DELEGATION IN MULTI-ESTABLISHMENT FIRMS:

THE ORGANIZATIONAL STRUCTURE OF I.T. PURCHASING AUTHORITY

by

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CES 10-35 October, 2010

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Abstract

A rare large-scale empirical study of delegation within firms, this paper investigates how decision rights over information technology investments are allocated within multi-establishment firms. The core results indicate that a relatively high contribution to firm sales is highly correlated with authority being delegated to the local establishment. Firm-wide operational complexity and local information advantages are also associated with local discretion for IT purchases. Certain IT investments are also positively correlated with delegation. On the other hand, significant operational interdependencies evince a positive correlation with centralization, as do productive similarities among establishments. Surprisingly, absolute size of the firm and having a large IT budget are also correlated with centralized IT decision-making. With the exception of these latter effects, the results are consistent with models of organizational design that predict delegation where there is great demand for locally adapted choices and centralization where firm-wide coordination is most important. The findings document and make sense of widespread heterogeneity in decision rights across a range of firm and industry settings – even among establishments belonging to the same parent firm. Finally, they suggest important considerations for future empirical and theoretical research into the determinants of delegation.

JEL classifications: L23, D23, M15

* Thanks are due to Niko Matouschek, Bob Gibbons, Oliver Hart, Shane Greenstein, Scott Stern, and Andrew King for invaluable comments and to Guy Arie for superior research assistance. This work benefitted greatly from feedback provided in the Harvard/MIT Organizational Economics seminar, the NBER Productivity Lunch, and the HBS TOM unit seminar. Any opinions and conclusions expressed herein are those of the author and do not necessarily represent the view of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. Support for this research from the NSF (awards no. SES-0004335 and ITR-0427889) and the Census Bureau's Dissertation Fellowship program is also gratefully acknowledged. All errors remain my own.

1. Introduction

The economic significance of information technology (IT) in the modern economy is difficult to overstate. One-half of all equipment investment by U.S. businesses is in information processing equipment and software, which amounted to over $522 billion in 2009 even in the midst of recession (BEA 2009). This figure was nearly $563B in 2008.

Yet it is not clear that firms consistently reap the expected value of these investments. [1] Industry experts point to a lack of centralized control and coordination of firm-wide IT purchases that has historically led to high complexity and ever-growing costs of technology ownership. An instructive example is provided by IBM in the late 1990s, which had 125 separate data centers worldwide with 128 CIOs, 31 private and separate networks, as well as hundreds of different configurations of PC installations. Data processing costs were a dramatic three times the industry average (Austin and Nolan 2000).[2] On the other hand, evidence suggests that unwieldy enterprise solutions often fail to address the range of needs within multi-divisional firms, compelling them to adapt their processes to the technology, or vice versa – often at the expense of the overall success of the project (Hong and Kim 2002). In short, both the decentralized and centralized approaches to investing in information technology entail costs and benefits that firms must trade off in determining what best fits with their operations and business strategy.

The difficulty in making this determination arises from a deep tension between adaptation and coordination in making IT purchasing decisions. How to achieve IT that is responsive to local needs while ensuring maximum coordination throughout the entire firm? Depending on where authority rests for making the purchases, the balance is likely to tip in favor of local adaptation over global coordination – or vice versa. However, no authority structure is likely to promote both objectives equally.

[1] Failures of technology implementations in firms have been estimated to run between 40 and 75 percent (Griffith, Zammuto and Aiman-Smith 1999).

[2] An extreme example of the costs that can arise from IT coordination failures comes from the two-year delay in the development of Airbus' A380 megajet due to incompatible versions of the company's CATIA design software at its Toulouse and Hamburg plants. Costing $6.1 billion in lost profits, it has been deemed "one of the costliest blunders in the history of commercial aerospace" (*Businessweek*, October 5, 2006).

This tension reflects the fundamental organizational challenge of devising structures that support specialized yet interdependent functions within the firm (Hayek 1945, Lawrence and Lorsch 1967, Becker and Murphy 1992, Hart and Moore 2005, *inter alia*). A rich theoretical literature in the economics of organizations addresses this challenge from a variety of perspectives (see Gibbons and Roberts forthcoming). In particular, there are an increasing number of influential works that explore the tradeoff between adaptation and coordination in team-theory models of organizational design. However there as yet exists no empirical evidence supporting or challenging the usefulness of this framework in practice.

This paper addresses this gap with large-scale empirical evidence of how the adaptation-coordination tradeoff plays out in the setting of IT systems purchasing authority. Using a rich data set on IT purchasing decision rights matched with U.S. Census data, I estimate the determinants of local discretion for IT investments. I use these estimates to test a series of propositions about how demands for adaptation and coordination influence delegation within multi-establishment firms.

According to insights from team theory models that transfer readily to the IT purchasing setting, delegation should be more likely when the value of adaptation at a given establishment is quite high. It should also be more likely in instances when communication will be less effective in achieving well-adapted IT choices – for instance, if complexity and/or information asymmetries within the firm are high. In contrast, centralization is expected when the value of coordination within the firm is greater, for example when there is a high value of interdependent production within the firm or economies of scale in purchasing. Existing IT investments within the firm also ought to have an effect on delegation, though the only unambiguous prediction relates to "co-invention" costs within the firm: sites with more legacy or idiosyncratic technology environments will be more likely to have their own purchasing authority, all else equal.

The empirical results – based on roughly 6,700 establishments belonging to more than 3,000 firms throughout the U.S. manufacturing sector – largely support these propositions. At establishments with relatively large contributions to firm sales – i.e., where locally optimal decisions will contribute most to overall firm value– the likelihood of delegation is quite high. However, establishments that belong to

operationally more diverse firms (which hence must contend with greater complexity in IT decision-making) are also more likely to have discretion. Similarly for establishments that operate outside the mainstream of their parent firm, consistent with information asymmetries favoring delegation to local managers. On the other hand, where firm-wide coordination is important, for instance, among firms with a great deal of operational interdependency, centralization is more likely. Economies of scale in the number of establishments can promote centralization, particularly when there is considerable homogeneity amongst them. In fact, the number of establishments and the diversity of establishments have significant and opposing impacts on the likelihood of delegation. Finally the impact of other IT investments at the establishment and within the firm is also significant: greater prevalence of internet technology boosts the likelihood of delegation, as does a highly idiosyncratic local IT environment.

While the empirical results are largely consistent with expectations arising from both theory and qualitative evidence, they nevertheless offer a couple of surprises. Contrary to common models that conceptualize the firm as an information-processing entity, the absolute size of the firm has a large negative correlation with on the likelihood of delegation. Contrary to common intuition, the likelihood of delegation is highest amongst establishments with the largest budgets.

This paper's findings have significant implications for our understanding of how decision rights are allocated in multi-divisional firms. Despite meaningful variation amongst industries in the likelihood of delegation, the core findings cut across industry lines: demands for adaptation and coordination have significant impacts on how firms allocate decision rights in practice. This paper represents the first set of stylized facts related to this phenomenon. In addition, the overall pattern of results demonstrates the importance of a comprehensive approach to the question: the demand for adaptation and the demand for coordination need to be considered together. Omitting or confounding any of these or other key factors can significantly bias the empirical results. And, finally these nuanced and conflicting needs within the firm prove to be highly context-specific: detailed knowledge of the operational (and in this case, technological) setting may be essential for forming expectations about a firm's organizational structure.

To date, data limitations have hindered large-scale empirical research into the determinants of delegation within firms. Evidence has been limited primarily to case-studies and single-industry analyses.[3] Notable exceptions include a widely-cited paper by Bresnahan, Brynjolfsson, and Hitt (2002) and a related paper by Caroli and Van Reenen (2001) which report evidence of complementarities between innovative organizational practices (which include increased delegation, among others), information technology, and skilled labor. Colombo and Delmastro (2004) find evidence that local informational advantages are associated with delegation among 438 Italian metalworking plants, but that the effect disappears in the presence of modern communication technology. Rajan and Wulf (2006) document a trend towards flatter hierarchies between 1986 and 1999. Acemoglu et al. (2007) find a positive correlation between certain types of local information advantages and organization into profit centers – their measure of decentralization. Bloom, Sadun, et al. (2009) explore empirical correlates of delegation across different countries. Graham et al. (2010) investigate decision rights for the allocation of capital within firms.

This study supplements and extends prior work by overcoming many common data constraints. Combining comprehensive operational data on all manufacturing establishments in the United States with a large proprietary data set containing a narrow – but clearly defined – measure of authority offers useful advantages. First, it makes it possible to document the significance and magnitude of theoretically important but heretofore unmeasured constructs such as the economic value of internal coordination. It also permits the construction and investigation of novel explanatory variables such as the relative economic importance of an establishment. Finally, it makes it possible to disentangle influences that are easily confounded (e.g., different drivers of "complexity") and to control for important sources of unobserved heterogeneity.

[3] Ichniowski and Shaw (1999 & 2003) co-authors (1997, 2007) analyze the adoption of innovative human resource management practices, including decentralized problem-solving, in steel finishing production and steel minimills. Hubbard (2000) studies how the use of on-board computers influences agency costs – and, potentially, delegation – in the U.S. trucking industry. Garicano and Hubbard (2007 & 2008) examine specialization and hierarchies in law firms.

The remainder of the paper is organized as follows. Section 2 develops the core empirical propositions and relates them to the existing literature. Section 3 describes the data, while section 4 presents the econometric model. The results are discussed in section 5. Section 6 concludes.

2. Adaptation and Coordination in IT Systems Purchasing Decisions

Selecting IT systems for dispersed manufacturing firms involves a fundamental tradeoff between adaptation and coordination. The modern multi-divisional firm makes a range of products for different markets, employing a commensurate variety of technologies and business processes. For example, among those with at least five manufacturing establishments, the average firm has 10 establishments with different primary product classifications and multiple types of computer software, hardware, and peripheral equipment. Nevertheless, important firm activities from accounting and financial reporting to production and strategic planning require an integrated view of the entire firm.

2.1 Demand for Adaptation

Production sites making different products, selling to different customers, and purchasing from different suppliers will typically have very different IT needs, because the data objects and process flow they are looking to support will be different. For example, a site selling to automotive manufacturers will need to center on electronic data interchange (EDI) transactions for order execution and payment. However, a chemical manufacturer will rely on solutions with a strong engineering focus to help formulate a product for a particular use (Woods and Swanton 2010). As a result, IT solutions can vary widely by industry and business function. This was particularly true in the late 1990s, when there existed a greater proliferation of software vendors, many of whom were still anchored to early successes with tailored “best-of-breed” solutions for particular industries (e.g., chemicals, consumer packaged goods, automotive, electronics, medical devices, etc.) or business functions (e.g., accounting, customer

relationship management, production planning and scheduling, etc.).[4] Being well-adapted in the context of information technology systems means selecting solutions from this wide variety of IT options that fit closely with the data and workflow requirements of the local site.

Making well-adapted IT decisions typically involves a thorough understanding of the local site's business needs. What core processes does the technology need to support? How do the potential users think about the information they need to capture and manage? How much training will be required to bring local users up to speed on a system? Will the solutions they already use and understand interface smoothly with the new technology? Will changes in local processes be necessary? Answering these questions requires deep industry knowledge, familiarity with local production processes and employee skills, as well as awareness of the existing local IT infrastructure. Intimacy with legacy systems may be particularly important, because these often need to interact with new IT investments but may be poorly documented and/or highly idiosyncratic to the local organization. This detailed local knowledge is widely recognized to be the domain of local IT managers who are steeped in the day-to-day operations of their establishments and their existing technology environments.

In addition to being the most able, local managers tend to have the best incentives to choose solutions that fit well in their local environments. They are the ones responsible for managing the technology's daily functioning and have as their main stakeholders the production managers who oversee local processes and employees. If an IT system is a poor fit for what local users would like to do, local IT managers will be the first to hear complaints or engineer work-arounds. Thus, they tend to have strong preferences for systems that are closely configured to the routine tasks of their site's workers and they are the most responsive when local IT needs change.

Thus, one mechanism for achieving a high level of IT adaptation within a multi-establishment firm is to delegate IT purchasing authority to these local managers. This ensures that the IT choices will be made by those with the best information and the best motivation to remain informed about local needs.

[4] An AMR report from the time states: "No one system fits all industries or geographies. Each is unique, with functions or additional applications available to support various legal requirements and business practices." (AMR Outlook for Enterprise Applications, January 1, 1999)

This is consistent with models in organizational economics where delegation increases efficiency by co-locating decision rights with specific local knowledge (Jensen and Meckling 1992) or where proximity to local business environments conveys useful information advantages (Dessein, 2002; Acemoglu et al., 2007). It also fits with principal-agent models addressing worker motivation, where delegation improves the incentives of employees to gather the best information (Aghion and Tirole, 1997).

2.2 Demand for Coordination

The cost of delegating authority, however, is typically a reduced level of coordination throughout the firm. Coordination in the IT systems context means ensuring that hardware and software applications interact seamlessly throughout all of the firm's establishments. Coordination can theoretically be achieved with widely diverse IT systems, provided sufficient commonality in data definitions and appropriate application program interfaces (APIs) are in place. However, this ex-post integration of incompatible IT solutions is costly[5] and difficult to maintain as the IT innovation cycle shrinks (*CIO Magazine*, November 26, 2007). As a practical matter, therefore, coordination in this context typically means using a single IT solution throughout the firm, even at the expense of "best-of-breed" functionality.

Centralizing control for IT purchases at headquarters is the primary mechanism for choosing and enforcing these unified systems. Central managers have a global view of the firm, making it easier to keep new IT investments in line with overall firm strategy and monitor firm-wide return on IT investment. Also, CIOs typically bear the cost and responsibility of maintaining integration layers between incompatible systems and ensuring interoperability between different units within the firm. Given these incentives, they are unsurprisingly and overwhelmingly in favor of interoperability (Cameron 2010). Thus, central IT managers have both the information and incentives to impose coordination (sometimes at

[5] According to CIO Magazine, the largest 3,500 firms were expected to spend an average of $6.4 million in 2003 alone on systems integration.

the cost of adaptation) throughout the firm as a whole. This is consistent with team theory frameworks that model the importance of coordination within the firm (Dessein and Santos 2006; Rantakari 2008).

2.3 Adaptation vs. Coordination in a Team Theory Model

This tension between local adaptation and firm-wide coordination that emerges from industry descriptions and anecdotes is consistent with many team theory models of organizational design.[6] This style of model highlights the role of information-processing and communication costs in determining organizational structure. In this stream of research, principals who are boundedly rational (Simon 1957; March and Simon 1958; Williamson 1967) are expected delegate in order to improve the quality and/or timeliness of decisions when there is a high volume of decision-relevant information. However, delegation can entail significant vertical and/or horizontal coordination costs within the firm.[7]

A rich team-theory model exploring the details of how adaptation and coordination might determine decision rights within firms is beyond the scope of this paper. However, a simple example based on common team theory models provides useful structure for the qualitative evidence and crystallizes the essential intuition for the propositions to follow.

Consider a stylized firm consisting of two establishments and a headquarters. Denote local conditions at establishment $i, i \in \{1,2\}$ by θ_i ($\theta_i \in \Re \ \forall i$) and the information technology decision for establishment i as d_i. Total firm value is a function of how well-adapted the IT decision is to local conditions at each establishment $i, (d_i - \theta_i)^2$, as well as the value of adaptation at that establishment, α_i. It also depends on how well-coordinated the IT decisions are across establishments, $(d_1 - d_2)^2$, as well as the firm-wide value of coordination, γ. Firm value is thus expressed by:

[6] The extensive team-theory literature is anchored by contributions from Marschak and Radner (1972); Radner (1992 & 1993); Bolton and Dewatripont (1994); and Van Zandt (1999b).Van Zandt (1999a) provides a comprehensive review.

[7] Another stream in the literature on delegation downplays informational costs to focus on the incentive-based tradeoffs of delegation. In this agency-oriented style of model, delegation improves managers' motivation but results in a potentially costly loss of control if agents' incentives are not aligned with those of the principals. Mookherjee (2006) provides an excellent review grounded in the mechanism design perspective. See Eisenhardt (1989) for an analogous treatment of these issues in the management literature.

$$\pi = K - \alpha_1(d_1 - \theta_1)^2 - \alpha_2(d_2 - \theta_2)^2 - \gamma(d_1 - d_2)^2 \quad (1)$$

Where K represents the maximum profit the firm can realize.

Under delegation, the local manager at establishment *i* has decision rights over d_i. The firm could be completely delegated (both managers have local discretion), or partially so (where one manager has local discretion while the other is subject to centralized authority). It is public knowledge that θ_i is drawn independently from distributions with mean θ_i^0 for *i* = 1, 2. Local managers observe their local conditions θ_i but have no precise information about local conditions at the other establishment, $\theta_{\sim i}$.

One way to acquire this information might be through intra-firm communication. Recent models of this type (e.g., (Dessein and Santos 2006); (Dewatripont 2006); (Alonso, Dessein and Matouschek 2008) typically go on to model the communication game that takes place within the firm to exchange information about $\theta_{\sim i}$. Communication will be deferred to later in this section, however, to maintain simplicity.

Under complete centralization, the central manager chooses both d_1 and d_2.Under partial centralization, headquarters chooses for the establishment that does not have its own decision rights. While unable to observe θ_i directly, the central manager knows their distributions and can form expectations over the mean local conditions θ_i^0. She also observes decisions taken under partial delegation.

Simple inspection of (1) suggests that delegation, which permits a tight correlation between d_i and θ_i will increase overall firm value in situations where α_i – the value of local adaptation – is relatively high compared to γ. If α_i is quite high but $\alpha_{\sim i}$ quite small, partial delegation only to the prior

establishment makes economic sense. Delegation may come, however, at the cost of a greater difference between d_1 and d_2 – i.e., at the cost of reduced coordination.[8]

In contrast, centralization will reduce (or even eliminate) the difference between d_1 and d_2. This will be favorable to the overall firm when γ – the importance of coordination – is relatively high. However, the central manager will be making d_1 and d_2 based on imperfect information about local conditions, possibly resulting in adaptation failures at one or both sites. This adaptation loss will be greatest at establishments whose local conditions deviate the most from expectation (i.e., when $(\theta_i - \theta_i^0)$ is greatest) and/or where the value of adaptation (α_i) is highest.

Communication: Its Role and Limitations

In addition to delegation, another potential mechanism for achieving good adaptation throughout the firm is communication.[9] Local managers know best what is needed at their individual establishments (i.e., they observe θ_i), but instead of making the choices themselves, they might communicate those needs to decision-makers at headquarters. This approach has the advantage of putting decision rights at the center, which may permit better overall coordination, as well. If one were to layer a very simple communication structure on the example in (1), this would result in the obvious prediction that firms should centralize decision making authority and communicate freely about the local conditions, θ_i .Then it would be possible to optimally balance adaptation and coordination needs using centralized decision-making.

However, the tradeoff in both practice and theory is that centralized managers typically have some limitation on their ability to interpret or respond to information communicated by local managers. In

[8] Rantakari (2008) considers the possibility of directional authority, where one establishment can decide both for itself and for another establishment. However, this organizational structure is not present in this particular context.
[9] Alonso, Dessein and Matouschek (2009) take the complementary view, i.e., that *coordination* is possible using communication in lieu of centralized control. This work, as well as that by Rantakari (2009) suggest that when the value of coordination is either quite low or quite high, delegation will be most efficient (i.e., the likelihood of delegation is non-monotone in the importance of coordination).

the framework of our example, they are unable to fully know θ_i, even when a message about it is sent to them; or, they perceive all of the θ_i information and yet are unable to select d_i in a way that is sufficiently aligned for one or more establishments. Thus, a more realistic treatment of communication within the firm reinstates the adaptation losses arising from centralization.

In practice, the most commonly cited communication failures within the firm boil down to "information overload" and what can best e described as a limited "receptivity" of headquarters to idiosyncratic local demands. CIOs and other central IT managers consistently report trouble navigating fluid business needs and accelerating technology innovation. Industry observers refer to "Moore's Flaw" – wordplay on the more famous "Moore's Law" predicting exponential increases in computing power – stating that "keeping up with this floodtide of innovation quickly becomes too difficult (and too costly) for anyone to manage" (*CIO Magazine*, November 26, 2007). This is in addition to a daily deluge of incoming e-mail messages about software and hardware malfunctions throughout the firm that require immediate attention.

This is consistent with the notion in organization theory that managers are boundedly rational – i.e., they cannot receive, process, and optimize an unlimited stream of information and options. Thus, even when communication within the firm is accurate and contains all of the relevant information, the difficulty of processing all of the incoming data imposes limitations on the ability of centralized authorities to make optimal decisions for all of the establishments within the firm. The problem grows as complexity increases. The common solution – in both practice and theory (e.g., Marshak and Radner 1972, Radner 1993, Bolton and Dewatripont 1994, van Zandt 1999b) – is to delegate decision-making authority away from the center.

Another justification for delegation is that centralized managers have a strong information disadvantage, making the communication of all decision-relevant information either impossible or extremely costly. In practice, local managers – particularly of relatively specialized processes – complain that their particular IT needs are often unfamiliar and/or undervalued at headquarters. Central managers

are not receptive to requests that lie outside what is considered mainstream for the firm. Local managers do not get the IT they feel they need to meet local demands, or else they exaggerate what they ask for in expectation that they will only be met part-way. Alternatively, they often invest heavily in educating and lobbying senior managers in support of their requests.

The notions that communication might have imperfect information content or simply be quite costly are consistent with a number of theories focused on limitations to communication such as constraints on the message space (e.g., Melumad et al., 1992 & 1997), strategic sharing of information (Dessein 2002; Alonso et al. 2008), and costly communication (Dewatripont 2006). It also makes sense in light of prior research suggesting that problem-solving knowledge within the firm tends to be "sticky" (von Hippel, 1994), granting strong information advantages to local managers that are difficult to transfer to the center. This difficulty in exchanging information is attributable to a variety of mechanisms including the development of tacit knowledge (Polanyi, 1958) or the need to be already deeply familiar with a specific technology before finding solutions to its problems (Rosenberg, 1982).

2.4 Testable Propositions

Combining the qualitative evidence and theory together suggests that delegation of IT systems purchasing authority will be promoted by factors that increase the value of adaptation within the firm or reduce the effectiveness of communication in achieving it. On the other hand, factors that increase the value of firm-wide coordination will promote centralization of these decision rights. The remainder of this section identifies circumstances when these various factors are most likely to hold sway and formulates associated propositions that can be brought to the data.

High Value of Adaptation

The value of adaptation at a given establishment will be highest when the costs of mis-adaptation at that location have the most severe consequences for the firm as a whole. Consider that these costs could be either variable or fixed. If the costs of a poor IT choice for a particular site manifest at the level of individual processes or transactions (i.e., if costs are variable) then the overall penalty to the firm will be a function of that site's volume of activities. If adaptation costs are instead fixed, for instance if a one-time investment is required to integrate a new purchase with existing legacy systems, we would still expect the magnitude of that fixed cost to be highest at establishments with the greatest volume of activity because more systems are likely to be involved. Thus, in both cases, the value of a high level of adaptation in IT choices will be greatest at establishments that contribute disproportionately to total firm value.

In the context of the team-theory example provided above, this equates to a large value for α_i relative to γ in (1). Importantly, however, because firms of different absolute sizes can withstand different levels of absolute mis-adaptation costs, the relevant empirical measure will be the importance of a given establishment relative to total revenues or profits. Thus, <u>the likelihood of delegated IT systems purchasing authority ought to be highest amongst establishments with the greatest relative contribution to overall firm value.</u>

Existing theoretical models typically do not focus on the relative value of an establishment in driving the likelihood of delegation.[10] However, anecdotal evidence is strong that relatively important divisions within companies tend to have more discretion in their IT systems purchasing decisions. While this is often ascribed by observers to a vague notion of the "power" these managers wield within the firm, this paper advances a precise and economics-based explanation for the enhanced influence.

[10] A possible exception is Rantakari (2008), where division size influences the optimal allocation of discretion. Although whether absolute or relative size is the salient characteristic in his framework is unclear.

Complexity

Complexity hampers the reception and processing of communication and contributes to information overload at the center, with the effect of tipping the firm towards delegation. A first-order driver of complexity in both business needs and existing IT infrastructure is diversity in a firm's operations. Insofar as different establishments within the firm pursue fundamentally different lines of business – with different production processes, supply chains and customers – they will have more diverse needs as well as a wider variety of existing IT systems and technology environments. A central manager trying to select IT solutions to adapt to this diversity of contexts will face a far more challenging optimization problem than one whose firm specializes in one or two types of production. Thus, establishments belonging to firms with a greater degree of operational diversity ought to be far more likely to have some local discretion for IT purchases.

Local Information Advantage

If communication is imperfect or hampered by existing information asymmetries within the firm, then assigning decision rights to the party with superior information is essential. Thus we would expect the likelihood of delegation to be highest where information advantages of an establishment are greatest vis-à-vis the center. While it is typical for local managers have better information about day-to-day business needs than those at headquarters, a circumstance that dramatically increases their relative information advantage is when a plant is doing something that is unique or unusual in the context of the rest of the firm. In this case, central managers will tend to have less familiarity with or receptivity to particular local needs, decreasing the effectiveness of communication and increasing the adaptation losses at that site.

A relevant indicator of idiosyncratic production activities is whether the plant produces the same types of products that are found throughout the rest of the firm. We would expect establishments operating outside the main product focus of the firm to have a higher likelihood of delegated IT purchasing authority.

High Value of Coordination

The balance will tend to shift away from delegation, however, when high levels of IT coordination are demanded within the firm. An important example unaddressed in prior work of when this will occur is when production processes at different locales are interdependent. This is because efficiency in production demands tight coordination of goods and schedules across disparate plants. This operational coordination, in turn, depends on widespread, reliable, and timely exchange of production information throughout the firm – i.e., it depends on firm-wide IT coordination.

The value of this coordination to the firm will be a function of the value of interdependent production. Thus, the proposition logically follows that a high value of interdependent production within the firm will increase the value of IT coordination and thereby increase the likelihood of centralization of IT purchasing, all else equal.

Economies of Scale

Another reason emphasized by industry observers for a firm to centralize information systems purchases is economies of scale. In particular, following a "one-solution-fits-all" strategy tends to reduce the per-establishment costs of both evaluating IT solutions and purchasing software licenses. However, this will work best when there is sufficient similarity among sites. In this particular situation, the process of matching IT to an establishment's business requirements can be done once and done *effectively* for all of them. In contrast, with a greater diversity of activities, a large number of establishments may be sufficient to generate some scale economies, but the mis-adaptation costs will also rise (as discussed).

This leads to the proposition that a large number of *homogeneous* establishments will have a positive correlation with centralization. The predicted relationship between centralization and the sheer number of establishments at the firm is somewhat more ambiguous. Some economies of scale may result, also promoting centralization. However, operational complexity and mis-adaptation costs might rise, too not to mention the increased information volume communication costs that might ensue to favor

decentralized decision-making. Thus, the net effect of having numerous establishments within the firm is ultimately an empirical question.

Existing Information and Communication Technology

In the late 1990s, at the time of this study, firms already had a wide range of information technology systems in place. This is relevant to the allocation of IT systems purchasing authority for two reasons. The first is that advanced IT systems have a first-order impact on the costs of exchanging information within the firm. Newly diffusing internet connectivity, in particular, dramatically reduced the cost of transferring large quantities of real-time data anywhere in the world.

A common prediction in the team-theory literature is that increased information-processing or communication costs will promote delegation. However, the converse may not be true. Reduced communication costs need not promote centralization if the driver of reduced communication costs is modern information technology. While IT can increase information flowing to the center, thereby enhancing centralized decision-making, it might also improve decentralized coordination (Marshak 2004) or improve monitoring of local managers with decision rights (Hubbard 2000), thereby promoting delegation. Which effect applies (or dominates, in the event that they both do) is an empirical question. The relationship between IT purchasing delegation and modern information and communication technologies such as the internet, therefore, is ambiguous.

The second reason to consider the effect of existing IT investments on delegation in this context is the role they play in enhancing local advantages for selecting well-adapted IT systems. Not only do local managers have the best information about existing legacy systems, but they have the wherewithal to ensure the best return on those IT investments. Prior work by Bresnahan and Greenstein (1996) emphasizes the role of “co-invention” in determining IT adoption: existing IT, business processes, and new IT investments must come together in a costly and uncertain process of innovation and co-evolution that requires significant investment and risk, particular for the most technologically complex and sophisticated establishments.

At the time of the study, a wide range of legacy and proprietary IT systems were in place throughout American manufacturing. First- and second generation manufacturing resource planning (MRP) systems were deeply embedded in production processes yet notoriously difficult to integrate with modern scheduling and accounting systems. Establishments had developed their own proprietary systems that did not always comply with modern standards. Even relatively modern and standard-compliant systems may have been heavily configured by local programmers to support specific business needs. Factors such as this will tend to increase the co-invention required to effectively deploy new IT systems. Thus, increased co-invention costs will tend to enhance the benefits of placing the decision (and implementation) authority in the hands of local IT managers.

3. Data and Descriptive Statistics

The data for this study were derived by combining records from the Harte Hanks Market Intelligence CI database (hereafter HH) and the 1997 U.S. Census of Manufactures (hereafter CMF). Combining disparate data sets comes at the cost of many observations but leaves a sizeable (roughly 7,700 establishments) matched data set with extraordinarily rich information on plants and firms in the U.S. Manufacturing sector.[11]

The sampling unit across all data sets is a single plant, or "establishment." This is extremely useful for testing propositions that speak to the likelihood of delegation at particular establishments and a conceptual framework that does not treat decentralization as an all-or-nothing proposition for the firm.

The HH data set comprises commercial establishments with over 100 employees surveyed between June of 1996 and December of 1998. The raw data set contains over 116,000 sites located throughout the United States, roughly 30% of which are classified as being in manufacturing industries. The primary dependent variable for this study, IT systems purchasing discretion, comes from this source, which identifies the level of the organization with authority for IT systems purchasing, as well as contact information for the individual or department with those decision rights.

[11] Additional information on the matched data set, including how it was derived and how the sample distribution relates to those of the parent data sets, is available from the author upon request.

It is worth noting that the purpose of the HH data set is to help vendors of information technology identify potential customers. As a result, the quality of information on the locus of IT systems purchasing authority is essential to Harte Hank's value proposition, granting the firm collecting this essential piece of data a strong incentive to keep it as accurate and updated as possible.

Almost all of the other plant, firm, and market characteristics used in this study come from the 1997 CMF. This survey, conducted every five years by federal statute, collects detailed plant-level data on production inputs, inventory, revenues, and the like. Because it covers the entire population of over 370,000 manufacturing plants, characteristics of each establishment's parent firm and market environment can be accurately derived from this source.

3.1 Dependent Variable

In the economic theory literature, delegation is generally taken to mean broad authority to make operational and financial decisions for the firm. In practice, there are a number of different activities that can be centrally controlled – or not – within the firm. Colombo and Delmastro (2004) investigate different degrees of discretion over a variety of activities from workforce and labor decisions to capital acquisition and new technology introduction. Acemoglu et al. (2007) define delegation as a firm being organized into cost centers.

In the context of this paper, discretion is very precisely defined: the survey reports whether non-PC computer systems purchasing authority is assigned to the local plant or to its corporate parent.[12] This type of discretion is quite common: over 93% of manufacturing firms in the master (i.e., pre-matched) HH data set have at least one non-headquarters establishment with local purchasing discretion. The average likelihood of delegated authority is 66%.

However, discretion is not an all-or-nothing choice for firms with many establishments. Figures 1 and 2 illustrate the heterogeneity in discretion among firms by graphing the percentage of sites within

[12] In this data set, there is no "directional authority" (Rantakari, 2008) in which IT investment decisions at one site are assigned to a different, non-headquarters site within the firm.

multi-establishment firms that have localized decision rights. For firms with more than 10 sites, 90% of firms fall within the 15% to 84% range.

This heterogeneity motivates the central question of this paper: why do certain establishments have discretion and others do not – even among plants belonging to the same parent firm or to the same industry? Answering this question, however, poses a nontrivial data challenge. Many of the key determinants of delegation mentioned by industry observers or presented in the theoretical literature are difficult to measure, costly to acquire in large numbers, and easy to confound (e.g., different measures of size and complexity). This study takes advantage of the detailed and comprehensive data collected by the U.S. Census Bureau to make progress on a few fronts.

3.2 Explanatory Variables

A central advantage of using Census data is the ability to accurately characterize the overall firm in which a given establishment operates, even if decision rights are only observed for a small subset of the firm's plants.[13] This makes it possible to capture important – but heretofore novel – effects such as the *relative* importance of an establishment within the firm (as opposed to its absolute size or sales).

The range and number of productive activities within the firm can also be observed, making it possible to flag those establishments that lie primarily outside the main product category for the firm, as well as to differentiate between the number and the diversity of productive units that comprise the parent enterprise. In this fashion, specific influences on decision rights allocation can be separately estimated and disentangled.

In addition, the Census survey requires that firms estimate the value of goods and services that are transferred to other establishments within the same firm. This is useful for testing the proposition that the need for centralized authority over IT purchasing ought to be highest among firms where the value of within-firm transactions is highest. While the characteristics of transactions within the firm boundary are

[13] This stands in contrast to prior work (e.g., Bloom, Sadun, et al. 2009), that, due to data limitations, must make the assumption that plants in the sampling frame are representative of the firm as a whole. This proves to be a somewhat strong assumption in light of the significant within-firm variation I observe.

typically unavailable in large-scale datasets, one can make the argument (e.g., Baldwin 2008), that transactions are necessary for the transfer of goods and services. Therefore, within-firm *transfers* will therefore reflect within-firm *transactions*, making this a reasonable proxy. A limitation of the Census data is that it only tracks one direction of the transfer – from the establishment to the rest of the firm (i.e., it records outbound "sales" to the rest of the firm but does not record the value of inbound "purchases" from other establishments within the firm). However, aggregating all of the outbound transfers that stay within the firm boundary generates a defendable measure of the value of within-firm exchange and, by extension, a novel measure of the value of within-firm coordination.

Information on IT budgets is available for slightly over half of the observations. While Harte Hanks tracks five budget bands ranging from less than $500,000 to greater than $50M, the upper levels are very sparsely populated in the data. To address this, I combine the $500K - $999K range with the $1M - $9.9M range and designate them "high budget" sites. The very highest levels ($10M to $49.9M and greater than $50M) are omitted due to a lack of observations.

3.3 Controls

Prior work (Caroli and Reenen 2001; Bresnahan, Brynjolfsson and Hitt 2002) has found complementarities between innovative organizational practices (which include increased delegation, among others), information technology, and skilled labor. I therefore control for this effect by accounting for the labor composition at each establishment. The ratio of non-production worker (i.e., skilled labor) wages to production worker (i.e., unskilled labor) wages is included in most specifications.

Also, one might worry that a particular establishment is granted IT purchasing authority for reasons completely unrelated to the adaptation and coordination considerations of primary interest in this study. In particular, certain establishments are designated as being divisional headquarters within the firm. These divisional HQ's have a disproportionately high likelihood of discretion that might arise primarily from this specialized function within the firm. I control for this effect with an appropriate indicator variable.

Finally, the size and fine resolution of the of the data set permits a full set of industry (4-digit NAICS) fixed effects in nearly all specifications to control for unobserved heterogeneity that might confound the principal results.

4. Empirical Framework

To predict the likelihood of discretion at a given establishment, I estimate a probit model of organizational design choice with discretion as the binary dependent variable. The general form of the estimating equation is:

$$\Pr(disc_i = 1) = \beta_1 PcntFirmSales_i + \beta_2 Diversity_j + \beta_3 NotMain_i + \beta_4 FIPT_j + \beta_5 EconScale_j + \beta_6 IT_i + X_i\delta_i + IND_i\lambda_i + \varepsilon_i$$

where $PcntFirmSales_i$ captures the relative economic importance of establishment *i*, measured by contribution to total firm sales, and $Diversity_j$ captures the operational diversity of the parent firm, *j*. $NotMain_i$ is a dummy variable indicating whether the establishment's primary product classification is different from the main one of its parent firm, thus granting local information advantages to local managers at establishment *i*. $FIPT_j$ represents the estimated value of goods and services transferred amongst all of the manufacturing establishments within same parent firm, *j* (i.e., firm inter-plant transfers).[14] $EconScale_j$ is a measure of the total number of establishments at the parent firm in the same primary product classification. Some specifications also explore just the sheer number of sites (*NumSites*). IT_i captures various measure of the information technology at the establishment, in particular, the prevalence of internet access throughout the firm. X_i constitutes a vector of establishment-level controls such as the skill mix of workers and whether or not the establishment is a divisional headquarters. IND_i represents a vector of industry controls to account for unobserved industry heterogeneity in the broad

[14] Establishment-level variation in the value of inter-plant transfers is available, but it only captures outbound dependency of the site. Moreover, the distinction has almost no practical significance for the empirical result.

cross section of data, and ε_i constitutes a normally-distributed error term. See Table 1 for additional details on the covariates.

A significant challenge in estimating this rich model is the issue of collinearity among the explanatory variables. For instance, sites with a large value of sales also tend to have a large value of inter-plant transfers. Table 2 provides information on the pair-wise correlation of various proxies. As much as possible, I focus on specifications with less multicollinearity or show how the estimates change as new variables are added (and subtracted). The range of model specifications is discussed in the next section.

5. Results

The baseline empirical results are presented in Table 3, which focuses on plant- and firm-level attributes affecting discretion. Table 4 reports absolute size effects, measured in terms of total sales or number of employees. Table 5 introduces economies of scale, a control for the productivity of the plant, and the breakdown by budget bands. Table 6 presents the co-invention results. In order to facilitate a comparison among the various empirical findings, I present in Table 7 the average partial effects expected from varying the explanatory variables in select specifications by one standard deviation (for continuous variables) or by switching an indicator variable from 0 to 1. Robustness checks in Table 8 show the stability of the point estimates across specifications, provided they contain the key variables. Table 9 illustrates how estimates shift when core variables are purposefully omitted.

Overview of Results

At a high level, these results suggest that, while there are many statistically significant correlates of site-level discretion for IT systems purchasing, the likelihood of local authority appears to be *most* related to the relative economic importance of an establishment within the firm. Next in order of magnitude are the influence of local information advantages and the value of interdependent operations,

the latter of which has a moderate negative correlation to delegation, particularly at the top of the distribution.

Contrary to how size effects are treated in the theoretical literature, the influence of *absolute* size of the firm – either sales or number of employees – has a surprisingly large and negative relationship to delegation. The number of plants belonging to the same firm is also negatively related to delegation, suggesting some economies of scale in IT systems purchasing. However, having sites that focus on a wide range of activities throughout the firm runs counter to this tendency, actually favoring delegation. Thus, there is an empirically meaningful distinction between numerosity and diversity in how firms structure their IT systems purchasing authority.

The interconnectedness of these effects warrant some mention up-front, as well. Omitting key variables can significantly bias the estimates of the others. For instance, omitting the relative contribution of a plant to firm sales more than doubles the (negative) coefficient on interdependent production, eliminates the precision on the effect of product diversity, and reverses the sign on idiosyncratic production (Table 9). Details of these results, their magnitudes, and their implications follow in the rest of this section.

High Value of Adaptation

A one-standard-deviation increase in a site's percentage of firm sales increases the likelihood of discretion by nearly 22 percentage points. This is a significant increase –35% – over the mean probability of 62%. The implication is that sites with extremely large relative sales volumes will virtually always have discretion. This turns out to be true (in fact, this empirical fact motivates the restriction of the sample to plants that constitute less than 100% of firm manufacturing sales). Nevertheless, the marginal effect of plant share of revenues diminishes as share increases (results not reported), suggesting the threshold at which revenue share overwhelmingly determines delegation is much lower than 100%.

Tables 3 and 4 together make the case that it is *relative* importance of activity, not *absolute* scale that is associated with delegation in this setting. Increasing revenues or total number of employees at the

establishment does little to change the likelihood of discretion. A larger scale of activity at the parent firm, measured in either revenues or employees have a strong negative association with delegation. Increasing logged firm sales by one standard deviation is associated with a greater than 14-point drop in the likelihood of local IT purchasing authority.[15]

The results on relative contribution to the firm are consistent with the notion that larger demands for local adaptation will promote delegation. The large negative association with overall firm size, however, is puzzling in light of both theory and evidence that a greater volume of activity throughout the firm will increase information processing costs at headquarters (and, hence, promote delegation). An alternative framework that makes sense of this finding may be found in agency theory. If there are incentive conflicts between local establishments and headquarters, and if greater firm scale increases the costs of monitoring, then larger firms may find the loss of control associated with delegation to be relatively more costly (see, e.g., Hubbard 2000). Because no ready measures for agency or monitoring costs exist in this data set, resolving the puzzle is left for future work.

Diversity as Measure of Complexity

Section 2 developed the proposition that complexity will tend to increase the likelihood of delegation and argued that operational diversity is a first-order driver of complexity. The empirical results support this notion. Operational diversity – at the firm level – has a moderate impact on the likelihood of IT systems purchasing discretion. However, the magnitude of the coefficient is sensitive to the overall model specification. The effect of increasing the number of distinct plant classifications by one standard deviation ranges from a low of 2.5 percentage points in sparser models (Table 3, columns 2 & 3) to 6.7 percentage points in specifications controlling for the size of the firm (either with number of employees as in Table 4, column 5, or with number of sites as in Table 5, column 3). This corresponds to an increase of

[15] This contrasts with findings of Colombo and Delmastro (2004) that the likelihood of discretion increases with the number of employees (in the absence of advanced communication technologies).

4% - 10% in the likelihood of delegation. This effect is consistent with increasing information-processing challenges at headquarters when faced with more firm-wide complexity.[16]

Local Information Advantages

An important proposition in this and related work (e.g., Acemoglu et al. 2007)[17] is that the informational advantages enjoyed by local managers will promote delegation. I find a highly significant conditional correlation with an indicator of whether the site produces outside the main focus of its parent firm (i.e., it is equal to one if the site is *not* in the main industry). Despite being a relatively rough measure of productive heterogeneity within the firm, this coefficient is associated with up to 14% greater likelihood of local discretion compared to sites whose primary product category conforms to that of their parent firms. This maximal result comes from models (see Table 3 columns 5 and 6) that controls as much as possible for unobserved heterogeneity within the firm; less demanding specifications estimate a smaller effect of around 7-8% (Tables 3-5).

Importance of Coordination

Both intuition and theory suggest that more interdependent operations within the firm may limit the scope for discretion at individual sites. This conjecture is supported by the empirical results. Increasing the ratio of firm inter-plant transfers to firm revenues (FIPT/Rev) by one standard deviation, holding other factors constant, is a decrease in the probability of discretion by 1.6 percentage points (nearly a 3% decline).

While this effect seems modest at best, the attributes of this variable's distribution suggest that this measure substantially underestimates how much the need for operational coordination impacts the

[16] Complexity operating at the level of the local establishment seems to have no influence, as the number of product lines or the number of materials consumed at the plant have no statistically significant relationship to IT delegation (results not shown but available upon request).

[17] Acemoglu et al. (2007) present a detailed model and empirical test of how this mechanism might work, focusing on the effects of distance to the technological frontier, age of the establishment, and heterogeneity of the product market environment in predicting decentralization. In contrast to their findings, my empirical investigation (available upon request) indicate that firm age and proximity to the productivity frontier have little or no significant impact on the likelihood of IT purchasing discretion.

likelihood of IT purchasing discretion. A large fraction of sites – both within the overall population and within the sample – report zero for the value of IPT. Only 10% of the relevant Census sample (i.e., establishments with more than 100 employees) and 21% of the sample report IPT greater than zero. The percentage of *firms* with positive FIPT values is higher: 36% of Census sites and 60% of sites in the sample belong to firms with non-zero IPT.[18]

Column 4 of Table 3 and column 1 of Table 5 focus on exploring different measures of within-firm dependency. To begin, belonging to a firm with non-zero FIPT is associated with an 8.5% (5.3 percentage point) lower likelihood of discretion. Belonging to a firm whose ratio of FIPT to sales (FIPT/Rev) is on the lower side (i.e., between the 25th and 75th percentile of the non-zero FIPT/Rev distribution) is associated with a similar decline in the likelihood of discretion (reported in column 1 of Table 5). However, a high value of FIPT/Rev (i.e., belonging to firms in the 75th percentile or above, conditional on non-zero FIPT) dramatically reduces the likelihood of discretion: these sites are over 12% (roughly 7.7 percentage points) less likely to have local IT systems purchasing authority.

The effect of site-level inter-plant transfers has a similar, though smaller magnitude effect. Having non-zero interplant transfers is associated with 4.4 fewer percentage points in the likelihood of discretion in the firm fixed-effect model (column 6, Table 3). This may be due in part to the fact that this variable only measures one side of the operational dependency (i.e., it only measures *outbound* transfers from the establishment, as opposed to the sum of all within-firm transfers across all manufacturing establishments belonging to the firm).

This is consistent with the proposition that firms will be more likely to centralize decision-making when the importance of coordination is quite high. This constitutes the first empirical evidence of such a relationship in the organizational economics literature.

[18] While this would normally call into question the quality of this variable, this pattern of within-firm exchange is corroborated by a recent study conducted by Ali Hortacsu and Chad Syverson (2007). Based on a different survey instrument, the authors find that only 35-40% of sites belonging to multi-establishment firms are vertically integrated. Moreover, only a small share of their shipments are destined for internal use – only one third of vertically integrated upstream establishments' shipments go to downstream units in the same firm.

Centralized authority, however, is not the only coordination mechanism considered in the organizational economics literature. Alternatives include intensive horizontal communication (Alonso, Dessein, and Matouschek, 2008) and ex ante coordination through task design (Dessein and Santos, 2002). To the extent that these other solutions to the coordination problem are employed by firms, this will tend to weaken the empirical link between the demand for coordination and centralized authority and would work against finding any statistically significant result at all.

Moreover, other predictions related to decentralized coordination do not hold in this empirical setting. To begin, IT purchasing delegation appears to be associated with greater diversity of IT vendors (not yet cleared for disclosure). Also, the notion that the importance of coordination might become high enough so as to promote delegation in situations where it is both least important and most important (i.e., predicting a non-monotone relationship between the value of coordination and delegation), is also not borne out. The impact of FIPT/Rev is nearly constant across the range of its distribution (results available upon request).

Finally, Column 5 of Table 8 provides a useful falsification test of whether the need to coordinate IT systems throughout the firm is truly driving increased centralization of IT purchasing decisions for the most interdependent firms. Harte Hanks also reports on the locus of purchasing authority for personal computers (PCs). A key feature of PCs is that their functionality within firms does not automatically require interoperability of the machines, themselves. While it helps (as any Mac users will attest), even as early as 1998, there was widespread ability to exchange files amongst different PC operating systems. Thus, there would be no need to coordinate PC purchases as a result of interdependent operations within the firm. There might be other reasons to centralize, but it would not be associated with the value of within-firm transfers in the same way that other, non-PC computer systems are affected.

This is exactly what the empirical results show. The ratio of firm inter-plant transfers to revenue has no statistically significant correlation with the likelihood of PC purchasing authority being delegated to the local plant.

Economies of Scale vs. Complexity

To the extent that larger firms tend to have more establishments and therefore more information to process, we might expect a positive relationship between the number of sites and the likelihood of discretion. After all, more sites to manage ought to increase the information-processing load and make centralization more difficult. However, industry anecdotes strongly suggest that there are economies of scale in centralizing IT purchasing decisions – i.e., making them once for all of the establishments. How to reconcile these contradictory predictions?

The first way is to follow the proposition laid out in Section 2, which emphasizes the economies of scale to be gained by choosing IT for sites that are sufficiently *homogeneous*. I find results consistent with this hypothesis: increasing the number of sites *in the main industry classification of the firm* by one standard deviation is associated with a 2.7 percentage point (or 4%) reduction in the likelihood of local IT purchasing discretion.

However, controlling for the diversity amongst these entities, the sheer number of sites also has a significant negative relationship with local decision rights. While the coefficient on the marginal effect is roughly half (or less) the magnitude of that for homogenous sites, a one-standard-deviation increase in the variable is associated with a 3.7 percentage-point drop in the dependent variable. (This larger-magnitude effect is due in large part to the greater dispersion of the straightforward site count.)

Similar to the results on absolute firm size, this "numerosity" effect poses a puzzle for the team-theory setting. Instead, it is more in line with agency-based models of the firm, whereby loss of control is likely to increase (and increase in cost), the larger and more dispersed the organization. This surprising finding points out the importance of separately controlling for the *number* and *diversity* of establishments within the firm, a distinction that is easy to gloss over in abstract treatments of "complexity."

Existing Information and Communication Technologies

Much recent work has focused on the potential importance of advanced communication technologies in determining organizational structure (e.g., Marshak, 2004; Colombo and Delmastro,

2004; Bloom, Sadun, et al., 2009). My results indicate a positive correlation between the presence of Internet technologies and local IT systems purchasing authority. A one-standard deviation increase in the number of establishments with internet access is associated with a greater than 3 percentage-point (roughly 5-6%) higher likelihood of local IT systems purchasing authority (Tables 3 and 5).[19] The effect is similar if we look at the impact of having internet access at a site in a firm fixed-effect model (Table 3, column 6) or alternative measures of internet use (such as a 0-1 dummy for internet access or the number of internet developers at the establishment).[20] These results are consistent with communication technologies reducing the costs of monitoring dispersed local managers, again suggesting that an agency framework (and the means to test it) could prove helpful in the IT purchasing setting.

Other IT investments also have significant correlations with IT purchasing delegation (see Table 6). Consistent with the "co-invention" argument presented in Section 2, establishments with idiosyncratic or legacy IT systems are more likely to have local IT purchasing authority. Not only will local managers have better information about the IT at the site, they will have the authority to ensure that new IT implemented at the site integrates well with the local systems and business processes.

An infamously inflexible type of IT system for manufacturing is Manufacturing Resource Planning (MRP) software. Highly vertical-specific and difficult to configure, these systems survive in the face of far more flexible and powerful systems because the switching costs for plants are extremely high. As expected, the presence of MRP at the site significantly increases the likelihood of local IT purchasing authority: by 10.1 percentage points or over 16%. Similar results are found for the presence of industry-specific software (10.9 percentage points) and manufacturing software that was developed "in-house" at the local plant (6.1 percentage points). These measures capture the demand for co-invention (and the costs of ignoring it).

We can also consider the supply of co-invention (i.e., the benefits of exploiting it), which might also promote local decision-making for similar reasons. The presence of application development

[19] This conflicts with the finding of Bloom, Garicano, et al., 2009 that communication-enhancing technologies lead to more centralization.
[20] Results not yet cleared for disclosure.

capabilities – i.e., the local ability to configure software to match existing IT or business processes – have a very similar (10.8 percentage-point) correlation with delegation. This relationship, in particular, supports the notion of co-invention as being a step beyond simple information advantage.

IT Budget

The relationship of IT purchasing delegation and the size of the IT budget runs counter to common intuition (Table 5, columns 5 and 6). While the prevalence of delegation is high across budget bands, fully 86% of establishments with budgets greater than $500,000 have local purchasing authority (as opposed to 60% of those below this threshold). In addition, while the general pattern of results holds for the lower range, there are significant differences for the high-budget plants. In particular, the effect of producing outside the firm's main product focus is associated with a 5.6 percentage point *reduction* (a roughly 6.5% decrease relative to the mean of 86%) in the likelihood of delegation. This is the opposite of the effect for either the full sample or the lower-budget subsample.

The implications of this finding are difficult to determine within the confines of this study. One possibility is that the value of the activity is unrelated to the cost of the investment – small but interrelated IT purchases may still be costly to the firm if they are not interoperable, promoting centralization even at low levels of expenditures. Another is that budget data may not be collected or reported at random (it is available for slightly more than half of the sample). Higher-budget sites may be systematically less willing to report the information to an outside marketing firm. If these sites are also systematically less likely to have authority, that could account for this counter-intuitive finding.

Interdependencies

Table 9 reports on the effect of omitting key variables from the empirical specification. Column 1 demonstrates that ignoring the relative importance of a plant within the firm leads to an insignificant coefficient for operational diversity and a large negative effect (i.e., reversed sign) on not being in the firm's main industry classification. It also more than doubles the magnitude of the effect of within-firm transfers and the coefficient on the number of homogeneous sites. Omitting the *NotinMain* variable

reduces the magnitude of *PcntFirmSales* by several percentage points, but is otherwise a bit more innocuous. Omitting the controls for within-firm coordination also puts some downward pressure on effect of the relative importance of the plant.

Controls: Productivity, Skill Mix, Division HQ and 4-Digit NAICS Codes

Column 4 of Table 5 adds a control for the productivity of the establishment. One alternative explanation for the large impact of relative contribution to firm sales might be that "better" establishments get to have their own IT purchasing authority. Since they might also tend to have higher revenues (and hence greater contributions to the firm), this omitted factor might bias the results. However, the model including an estimate of logged total factor productivity (TFP) indicates no significant bias of the *PcntFirmSales* coefficient. The direct impact of productivity on IT delegation is quite minimal: an increase of 1.1 percentage points for one standard-deviation increase in logged TFP (less than 2% difference).

The proportion of skilled workers at a site is significantly correlated with the likelihood of discretion, consistent with arguments outlined in Bresnahan, Brynjolfsson and Hitt (2002). A one-standard-deviation increase in the proportion of white collar workers at the site is associated with a sizeable – 10-12 percentage point – increase in the likelihood of discretion.

The economic as well as statistical significance of this relationship justify its inclusion in nearly all specifications. However, it is worth noting that it is arguably orthogonal to the key covariates discussed thus far in the analysis. Columns 1 and 2 of Table 3 show that the exclusion of this variable (in addition to a couple of other covariates) does significantly impact the point estimates of the other coefficients.

The likelihood of delegation is also much higher among establishments flagged as being division headquarters within the firm. The effect ranges from 10 to 20 percentage points. However its omission (Table 8, column 1) does not introduce systematic biases on the other coefficients.

Except where noted, all reported specifications include 88 controls for industry heterogeneity at the 4-digit SIC code level. Coefficients of these indicator variables are not reported to protect confidential firm information. Column 4 of Table 8 shows that the main pattern of results is robust to their omission.

Other Effects in the Literature: Product Market Environment

Prior work in this area has found significant effects due to external market influences such as environmental heterogeneity (Acemoglu et al., 2007) and product market competition (Bloom, Sadun, et al., 2009). While I can replicate many of these tests with my data set, I find the effects in the IT purchasing setting to be dwarfed by those already discussed in this section.

6. Conclusion

This paper offers a window onto the economic determinants of a particular type of organizational design choice: decentralization of IT systems purchasing authority. The relative economic importance of a given establishment is in tension with the importance of firm-wide interdependencies in production, with the first being highly correlated with local discretion and the second strongly associated in the opposite direction. Local information advantages are also highly correlated with delegation. Accounting for these three effects – particularly the first one – across empirical specifications proves to be important and highlights the need for a nuanced treatment of competing and related influences of delegation in future work.

These findings provide the first empirical evidence consistent with prominent team-theory models of organizational design, where demands for adaptation and coordination are in tension and determine decision rights based on the relative importance of these two forces as well as the information-processing and communication costs within the firm. However, a few surprises arise in other areas.

To begin, delegation is more prominent at higher budget levels. This runs counter to expectation that it is less costly to delegate authority over smaller sums of money. One explanation for this finding is

conceptually interesting and worthy of future study: the value of the activity may be quite divorced from the cost of the investment. Even low-budget investments may have big impacts on coordination within the firm. Unfortunately, evidence for or against this conjecture are beyond the scope of this study. The second explanation is more banal but also unverifiable: that budget data is not reported at random, creating a biased relationship between budget and delegation.

The other surprising finding is that greater sales, employees, and number of establishments have economically large associations with increased centralization of IT systems purchasing authority. The implications of these effects of absolute firm size are twofold. The first is that it is both conceptually and empirically important to distinguish between a wide *range* of activities and a large *scale* of activities. While operational diversity and number of sites are positively correlated, they have large and opposing correlations with delegation. When it comes to considering the information-processing costs within the firm – and, in particular, the role that "complexity" plays in shifting them – then "numerosity" and "diversity" are not the same and need to be treated separately.

The second implication has more profound theoretical implications. In particular, the team-theory model may be inadequate to fully capture the tradeoff between economies of scale in decision-making (which favor centralization) and coordination on the one hand – and the difficulty of monitoring and losing control of local managers in large dispersed firms, on the other. Just as the theory literature is moving towards combining information-processing and agency concerns into a single framework (see the discussion in Mookherjee (forthcoming)), these empirical results call for a similarly more comprehensive treatment in the empirical literature.

In many respects, the factors influencing the organizational structure of this type of authority mirror those that would be associated with much broader types of discretion within the firm: tradeoffs between local adaptation and firm-wide coordination, and between local information and motivation advantages and loss of centralized control, among others. However, care may be warranted in generalizing from this specific context to more general or abstract definitions of authority. Future work

may help lend insight into the generalizability of these findings by testing correlations between this narrow definition of authority and more general ones.

Finally, the question of how decision rights are allocated in firms, in addition to being of long-standing interest to organizational scholars, is of practical importance for the behavior and performance of firms. Suggestive evidence from this setting is consistent with the notion that delegation might increase complexity of outcomes, which may affect productivity or other performance measures in the long run. While the cross-sectional relationship between productivity and delegation is economically small, future work will focus on the relationships between IT, organizational structure, and firm performance over time.

Distribution of IT Systems Purchasing Discretion Among U.S. Manufacturing Firms[21], 1998

Figure 1.

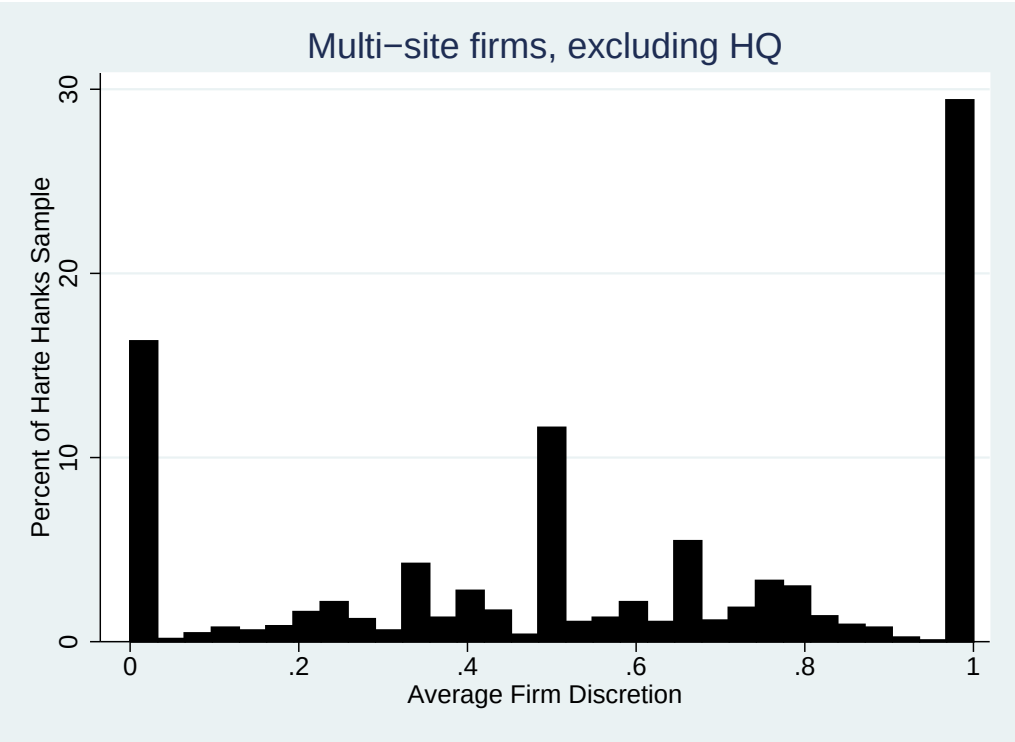
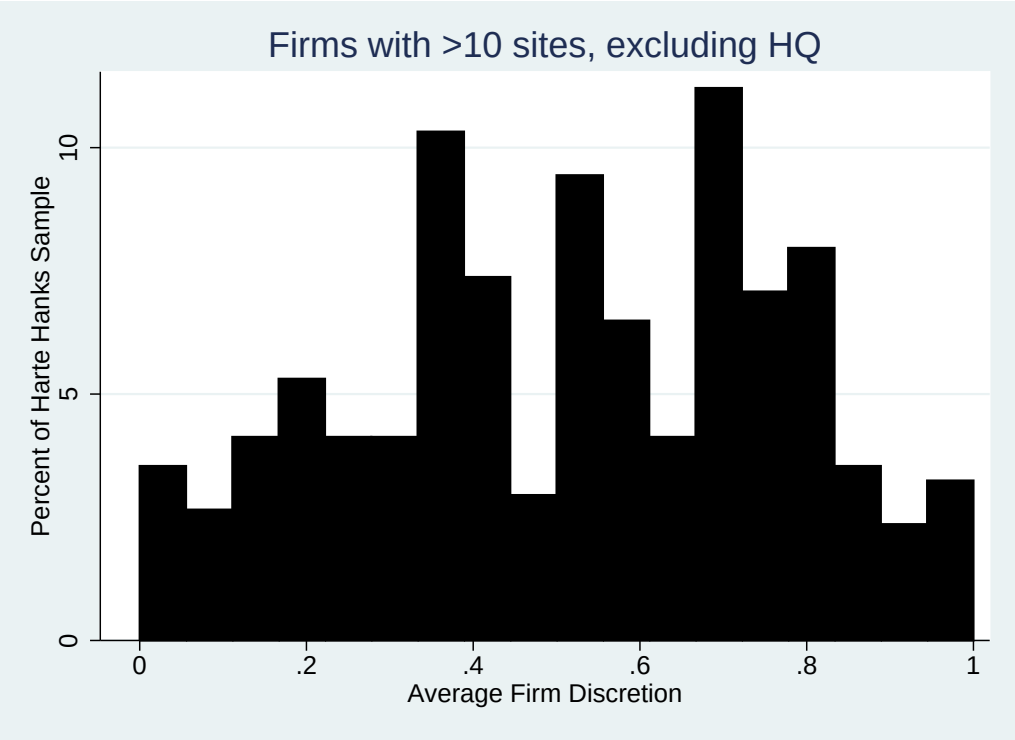


Figure 2.



[21] The distribution for firms in non-manufacturing industries follows a nearly identical pattern.

Table 1. Definitions, Means, and Standard Deviations of Variables

Variable	Definition	Sample Mean	Sample S.D.
Plant-Level Variables			
Discretion	= 1 if the plant has local discretion for IT systems purchasing; 0 else	.62	.49
Employees	Total number of employees at the plant	406	527
Logged Employees	Log of the total number of employees at the plant	5.61	.847
Sales	Total value shipped by the plant	$.12M	$.32M
Logged Estab. Sales	Log of the total revenues reported by the plant	$10.8	$1.16
% Firm Sales	Percent of the parent firm's total revenue that is shipped by the plant	.23	.28
High Share	=1 if the plant has above or equal to the matched sample[22] mean % of Firm Sales	.26	.44
Not in Main Industry	=1 if the plant is classified as being in a different SIC4 industry than the highest-revenue plant in the firm	.42	.49
IPT/Rev	The ratio of inter-plant transfers to total revenues at the plant	.06	.71
Has IPT	=1 if the plant has a non-zero value of inter-plant transfers; 0 else	.21	.41
Internet Users	Number of users reported by Harte Hanks at that establishment	19	63
Div HQ	=1 if the plant is a division headquarters	.05	.22
Skill Mix	Ratio of non-production worker wages to total salaries and wages	.39	.22
Logged TFP	Residual of a log-linear production function controlling for labor, capital, and materials inputs	1.74	.541
MRP	=1 if the plant reports having Manufacturing Resources Planning software; 0 else	.093	.29
Industry Specific SW	=1 if the plant is coded by Harte Hanks as having a software application that is "industry-specific"	.544	.498
In-House MFG SW	=1 if the plant is coded by Harte Hanks as having a software application that was developed by local programmers	.139	.346
Application Development	=1 if the plant reports having local application development capabilities	.292	.455

[22] Definitions for thresholds of dummy variables are based on the "matched sample" of firms, which consists of the matched observations between the Harte Hanks data and the 1997 CMF before dropping those establishments that represent 100% of manufacturing revenues.

Table 1. Definitions, Means, and Standard Deviations of Variables, con't

Firm-Level Variables		**Sample Mean**	**Sample S.D.**
Firm Product Diversity	The number of distinct primary SIC4 code classifications among all of the plants belonging to the same parent firm	7.5	8.4
Firm Inter-Plant Transfers (FIPT)	The dollar value of shipments destined for other establishments belonging to the same parent firm, summed over all establishments in the CMF	$0.30M	$1.8 M
Firm Inter-Plant Transfers/ Revenue	Ratio firm inter-plant transfers to firm revenues	.05	.10
Has FIPT	=1 if the sum of inter-plant transfers at the firm is greater than 0; 0 else	.60	.49
Low FIPT/REV	=1 if the ratio of inter-plant transfers at the firm to firm revenues is between the 25th and 75th for percentile of firms in the matched sample reporting non-zero FIPT; 0 else	.49	.50
High FIPT/REV	=1 if the sum of inter-plant transfers at the firm is greater than the 75th percentile for all firms in the matched sample reporting non-zero FIPT; 0 else	.11	.32
Number of Sites in Main	Number of manufacturing plants belonging to the same parent firm also belonging to its main (highest-revenue) industry classification.	8.9	13
Number of Sites	Number of manufacturing plants belonging to the same parent firm	28	37
Logged Firm Sales	Log of the sum of revenues for all plants belonging to the same parent firm	13.3	1.87
Logged Firm Employees	Log of the sum of employees for all plants belonging to the same parent firm	7.96	7.59
Internet Prevalence	% of manufacturing plants belonging to the same parent firm with internet access (based on a positive number of internet users)	.32	.34

Table 2. Variable Correlations for Main Continuous Variables[23]

	% Firm Sales	Sales	Firm Prod. Div	FIPT/ REV	IPT/ REV	Num Sites Main	Num Sites	Internet	Skill Mix	Ln Emp	Ln Firm Emp	Ln Sales	Ln Firm Sales
% Firm Sales	1.00												
Sales	.006	1.00											
Firm Prod. Div	-.469	.073	1.00										
FIPT/REV	-.192	.101	.127	1.00									
IPT/REV	-.037	.006	.008	.436	1.00								
Num Sites in Main	-.357	-.001	.140	.074	.006	1.00							
Num Sites	-.480	.062	.736	.163	.008	.568	1.00						
Internet	.125	.024	-.012	-.030	-.009	-.101	.068	1.00					
Skill Mix	.109	-.051	-.074	-.186	-.043	.028	.068	.028	1.00				
Logged Employees	.051	.429	.066	.084	.025	.002	.027	.198	-.070	1.00			
Logged Firm Employees	-.752	.221	.653	.246	.034	.467	.705	-.010	-.115	.355	1.00		
Logged Sales	-.013	.576	.127	.143	.001	.004	.106	.121	-.102	.752	.383	1.00	
Logged Firm Sales	-.737	.306	.616	.267	.032	.412	.665	-.025	-.123	.325	.952	.497	1.00

[23] Following the standards established by the Census Bureau to prevent the disclosure of proprietary firm information or firm identities, cross-tabs of indicator variables are not provided.

Table 3. Probability of Local Discretion: Plant- and Firm-Level Attributes
Basic Probit and Firm Fixed-Effect Models

		(1)	(2)	(3)	(4)	(5)	(6)
Value of Adaptation	% of Firm Sales	.772*** (.090)	.869*** (.091)	.778*** (.088)	.716*** (.092)	.835*** (.235)	.836*** (.233)
	% of Firm Sales^2	-.165 (.107)	-.224** (.107)	-.215** (.107)	-.177* (.105)	-.300 (.369)	-.341 (.364)
Complexity (Diversity)	Firm Product Diversity	.004*** (.001)	.003*** (.001)	.003*** (.001)	.004*** (.001)		
Local Info. Adv.	Not in Main Industry		.078*** (.013)	.058*** (.012)	.058*** (.013)	.092*** (.019)	.089*** (.019)
Importance of Coordination	Firm Inter-Plant Transfers/Revenue (FIPT/REV)	-.233*** (.066)	-.231*** (.067)	-.158*** (.059)			
	Has FIPT				-.053*** (.016)		
	Has (Establishment) IPT						-.044*** (.020)
IT	Internet			.103*** (.016)	.107*** (.017)		
	Internet Users					.0004*** (.0001)	.0004*** (.0001)
Controls	Division HQ	.234*** (.029)	.226*** (.029)	.173*** (.028)	.173*** (.028)	.226*** (.039)	.227*** (.039)
	Skill Mix			.501*** (.031)	.502*** (.031)	.612*** (.052)	.603*** (.053)
	Industry Controls	Yes	Yes	Yes	Yes		
	Firm Fixed Effects					Yes	Yes
	N	~6,700	~6,700	~6,700	~6,700	~3,500	~3,500
	McFadden's Pseudo R^2	.1841	.1883	.2241	.2249	TBD	TBD

Maximum-likelihood probit estimation in Stata 11, reporting estimated average partial effects. As indicated, specifications contain 88 dummy variables to control for industry effects at the 4-digit NAICS level or firm-specific fixed effects. The omitted category is NAICS 3261 (Plastics product manufacturing). Robust standard errors are clustered by firm where appropriate. Significance levels are denoted as follows: *10%, **5%, ***1%.

Table 4. Absolute Size Effects (Sales and Employees)

		(1)	(2)	(3)	(4)	(5)
Absolute Size	Logged Estab. Sales	-.006 (.006)				
	Logged Firm Sales		-.077*** (.005)			
	Logged Estab. Employees			.015** (.008)		-.005 (.007)
	Logged Firm Employees				-.092*** (.006)	
	% of Firm Sales					.572*** (.031)
Complexity (Diversity)	Firm Product Diversity	-.0002 (.001)	.007*** (.001)	-.0003 (.001)	.008*** (.001)	.003*** (.001)
Local Info Adv.	Not in Main Industry	-.024*** (.013)	.015 (.012)	-.020 (.013)	.010 (.012)	.051*** (.012)
Importance of Coord.	Low FIPT/REV	-.151*** (.017)	-.056*** (.017)	-.157*** (.017)	-.052*** (.017)	-.046** (.017)
	High FIPT/REV	-.200*** (.021)	-.064*** (.022)	-.209*** (.020)	-.07*** (.022)	-.087*** (.021)
	INET	.151*** (.017)	.157*** (.016)	.140*** (.017)	.159*** (.017)	.110*** (.017)
	Division HQ	.172*** (.031)	.177*** (.029)	.166*** (.031)	.179*** (.029)	.173*** (.028)
	Skill Mix	.583*** (.034)	.505*** (.032)	.590*** (.034)	.502*** (.031)	.496*** (.031)
	N	~6,700	~6,700	~6,700	~6,700	~6,700
	McFadden's Pseudo R^2	.1785	.2105	.1789	.2110	.2154

Maximum-likelihood probit estimation in Stata 11, reporting estimated average partial effects. All specifications contain 88 dummy variables to control for industry effects at the 4-digit NAICS level. The omitted category is NAICS 3261 (Plastics product manufacturing). Robust standard errors are clustered by firm. Significance levels are denoted as follows: *10%, **5%, ***1%.

Table 5. Probability of Local Discretion: Other Plant- and Firm-Level Attributes & Breakdown by Budget Category

		(1) FIPT Groups	(2) Num Sites in Main	(3) Num Sites	(4) TFP	(5) < $500K Budget	(6) >= $500K Budget
	% w/ Discretion					~60%	~86%
Value of Adaptation	% of Firm Sales	.705*** (.092)	.578*** (.096)	.578*** (.093)	.589*** (.098)	.641*** (.131)	-.135 (.214)
	% of Firm Sales^2	-.167 (.105)	-.062 (.107)	-.053 (.106)	-.066 (.109)	-.045 (.151)	.320 (.230)
Complex. (Divers.)	Firm Product Diversity	.004*** (.001)	.004*** (.001)	.008*** (.001)	.004*** (.001)	.003** (.001)	.002 (.002)
Local Info. Adv.	Not in Main Industry	.059*** (.013)	.047*** (.013)	.052*** (.012)		.069*** (.018)	-.056* (.029)
Import. of Coord.	FIPT/REV					-.243** (.100)	-.430** (.187)
	Low FIPT/REV	-.044*** (.017)	-.042*** (.016)	-.047*** (.016)	-.046*** (.016)		
	High FIPT/REV	-.085*** (.021)	-.077*** (.020)	-.075*** (.020)	-.075*** (.021)		
Economies of Scale	Number of Sites in Main		-.002*** (.0005)		-.002*** (.0006)	-.003*** (.001)	-.003*** (.001)
	Number of Sites			-.001*** (.0003)			
	Total Factor Productivity				.021* (.013)		
IT	Internet	.106*** (.017)	.104*** (.016)	.104*** (.016)	.106*** (.017)	.080*** (.023)	.022 (.043)
Controls	Division HQ	.171*** (.028)	.168*** (.028)	.161*** (.028)	.163*** (.028)		
	Skill Mix	.498*** (.031)	.495*** (.031)	.493*** (.031)	.511*** (.032)	.550*** (.044)	.322*** (.074)
	N	~6,700	~~6,700	~6,700	~6,000	~3,000	~900
	McFadden's Pseudo R^2	.2257	.2282	.2300	.2318	.2456	.1500

Maximum-likelihood probit estimation in Stata 11, reporting estimated average partial effects. Where indicated, specifications contain 88 dummy variables to control for industry effects at the 4-digit NAICS level or firm-specific fixed effects. The omitted category is NAICS 3261 (Plastics product manufacturing). Robust standard errors are clustered by firm where appropriate. Significance levels are denoted as follows: *10%, **5%, ***1%.

Table 6. Probability of Local Discretion: Other IT at the Site (Co-Invention Effects)

	(1)	(2)	(3)	(4)
MRP	.101*** (.019)			
Industry-Specific Applications		.109*** (.010)		
In-House Manufacturing Applications			.061*** (.016)	
Application Development @ Establishment				.108*** (.012)
N	~6,700	~6,700	~6,700	~6,700
McFadden's Pseudo R^2	.2331	.2426	.2317	.2392

Maximum-likelihood probit estimation in Stata 11, reporting estimated average partial effects. All specifications contain the same covariates as Table 5, column 3: controls for plant share of firm sales (and that value squared), firm product diversity, whether the establishment is in the main firm industry classification, firm inter-plant transfers over revenues, the number of manufacturing sites belonging to the firm, the share of sites with internet access, whether it is a division headquarters, and skill mix. Specifications also contain 88 dummy variables to control for industry effects at the 4-digit NAICS level or firm-specific fixed effects. The omitted category is NAICS 3261 (Plastics product manufacturing). Robust standard errors are clustered by firm. Significance levels are denoted as follows: *10%, **5%, ***1%.

Table 7. Marginal Effects on the Probability of Discretion, Select Specifications

		Table 3		Table 4	Table 5		Table 6	Table 9
		(3)	(6)	(2)	(1)	(2)	(1)	(1)
Value of Adapt.	% of Firm Sales	21.7***	9.8***		16.1***	16.1***		
Abs. Size	Logged Firm Sales			-14.4***				
Complex.	Firm Product Diversity	2.5***		5.9***	3.4***	6.7***		0.8
Loc. Info. Adv.	Not in Main Industry	5.8***	8.9***	1.5	4.7***	5.2***		-3.4***
Econ. of Scale	Number of Sites in Main				-2.7***			-6.7***
	Number of Sites					-3.7***		
Imp. of Coordination	Firm IPT/Revenue	-1.6***						
	Plant IPT/Revenue		-4.4***					
	Low FIPT			-5.6***	-4.2***	-4.2***		-12.9***
	High FIPT			-6.4***	-7.7***	-7.7***		-16.5***
Co-Inv.	MRP						10.1***	
Controls	Internet	3.5***		5.4***	3.6***	3.6***		1.2***
	Internet users		2.9***					
	Skill Mix	10.8***	12.7***	10.9***	10.7***	10.7***		12.3***
	Observed Probability of Discretion	62%	49%	62%	62%	62%	62%	62%

Percentage point increases in the likelihood of discretion. Based on average partial effects for all continuous variables, I calculate the effect of multiplying the coefficient by a one-standard-deviation increase in the underlying variable. Significance levels from the original estimations are denoted as follows: *10%, **5%, ***1%.

Table 8. Robustness Checks

	Table 5 Column (2)	(1) No Division HQ Control	(2) High Share Dummy	(3) Linear Model	(4) No Industry Controls	(5) PC Purchasing Authority
High Share of Sales			.244*** (.018)			
% of Firm Sales	.578*** (.096)	.579*** (.096)		.805*** (.091)	.689*** (.104)	.619*** (.101)
(% Firm Sales)^2	-.062 (.107)	-.066 (.108)		-.379*** (.085)	-.137 (.113)	-.169 (.111)
Firm Product Diversity	.004*** (.001)	.004*** (.001)	.003*** (.001)	.004*** (.001)	.005*** (.001)	.004*** (.001)
Not in Main Industry	.047*** (.013)	.050*** (.013)	.035*** (.015)	.056** (.014)	.067*** (.015)	.031** (.014)
Low FIPT/REV	-.042*** (.016)	-.043*** (.018)	-.064*** (.018)	-.043*** (.017)	-.035** (.018)	-.001 (.017)
High FIPT/REV	-.077*** (.020)	-.080*** (.020)	-.127*** (.022)	-.090*** (.022)	-.095*** (.022)	-.282 (.022)
Num Sites in Main	-.002*** (.0005)	-.002*** (.001)	-.005*** (.001)	-.003*** (.001)	-.003*** (.001)	-.001* (.0006)
Internet	.104*** (.016)	.102*** (.017)	.154*** (.017)	.097*** (.014)	.140*** (.017)	.123*** (.017)
Div HQ	.168*** (.028)		.193*** (.030)	.171*** (.023)	.191*** (.029)	.169*** (.033)
Skill Mix	.495*** (.031)	.521*** (.031)	.531*** (.031)	.506*** (.031)	.514*** (.030)	.389*** (.034)
N	~6,700	6,700	~6,700	6,700	6,700	~6,000
McFadden's Pseudo R^2	.2282	.2231	.1726 – missed the N4 dummies	.41967	.1897	.2122

Maximum-likelihood probit estimation, reporting estimated marginal effects for continuous variables and discrete change from 0 to 1 for dummy variables. All specifications contain 88 dummy variables to control for industry effects at the 4-digit NAICS level, except for specification (4). Instead of authority for IT systems purchasing, specification (6) looks at the delegation of PC purchasing within the firm. Robust standard errors are clustered by firm and are included in parentheses. Significance levels are denoted as follows: *10%, **5%, ***1%.

Table 9. Specification Tests: Results of Omitting Key Variables

		(1)	(2)	(3)
Value of Adaptation	% of Firm Sales		.500*** (.093)	.663*** (.092)
	% of Firm Sales^2		-.011 (.107)	-.120 (.106)
Complexity (Diversity)	Firm Product Diversity	.001 (.001)	.004*** (.001)	.003*** (.001)
Local Info. Adv.	Not in Main Industry	-.034*** (.013)		.046*** (.013)
Importance of Coordination	Firm Inter-Plant Transfers/Revenue (FIPT/REV)			
	Low FIPT/REV	-.129*** (.016)	-.042*** (.016)	
	High FIPT/REV	-.165*** (.021)	-.076*** (.020)	
	Has Firm Inter-Plant Transfers			
Econ. of Scale	Number of Sites in Main	-.005*** (.001)	-.003*** (.001)	-.002*** (.001)
IT	Internet	.135*** (.016)	.105*** (.016)	.101*** (.016)
Controls	Division HQ	.162*** (.030)	.171*** (.028)	.170*** (.028)
	Skill Mix	.567*** (.032)	.505*** (.031)	.504*** (.031)
	N	~6,700	~6,700	~67,700
	McFadden's Pseudo R^2	.1909	.2266	.2261

All specifications contain 88 dummy variables to control for industry effects at the 4-digit NAICS level and a squared term for percent of firm sales (which is never significantly different from zero). Maximum-likelihood probit estimation in Stata 10 reporting estimated average partial effects. Significance levels are denoted as follows: *10%, **5%, ***1%.

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