			
																	Mean	SD	
Dependent variable																			
<i>Total contract dollars<sup>a</sup></i>																		8.48	6.45
Independent variables: Interproduct and intraproduct coordination																			
(1) <i>High inter- and high intraproduct coordination</i>																		0.38	0.48
(2) <i>High inter- and low intraproduct coordination</i>																		0.19	0.39
(3) <i>Low inter- and high intraproduct coordination</i>																		0.14	0.35
Independent variables: Moderating characteristics																			
(4) <i>Product complementarity</i>																		0.40	0.29
(5) <i>Organizational grouping</i>																		0.61	0.28
Independent variables: Controls																			
(6) <i>Postshock dummy</i>																		0.46	0.50
(7) <i>Preshock size<sup>a</sup></i>																		12.60	1.93
(8) <i>Preshock product count</i>																		6.51	12.05
(9) <i>Preshock customer count</i>																		6.77	17.60
(10) <i>Industry interproduct coordination (product)</i>																		4.96	3.22
(11) <i>Industry intraproduct coordination (product)</i>																		2.54	1.08
(12) <i>Industry interproduct coordination (customer)</i>																		4.21	2.89
(13) <i>Industry intraproduct coordination (customer)</i>																		2.40	0.61
(14) <i>Positioning change, high to high</i>																		0.29	0.45
(15) <i>Positioning change, high to low</i>																		0.27	0.44
(16) <i>Positioning change, low to high</i>																		0.21	0.40
(17) <i>Interproduct Herfindahl</i>																		0.08	0.12
(18) <i>Intraproduct Herfindahl</i>																		0.04	0.08
(B) Pairwise correlations of independent variables																			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	
(1)	1.00																		
(2)	-0.38	1.00																	
(3)	-0.32	-0.20	1.00																
(4)	0.05	0.12	-0.06	1.00															
(5)	-0.30	0.07	-0.05	-0.02	1.00														
(6)	0.02	0.00	0.00	-0.00	0.00	1.00													
(7)	0.47	0.00	-0.05	0.14	-0.47	0.02	1.00												
(8)	0.26	-0.01	-0.08	-0.01	-0.30	0.01	0.48	1.00											
(9)	0.23	-0.10	-0.01	-0.05	-0.28	0.01	0.39	0.81	1.00										
(10)	0.04	0.02	-0.05	-0.07	0.01	0.00	0.06	0.15	0.09	1.00									
(11)	0.02	-0.12	0.08	-0.20	0.04	-0.00	-0.13	0.06	0.15	0.41	1.00								
(12)	0.06	-0.02	-0.01	-0.14	-0.04	0.00	0.13	0.16	0.10	0.49	0.21	1.00							
(13)	0.00	-0.14	0.08	-0.19	0.03	0.00	-0.08	0.08	0.14	0.30	0.46	0.46	1.00						
(14)	0.01	-0.01	0.00	-0.05	0.02	0.00	-0.04	0.02	0.02	0.01	0.02	0.02	0.08	1.00					
(15)	0.05	-0.02	-0.02	-0.07	-0.01	0.00	0.04	0.04	0.03	0.12	0.05	0.10	0.04	-0.38	1.00				
(16)	-0.03	0.01	0.01	-0.03	0.01	-0.00	-0.05	-0.03	-0.01	-0.06	0.06	-0.06	-0.01	-0.32	-0.31	1.00			
(17)	0.04	0.30	0.03	0.03	-0.08	0.01	0.07	-0.03	-0.01	0.02	0.03	0.04	0.00	0.00	0.00	0.00	1.00		
(18)	0.31	-0.26	0.33	-0.05	-0.16	0.01	0.14	-0.04	0.11	-0.12	0.10	-0.04	0.07	0.00	-0.01	-0.01	0.00	1.00	

<sup>a</sup>Logged.

similar across the three specifications.<sup>14</sup> The interaction term between *product complementarity* and *high inter- and low intraproduct coordination* is significantly negative, supporting Hypothesis 2, that the negative impact of interproduct coordination on adaptation performance is aggravated when the complementarity between the underlying products is higher. In addition, the main effect of *product complementarity* is also significantly negative, showing that the underlying nature of the products themselves can lead to challenges in postshock

performance growth as a result of the coordination challenges associated with managing postshock information flows across products with inherent underlying complementarities.

Turning to our second moderator, we find that the interaction between *organizational grouping* and *high inter- and low intraproduct coordination* is significantly positive, suggesting that the negative impact of interproduct coordination on postshock performance growth is mitigated when production activities are grouped within

Downloaded from informs.org by [194.221.86.200] on 11 January 2016, at 09:21. For personal use only, all rights reserved.

**Table 3 Impact of Preshock Interdependence Patterns on Postshock Performance (Firm-Year Level of Analysis)**

Independent variable	Dependent variable: $\ln(\text{Total contract dollars})$ ; firm fixed-effects OLS estimates with robust standard errors			
	Model (3-1)	Model (3-2)	Model (3-3)	Model (3-4)
<i>High inter- and high intra-product coordination</i> × <i>Post-2001</i>		−0.403*** (0.125)	−0.414*** (0.124)	−0.713*** (0.139)
<i>High inter- and low intra-product coordination</i> × <i>Post-2001</i>		−0.821*** (0.131)	−0.759*** (0.132)	−0.857*** (0.144)
<i>Low inter- and high intra-product coordination</i> × <i>Post-2001</i>		0.005 (0.136)	0.075 (0.136)	−0.230 (0.156)
<i>Post-2001</i>	5.948*** (0.282)	5.652*** (0.311)	6.973*** (0.340)	4.542*** (0.430)
$\ln(\text{Preshock size})$ × <i>Post-2001</i>	−0.582*** (0.023)	−0.535*** (0.028)	−0.662*** (0.031)	−0.604*** (0.032)
<i>Preshock product count</i> × <i>Post-2001</i>			0.033*** (0.006)	0.035*** (0.006)
<i>Preshock customer count</i> × <i>Post-2001</i>			0.008** (0.004)	0.002 (0.004)
<i>Industry interproduct coordination (product)</i> × <i>Post-2001</i>				0.032** (0.016)
<i>Industry intraproduct coordination (product)</i> × <i>Post-2001</i>				0.175*** (0.048)
<i>Industry interproduct coordination (customer)</i> × <i>Post-2001</i>				0.007 (0.019)
<i>Industry intraproduct coordination (customer)</i> × <i>Post-2001</i>				0.222** (0.087)
<i>Positioning, high to high</i> × <i>Post-2001</i>				1.037*** (0.118)
<i>Positioning, high to low</i> × <i>Post-2001</i>				0.804*** (0.121)
<i>Positioning, low to high</i> × <i>Post-2001</i>				0.373*** (0.128)
<i>Interproduct Herfindahl</i> × <i>Post-2001</i>				0.970** (0.395)
<i>Intraproduct Herfindahl</i> × <i>Post-2001</i>				1.537** (0.633)
Firm fixed effects	Yes	Yes	Yes	Yes
Constant	9.130*** (0.019)	9.130*** (0.019)	9.130*** (0.019)	9.129*** (0.019)
No. of observations	186,397	186,397	186,397	186,397
No. of unique firms	20,215	20,215	20,215	20,215
$R^2$	0.354	0.354	0.356	0.358

Note. Robust standard errors are reported in parentheses.

\*\*\*Statistically significant at the 1% level; \*\*statistically significant at the 5% level; \*statistically significant at the 10% level.

formal organizational units, in support of Hypothesis 3. Consistent with our theoretical discussion, it is easier to coordinate product activities within formal organizational boundaries, attenuating the negative effect of *interproduct coordination*. The main effect of *organizational grouping* is also positive, suggesting that such grouping can facilitate postshock adaptation more generally.

To summarize, consistent with Hypotheses 2 and 3, we find that the negative effect of interproduct coordination is stronger when the underlying products are more tightly complementary (i.e., when the underlying interdependencies are stronger) but weaker when these

interdependent activities are grouped together. It is also interesting to note that the two moderating variables have an insignificant influence on *low inter- and high intraproduct coordination*. According to our theoretical arguments, the mechanisms represented by the two moderating variables influence postshock adaptation because coordinating production activities increases information processing needs. When such needs are reduced as in the case of intraproduct interdependence, however, the moderating variables are rendered relatively unnecessary. Thus, the differential impacts of the moderating variables on interproduct versus intraproduct coordination provide

**Table 4 Product Complementarity and Organizational Grouping (Firm-Year Level of Analysis)**

Independent variable	Dependent variable: $\ln(\text{Total contract dollars})$ ; firm fixed-effects OLS estimates with robust standard errors		
	Model (4-1)	Model (4-2)	Model (4-3)
<i>High inter- and high intra-product coordination</i> × <i>Post-2001</i>	−0.655*** (0.139)	−0.422*** (0.140)	−0.346** (0.140)
<i>High inter- and low intra-product coordination</i> × <i>Post-2001</i>	−0.243 (0.216)	−1.826*** (0.322)	−1.181*** (0.363)
<i>Low inter- and high intra-product coordination</i> × <i>Post-2001</i>	−0.402* (0.243)	0.450 (0.320)	0.274 (0.371)
<i>Product complementarity</i> × <i>Post-2001</i>	−1.368*** (0.186)		−1.512*** (0.183)
<i>Product complementarity</i> × <i>High inter- and low intra-product coordination</i> × <i>Post-2001</i>	−1.054*** (0.375)		−0.911** (0.364)
<i>Product complementarity</i> × <i>Low inter- and high intra-product coordination</i> × <i>Post-2001</i>	0.547 (0.519)		0.570 (0.510)
<i>Organizational grouping</i> × <i>Post-2001</i>		3.607*** (0.216)	3.692*** (0.215)
<i>Organizational grouping</i> × <i>High inter- and low intra-product coordination</i> × <i>Post-2001</i>		1.506*** (0.441)	1.377*** (0.439)
<i>Organizational grouping</i> × <i>Low inter- and high intra-product coordination</i> × <i>Post-2001</i>		−0.638 (0.454)	−0.625 (0.453)
<i>Post-2001</i>	5.035*** (0.433)	−0.228 (0.489)	0.222 (0.492)
$\ln(\text{Preshock size})$ × <i>Post-2001</i>	−0.570*** (0.032)	−0.411*** (0.033)	−0.373*** (0.033)
<i>Preshock product count</i> × <i>Post-2001</i>	0.033*** (0.006)	0.041*** (0.008)	0.040*** (0.007)
<i>Preshock customer count</i> × <i>Post-2001</i>	0.001 (0.004)	0.005 (0.004)	0.004 (0.004)
Industry coordination controls	Yes	Yes	Yes
Positioning controls	Yes	Yes	Yes
Herfindahl controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Constant	9.128*** (0.019)	9.127*** (0.019)	9.126*** (0.019)
No. of observations	186,397	186,397	186,397
No. of unique firms	20,215	20,215	20,215
$R^2$	0.359	0.364	0.365

Notes. Robust standard errors are reported in parentheses. Industry coordination, positioning, and Herfindahl controls are those from (3-4) and are qualitatively similar to the estimates in that specification.

\*\*\*Statistically significant at the 1% level; \*\*statistically significant at the 5% level; \*statistically significant at the 10% level.

further support for our conceptual mechanisms linking coordination and postshock adaptation.

## Discussion and Conclusion

This study examines incumbent firm adaptation to an industry-wide demand shock, focusing on the performance impact of alternative preshock organization designs. We suggest that the different coordination challenges presented by the patterning of a firm's production-related activities (bundling versus customization) can help explain heterogeneous incumbent firm adaptation to such a shock. We find

that although higher levels of interproduct coordination (product bundling) can impede postshock adaptation, such effects are not apparent for intraproduct coordination (product customization). With interproduct coordination, the effects of a demand shock cross modular product boundaries; the intraproduct coordination case, however, allows for greater decomposability, resulting in an organization more amenable to demand-side change. The two boundary conditions we examine provide further support for our theorized mechanisms: higher levels of product complementarity exacerbate the negative interproduct

coordination effect and higher levels of organizational grouping mitigate this effect. Considered together, our results support the idea that a firm's locus of coordination is an important consideration in understanding the effects of industry-wide change.

There are three sets of caveats to our analysis to note before we turn to our contributions to the literature. First, because we focus on the full universe of defense contracts over our sample period, we face the natural trade-off of being unable to collect more detailed firm-level data at this scale. We therefore utilize a within-firm empirical design to reduce concerns regarding the possible effects of such variation. Although our study takes a first step toward examining the influence of organization design on performance in the context of industry change, future studies using a subsample of firms may further examine this issue by focusing on changes to individual products or on more granular changes in interdependence.

Second, the defense industry context raises the possibility that the dynamics in other industries might differ; future studies replicating and expanding our results in other settings would thus be welcome. It should be noted, however, that defense contractors represent a broad swath of the economy (ranging from weapons manufacturers to information technology providers), lending support to the overall generalizability of our results.

Finally, because our empirical design has the beneficial feature of separating out organization design choices from firm performance (because of the exogenous nature of the shock), we are able to identify the average *between*-period effects of different design choices. We leave it to future research to examine the equally interesting question of how design choices may influence growth trajectories *within* periods: the trajectory and path of adaptation may have important nuances that provide additional color to the outlines we have sketched in this study.

### Demand-Side Shocks

One set of contributions we make with this paper is to the burgeoning body of work on demand-side change and its influence on organizational performance (e.g., Adner and Levinthal 2001, Tripsas 2008). The shock we study is one in which demand-side conditions shift, but in contrast with technology-driven change (e.g., Tushman and Anderson 1986), underlying technology conditions do not. As a consequence, production processes associated with any given product remain intact, whereas there is a shift in the composition of customer preferences with respect to heterogeneous product markets. Incumbent firms must as a consequence reconsider the direction and magnitude of resource allocation in response to these changing preferences. This is challenging because it requires reshuffling product portfolios based on opportunity costs (e.g., Levinthal and Wu 2010), managing adjustment costs in redeploying resources (e.g., Helfat and Eisenhardt 2004), and contending with conflicts across

different product areas (e.g., Christensen 1997). We offer one of the first large-sample empirical studies to examine incumbent adaptation in the face of such change. The nature of the shock—where aggregate demand expanded rather than contracted—is particularly interesting in light of the associated heterogeneity in firm performance. This heterogeneity underscores the importance of deeply analyzing the nature of the shock to understand incumbent adaptation, as postshock aggregate demand can often mask the more interesting patterns beneath the surface.

Future research might examine our findings in light of other types of external change. Although our conceptualization of a demand shock is one in which there is no change to an industry's underlying technology, the basic principles of our argument may also apply in situations where the demand shock itself is driven by changes in technology (e.g., in cases where technology shifts cause relative demand across products to change, but where the subassemblies of any particular product remain intact). In addition, future studies might examine other types of nontechnological demand changes, such as those resulting from political and regulatory decisions and altered customer complexity (Tripsas 2008), as well as outcome measures beyond adaptation performance, such as the nature of firm diversification.

### Organization Design

Another set of contributions we make relates to the literature on organization design. The use of an environmental shock allows us to understand more precisely the effects of factors such as organizational decomposability. Our study is anchored in the classic and more recent organization design literatures, touching on the notions of information flows across organizational modules (e.g., Thompson 1967), as well as the idea of predictive knowledge (e.g., Puranam et al. 2012). The link to external change reinforces the role that the formation and renewal of knowledge plays in influencing organizational adaptation to changing conditions, per Puranam et al. (2012, p. 434, italics in original), who note that “the dynamism of the environment can be related to *shocks* to the designer's architectural knowledge and/or the agents' predictive knowledge.”

Our study also sheds light on the intertemporal trade-offs of organizational activity choices (Ghemawat and Levinthal 2008). Although the interconnectedness of such choices can have positive virtues (Milgrom and Roberts 1990, Porter 1996), there can be downsides to tight coupling among activities, particularly in the context of environmental change (Siggelkow and Rivkin 2005, Ghemawat and Levinthal 2008, Puranam et al. 2012). By articulating the connection between a firm's technology and its organization, we offer a deeper understanding of the mechanisms through which this trade-off occurs. This tension is captured by the change in demand conditions we study. Between the end of the Cold War and 2001, the

defense industry was in a consolidation phase, with firms in the industry aiming to survive by creating economies of scope through tightly coupled product portfolios. Though such strategies may have been beneficial in ensuring survival in the post-Cold War period, the survivor's paradox is that when demand conditions changed, such interdependencies hindered performance growth. We unpack the locus of such hindrance, identifying the circumstances under which this can be either aggravated or mitigated.

Our empirical approach supports the contribution we make to the organization design literature. A long-recognized issue is that it is difficult to offer consistent empirical guidance on the relationship between organizational structure and performance outcomes. Siggelkow and Rivkin (2009, p. 602), for example, note that “a critical review of scores of empirical studies published when researchers' interest in this arena peaked reported a vexing array of ‘mixed, ambiguous, and near-zero associations’ between organizational structure and performance (Dalton et al. 1980, p. 61).” This point has attracted sustained interest in more recent literature (e.g., Puranam et al. 2012); we add to this conversation by exploiting an exogenous shock to tease out the influence of particular structures of product organization on firm performance.

Although our focus in this paper is at the firm level, future work could expand the scope of our findings into contexts such as alliance relations (e.g., Gulati and Singh 1998, Steensma and Corley 2000, Reuer et al. 2002), complex product systems (e.g., Ethiraj 2007, Kotha and Srikanth 2013), and product ecosystems (e.g., Schilling 2000, Adner and Kapoor 2010). Future research could also dig more deeply into issues such as division-level (Gupta and Govindarajan 1986, Birkinshaw and Lingblad 2005) and individual-level (e.g., Reagans et al. 2005, Raveendran et al. 2013) effects. Insights from different levels of analysis can likely complement each other, offering a richer understanding of environmental dynamism, organization structure, and strategic change (Rajagopalan and Spreitzer 1997, Gupta et al. 2007).

### The Locus of Coordination

Ultimately, identifying the “locus of coordination” within a firm enables us to expand our understanding of the drivers of incumbent heterogeneity in dynamic environments (Mitchell 1989, Tripsas 1997, Sosa 2013). Our contribution here is to disentangle particular types of interdependence within organizations, a construct that has often been treated as a single-dimension factor. Identifying *where* inside the organization an environmental shock hits and has effects can offer more precise predictions as to the adaptation challenges associated with ongoing environmental change. The interproduct coordination effects, combined with our moderating variable results, illustrate the situations in which coordination difficulties are most significant.

We show that coordinated changes across a range of activities are challenging when the underlying products are complementary to one another, an issue that exacerbates the reduced decomposability associated with interproduct coordination. Our results on organizational grouping show that organizational arrangements can be used to mitigate one particular form of interdependence, but not another, resonating with an important, yet understudied, early insight by Thompson (1967, p. 57, italics in original): “The question is not which criterion to use for grouping, but rather in which *priority* are the several criteria to be exercised.” He goes on to say that this is “determined by the *nature* and *location* of interdependency, which is a function of both technology and task environment” (emphasis added).

Although in the current analysis we focus only on incumbent heterogeneity, as recent research (Sosa 2013) points out, it is also important to decompose the heterogeneity of entrants and, in particular, diversifying entrants. Future research might thus examine not only the interdependencies within or across product modules but also those between diversifying entrants' previous business and new business. A finer-grained decomposition that builds on the insights we have developed here can thus enable us to better understand the origin of heterogeneous adaptation performance outcomes in the context of environmental change.

### Managerial Implications

Managerial implications flow naturally from the contributions outlined above: the importance of understanding the nature of a demand shock, the associated intertemporal trade-offs, and the importance of identifying the locus of coordination. Our results show that managers should carefully analyze the nature of demand changes. Changes of the current sort can be particularly dangerous: whereas with direct environmental threats managers would be aware of potential challenges to their competitive standing, heterogeneity in demand may be concealed by an increase in its aggregate levels, deceiving those who do not take a deeper look at the nature of the shock and heed the consequential prescriptions for managing internal interdependencies.

Although we have focused here on a single, one-time shock, as this quasi-experimental setting allows us to cleanly identify the issues around the intertemporal trade-off underpinned by the mapping between technology and organization, the insights are important as well in situations where environmental changes are more continuous. Paying attention to intertemporal trade-offs can allow managers to better predict and manage risks associated with ongoing environmental change and to then allocate attention and resources to different dimensions of adaptation following such a change in a more targeted manner. Our study is focused on incumbents, but its insights have relevance to entrants as well, offering a

deeper understanding of when and how environmental change can negatively influence industry incumbents, thereby opening up possible windows of opportunity for entry.

### Conclusion

To conclude, by more fully analyzing the implications of a demand-side shock, by identifying the intertemporal implications of the mapping between technology and organization, and by highlighting the importance of an organization's locus of coordination, we offer a theoretical perspective that sheds new light on the interrelationship between organization design and environmental conditions, and the impact of these factors on incumbent firm adaptation in the context of external change.

### Acknowledgments

The authors thank Jay Anand, Phil Anderson, Stefano Brusoni, Erwin Danneels, Kathy Eisenhardt, Henrich Greve, Phanish Puranam, Evan Rawley, Brian Silverman, Kannan Srikanth, David Waguespack, Maggie Zhou, two anonymous reviewers, participants at the Academy of Management, ACAC, DRUID, Strategic Management Society, and Midwest Strategy conferences, as well as seminar participants at Boston College, the University of Hong Kong, INSEAD, the University of Michigan, National University of Singapore, and Washington University in St. Louis, for valuable comments. The authors gratefully acknowledge the INSEAD Alumni Fund, the University of Michigan Research Initiatives Fund, and the Mack Center for Technological Innovation at the Wharton School for generous funding. Both authors contributed equally and are listed in alphabetical order.

### Endnotes

<sup>1</sup>Note that this does not imply a one-to-one correspondence between tasks (technology) and organization. Rather, we recognize the equifinality between the two constructs (e.g., Puranam et al. 2012), which is indeed the source of empirical variations in our research context. Conditional on a particular structure being chosen to carry out a set of tasks, however, the particular structure will be stable and sticky in the short run.

<sup>2</sup>It is important to acknowledge that adaptation in our context is fundamentally intertwined with selection (e.g., Levinthal 1991). What we refer to as adaptation more generally (in line with Levinthal 1997) is in practice the *joint* process of organizational adaptation and environmental selection. We do not intend to make a broader statement as to whether it is one or the other at work; rather, our use of the term “adaptation performance” throughout relates to an outcome in which both processes are likely occurring. Empirically, we control for stable managerial *ability* to adapt by using firm fixed effects; thus, whereas firms may well have differing abilities to adapt, our focus is on the effects of different types of interdependence on average postshock adaptation performance.

<sup>3</sup>As we discuss in the next section, these forms of coordination stem from the *patterns* associated with the organization of the firm's aggregate set of production-related activities. To draw an analogy to the literature using NK-modeling techniques (e.g., Levinthal 1997), we can conceptualize an organization's

aggregate level of interdependencies within the firm as the parameter  $K$ , whereas the locus of coordination might be thought of as the patterning of these  $K$  interdependencies.

<sup>4</sup>Although the type of demand shock we study is one in which there are no corresponding changes in technology, it is possible that certain types of technological changes can lead to changes in demand. This provides a boundary condition for our theory in that we are focusing on *nontechnology-driven* demand change; it also suggests a possible extension of our theory in that the basic principle of our argument may well apply under a more restrictive set of assumptions: namely, if a technology shock happens to affect the relative level of demand across different products but does not affect the subassemblies of any individual product within the broader system, the overall implications of our theory would still hold.

<sup>5</sup>We conducted a series of interviews with 11 firms in the defense industry to understand the nature of coordination within and across modules of product- and customer-related activities in such firms. The insights from these interviews are consistent with our view of product-oriented activities being at the core of the firm, with interviewees highlighting the salience of within- and across-product interdependencies. Customer-related activities were generally seen as complementary to the firm's production activities, involving actions such as introducing products to customers, and gathering information on their needs, with distinct customer-facing units generally requiring minimal cross-module coordination. Such coordination, when it did occur, was focused primarily on information sharing related to customer leads, etc. We thank an anonymous reviewer for encouraging us to examine this issue in more depth.

<sup>6</sup>Paruchuri and Ingram (2012) also examine the impact of the September 11 shock, focusing on its effects on business foundings in New York City.

<sup>7</sup>Whereas the dependent variable is time varying in our specification, the main (preshock) coordination variables are invariant with respect to the preshock period. This design allows us to address our theoretical outcome of interest: within-firm, between-period performance change. An alternative specification in which coordination variables vary year-to-year within periods, examining how coordination in any given year affects subsequent-year performance, would create econometric problems because expectations about future-year conditions would influence current-year design choices, leading to a simultaneity bias between a firm's current-year choices and its subsequent-year performance. By contrast, the current design enables us to exploit an exogenous shock to recover consistent estimates of the effect of preshock organization structure on postshock adaptation performance.

<sup>8</sup>This is analogous to the industry concentration measure used in prior literature; in our case, we can think of the distribution of interdependencies as “market shares” (e.g., in a firm with three products, which are connected to five, three, and two other products via a common customer, respectively, the products would have shares of 50%, 30%, and 20%). We apply the typical definition of a Herfindahl index to calculate the concentration measure for interproduct coordination (and use a similar measure for number of customer ties for the intraproduct coordination case).

<sup>9</sup>Our results (available upon request) are robust to alternatively using the continuous versions of these measures. We use the categorical measures in the four quadrants because this is both

consistent with our theory and enables us to explain our results more intuitively.

<sup>10</sup>The use of our quadrant-based measures is equivalent to a specification that includes the main effects and an interaction term (though the upper right quadrant coefficient does not directly map to the interaction coefficient).

<sup>11</sup>We obtain the mapping between product codes and SIC codes directly from the contracts themselves; each contract contains separate fields for these values.

<sup>12</sup>Whereas the product and customer count variables are correlated, our specifications are robust to including just one or the other. We include both to ensure that we control for as many scope correlates as possible. Another advantage of including these two variables is that they capture all potential interactions between products and customers. The correlation between interactions actually formed and these two scope variables is around 90%. We also ran an alternative model where we add a variable for actual interactions normalized by product and customer scope; results are robust and available upon request.

<sup>13</sup>For a concise discussion of our results in this section, since each of our right-hand-side (RHS) terms is an interaction with the *post-2001* dummy, when we refer to the coefficient of any of our RHS terms, we refer to it simply by the name of the main variable. For example, when we say “the effect of *pres shock size*,” we mean the *post-2001* effect associated with *pres shock size*, and we are in fact referring to the coefficient of the *pres shock size* × *post-2001* dummy interaction term.

<sup>14</sup>Comparing the effects of *high inter- and high intraproduct coordination* and *high inter- and low intraproduct coordination* in (4-1) through (4-3) involves estimating the total effect of *high inter- and low intraproduct coordination* for specific values of the moderating variables. Additionally, note that *high inter- and high intraproduct coordination* becomes smaller in specification (4-3) compared with (3-4), perhaps because the interaction between the two types of interdependences is correlated (−0.30) with *organizational grouping*. The *high inter- and high intraproduct coordination* effect is not our theoretical focus, however; its effect involves a more complex set of interactions between the two types of interdependence we study and is beyond the scope of what we study here.

## References

- Abernathy WJ, Clark KB (1985) Innovation: Mapping the winds of creative destruction. *Res. Policy* 14(1):3–22.
- Adner R, Kapoor R (2010) Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management J.* 31(3):306–333.
- Adner R, Levinthal D (2001) Demand heterogeneity and technology evolution: Implications for product and process innovation. *Management Sci.* 47(5):611–628.
- Agarwal R, Helfat CE (2009) Strategic renewal of organizations. *Organ. Sci.* 20(2):281–293.
- Anand J, Singh H (1997) Asset redeployment, acquisitions and corporate strategy in declining industries. *Strategic Management J.* 18(S1):99–118.
- Argyres NS (1995) Technology strategy, governance structure and inter-divisional coordination. *J. Econom. Behav. Organ.* 28(3):337–358.
- Baldwin CY, Clark KB (2000) *Design Rules: The Power of Modularity* (MIT Press, Cambridge, MA).
- Benner MJ (2007) The incumbent discount: Stock market categories and response to radical technological change. *Acad. Management Rev.* 32(3):703–720.
- Birkinshaw J, Lingblad M (2005) Intrafirm competition and charter evolution in the multibusiness firm. *Organ. Sci.* 16(6):674–686.
- Chatterji AK, Fabrizio K (2012) How do product users influence corporate invention? *Organ. Sci.* 23(4):971–987.
- Christensen C (1997) *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Harvard Business School Press, Boston).
- Christensen CM, Bower JL (1996) Customer power, strategic investment, and the failure of leading firms. *Strategic Management J.* 17(3):197–218.
- Colfer L, Baldwin CY (2010) The mirroring hypothesis: Theory, evidence and exceptions. HBS Working Paper 10-058, Harvard Business School, Boston.
- Dalton DR, Todor WD, Spendolini MJ, Gordon JF, Porter LW (1980) Organization structure and performance: A critical review. *Acad. Management Rev.* 5(1):49–64.
- Danneels E (2003) Tight-loose coupling with customers: The enactment of customer orientation. *Strategic Management J.* 24(6):559–576.
- Dial J, Murphy KJ (1995) Incentives, downsizing, and value creation at General Dynamics. *J. Financial Econom.* 37(3):261–314.
- Dushnitsky G, Shaver JM (2009) Limitations to interorganizational knowledge acquisition: The paradox of corporate venture capital. *Strategic Management J.* 30(10):1045–1064.
- Ethiraj SK (2007) Allocation of inventive effort in complex product systems. *Strategic Management J.* 28(6):563–584.
- Fan JPH, Lang LHP (2000) The measurement of relatedness: An application to corporate diversification. *J. Bus.* 73(4):629–660.
- Feldman MS, Pentland BT (2003) Reconceptualizing organizational routines as a source of flexibility and change. *Admin. Sci. Quart.* 48(1):94–118.
- Galbraith JR (1977) *Organization Design* (Addison-Wesley, Reading, MA).
- Ghemawat P, Levinthal D (2008) Choice interactions and business strategy. *Management Sci.* 54(9):1638–1651.
- Goyal VK, Lehn K, Racic S (2002) Growth opportunities and corporate debt policy: The case of the defense U.S. industry. *J. Financial Econom.* 64(1):35–59.
- Greene WH (2002) *Econometric Analysis* (Prentice Hall, Upper Saddle River, NJ).
- Greve HR, Goldeng E (2004) Longitudinal analysis in strategic management. Ketchen DJ Jr, Bergh DD, eds. *Research Methodology in Strategy and Management*, Vol. 1 (Elsevier, Amsterdam), 135–163.
- Gulati R, Puranam P (2009) Renewal through reorganization: The value of inconsistencies between formal and informal organization. *Organ. Sci.* 20(2):422–440.
- Gulati R, Singh H (1998) The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Admin. Sci. Quart.* 43(4):781–814.
- Gulati R, Lawrence PR, Puranam P (2005) Adaptation in vertical relationships: Beyond incentive conflict. *Strategic Management J.* 26(5):415–440.
- Gupta AK, Govindarajan V (1986) Resource sharing among SBUs: Strategic antecedents and administrative implications. *Acad. Management J.* 29(4):695–714.
- Gupta AK, Tesluk PE, Taylor MS (2007) Innovation at and across multiple levels of analysis. *Organ. Sci.* 18(6):885–897.
- Helfat CE, Eisenhardt KM (2004) Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management J.* 25(13):1217–1232.

- Henderson RM, Clark KB (1990) Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Admin. Sci. Quart.* 35(1):9–30.
- Hill CWL, Hoskisson RE (1987) Strategy and structure in the multi-product firm. *Acad. Management Rev.* 12(2):331–341.
- Khandwalla PN (1977) *The Design of Organizations* (Harcourt Brace Jovanovich, New York).
- Kotha S, Srikanth K (2013) Managing a global partnership model: Lessons from the Boeing 787 “Dreamliner” program. *Global Strategy J.* 3(1):41–66.
- Kumar MVS (2013) The costs of related diversification: The impact of the core business on the productivity of related segments. *Organ. Sci.* 24(6):1827–1846.
- Lawrence PR, Lorsch JW (1967) *Organization and Environment: Managing Differentiation and Integration* (Harvard University Press, Cambridge, MA).
- Lee GK (2009) Understanding the timing of “fast-second” entry and the relevance of capabilities in invention vs. commercialization. *Res. Policy* 38(1):86–95.
- Lenox MJ, Rockart SF, Lewin AY (2006) Interdependency, competition, and the distribution of firm and industry profits. *Management Sci.* 52(5):757–772.
- Leonard-Barton D (1992) Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management J.* 13(S1):111–125.
- Levinthal DA (1991) Organizational adaptation and environmental selection—Interrelated processes of change. *Organ. Sci.* 2(1):140–145.
- Levinthal DA (1997) Adaptation on rugged landscapes. *Management Sci.* 43(7):934–950.
- Levinthal D (2000) Organizational capabilities in complex worlds. Dosi G, Nelson RR, Winter SG, eds. *The Nature and Dynamics of Organizational Capabilities* (Oxford University Press, New York), 363–380.
- Levinthal DA, Wu B (2010) Opportunity costs and non-scale free capabilities: Profit maximization, corporate scope, and profit margins. *Strategic Management J.* 31(7):780–801.
- Madsen TL, Walker G (2007) Incumbent and entrant rivalry in a deregulated industry. *Organ. Sci.* 18(4):667–687.
- McGahan A (2004) *How Industries Evolve: Principles for Achieving and Sustaining Superior Performance* (Harvard Business School Press, Boston).
- Milgrom P, Roberts J (1990) The economics of modern manufacturing: Technology, strategy, and organization. *Amer. Econom. Rev.* 80(3):511–528.
- Mintzberg H (1979) *The Structuring of Organizations* (Prentice Hall, Englewood Cliffs, NJ).
- Mitchell W (1989) Whether and when? Probability and timing of incumbents’ entry into emerging industrial subfields. *Admin. Sci. Quart.* 34(2):208–230.
- Nadler D, Tushman ML (1997) *Competing by Design: The Power of Organizational Architecture* (Oxford University Press, New York).
- Nickerson JA, Silverman BS (2003) Why firms want to organize efficiently and what keeps them from doing so: Inappropriate governance, performance, and adaptation in a deregulated industry. *Admin. Sci. Quart.* 48(3):433–465.
- Nickerson JA, Zenger TR (2002) Being efficiently fickle: A dynamic theory of organizational choice. *Organ. Sci.* 13(5):547–566.
- Paruchuri S, Ingram P (2012) Appetite for destruction: The impact of the September 11 attacks on business founding. *Indust. Corporate Change* 21(1):127–149.
- Porter ME (1996) What is strategy? *Harvard Bus. Rev.* 74(6):61–78.
- Puranam P, Raveendran M, Knudsen T (2012) Organization design: The epistemic interdependence perspective. *Acad. Management Rev.* 37(3):419–440.
- Puranam P, Singh H, Chaudhuri S (2009) Integrating acquired capabilities: When structural integration is (un)necessary. *Organ. Sci.* 20(2):313–328.
- Rajagopalan N, Spreitzer GM (1997) Toward a theory of strategic change: A multi-lens perspective and integrative framework. *Acad. Management Rev.* 22(1):48–79.
- Rajan RG, Zingales L (1998) Financial dependence and growth. *Amer. Econom. Rev.* 88(3):559–586.
- Raveendran M, Puranam P, Warglien M (2013) The emergence of the division of labor: Evidence from the lab. Working paper, London School of Business, London.
- Rawley E (2010) Diversification, coordination costs, and organizational rigidity: Evidence from microdata. *Strategic Management J.* 31(8):873–891.
- Reagens R, Argote L, Brooks D (2005) Individual experience and experience working together: Predicting learning rates from knowing who knows what and knowing how to work together. *Management Sci.* 51(6):869–881.
- Reuer JJ, Zollo M, Singh H (2002) Post-formation dynamics in strategic alliances. *Strategic Management J.* 23(2):135–151.
- Rivkin JW, Siggelkow N (2003) Balancing search and stability: Interdependencies among elements of organizational design. *Management Sci.* 49(3):290–311.
- Sanchez R, Mahoney JT (1996) Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management J.* 17(Winter):63–76.
- Schilling MA (2000) Toward a general modular systems theory and its application to interfirm product modularity. *Academy of Management Rev.* 25(2):312–334.
- Schilling MA, Steensma HK (2001) The use of modular organizational forms: An industry-level analysis. *Acad. Management J.* 44(6):1149–1168.
- Schumpeter JA (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle* (Harvard University Press, Cambridge, MA).
- Siggelkow N, Rivkin JW (2005) Speed and search: Designing organizations for turbulence and complexity. *Organ. Sci.* 16(2):101–122.
- Siggelkow N, Rivkin JW (2009) Hiding the evidence of valid theories: How coupled search processes obscure performance differences among organizations. *Admin. Sci. Quart.* 54(4):602–634.
- Simon HA (1962) The architecture of complexity. *Proc. Amer. Philos. Soc.* 106(6):467–482.
- Simon HA (1969) *The Sciences of the Artificial* (MIT Press, Cambridge, MA).
- Sosa ML (2009) Application-specific R&D capabilities and the advantage of incumbents: Evidence from the anticancer drug market. *Management Sci.* 55(8):1409–1422.
- Sosa ML (2011) From old competence destruction to new competence access: Evidence from the comparison of two discontinuities in anticancer drug discovery. *Organ. Sci.* 22(6):1500–1516.
- Sosa ML (2013) Decoupling market incumbency from organizational prehistory: Locating the real sources of competitive advantage in R&D for radical innovation. *Strategic Management J.* 34(2):245–255.
- Sosa ME, Eppinger SD, Rowles CM (2004) The misalignment of product architecture and organizational structure in complex product development. *Management Sci.* 50(12):1674–1689.
- Srikanth K, Puranam P (2011) Integrating distributed work: Comparing task design, communication, and tacit coordination mechanisms. *Strategic Management J.* 32(8):849–875.

- Steensma HK, Corley KG (2000) On the performance of technology-sourcing partnerships: The interaction between partner interdependence and technology attributes. *Acad. Management J.* 43(6):1045–1067.
- Teece DJ (1982) Towards an economic theory of the multiproduct firm. *J. Econom. Behav. Organ.* 3(1):39–63.
- Teece DJ (1986) Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Res. Policy* 15(6):285–305.
- Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. *Strategic Management J.* 18(7):509–533.
- Thompson JD (1967) *Organizations in Action* (McGraw-Hill, New York).
- Tripsas M (1997) Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry. *Strategic Management J.* 18(S1):119–142.
- Tripsas M (2008) Customer preference discontinuities: A trigger for radical technological change. *Managerial Decision Econom.* 29(2–3):79–97.
- Tushman ML, Anderson P (1986) Technological discontinuities and organizational environments. *Admin. Sci. Quart.* 31(3):439–465.
- Tushman ML, Nadler DA (1978) Information processing as an integrating concept in organizational design. *Acad. Management Rev.* 3(3):613–624.
- Ye G, Priem RL, Alshwer AA (2012) Achieving demand-side synergy from strategic diversification: How combining mundane assets can leverage consumer utilities. *Organ. Sci.* 23(1):207–224.
- Zhou YM (2011) Synergy, coordination costs, and diversification choices. *Strategic Management J.* 32(6):624–639.

---

**Vikas A. Aggarwal** is an assistant professor of entrepreneurship and family enterprise at INSEAD. He received his Ph.D. from the Wharton School at the University of Pennsylvania. His research examines issues of strategy, innovation, and organization design in dynamic and entrepreneurial settings.

**Brian Wu** is an assistant professor of strategy at the University of Michigan's Ross School of Business. He received his Ph.D. from the Wharton School at the University of Pennsylvania. His research examines the role of firm capabilities in influencing the dynamics of corporate scope and the evolution of industries.