DELEGATION IN MULTI-ESTABLISHMENT FIRMS: EVIDENCE FROM I.T. PURCHASING

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ABSTRACT

Recent contributions to a growing theory literature have focused on the tradeoff between adaptation and coordination in determining delegation within firms. Empirical evidence, however, is limited. Using establishment-level data on decision rights over information technology investments, I find that a high net value of adaptation is strongly associated with delegation, as are local information advantages and firm-wide diversification; in contrast, a high net value of within-firm coordination is correlated with centralization. Variation across establishments within firms is widespread: most firms are neither fully centralized nor fully decentralized. Delegation patterns are largely consistent with standard team-theory predictions; however, certain findings, such as a negative correlation between delegation and firm size, call for a consideration of agency costs, as well.

1. INTRODUCTION

Long-standing interest in the economic determinants of firms' organizational structures has led recently to a rise in the number and sophistication of models predicting when firms are more or less likely to be decentralized. Yet empirical evidence lags behind. This is due, in part, to a lack of large-scale data on the locus of authority within firms combined with limited information on theoretically relevant establishment and firm characteristics. This paper overcomes several measurement challenges to empirically investigate delegation in multi-establishment firms and document a set of novel facts concerning firms' organizational design choices.

The context for this study is the allocation of authority over information technology (IT) investments within multi-establishment U.S. manufacturing firms. This setting is useful for studying how decision rights, more generally, are allocated within firms because tradeoffs featured in many economic models figure prominently in determining the decision-making structure for this activity. In particular, the tension between adaptation and coordination in influential team-theory treatments of organizational design (e.g., Dessein and Santos 2006; Dewatripont 2006; Alonso, Dessein, and Matouschek 2008; Rantakari 2008) manifests strongly in the case of IT investment – with significant consequences.

Tellingly, although one-half of all equipment investment by U.S. businesses is in information processing equipment and software[1], firms often do not realize the outcomes they anticipate from these

[1] This amounted to over $522 billion in 2009 even in the midst of economic recession (BEA 2009).

investments.[2] Many industry experts believe that a lack of centralization has led to unacceptably high costs of technology ownership. They further blame decentralization for IT coordination failures such as Airbus' use of incompatible versions of CATIA design software in two plants, which resulted in a two-year delay in the development of its A380 mega jet and $6.1 billion in lost profits (Matlack 2006).

Yet evidence suggests that centrally directed IT solutions often fail to address the full range of needs within multi-divisional firms. A poor alignment between features of the technology and local business needs can force business units to reengineer their processes to fit the IT – commonly at the expense of the overall success of the project (Hong and Kim 2002) – or abandon the technology in favor of manual workarounds (Gattiker and Goodhue 2004). The challenge of achieving firm-wide coordination through IT integration across a large, distributed organization has been credited with the actual demise of companies such as FoxMeyer and TriValley Growers in the late 1990s (Koch 2004).

A goal of this paper is to explore how and to what extent these conflicting demands for adaptation and coordination appear to influence the allocation of authority within multi-divisional firms. By investigating whether observed delegation patterns may be explained by leading models of organizational design – or alternative explanations – this paper aims to contribute new facts to a body of work that has been overwhelmingly theoretical to date.

I begin by applying considerations from the team-theory literature to the IT purchasing setting in order to generate a series of propositions. For instance, delegation ought to be more likely when the value of well-adapted IT at a given establishment is high relative to other organizational objectives. Delegation is also more likely when communication will be less effective in achieving well-adapted IT solutions: for instance, when a local establishment has significant information advantages vis-à-vis headquarters or when central managers' information-processing burden is too high. In contrast, centralization is expected when the value of coordination within the firm outweighs adaptation and information-processing concerns. While I consider other mechanisms highlighted elsewhere in the theory literature (in particular,

[2] See, for example, Davenport (1998). Failures of large technology implementations in firms have been estimated to run between 40 and 75 percent (Griffith, Zammuto, and Aiman-Smith 1999).

agency costs), I focus primarily on potential determinants of delegation that have been largely missing from prior empirical work and to which my data are particularly well-suited. I also consider influences, such as economies of scale and "co-invention" costs that are potentially salient in this setting but absent from the core theory.

To see whether observed empirical patterns conform to these predictions, I exploit a large and representative proprietary data set with establishment-level information on IT purchasing authority and rich establishment- and firm-level variation along important dimensions. A surprising fact that emerges from the data is that, in addition to widespread heterogeneity among firms in their organizational structures, significant heterogeneity exists *among establishments belonging to the same corporate parent*. Most firms are neither fully centralized nor fully decentralized, but have a mix of establishments with and without local IT purchasing authority (see Figures 1 and 2).

In order to understand the potential drivers of this heterogeneity, I match the IT delegation data with establishment-level data from the U.S. Census of Manufactures. This narrows the range of industries but overcomes data constraints that have hindered testing of several theoretically important –and distinct – establishment and firm characteristics. For instance, the comprehensive Census data make it possible to accurately characterize a plant's parent firm, permitting measurement of the relative importance of the plant within the firm separately from its absolute size. Thus, it is possible to disentangle the value of adaptation from plant-level economies of scale that might confound the results. It also provides estimates of the importance of firm-wide coordination – generating some of the first evidence on how variation in the demand for coordination is associated with delegation. Rich controls for skill mix, age, acquisition status, industry context, and measures of IT adoption also strengthen the empirical results and enable comparisons with prior empirical work in this area.

Robust conditional correlations – based on roughly 6,700 plants belonging to more than 3,000 firms throughout the U.S. manufacturing sector – are largely consistent with the theoretical propositions. At establishments with relatively large contributions to firm sales – i.e., where locally adapted decisions will be most important for overall firm value– the likelihood of delegation is quite high. Plants within

firms that produce a greater diversity of products – i.e., where managers must contend with greater operational complexity – are also more likely to have delegated authority. Similarly, plants that operate outside the mainstream of their parent firm's activities are more likely to retain their own IT purchasing authority, consistent with information asymmetries that favor delegating to local managers. On the other hand, a greater value of integrated production is negatively associated with delegation, consistent with predictions that a high net value of firm-wide coordination will promote centralized decision-making.

However, contrary to models that conceptualize firms as information-processing entities, firm size has a large negative association with the likelihood of delegation. Potential alternative explanations include: 1) firm-wide economies of scale in purchasing that increase the benefits of centralized buying, and 2) agency costs that increase with firm size. While firm-level scale economies cannot be ruled out, evidence is suggestive that agency considerations may play an important role. Also, the scale of production and its diversity have opposite correlations with delegation, a distinction largely missing from prior work. These and other fact patterns highlight potentially important directions for future theoretical and empirical investigation.

This paper contributes to a small empirical literature addressing the determinants of delegation within firms.[3] Evidence to date has been limited primarily to single-industry studies[4] or those based on firm-level data.[5] While my results confirm that firm-level characteristics may explain important variation in delegation choices, establishment-level differences remain significant even controlling for firm fixed effects. This, combined with the patterns described in Figures 1 and 2, suggests caution in characterizing an entire firm as either "centralized" or "decentralized" in either theory or practice.

[3] See Gibbons and Roberts (forthcoming) for a review of the literature.
[4] Ichniowski and Shaw (1999 & 2003), Ichniowski, Shaw, and Prennushi (1997), and Boning, Ichniowski, and Shaw (2007) focus on steel production, Hubbard (2000) takes place in trucking, and Garicano and Hubbard (2007 & 2008) concern legal services.
[5] See Rajan and Wulf (2006) and Acemoglu et al. (2007). Bloom et al. (forthcoming) rely on establishment-level data but do not observe multiple establishments within the same firm. Other empirical studies of the determinants of delegation include Colombo and Delmastro (2004), which surveys a wide range of delegated decisions within Italian metalworking plants, and Graham et al. (2011), which focuses on delegation of capital allocation decisions by a firm's CEO. A related paper in the information systems literature investigates IT governance amongst divisions of Fortune 1000 companies (Gu et al. 2011). Performance implications of delegation are explored in Thomas (2010) and Wu (2011).

Another related stream of research (Bresnahan, Brynjolfsson, and Hitt 2002; Caroli and Van Reenen 2001) focuses on complementarities between certain organizational practices (including increased delegation, among others), information technology, and skilled labor. Bloom et al. (2011) also emphasize the role of IT in influencing delegation. While my empirical approach takes into consideration both skill mix and the potential influence of IT diffusion throughout the firm, I focus primarily on considerations that have received less or no attention to date: e.g., how an establishment's relative economic contribution to the firm or need for co-invention may promote delegation, or how a greater need for firm-wide coordination may increase centralization. This latter consideration relates to another rich body of work studying the influence of within-firm coordination on firm boundary decisions.[6]

The remainder of the paper is organized as follows. Section 2 develops the core intuition and theoretical propositions. Section 3 presents the econometric model, while section 4 presents the data. The results are discussed in section 5. Section 6 concludes.

2. CONCEPTUAL FRAMEWORK

The modern multi-establishment firm makes a range of products for different markets, employing a commensurate variety of technologies and business processes. For example, the average firm in this sample has around 28 plants classified in 7-8 different primary product classifications and owns more than 30 types of computer software, hardware, and peripheral equipment per manufacturing site. Plants 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 flows they must support will vary considerably. For example, a plant selling to automotive clients will need to focus on electronic data interchange (EDI) technology for order execution and payment. However, a chemical manufacturing plant will rely on IT solutions with a strong engineering focus to formulate products for particular customer uses (Woods 2010). As a result, IT applications can vary widely by both industry and business function.

[6] See Forbes and Lederman (2009) and Baker and Hubbard (2003 & 2004). Hubbard (2008) provides a review of this growing literature.

This was particularly true in the late 1990s (the time of the data sample), when there existed a greater number of enterprise software vendors, many of which 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.).[7] Adaptation in this IT purchasing context means selecting from amongst these many solutions the IT that best fits the data and workflow requirements of the local establishment.

Nevertheless, important firm activities from accounting and financial reporting to production and planning typically require an integrated view of the entire firm. Coordination in this context means ensuring that hardware and software applications interact effectively throughout all of the firm's establishments to manage data and processes flows. Coordination can theoretically be achieved with diverse IT systems (provided that there is sufficient commonality in data definitions and appropriate application program interfaces). However, this ex-post integration of incompatible IT solutions has historically been costly and difficult to maintain – even more so as the software product lifecycle shrinks.[8] As a practical matter, good firm-wide coordination typically means using a single, unified IT solution throughout the organization, even at the expense of highly adapted "best-of-breed" functionality (Caruso 1999), as well as significant centralization of decision-making (Chabrow 2002).

2.1 ADAPTATION VS. COORDINATION IN A TEAM-THEORY EXAMPLE

The tradeoff between adaptation and coordination in determining decision rights within firms has been a central theme of many recent team-theory[9] contributions to the literature.[10] This framework

[7] An AMR Research report released at the time (Caruso 1999) emphasizes: "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."

[8] According to *CIO Magazine* (Gruman 2007), the largest 3,500 firms were expected to spend an average of $6.4 million in 2003 alone on systems integration.

[9] This extensive literature, which highlights the role of information-processing and communication costs in determining organizational structure, 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. A recent contribution and extension is Van den Steen (2011).

therefore offers a natural starting point for forming predictions about delegation in the IT purchasing setting. A formal team-theory model is beyond the scope of this investigation. However, a simplified example based on the predominant modeling approach in this literature (Dessein and Santos 2006, Dewatripont 2006; Alonso, Dessein, and Matouschek 2008; Rantakari 2008) provides useful structure for the empirical evidence and grounds the intuition for many of 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 purchasing 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, $(d_i - \theta_i)^2$, as well as the value of adaptation at that establishment, α_i. Firm value 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. It can be succinctly expressed by:

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

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 (one manager has discretion while the other is subject to headquarters' authority).[11] Incentives are aligned throughout the firm, so that the objective function of both managers and headquarters is to maximize the value of π.[12]

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

[10] Another stream in the literature on the determinants of delegation downplays informational costs to focus on the incentive-based tradeoffs of delegation. In these agency-oriented models, 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 from a mechanism-design perspective.

[11] Rantakari (2008) considers the possibility of "directional authority," where one establishment can make decisions both for itself and for another establishment, ensuring adaptation at the first location and some level of coordination across the two. However, this authority structure is not observed anywhere in the IT data set I use.

[12] This assumption is characteristic of team-theory models. Agency costs arising from misaligned incentives between managers and headquarters are explored in the empirical tests to the extent permitted by the data.

at the other establishment. One way to acquire this information might be through within-firm communication. Recent studies in this vein typically go on to model the communication game that takes place within the firm to exchange information about θ_i. For simplicity, consideration of communication is temporarily deferred.

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 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 whenever α_i – the value of local adaptation – is relatively high compared to γ. If α_i is quite high at one establishment but $\alpha_{\sim i}$ quite small, partial delegation only to the first establishment may be more efficient – again depending on the relative value of γ.

Centralization, in contrast, has the potential to reduce mis-coordination costs by minimizing the difference between d_1 and d_2. Centralization will therefore increase the overall value of the firm when γ – the importance of coordination – is relatively high compared to α_1 and α_2. In the absence of incentive conflicts between headquarters and local managers, the primary costs of centralization are the adaptation losses that arise when local conditions deviate the most from expectation (i.e., when $(\theta_i - \theta_i^0)$ is large) or when communication is inefficient at aligning expectations of θ_i with actual realizations.

A central question in the team-theory literature concerns the extent to which communication can be used as an alternative to delegation for achieving adaptation. Local managers know best what is needed at their individual establishments (they directly observe θ_i), but instead of making the choices themselves, they might communicate those needs to decision-makers at headquarters, who would optimally balance adaptation and coordination throughout the firm. Layering a simple communication

structure on the example in (1) would result in the prediction that firms should always centralize decision-making while communicating freely within the firm about conditions at the various establishments.

However, the tension in both theory and practice is that centralized managers typically have limitations on their ability to optimally interpret or respond to information communicated from lower levels within the firm hierarchy. In the framework of this example, they are unable to fully know θ_i, even when a message about it is sent to them. Reasons for communication failures highlighted in prior work are delays (Radner 1992; Van Zandt 1999b), limitations on communicable content (e.g., Melumad et al. 1992 & 1997), or – introducing some agency concerns – distortions due to strategic communication on the part of local managers (e.g., Dessein 2002; Acemoglu et al. 2007; Alonso et al. 2008; Rantakari 2008). Moreover, even if information is assumed to be transmitted fully and costlessly, the information processing burden for boundedly rational managers at the center – particularly in more complex or larger organizations – is expected to promote decentralized decision-making (Simon 1979; Williamson 1967; Marschak and Radner 1972; Radner 1993; Bolton and Dewatripont 1994; Van Zandt 1999b).

2.2 TESTABLE PROPOSITIONS

A key objective of this paper is to understand to what extent novel facts about the correlates of delegation tend to support predictions emerging from this type of theoretical framework. The remainder of this section identifies circumstances where the influences described above are most likely to hold in practice and formulates a series of propositions to bring to the data.

2.2.1 HIGH VALUE OF ADAPTATION

Anecdotal evidence is strong that relatively high-revenue divisions within companies tend to have more discretion in their IT systems purchasing decisions.[13] A straightforward but heretofore untested explanation can be found in the framework above. The value to the firm of adaptation at a given establishment will be greater when the costs of mis-adaptation at that location have the most severe

[13] While this is often ascribed by observers to the sociological power their managers wield within the firm, this paper advances a purely economics-based explanation for increased delegation at higher-revenue establishments.

consequences for the firm as a whole. Intuitively, if an establishment loses some small percentage in value for each transaction handled by a poorly adapted IT system (consider this the per-transaction cost of $d_i - \theta_i$), the overall economic value of adaptation will be greatest at establishments with the highest value of transactions. In the context of the model, α_i will therefore be an increasing function of total establishment value. This leads to the testable prediction that *the likelihood of delegated IT purchasing authority ought to be higher amongst non-headquarters establishments with the greatest contribution to overall firm value, all else equal.*[14]

However, a high-value establishment may also possess high-value linkages to other sites within the firm. If this holds, the value of coordination may also increase with the economic value of the establishment, instead decreasing the likelihood of delegation. If this is the case, a measure of how delegation varies with the relative economic importance of an establishment will instead be informative about the *ratio* of adaptation benefits to coordination costs within firms. Ultimately, it is an empirical matter which one will increase more rapidly with an establishment's contribution to overall sales.

A perhaps more straightforward measure of the benefits of adaptation might be whether or not an establishment does something that departs from the standard activities within the firm. In this case, a decision that is optimal for the rest of the firm is likely to be less well-adapted at that particular establishment (i.e., resulting in a large value of $d_i - \theta_i$); if adaptation is relatively very important, it might seem optimal to delegate the decision-making to a local manager who is better informed about local needs. However, this argument presupposes that a central manager would not or could not choose a locally appropriate d_i for the non-standard establishment. In *theory*, delegation to this establishment would therefore arise only due to some form of communication failure.

[14] Economies of scale in purchasing are also credited with increased delegation of purchasing authority to large establishments. I address issues related to the absolute size of the establishment and of the parent firm below and control for these effects separately in the empirical analysis.

2.2.2 *LOCAL INFORMATION ADVANTAGES*

In *practice*, this may indeed be the case. There is widespread anecdotal evidence that local managers – particularly of relatively specialized processes –find that their specific IT needs are unfamiliar and/or undervalued at headquarters. They feel they do not receive the systems they need to meet local production requirements (Gattiker and Goodhue 2004), or they invest heavily in lobbying senior managers to support their requests. In the model, this corresponds to central managers having inaccurate expectations regarding local business needs (i.e., a large discrepancy between θ_i and θ_i^0) and a decreased receptiveness to messages from local managers (i.e., a communication failure). This is consistent with other models of delegation that explore local information advantages (e.g., Acemoglu et al. 2007).

Delegation will therefore be most likely where local information advantages are greatest. This will tend to occur at establishments engaged in productive activities outside the main focus of the parent firm, because managers located at headquarters will have limited familiarity with the processes, data objects, and workflows involved in this idiosyncratic production. A relevant indicator of idiosyncratic business needs in a manufacturing setting is whether a given plant engages in production that is classified as being outside of the primary industry classification to which the parent firm belongs. Thus, *the likelihood of delegated IT purchasing authority ought to be higher at establishments outside the main production focus of the firm, all else equal.*

2.2.3 *HIGH VALUE OF COORDINATION*

While local managers may have information advantages for making locally optimal decisions, they may nevertheless lack the knowledge to make decisions that are best for the firm as a whole (Aoki 1986; Geanakoplos and Milgrom 1991; Nickerson and Silverman 2003).[15] In the case of IT systems, the cost of distributed purchasing authority can be a patchwork of incompatible technical standards.[16]

[15] Stepping outside the team-theory framework, they may also have incentives that are not aligned with those of central managers (e.g., Aghion and Tirole 1997).

[16] An illustrative example is provided by IBM, which, in 1990, "had 125 separate data centers worldwide, 128 CIOs, 31 private and separate networks, and literally hundreds of different configurations of PC installations. Data processing costs were a dramatic three times the industry average" (Austin & Nolan 2000).

Therefore, centralization of IT purchasing decisions ought to be most likely amongst firms where the net value of IT coordination is highest. A novel measure of the value of within-firm coordination is the value of integrated production that needs to be managed across locations within the firm. The logic is as follows: integrated operations require the coordination of goods and schedules across separate plants in the value chain. This coordination requires widespread, reliable, and timely exchange of production information– i.e., interoperable IT systems. Because a higher economic value of within-firm exchange will make any IT-based coordination failures commensurately more costly for the firm, the resulting proposition is that *the likelihood of delegated IT purchasing authority will be lower for plants belonging to firms with a high value of integrated production, all else equal.*

2.2.4 COMPLEXITY

The advantages of centralized coordination can be overshadowed, however, when the information-processing burden at the center becomes too great. In the IT purchasing setting, the most commonly cited communication problems within the firm can be summed up as "information overload." Chief Information Officers (CIOs) and other central IT managers consistently report trouble navigating fluid business needs and accelerating technology innovation cycles. Industry observers refer to "Moore's Flaw" – wordplay on the more famous "Moore's Law"– complaining that "keeping up with this floodtide of innovation quickly becomes too difficult (and too costly) for anyone to manage" (Gruman 2007).

In general, complexity of tasks is assumed to exacerbate information processing costs (e.g., Radner 1992). A first-order driver of complexity in matching IT to local business needs is diversity in a firm's operations. To the extent that establishments within the firm pursue different lines of business, the firm will have more diverse production and business processes to support and more diverse data requirements. A central manager selecting IT solutions for this diversity of contexts will face a more challenging optimization problem than one whose firm specializes. Thus, *the likelihood of delegated IT purchasing authority ought to be higher for establishments belonging to more-diversified firms, all else equal.*

2.2.5 SIZE

A factor widely credited with increasing the costs of centralized control is firm size. The standard prediction is that larger firms will delegate decision-making to reduce firm-wide information-processing costs. The team-theory based prediction, therefore, is that *the likelihood of delegated IT purchasing authority will be higher at establishments belonging to larger firms, all else equal.*

However, this is a place where the predictions of team-theory and agency-based frameworks most notably diverge. In models where incentives between principals and agents are misaligned, a greater scale of activity makes monitoring more difficult and increases agency costs. If this effect dominates, it would tend to promote a *negative relationship between firm size and the likelihood of delegation, all else equal.*

It is straightforward to compare these predictions by testing the empirical relationship between the absolute size of the firm and the likelihood of delegated IT purchasing. It is less straightforward to accept the results as a reasonable test of the theory due to important practical concerns that are missing from the core theory but that may dominate in this setting. Of particular interest is the influence of economies of scale in IT purchasing contracts. Industry observers emphasize the cost advantages of centralizing purchasing decisions for a large number of users. Note that this essentially represents a different measure of the value of centralized coordination – one unrelated to the need for interoperability of the IT.

If economies of scale in IT purchasing are large, then a negative association between absolute firm size and delegation – although it would appear to contradict standard team-theory predictions – could be interpreted as a high value of coordination arising from the volume of purchases to be made. However, agency costs would generate the same empirical correlation for reasons unrelated to the adaptation-coordination tradeoff. In the estimation, I leverage details of the type and location of productive activities across different plants within the firm to try to disentangle these effects.

Economies of scale may also apply at the establishment level. If this is the case, larger establishments ought to exhibit a greater likelihood of local IT purchasing authority, all else equal. However, the way that size is defined may matter for understanding the underlying mechanisms. To the

extent possible with the data, I separately address *absolute* size of the establishment – which will drive economies of scale in purchasing – and *relative* size of the establishment – which is more salient to the tension between adaptation and coordination in the theory.

2.2.6 CO-INVENTION

Another concern that applies specifically to the IT setting is the role of prior IT investments in determining certain types of adaptation costs. Thus far, the conceptual emphasis has been on how the *ex-ante* selection of IT to fit local business needs (i.e., choosing d_i to match θ_i) affects the adaptation-coordination tradeoff. However, delegation is theorized to also influence the willingness of local managers to exert effort on behalf of the firm (e.g., Aghion and Tirole 1997). In the IT setting, not only do local managers have the best information about existing business needs and legacy systems at the establishment, but they also have the wherewithal to ensure the best return on those investments, *ex post*, through their efforts to manage the integration of new IT purchases with existing systems.

Prior work by Bresnahan and Greenstein (1996) emphasizes the role of "co-invention" in IT adoption: existing technology infrastructure, business processes, and new IT investments must come together in a costly and uncertain process of innovation and co-evolution (i.e., co-invention) that requires significant investment in order to be successful. They find this to be particularly true in the most technologically complex and sophisticated environments. It also ought to apply in environments with the most idiosyncratic or difficult-to-integrate legacy IT.

At the time of the study, a wide range of legacy and proprietary IT systems were in place throughout American manufacturing firms. 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. Many establishments had developed their own proprietary systems that did not always comply with modern standards. Even relatively standard-compliant systems were often heavily configured by local programmers to support specific business needs. The presence of these factors at a given plant will tend to increase the co-invention required to effectively deploy new IT

systems – and hence the benefits of placing the decision (and implementation) authority in the hands of local IT managers. Thus, the prediction is that *the likelihood of delegated IT purchasing authority will be higher at establishments with a greater demand for co-invention.*

2.2.7 *Inter-Plant Dependencies*

Leading investigations of the economic determinants of delegation within firms tend to categorize firms as being either centralized or decentralized (e.g., Acemoglu et al. 2007; Bloom et al. forthcoming). This would make sense in the presence of firm-wide management practices that favor delegation or other constraints on the differential treatment of divisions within the same parent firm. However, an implication arising from the theory runs counter to this assumption. In particular, the cost to the firm of good adaptation at more than one establishment is an increased likelihood of firm-wide coordination failure. In the model, a relatively low value of $\alpha_{\sim i}$ compared to α_i and a high value for γ would tend to promote partial delegation: the need for adaptation is met by giving *i* local decision rights, while the need for coordination is satisfied by subjecting ~*i* to headquarters' authority. A reduced-form prediction based on this intuition is that *the likelihood of delegated IT purchasing authority at a given establishment ought to be <u>lower</u> if another establishment within the firm has local IT-purchasing authority, all else equal.*

3. EMPIRICAL FRAMEWORK

3.1 ESTIMATING EQUATION

To predict the likelihood of delegation at a given establishment, I estimate a probit model of organizational design choice. The general form of the estimating equation is:

$$\Pr(d_i = 1) = \beta_1 Adapt_i + \beta_2 Coord_j + \beta_3 Info_i + \beta_4 Complex_j + \beta_5 Size_{i \text{ or } j} + \beta_6 CoInv_i + X_i\delta_i + X_j\gamma_j + \varepsilon_i \quad (2)$$

where establishment *i* has authority for its own information technology purchases when $d_i = 1$. $Adapt_i$ captures the relative economic importance of establishment *i*, providing an estimate of the importance of local adaptation net of any firm-wide coordination costs that might also vary with establishment size.

$Coord_j$ represents the net value of coordination throughout firm j. $Info_i$ is an indicator of local information advantages. $Complex_j$ captures the operational complexity of the parent firm, j.

Certain specifications explore various measures of *Size* at either the level of the establishment (i) or of the firm (j). Some specifications consider the influence of establishment-level IT that would demand significant co-invention investments ($CoInv_i$). X_i constitutes a vector of establishment-level controls; X_j represents firm-level characteristics such as the number and distribution of establishments within the firm. ε_i constitutes a normally-distributed establishment-level error term.

I account for the likelihood that decisions to delegate purchasing authority to establishments within the same firm are interdependent in two ways. First, I use robust standard errors that are clustered by firm in all specifications. Second, I explore the empirical impact of delegation elsewhere in the firm by including an indicator of whether at least one other establishment within the firm has local decision rights.

3.2 IDENTIFICATION

The standard identifying assumption for this type of analysis is that the explanatory variables measuring the value of adaptation, coordination, and other key constructs are uncorrelated with unobservable factors that would also influence firm incentives to delegate. A central challenge to this assumption is that both delegation and many relevant plant and firm characteristics are, ultimately, outcomes of strategic decisions that might affect many firm attributes simultaneously. For example, acquisitions of upstream plants might simultaneously boost the size, number of establishments, value of within-firm transfers, and potentially the product diversity of a firm – while the likelihood of delegation might remain unchanged for exogenous reasons (e.g., due to legacy decision-making structures), or persist endogenously due to retained local information advantages. If acquired establishments systematically retain local IT purchasing discretion, this would potentially boost the coefficients in equation (2) for reasons unrelated to those put forward in Section 2. I control for acquisition status in all of the main specifications to help mitigate this concern.

While this is an illustrative example, there may be many such unobserved firm decisions. My main approach to addressing endogeneity is to exploit the richness of the Census data to control for as many potentially-confounding firm and establishment characteristics as possible. The specific controls and motivation for using them are described in detail with the data in Section 4.3. Despite including these controls as well as a full set of 86 industry (4-digit NAICS) controls, some endogeneity concerns may, however, remain.

A somewhat subtle identification challenge is selection bias in the data generating process that might arise due to unobserved organizational design choices. As above, firm boundary decisions are an important concern. Consider the potential for production outsourcing to substitute for delegation wherever there are strong local information advantages. If this were to occur, plants that would otherwise have a high probability of delegation would manifest as separately-owned establishments. In this case, any relationship between delegation and idiosyncratic production would be systematically missing from observed outcomes. As this would work against finding an empirical correlation in the data, the estimates in this case could be interpreted as a lower bound on the phenomenon.

Another concern is the potential for reverse causation. For instance, prior delegation might have increased the relative performance of an establishment (thereby boosting its relative share of sales). A standard econometric solution is to employ panel data methods to disentangle causality. However, data for a nearby year (2002) did not exhibit sufficient variation to identify the coefficients of interest.

Given the impossibility of controlling for establishment factors beyond those addressable with the detailed Census data or ruling out all potential sources of selection bias or reverse causation, the results ultimately must be interpreted as conditional correlations. Note, however, that strict causation may not necessary to be informative about the empirical usefulness of the theory, which is fundamentally concerned with equilibrium correlations between delegation and potentially complementary organizational characteristics. For instance, if delegated IT purchasing authority turns out to have a (reverse) causal impact on the sales performance of a plant, it is likely to be through a close fit of the

establishment's IT to its local business needs – i.e., *because of adaptation*.[17] Indeed, the profit improvement (or to be precise, the reduced adaptation loss) that comes from delegation whenever there are adaptation needs within the firm is a maintained assumption of standard team-theory models. Assuming selection is not the main driver of the effect, a positive correlation in the data arising in this fashion would not contradict the intuition developed in Section 2. Similar caveats apply to other organizational complements of delegation. I interpret the results with care in light of these concerns and return to their implications in Sections 5 and 6.

4. DATA AND DESCRIPTIVE STATISTICS

The data for this study were derived by combining records from the Harte Hanks Computer Intelligence database (hereafter CI) and the 1997 U.S. Census of Manufactures (hereafter CMF) using name and address matching. The sampling unit across both data sets is a single establishment. This unusually granular level of data is useful for testing propositions that do not treat delegation as an all-or-nothing proposition for the firm.

The CI data set comprises commercial establishments with over 100 employees surveyed between June of 1996 and December of 1998. The raw CI data set contains over 116,000 establishments located throughout the United States, roughly 30% of which are classified as being in manufacturing industries. While the sample is slightly skewed towards larger establishments, it is, overall, quite representative of the U.S. economy (see Forman et al. 2003, p. 118). The primary dependent variable for this study comes from this source, which identifies the level of the organization with authority for IT purchasing, separating out PC and non-PC IT purchasing discretion.

It is worth noting that the primary purpose of the CI data set is to help vendors of information and communications technology identify potential customers and make sales contacts. As a result, the quality of information on the locus of IT purchasing authority is essential to Harte Hank's value proposition, giving rise to a strong incentive to keep this information as accurate and updated as possible.

[17] This is the explanation most consistent with anecdotal evidence (e.g., Boynton et al. 2002).

Almost all of the other plant, firm, and market characteristics come from the 1997 CMF. This census, conducted every year ending in 2 or 7 by federal statute, collects detailed plant-level data on production inputs and outputs, product classifications, inventory, revenues, etc., for manufacturing establishments in the United States. Basic information is available for over 400,000 establishments nationwide, although over 7,000 of the smallest establishments have records based purely on administrative data and are therefore typically excluded from econometric analyses (e.g. Foster et al. 2008). I leverage these records for characterizing the firm context, but do not include them in the analysis. Combining the two data sets leaves a sizeable matched data set of over 15,000 plants. An important feature of these data is that, in addition to the matched plants for which complete data (including delegation status) are available, the CMF universe makes it possible to link to essentially *all* of the U.S-based manufacturing establishments associated with a given firm. This makes it possible to accurately characterize the total manufacturing revenues, number of plants, range of manufacturing activities, number of manufacturing employees, etc., for nearly the entire firm – even when only a subset of that firm appears in the matched data set. For instance, although the average firm in the sample actually owns 28 manufacturing plants, the delegation status is observable for only 6-7 of those establishments. Many firms in the analysis sample have only 1 or 2 plants with delegation information (see Figure 3 for the distribution of matched establishments per firm in the sample). This unusual feature of the data helps to significantly reduce the measurement error associated with key firm-level variables such as number of establishments within the firm, number of product classifications, firm-wide employment, and the like.

Because the study concerns behavior in multi-establishment firms and has percent of revenue as a key explanatory variable, the analysis sample is restricted to matched plants belonging to multi-unit firms that constitute less than 100% of the firm's manufacturing revenues. The final sample consists of roughly 6,700 plants belonging to just over 3,000 firms – or roughly 32% of the relevant[18] Census population.

[18] There are roughly 21,000 establishments in the 1997 CMF that would have been "eligible" for inclusion in this analysis by dint of being non-administrative records for establishments belonging to multi-establishments firms with employment greater than 100.

4.1. DELEGATION MEASURE

In the 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.[19] In the context of this paper, delegation is very precisely defined: the survey reports whether non-PC information technology purchasing authority is assigned to the local establishment or to its corporate parent. The kinds of technology investments covered by this authority include, among others: network equipment, servers, terminals, and enterprise software applications such as enterprise resource planning (ERP) and customer relationship management (CRM). The cost of these investments (which may or may not reflect their economic value) range widely: budgets reported in the data range from the lower end (less than $500,000) all the way up to more than $50 million.

This type of discretion is quite common: over 93% of manufacturing firms in the pre-matched CI data set have at least one non-headquarters establishment with delegated purchasing authority. The average likelihood of delegation is 66%; in the matched sample it is only slightly lower at 62%. However, delegation is not a uniform choice for firms with many establishments, as Figures 1 and 2 illustrate. For firms in the raw CI data with more than 10 establishments, 90% fall within the range of having 15-84% of their observed plants report establishment-level IT purchasing authority.

The objective of the empirical analysis is to understand the extent to which the adaptation-coordination tradeoff described in Section 2 could potentially explain this within-firm heterogeneity. Many of the key complements 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 firm 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.

[19] 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. Bloom et al. (forthcoming) investigate decentralization of investment, hiring, production, and pricing decisions. Graham et al. (2011) survey executives to discover the extent to which CEOs and CFOs delegate investment, capital allocation, payout, financing, and acquisition decisions.

4.2 EXPLANATORY VARIABLES

The relative economic importance of a plant within the firm is measured by taking the ratio of its revenues to the sum of all manufacturing revenues attributed to the parent firm by the CMF. The absolute size of both the plant and firm are measured in terms of the log of the number of employees.

The Census questionnaire requires that firms estimate the value of goods and services that are transferred to other plants within the same firm – referred to as "inter-plant transfers" (or *IPT*). A limitation of the Census data is that they only track one direction of the transfer – from the establishment to the rest of the firm (i.e., plants report outbound "sales" to the rest of the firm but do not record the value of inbound "purchases" from other plants within the firm). However, aggregating all of the outbound transfers that stay within the firm boundary (i.e., Firm IPT or *FIPT)* generates a useful firm-level estimate of the value of internal exchange and, by extension, a novel measure of the value of within-firm coordination. In the econometric analysis, this variable is scaled by firm manufacturing revenues (*FIPT/Revenues*).

Detailed plant-level information on production and geographic location contained in the CMF is used extensively to construct the other key explanatory variables. Assuming that a firm or plant's primary industry focus will be the one associated with the greatest revenues, I flag those that lie outside the firm's primary industry focus as defined by revenues (*Not in Main Industry*). I differentiate between the number and the diversity of productive units that comprise the firm by separately measuring: the number of establishments belonging to the parent firm (*# Establishments)*, the number of establishments with distinct industry classifications (*Firm Product Diversity*), and the number of establishments in the firm's main product category by revenues (*# Establishments in Main Industry*). Under the assumption that greater geographic dispersion increases monitoring costs, I explore variation in this dimension by counting the number of distinct locations (either Metropolitan Statistical Areas or, for rural establishments, counties) in which the firm has an establishment (*# Metropolitan Statistical Areas*).

Information on IT budgets comes from the CI data. 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 conform to disclosure avoidance requirements for using the Census data, I combine observations with budgets of less than $500K in one band and the rest into a separate high-budget category.

Information on legacy information technology at the plant is available for all plants reporting on the locus of IT purchasing authority. While a wide range of IT investments are covered by the Harte Hanks CI survey, I focus on those that are well-known to be difficult to integrate with other IT systems or that signal significant investments in IT intended for local use: manufacturing resource planning (*MRP*) applications, industry-specific applications, manufacturing applications developed "in-house", and localized software application development signaled by the presence of local computer programmers.

4.3. CONTROLS

A central identification concern is that a particular establishment is granted IT purchasing authority for reasons completely unrelated to the adaptation and coordination considerations of interest in this study. In particular, certain establishments are designated as being divisional headquarters within the firm and have a disproportionately high likelihood of discretion (potentially arising from this specialized function within the firm). I control for this effect with an indicator of whether the establishment is a divisional headquarters (*Division HQ*).

As discussed in Section 3.2, another unrelated determinant of IT purchasing authority may be the acquisition status of the establishment. Linking to the Census Bureau's Longitudinal Business Database (Jarmin and Miranda 2002) makes it possible to determine whether ownership of any of the establishments in the data has changed since 1976. A dummy variable indicating acquisition in that time period (*Acquired*) is included as a control in all major specifications. Robustness checks are run that omit this variable and that restrict it to acquisitions happening only in the prior three years.

Prior works (Caroli and Reenen 2001; Bresnahan, Brynjolfsson, and Hitt 2002) have found evidence of complementarities between delegation, information technology, and skilled labor. I control for these effects with the skill mix of employees at each plant and the presence of internet technology. The ratio of non-production worker to production worker wages is the proxy for *Skill Mix*. Whether or not

plants report some use of the internet in the CI data captures the presence of an important information and communication technology. *Firm Internet Prevalence* is the percent of plants within the firm using the internet; *Has Internet* is the plant-level measure.

Other prior work has emphasized the role of an organization's age in influencing delegation (e.g., Acemoglu et al. 2007). Establishment age (*Age*) is calculated for all plants founded after 1976 by linking to the Longitudinal Business Database (Jarmin and Miranda 2002) and is included in all of the main specifications. Robustness of the results to using age of the firm (*Firm Age*), instead, is also explored. Following the work of Haltiwanger, Jarmin, and Miranda (2010), this latter measure is calculated as the age of the oldest of the firm's constituent establishments.

A full set of 86 industry (4-digit NAICS) fixed effects is included to address unobserved industry-level heterogeneity. Definitions and descriptive statistics for all variables are provided in Table 1.

5. RESULTS

My discussion of the empirical results proceeds in several steps. First, I discuss the baseline specifications reported in Table 2, which include the main variables from equation (2). I next explore robustness of the results to the inclusion of firm fixed effects and present a falsification test for the findings related to within-firm coordination. I explore the results related to size in Table 3, next, followed by the breakdown of results by budget band. Then, I discuss in Table 4 the results related to the propositions on co-invention and within-firm dependencies. I then briefly discuss the control variables included in all of the tables as well as the robustness checks reported in Table 5.

5.1 Baseline Results

The importance of an establishment's contribution to firm value stands out in terms of magnitude. In Table 2, multiplying the average partial effect of *% of Firm Sales* by one standard deviation of the variable is equivalent to an increase in the likelihood of delegation by roughly 18-22 percentage points. This is economically significant compared to the mean probability of 62%. It is also stable across

specifications that exclude controls for acquisition status, internet prevalence at the firm, skill mix and age (columns 1-2 of Table 2).

In contrast, a high net value of coordination has a significant and opposite correlation with the likelihood of delegation. However, the magnitude of the relationship is sensitive to measurement issues that warrant additional discussion. Multiplying the ratio of firm inter-plant transfers to firm revenues (*FIPT/Revenues*) by one standard deviation of the variable is equivalent in columns 1- 3 of Table 2 with a decrease in the probability of discretion by 1.6-2.4 percentage points (roughly a 3-4% decline).

While this magnitude seems modest at best, attributes of this variable's distribution suggest that this is a lower bound on the true conditional correlation. A large fraction of establishments – both within the overall population and within the sample – report zero for the value of inter-plant transfers (*IPT*). Only 10% of the relevant Census sample and 21% of the matched sample report *IPT* greater than zero. The percentage of plants belonging to firms with positive firm-wide inter-plant transfers (*FIPT*) is higher: 36% of Census establishments and 60% of establishments in the sample belong to firms with non-zero *FIPT*.[20]

Columns 4 & 5 of Table 2 explore different cut-offs for capturing the extent to which production is integrated across plants within the same firm. Belonging to a firm with non-zero *FIPT* has a larger negative correlation with delegation of 5.1 percentage points (column 4). Belonging to a firm with low-to-moderate inter-plant transfers has a similar negative correlation (*Low FIPT/Revenues* in column 5). However, a high value of within-firm trade (*High FIPT/Revenues*) has a larger effect: being above the 75th percentile of the non-zero FIPT distribution is correlated with a 7 percentage-point lower likelihood of local IT purchasing authority.

Overall, the pattern of core results is consistent with the predictions from leading team-theory models that firms will be more likely to delegate authority when the value of adaptation within the firm is

[20] This low rate of within-firm exchange is corroborated by a recent study by Atalay, Hortaçsu, and Syverson (2012). Using a different Census survey instrument, these authors find that roughly one-half of upstream plants report no shipments to their firms' downstream plants.

relatively high and to centralize decision-making when the economic importance of within-firm coordination dominates. This constitutes some of the first empirical evidence, to my knowledge, consistent with such a relationship in the literature.

Moreover, the results related to adaptation might underestimate the importance of this effect to the extent that firm-wide coordination costs may also increase with an establishment's contribution to sales (which would work against delegation). Ultimately, this measure can only be informative about the benefits of adaptation *net* of any coordination costs.

The next effect considered in Table 2 is the role of local information advantages in promoting delegation. The average partial effect of *Not in Main Industry* has a statistically and economically significant conditional correlation with the likelihood of delegation across most specifications. The effect is equivalent to an approximately 5-7 percentage-point greater likelihood of local discretion for plants whose primary product category differs from that of their parent firms.

The empirical results on operational complexity within the firm[21] are also consistent with the proposition developed in Section 2. Multiplying the effect for *Firm Product Diversity* by one standard deviation would be equivalent to an increase in the likelihood of delegation from 2.5 to over 3 percentage points in more parsimonious specifications (Table 2, columns 2 & 3) to nearly 7 percentage points in specifications controlling for the size of the firm (e.g., Table 3, column 3 – discussed below). This corresponds to 4% - 11% of the mean likelihood of delegation.

5.2 Firm Fixed Effects

To explore the robustness of these results, I control for unobserved firm influences (e.g. firm-wide management practices) by estimating models with firm fixed effects. The average partial effects for a fixed-effect probit estimation are reported in column 6 of Table 2. However, because probit models with large numbers of fixed effects are inconsistent, I also explore a conditional logit specification and a linear

[21] Complexity at the plant level seems to have no influence, as neither the number of product lines produced nor the number of materials consumed by the plant has a statistically significant relationship to IT purchasing delegation (results available upon request).

probability model. The coefficients of the conditional logit model (available upon request) are consistent with the probit specification in terms of signs, relative magnitudes, and statistical significance. Because there is no standardized approach for calculating average partial effects and their standard errors for the conditional logit, I report the average partial effects only for the linear probability model in Column 7 of Table 2. The results hold: multiplying the effect for *% of Firm Sales* in columns 6 and 7 by one standard deviation of the variable is equivalent to a 12-percentage-point increase in the likelihood of delegation.[22]

Having non-zero inter-plant transfers (*Has IPT*) is associated with a 4.6 percentage-point lower likelihood of local IT purchasing authority – commensurate with the firm-level effect in column 4. This may represent a lower bound on the effect, however, as it only measures the *outbound* side of the operational dependency. Data on *inbound* transfers to the plant are not available to test this hypothesis. Once firm-level effects are controlled for, *Not in Main Industry* has a larger magnitude at nearly 10 percentage points.

At a minimum, these results are informative about the level of analysis needed to investigate this type of organizational design choice. The robust statistical significance and magnitude of the plant-level coefficients highlight the importance of considering within-firm heterogeneity in both delegation and complementary establishment characteristics across a wide range of firm and industry settings.

5.3 Coordination Falsification Test

Column 8 of Table 2 reports the results of a falsification test of the proposition that firms with a higher value of integrated production will centralize IT purchasing for the purposes of better coordinating its IT infrastructure. Harte Hanks also collects data on the locus of purchasing authority for personal computers (PCs). Like the non-PC information technology discussed above, PCs serve many different

[22] Note that, while the coefficient is much larger – 0.91 as opposed to 0.65 – both the variance of the explanatory variable and mean rate of delegation are lower for this subsample of firms (0.13 and 0.50, respectively), leading to an economically comparable result (roughly 23% of the baseline probability of delegation).

uses that may require local adaptation.[23] Unlike non-PC purchases, however, the need for a shared technical standard amongst PCs is much lower. As early as 1998, there was widespread ability to exchange files among different PC operating systems. Thus, even firms with a high value of within-firm coordination would not need to coordinate PC purchases *for the purpose of within-firm communication*. There might be *other* reasons to centralize PC purchasing decisions, such as economies of scale in purchasing, but these would not depend on the coordination demands of integrated production across multiple plants. Thus, while one would expect the tension between adaptation and coordination to vary among sites within the firm – promoting delegation in some locations and not in others – one would expect no specific variation due to differences in the magnitude of within-firm transfers: the coefficient on *FIPT/Revenues* ought to be zero for this type of purchase. The results are consistent with this prediction: in column 8 of Table 2, *FIPT/Revenues* has no statistically significant correlation with the likelihood of PC purchasing authority being delegated to the local plant, conditional on the other firm characteristics.

5.4 Plant and Firm Size

Table 3 explores the association of delegation with various measures of size. A concern for interpreting the *% of Firm Sales* result is that there may be some minimum efficient plant size for conducting independent IT purchasing negotiations. However, measures of absolute size of the plant have very little economic significance in this setting (see column 1 of Table 3) – a one-standard-deviation increase in the log of plant employees would be equivalent to an increase in delegation of slightly more than one percentage point. This effect disappears once the relative economic importance of the establishment (*% of Firm Sales*) is included in column 2, despite a small (5%) pairwise correlation

[23] They are widely believed to be an important "general purpose technology" (Bresnahan and Trajtenberg 1995, Brynjolfsson and Hitt 2000) in that they can be adapted to many different productive uses within firms. Local requirements that may be salient but difficult to observe or monitor at headquarters include processing speeds, workspace dimensions, rate of software or hardware obsolescence, and platform preferences of employees (e.g., Mac vs. Wintel operating systems).

between the two variables. Overall, it appears that the *relative* importance of economic activity at a plant, not its *absolute* scale, is most correlated with delegation in this context.

At the firm level, a larger scale of activity has a strong negative correlation with delegation (columns 3 and 4 of Table 3): multiplying the effect for logged firm employment by one standard deviation is equivalent to a greater than 6-point drop in the likelihood of delegated IT purchasing authority. Contrary to the other results, this finding is *in*consistent with standard predictions from the team-theory literature; it is also inconsistent with empirical studies addressing the relationship between firm size and delegation in other settings (e.g., Colombo and Delmastro 2004; Bloom et al. forthcoming).

As discussed in Section 2, firm-wide economies of scale and agency concerns are potential alternative explanations for this finding. Disentangling the two in this setting, however, is delicate –as can be seen in columns 5-7 of Table 3. The result for *# Establishments* is consistent with scale economies in purchasing, which would make sense considering that many enterprise software licenses are negotiated on a site-by-site basis. However, the scale advantages of centralized purchasing should be greater for a greater number of *homogeneous* plants, because adaptation losses from centralizing this choice would be minimized by the similarity in IT needs across similar production environments. Yet, the results in column 6 of Table 3 do not support this proposition. The average partial effect for the homogenous measure (*# Establishments in Main*), at -.002, is identical to three decimal places to the sheer count of establishments. In fact, the economic magnitude of this latter measure is arguably *lower*: multiplying the effect for *# Establishments* in column 5 by one standard deviation of the variable would be equivalent to a 7 percentage-point drop – versus a 2.7 percentage-point drop for the less-dispersed *# Establishments in Main.*

In contrast, the result *for #MSAs* in column 7 favors an agency cost interpretation. While slightly greater in magnitude, the effect is not statistically different from the results in the previous two columns. The fact that the number of distinct plants and number of distinct locations have essentially the same relationship is suggestive that it is the dispersion of productive activity – and not just the scale, *per se* – that underlies this result.

An interesting pattern emerging from Table 3 is the distinct and opposite effects of the *diversity* and *number* of establishments. *Firm Product Diversity* is consistently significant and positive, while *# Establishments* is consistently significant and negative. Discussions of "complexity" in the existing literature often confound the two characteristics– a tendency that appears problematic in light of these empirical results.

5.5 Budget Effects

Another concern for interpreting the baseline findings is whether underlying heterogeneity in the "degree" of delegation might affect the results. In particular, if plants with observed delegation were to have systematically smaller budgets, the evidence would be informative about a very limited (though not necessarily unimportant) type of decision-making. The relationship between IT purchasing delegation and the size of the IT budget is addressed in Table 3, columns 8 and 9. While the prevalence of delegation is high across all budget bands, fully 79% of establishments with budgets greater than $500,000 have local purchasing authority - as opposed to 59% of those below this threshold. Thus it appears that higher-value decisions are not routinely more centralized in this setting.

While the general pattern of results found in the overall sample holds for the lower range, there are nevertheless significant differences for the high-budget plants. In particular, the economic importance of the establishment is insignificant and producing outside the firm's main product focus is associated with a 5.6 percentage point *reduction* in the likelihood of delegation. The first-gloss interpretation is that local adaptation and information advantages may have less influence on IT purchasing delegation when there is more money at stake, which is counterintuitive.

One explanation is that the economic implications of adopting information technology solutions may not be closely related to their investment costs. Low-priced IT purchases may have greater scope for local adaptation (hence more delegation where adaptation is important), but the economic benefits of adaptation *overall* may be dwarfed within the larger firm context (hence less delegation, on average). In contrast, high-priced IT investments (such as large-scale enterprise software) may not be particularly

adaptable in the first place, making the value of adaptation irrelevant (hence no effect for *% of Firm Sales*) and the likelihood of adopting incompatible systems less likely (hence more decentralized coordination and more delegation, on average). Alternatively, the delegation observed for the high-budget plants may come with significant unobserved oversight and/or the threat of reversion from headquarters (e.g., Hart and Holmstrom 2010). The full implications of these findings are difficult to determine within the confines of this study, and thus are left to future research.

The possibility of decentralized coordination is considered in detail in prior theoretical work. Alternatives to centralization include intensive horizontal communication (Alonso, Dessein, and Matouschek 2008) and *ex ante* coordination through task design (Dessein and Santos 2002). These alternatives cannot be easily addressed within the confines of this data set.[24] However, to the extent that these or other solutions to the coordination problem may be employed by firms in lieu of centralization, this will weaken the empirical link between the value of coordination and centralized authority; in this case, the results can be interpreted as a lower bound on the effect.

5.6 Co-Invention and Within-Firm Dependencies

Table 4 explores the propositions related to co-invention in IT adoption. Consistent with predictions from Section 2, plants with difficult-to-integrate legacy technology are more likely to have local IT purchasing authority. The magnitude of the effects range from 6 percentage points for the presence of manufacturing applications developed in-house to 10 or more percentage points for legacy MRP systems or industry-specific applications that may be tailored to the plant's particular production process. Plants with greater co-invention capabilities as measured by the ability to pursue local application development also have a significantly higher likelihood of local discretion.

[24] It is worth noting that other predictions related to coordination *without* centralization do not hold in this setting. For instance, 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., a non-monotone relationship between the value of coordination and delegation – see, for example, Alonso, Dessein, and Matouschek 2008 or Rantakari 2008), is also not borne out. The impact of *FIPT/Rev* is nearly constant across the range of its distribution – including at the top (results available upon request).

A causal interpretation of these results from a team-theory perspective would emphasize the importance of considering not only *ex ante* adaptation and coordination costs in allocating decision rights, but also the incentives for *ex post* investments in adaptation and coordination. These results are consistent with firms delegating authority to ensure that add-on investments integrate well with idiosyncratic IT at the local plant. However, causality cannot be established with these data: it is possible that delegated authority during early phases of IT investment may encourage particularly idiosyncratic hardware and software investments. In this alternative scenario, while legacy IT and delegation would be correlated in the cross-section, the implications for subsequent decision rights allocation would depend on the value of leveraging these prior investments as well as the costs and benefits of centralizing later purchases. Despite this limitation, it is ultimately informative that delegation and idiosyncratic IT purchases are apparently more valuable to the firm when chosen together, regardless of the causal direction. Exploring these questions in a setting where changes in both delegation and IT adoption over time may be observed would be an interesting direction for future study.

Column 5 of Table 4 presents the average partial effect for whether at least one other establishment within the firm has local IT purchasing authority. The effect is both statistically and economically significant – roughly 4.5 percentage points – and negative; the other results remain largely unchanged. This conditional correlation is consistent with the theoretical prediction that, all else equal, delegation at one establishment will tend to raise coordination costs if authority is delegated elsewhere within the firm, as well. The intuition developed in Section 2.2 suggests that this effect ought to be greater for firms with a higher value of coordination. However, interacting this variable with the indicator of whether or not the firm has inter-plant transfers (*Has FIPT*) does not generate statistically significant differences in the estimated effect (available upon request).

5.8 Controls & Robustness Checks

The primary focus of this paper is on developing facts about the correlates of delegation that have heretofore received little or no attention in the prior empirical literature. The richness of the data,

however, makes it possible to control for – and report on – effects that have been the focus of prior empirical studies and that might otherwise confound the results of interest (see the discussion of identification in Section 3.2). For instance, some recent work has focused on the potential importance of advanced communication technologies in determining organizational structure (e.g., Marschak 2004; Colombo and Delmastro 2004; Bloom et al. 2011). My results indicate a significant positive correlation between the presence of internet technologies and local IT systems purchasing authority. A one-standard deviation increase in the number of plants within the firm with internet access (*Firm Internet Prevalence*) is equivalent to a nearly 4 percentage-point (roughly 5-6%) higher likelihood of local IT systems purchasing authority (Table 2).[25] The effect is even greater for the plant-level indicator (*Has Internet*) in the firm fixed-effect models (Table 2, columns 6 and 7). These results are consistent with communication technologies being complementary to delegated decision-making (Bresnahan, Brynjolfsson, and Hitt 2002), possibly because they reduce the costs of monitoring within the firm (Hubbard 2000). This further suggests that agency considerations might be useful for understanding delegation in this setting.

An indicator of whether a plant has changed ownership (*Acquired*) has a positive and significant correlation with the likelihood of delegated IT purchasing authority across most specifications. Establishment *Age* has the opposite relationship. Their inclusion in the specification has no significant impact on the core results (e.g., column 1 of Table 2 or columns 6 and 7 of Table 5) and the magnitudes of the effects are not economically large. However, it may be worth noting that both effects are consistent with information advantages for local managers that may be greatest when a plant first becomes part of the firm (either through birth or acquisition), as in Acemoglu et al. (2007).

The proportion of skilled workers at a plant (*Skill Mix*) is significantly correlated with the likelihood of delegation, consistent with arguments outlined in Bresnahan, Brynjolfsson, and Hitt (2002). A one-standard-deviation increase in the proportion of white collar ("non-production") workers is equivalent to a sizeable – 10-12 percentage point – increase in the likelihood of delegation across most

[25] This result is inconsistent with the finding of Bloom et al. (2010) that communication-enhancing technologies are associated with greater centralization.

specifications. The economic as well as statistical significance justify its inclusion in nearly all specifications; however, its exclusion does not significantly impact the other estimated effects (columns 1 and 2 of Table 2).

Table 5 presents a series of additional robustness checks. Column 1 reports a specification with a rich set of controls for the purposes of comparison. Column 2 includes a control for unobserved plant "quality" in the form of estimated total factor productivity (*TFP*). There is no evidence that better-performing plants systematically enjoy both local purchasing authority and higher contribution to firm sales in ways that bias the results. Column 3 explores *Firm Age*, as opposed to establishment age. While the coefficient itself is relatively large and significant, the effects of the other main variables remain unchanged. Columns 4 and 5 shows that the results are robust to the exclusion of industry controls and of the acquisition indicator, respectively. Column 6 reports the stability of the effects when flagging only recent acquisitions (i.e., ones that occurred within the prior three years). Column 7 similarly reports consistent results when a linear probability model is used. Columns 8-10 report on how estimates shift when theoretically important covariates are omitted. The most notable feature is that omitting the relative economic importance of the establishment dramatically influences many of the other estimates. This makes sense in the context of the theoretical framework, where it is the *relative* magnitude of adaptation and coordination that matter for determining delegation. These results provide additional evidence that a comprehensive approach considering the *net* trade-off between these competing influences may be important for understanding the determinants of this essential organizational design choice.

6. CONCLUSION

This paper offers novel empirical evidence related to the determinants of delegation within multi-establishment firms. Leveraging an unusually rich data set to overcome several measurement challenges, the paper makes two central contributions to the literature. First, it documents widespread variation across a given firm's establishments in the locus of authority, suggesting care in characterizing firms as either "centralized" or "decentralized" in either theoretical or empirical work. Second, it generates a robust set

of conditional correlations that constitute some of the first empirical evidence related to prominent team-theory models of organizational design, with implications for future research.

In the IT purchasing setting – where the tension between adaptation and coordination is high – most of the findings are consistent with the predicted correlations: delegation is more likely where the value of adaptation is relatively most important and centralization is more likely when the value of coordination dominates. The influence of an establishment's relative financial contribution to the firm, while new to the empirical literature, proves to be the most economically significant correlate of delegation. This is consistent with firms assigning decision rights where it is, on net, most important to match IT functionality to local business needs. In contrast, a novel economic measure of the value of within-firm coordination is negatively correlated with delegation. This finding is consistent with firms centralizing authority to ensure high levels of interoperability throughout the firm's IT systems when coordination concerns are paramount.

Patterns in the data are also consistent with team-theory predictions regarding the influence of communication and information processing costs within the firm. Establishments that are likely to have local information advantages as a result of idiosyncratic production are more likely to have local discretion for IT purchasing. Plants in more operationally diverse firms are also more likely to have delegated IT purchasing authority. These conditional correlations are suggestive that limits on central managers' ability to know or process information about local needs throughout the firm will tend to promote delegation to local managers, all else equal.

Team-theory predictions related to firm size, however, are not supported by the empirical results. Even though larger firms are assumed to have a higher information-processing burden at the center, firm size measured in a variety of ways has a robust negative correlation with delegated IT purchasing authority. One possible explanation is firm-wide economies of scale that promote centralized purchasing – i.e., coordination benefits based on the volume of purchases, as opposed to the interoperability of systems. A problem for this explanation is that it does not hold for a measure of the number of *homogenous* establishments in the firm, where economies of scale net of adaptation costs ought to be

greatest. Another likely candidate – agency costs that increase with firm size – receives somewhat better empirical support. While neither explanation can be ruled out within the confines of this data set, these findings suggest that abstracting away from agency costs entirely may limit the explanatory power of this style of model in some settings. The positive correlation between internet prevalence and delegation – which is consistent with communication technologies reducing monitoring costs throughout the firm – also suggests that adding agency considerations would be a useful direction for future research.

Other findings entail implications for future work in this area. For instance, it turns out to be both conceptually and empirically important to distinguish between the *diversity* and *scale* of activities within a firm. While diversification and number of establishments are positively correlated with each other, they have large and opposing associations with delegation. Also, delegation at higher budget levels in this setting is both more likely and follows somewhat different patterns, suggesting care may be needed to account for different "degrees" of delegation in future work.

While the rich data make it possible to explore and control for a wide range of potential determinants of delegation (such as skill mix, age, and acquisition status), the focus has been primarily on considerations that have received little or no attention in prior empirical work. Amongst these is the potential importance of providing incentives for *ex post* investments in adaptation. In the IT purchasing setting, the presence of idiosyncratic legacy systems is highly correlated with delegated purchasing authority. While causality cannot be determined, the practical importance of these "co-invention" effects is informative about understudied complementarities in organizational design.

Because the causal direction of these effects, overall, cannot be established with the cross-sectional data, it is unclear what shocks to important variables such as the value of within-firm coordination might do to the allocation of delegation – or vice versa. Panel data showing meaningful changes to the relevant variables over time would be needed to further explore the dynamics of this organizational design choice. However, because more primitive drivers of firm behavior (e.g., market entry decisions or growth strategy) may entail complementary – and simultaneous – decisions regarding

many aspects of firm structure, more or better data might nevertheless be insufficient to resolve the issue of causality.

In many respects, the factors influencing the organizational structure of IT purchasing authority mirror those that would be associated with much broader types of discretion within the firm. However, care is 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.

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 performance of firms. Observed correlations between organizational design choices in this setting suggest that certain combinations are more valuable to firms than other choices they might have made. The ultimate implications for firm performance, however, are open to speculation. Focusing on the relationships between IT adoption, organizational structure, and firm performance over time would be a useful direction for future research.

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Figure 1. Distribution of IT Systems Purchasing Delegation Among U.S. Manufacturing Firms[26] in 1998

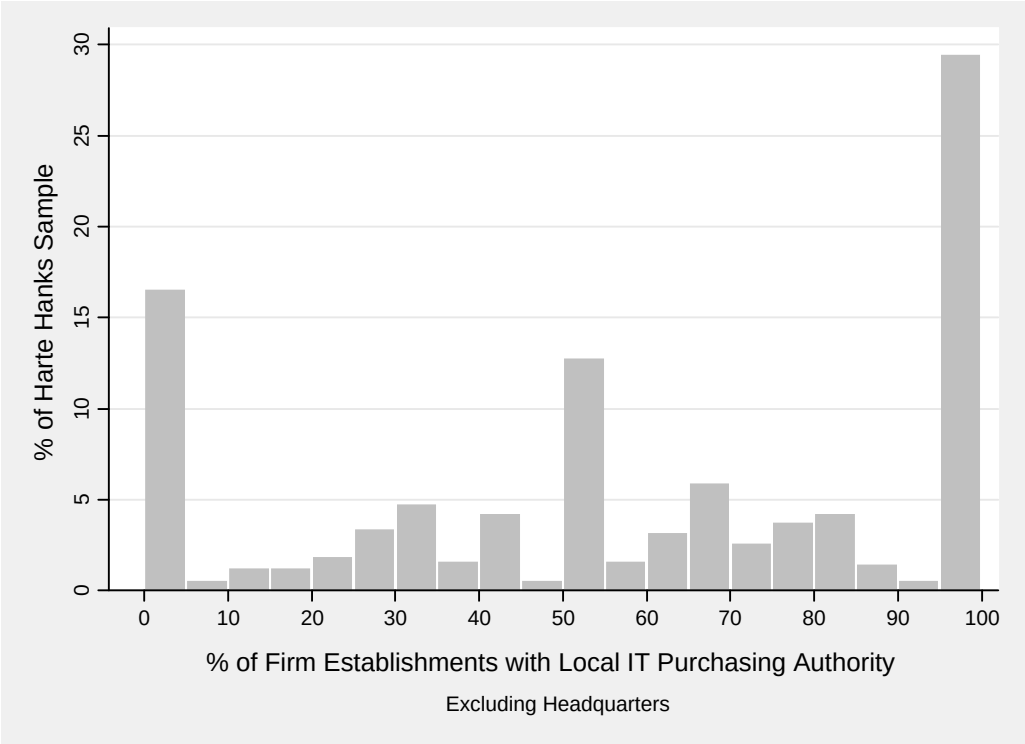
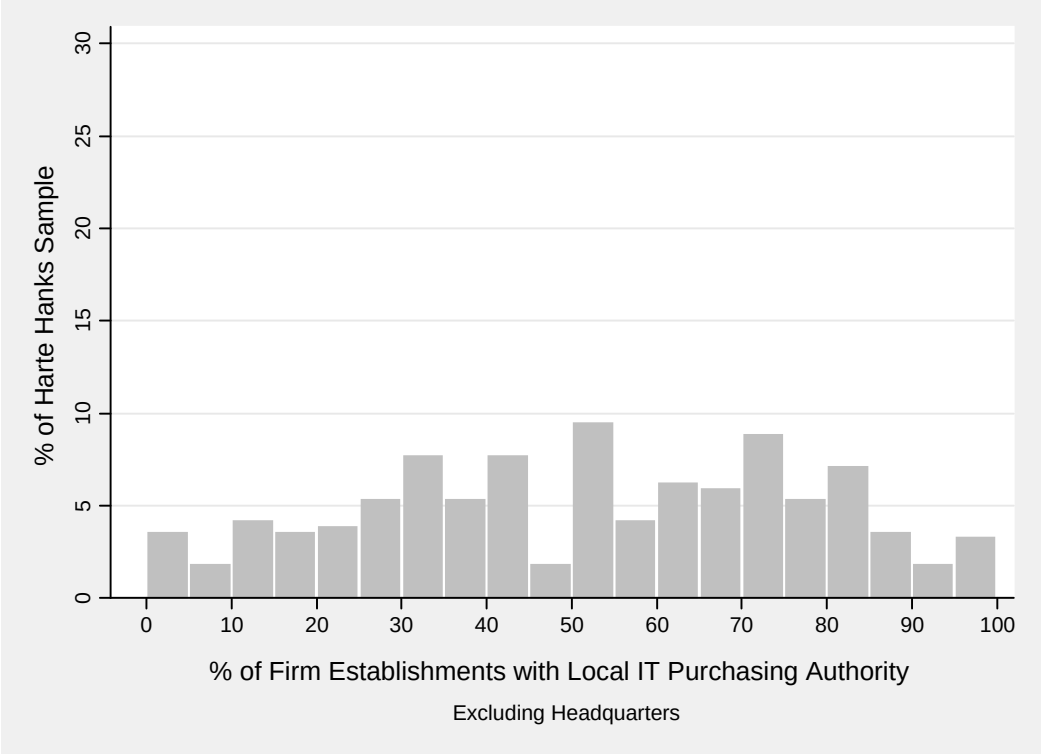
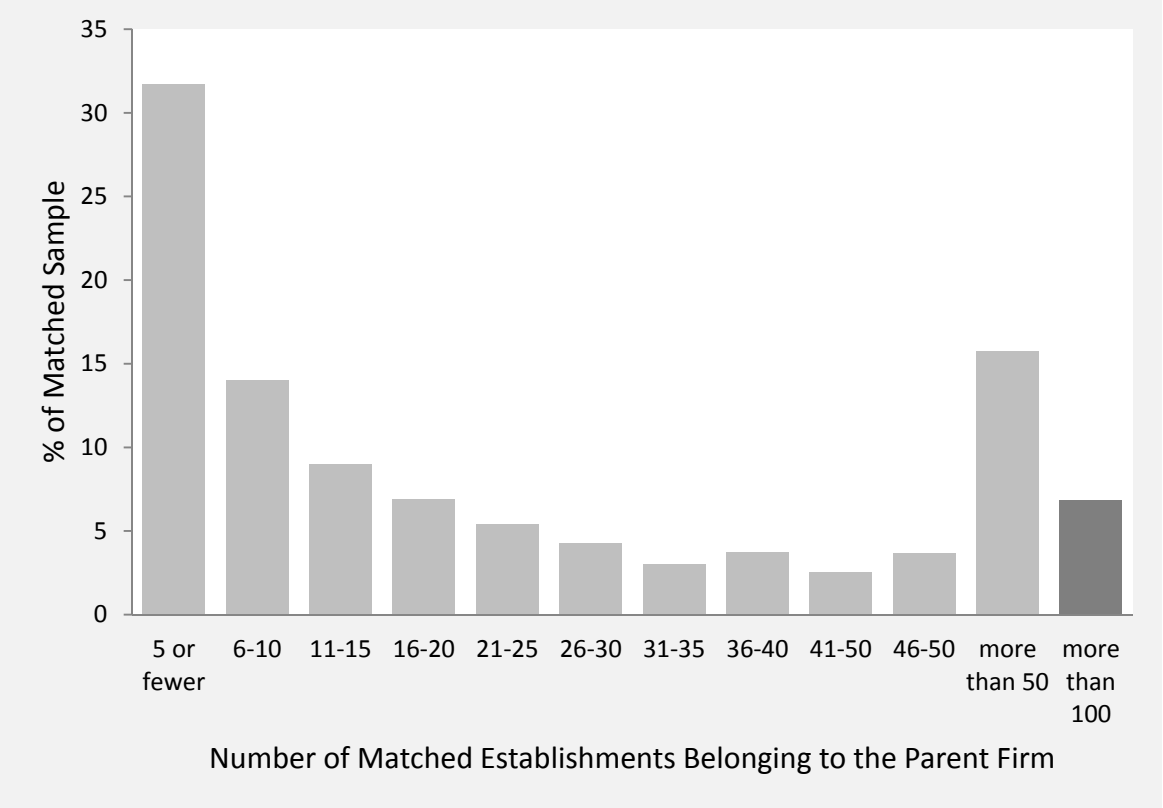


Figure 2. Distribution of IT Systems Purchasing Delegation Among U.S. Manufacturing Firms with Greater than 10 Establishments in 1998



[26] The distribution for firms in non-manufacturing industries follows the same basic pattern.

Figure 3. Distribution of Number of Establishments per Firm in the Matched Sample



Note: The skewed nature of the distribution leads to small cells in the upper categories of the distribution. To conform to Census disclosure avoidance guidelines, the top categories are collapsed into broader size ranges and the maximum number of establishments per firm is not reported.

TABLE 1
DEFINITIONS, MEANS, AND STANDARD DEVIATIONS OF VARIABLES
Plant-Level Variables

	Variable	Definition	Mean	Std. Dev.
Delegation	Delegation	= 1 if the plant has local authority for making non-PC IT purchases; 0 else	.62	.49
	PC Delegation	= 1 if the plant has local authority for making PC purchases; 0 else	.71	.46
Adapt	% of Firm Sales	Percent of the parent firm's total manufacturing revenue that is shipped by the plant	.23	.28
Coord	Has Inter-Plant Transfers (IPT)	= 1 if the plant has a non-zero value of inter-plant transfers (IPT); 0 else	.21	.41
Info	Not in Main Industry	= 1 if the plant is assigned to a different industry from the highest-revenue 4-digit NAICS code in the firm	.42	.49
Size	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 Establishment Sales	Log of the total revenues reported by the plant	$10.8	$1.16
Controls	Division HQ	= 1 if the plant is a division headquarters	.05	.22
	Has Internet	= 1 if the number of internet users reported by Harte Hanks at that establishment is greater than 0	.61	.49
	Acquired	= 1 if the establishment belonged to a different parent firm since 1976; 0 else	.59	.49
	Age	Age of the establishment in 1997, or number of years since 1976 if founded prior to that date	18	5.8
	Skill Mix	Ratio of non-production worker wages to total wages	.39	.22
	Total Factor Productivity (TFP)	Residual of a log-linear production function controlling for labor, capital, and materials inputs	1.74	.541
Co-Invention	MRP Software	= 1 if the plant reports having Manufacturing Resources Planning (MRP) software; 0 else	.09	.29
	Industry Specific Software	= 1 if the plant is coded by Harte Hanks as having a software application that is "industry-specific"	.54	.50
	In-House Manufacturing Software	= 1 if the plant is coded by Harte Hanks as having a software application that was developed by local programmers	.14	.35
	Application Development	= 1 if the plant reports having local application development capabilities	.29	.45

TABLE 1
(CONTINUED)
Firm-Level Variables

	Variable	Definition	Mean	Std. Dev.
Coordination	Firm Inter-Plant Transfers (FIPT)	The dollar value of shipments destined for other establishments belonging to the same parent firm (i.e., inter-plant transfers), summed over all same-firm establishments in the CMF	$0.30M	$1.8 M
	FIPT/Revenues	Ratio firm inter-plant transfers to total (manufacturing) revenues for the firm	.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/Revenues	= 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	.46	.50
	High FIPT/Revenues	= 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	.14	.32
Complex	Firm Product Diversity	The number of distinct primary NAICS4 code classifications for all of the plants belonging to the same parent firm	7.5	8.4
Inter-Depend	Other Delegated Establishment	= 1 if at least one other establishment at the firm has local IT purchasing authority	.52	.50
Size	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	8.0	1.6
Size Economies of Scale Monitoring Costs	# Establishments	Number of manufacturing plants belonging to the same parent firm	28	37
	# Establishments in Main Industry	Number of manufacturing plants belonging to the same parent firm also belonging to its main (highest-revenue) industry classification.	8.9	13
	# MSAs	Number of distinct Metropolitan Statistical Areas (MSAs) in which the parent firm has a plant	14	16
Control	Firm Internet Prevalence	% of manufacturing plants belonging to the same parent firm with one or more internet users	.32	.34
	Firm Age	Age of the oldest manufacturing establishment belonging to the same parent, or 22 years if the oldest establishment was founded prior to 1976	21.2	2.6

TABLE 2

TEAM-THEORY CORRELATES OF DELEGATION: ADAPTATION, COORDINATION, INFORMATION ADVANTAGES, AND COMPLEXITY

Dependent Variable:	Probability of delegated IT purchasing authority							PC purchasing authority
Mean:	.62	.62	.62	.62	.62	.50	.50	.70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	Probit	Probit	Probit	Probit	Probit	Probit	LPM	Probit
Importance of Adaptation								
% of Firm Sales	.795***	.794***	.708***	.660***	.653***	.914***	.939***	.628***
	(.058)	(.058)	(.056)	(.060)	(.060)	(.200)	(.243)	(.065)
Importance of Coordination								
Firm Inter-Plant Transfers (FIPT)/Revenues	-.231***	-.223***	-.151***					
	(.067)	(.065)	(.059)					
Has Firm Inter-Plant Transfers (FIPT)				-.051***				
				(.016)				
Low FIPT/Revenues					-.044***			-.001
					(.017)			(.017)
High FIPT/Revenues					-.070***			-.020
					(.020)			(.020)
Has Inter-Plant Transfers (IPT)						-.046**	-.047**	
						(.020)	(.023)	
Local Info Advantage								
Not in Main Industry	.078***	.078***	.058***	.058***	.059***	.098***	.097***	.038***
	(.013)	(.013)	(.012)	(.013)	(.012)	(.020)	(.023)	(.014)
Complexity								
Firm Product Diversity	.003***	.003***	.003***	.004***	.004***			
	(.001)	(.001)	(.001)	(.001)	(.001)			

Table 2
(Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Controls								
Division HQ	.226*** (.029)	.224*** (.029)	.172*** (.028)	.171*** (.028)	.170*** (.028)	.273*** (.042)	.243*** (.038)	.171*** (.033)
Acquired		.032*** (.011)	.026** (.011)	.026** (.011)	.025** (.011)	.032 (.021)	.031 (.024)	.025** (.012)
Firm Internet Prevalence			.106*** (.017)	.109*** (.017)	.109*** (.017)			.127*** (.018)
Has Internet						.081*** (.017)	.087*** (.020)	
Skill Mix			.495*** (.031)	.497*** (.031)	.493*** (.031)	.596*** (.056)	.580*** (.059)	.385*** (.035)
Age			-.0019** (.0009)	-.0018* (.0009)	-.0018* (.0009)	-.003* (.0017)	-.003 (.0020)	-.0019** (.0009)
Industry Controls	Yes	Yes	Yes	Yes	Yes			Yes
Firm Fixed Effects						Yes	Yes	
N	6,696	6,696	6,696	6,696	6,696	3,076†	3,076†	6,038
McFadden's Pseudo R^2	.1883	.1893	.2251	.2258	.2261	.2294	.2758	.2120

Notes: Columns 1-5 report estimated average partial effects from maximum-likelihood probit estimation in Stata 12 and include 86 industry controls at the 4-digit NAICS level. The effect of *% of Firm Sales* accounts for the effect of (*% of Firm Sales*)^2. The omitted category is NAICS 3261 (plastics product manufacturing). Robust standard errors are clustered by firm and reported in parentheses. Columns 6 and 7 report estimated average partial effects from probit and linear probability estimation including firm-fixed effects. Column 9 has as its dependent variable local authority for making PC purchases. Significance levels are denoted as follows: *10%, **5%, ***1%. See Table 1 for variable definitions.

† Firms with insufficient within-firm variation are automatically dropped from the estimation, reducing the total number of observations.

TABLE 3
OTHER CORRELATES OF DELEGATION: SIZE EFFECTS & BREAKDOWN BY BUDGET CATEGORY

Dependent Variable:	Probability of delegated IT purchasing authority								
Mean	.62	.62	.62	.62	.62	.62	.62	.59	.76
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Specification Description	Estab. Size	Estab. Size	Firm Size	Firm Size	# Estabs	# Estabs in Main	# MSAs	< $500K Budget	>= $500K Budget
Absolute Size									
Logged Establishment Employees	.017** (.008)	-.002 (.007)							
Logged Firm Employees			-.092*** (.006)	-.041*** (.007)					
Value of Adaptation		.574***		.445***	.565***	.560***	.560***	.628***	-.015
% of Firm Sales		(.031)		(.036)	(.060)	(.063)	(.061)	(.084)	(.135)
Importance of Coordination									
Low FIPT/Revenues	-.157*** (.017)	-.046*** (.017)	-.056*** (.017)	-.026 (.016)	-.048*** (.016)	-041*** (.016)	-.041*** (.016)		
High FIPT/Revenues	-.194*** (.020)	-.073*** (.020)	-.058*** (.021)	-.040* (.020)	-.059*** (.019)	-.064*** (.019)	-.064*** (.019)		
Local Information Advantages	-.019	.057***	.010	.054***	.052***	.047***	.053***	.069***	-.053*
Not in Main Industry	(.013)	(.012)	(.012)	(.012)	(.012)	(.013)	(.012)	(.018)	(.029)
Complexity	-.0002	.003***	.008***	.006***	.008***	.004***	.007***	.003**	.002
Firm Product Diversity	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
Economies of Scale					-.002***				
# Establishments					(.0003)				
# Establishments in Main Industry						-.002*** (.0005)		-.003*** (.0009)	-.003*** (.0010)
Monitoring Costs									
# Metropolitan Statistical Areas (MSAs)							-.003*** (.0006)		

TABLE 3
(CONTINUED)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Controls									
Division HQ	.164***	.172***	.179***	.175***	.160***	.166***	.162***	†	†
	(.031)	(.028)	(.029)	(.028)	(.028)	(.028)	(.028)		
Acquired	.025**	.024**	.009	.018	.023**	.024**	.022**	.009	.078***
	(.012)	(.011)	(.012)	(.011)	(.011)	(.011)	(.011)	(.015)	(.027)
Firm Internet Prevalence	.141***	.111***	.160***	.123***	.106***	.106***	.106***	.084***	.020
	(.017)	(.017)	(.017)	(.017)	(.016)	(.017)	(.017)	(.024)	(.043)
Skill Mix	.587***	.492***	.050***	.477***	.489***	.490***	.494***	.547***	.303***
	(.034)	(.031)	(.032)	(.031)	(.031)	(.031)	(.031)	(.044)	(.073)
Age	-.0011	-.0017*	-.0002	-.0013	-.0017*	-.0016*	-.0016*	-.0027**	-.0014
	(.0010)	(.0009)	(.0009)	(.0009)	(.0009)	(.0009)	(.0009)	(.0014)	(.0025)
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,696	6,696	6,696	6,696	6,696	6,696	6,696	3,305	866
McFadden's Pseudo R^2	.1791	.2258	.2109	.2302	.2305	.2287	.2296	.2466	.1581

Notes: Reporting estimated average partial effects from maximum-likelihood probit estimation in Stata 12. All specifications include 86 controls for industry effects at the 4-digit NAICS level. The effect of % of Firm Sales includes the effect of (% of Firm Sales)^2. The omitted category is NAICS 3261 (plastics product manufacturing). Robust standard errors are clustered by firm and reported in parentheses. Significance levels are denoted as follows: *10%, **5%, ***1%.

† The indicator for being a division headquarters is omitted due to thinly populated cells (which violate Census disclosure avoidance rules).

TABLE 4
CORRELATES OF DELEGATION: CO-INVENTION & WITHIN-FIRM DEPENDENCIES

Dependent Variable:	Probability of delegated IT purchasing authority				
	(1)	(2)	(3)	(4)	(5)
Co-Invention Variable:					
MRP Software	.101*** (.019)				
Industry-Specific Software		.110*** (.010)			
In-House Manufacturing Software			.061*** (.016)		
Application Development @ Establishment				.109*** (.012)	
Interdependence					-.045*** (.015)
Other Delegated Establishment					
% Firm Sales	.553*** (.060)	.512*** (.060)	.557*** (.060)	.521*** (.060)	.506*** (.065)
Low Firm Inter-Plant Transfers/Revenue	-.049*** (.016)	-.054*** (.016)	-.050*** (.016)	-.052*** (.016)	-.035** (.016)
High Firm Inter-Plant Transfers/Revenue	-.060*** (.019)	-.065*** (.019)	-.061*** (.019)	-.067*** (.019)	-.055*** (.020)
Not in Main Industry	.051*** (.012)	.046*** (.012)	.052*** (.012)	.050*** (.012)	.046*** (.013)
Firm Product Diversity	.008*** (.001)	.008*** (.001)	.008*** (.001)	.008*** (.001)	.004*** (.001)
Other Firm and Establishment Controls	Yes	Yes	Yes	Yes	Yes
N	6,696	6,696	6,696	6,696	6,696
McFadden's Pseudo R^2	.2336	.2433	.2323	.2399	.2277

Notes: Reporting estimated average partial effects from maximum-likelihood probit estimation in Stata 12. All specifications contain controls for *# Establishments*, *Division HQ*, *Acquired*, *Firm Internet Presence, Skill Mix, Age,* and 86 controls for industry effects at the 4-digit NAICS level. The omitted category is NAICS 3261. Robust standard errors are clustered by firm and reported in parentheses. Significance levels are denoted as follows: *10%, **5%, ***1%.

TABLE 5
ROBUSTNESS CHECKS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Description:	Baseline	TFP	Firm Age	No Industry Controls	Omit Acq.	Recent Acq. (≤ 3 yrs)	Linear Model	Omit % Firm Sales	Omit Local Info. Adv.	Omit Coord.
% of Firm Sales	.560***	.569***	.542***	.646***	.559***	.573***	.633***		.499***	.625***
	(.063)	(.064)	(.063)	(.069)	(.063)	(.060)	(.054)		(.060)	(.059)
Low FIPT/Revenue	-.041**	-.046***	-.042***	-.033*	-.042***	-.041***	-.042**	-.128***	-.041**	
	(.016)	(.016)	(.016)	(.018)	(.016)	(.016)	(.017)	(.016)	(.016)	
High FIPT/Revenue	-.064***	-.062***	-.066***	-.078***	-.067***	-.065***	-.074***	-.154***	-.062***	
	(.019)	(.020)	(.019)	(.021)	(.019)	(.020)	(.021)	(.020)	(.020)	
Not in Main Industry	.047***	.047***	.048***	.067***	.047***	.048***	.056***	-.034***		.046***
	(.013)	(.013)	(.013)	(.014)	(.013)	(.013)	(.014)	(.013)		(.013)
Firm Product Diversity	.004***	.004***	.004***	.005***	.004***	.004***	.005***	.001	.004***	.003***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
# Establishments in Main	-.002***	-.003***	-.002***	-.003***	-.002***	-.002***	-.003***	-.005***	-.003***	-.002***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Division HQ	.166***	.161***	.168***	.188***	.167***	.168***	.171***	.160***	.169***	.168***
	(.028)	(.028)	(.027)	(.029)	(.028)	(.028)	(.023)	(.030)	(.028)	(.028)
Acquired	.024**	.107***	.018*	.035***		.052***	.099***	.022*	.024**	.027**
	(.011)	(.017)	(.011)	(.012)		(.015)	(.014)	(.012)	(.011)	(.011)
Firm Internet Prevalence	.106***	.508***	.105***	.144***	.107***	.107***	.502***	.136***	.107***	.104***
	(.016)	(.032)	(.016)	(.017)	(.017)	(.017)	(.031)	(.016)	(.017)	(.016)
Skill Mix	.490***	-.0011	.492***	.507***	.495***	.489***	-.002*	.564***	.500***	.498***
	(.031)	(.010)	(.031)	(.030)	(.031)	(.031)	(.001)	(.032)	(.031)	(.031)
Age	-.002*	.023*	-.007***	-.003***	-.001	-.001		-.001	-.002*	-.002**
	(.001)	(.013)	(.002)	(.001)	(.001)	(.001)		(.001)	(.001)	(.001)
Total Factor Productivity		.023*								
		(.013)								
McFadden's Pseudo R^2	.2287	.2323	.2294	.1913	.2266	.2297	.2659	.1912	.2271	.2271

Notes: Estimated average partial effects from maximum-likelihood probit estimation, except (7). All specifications contain 86 industry dummies at the 4-digit NAICS level, except (4). The omitted category is NAICS 3261. The coefficient on *% of Firm* Sales takes account of the effect of *(% of Firm Sales*)^2. N= 6,696 for all columns. Robust standard errors in parentheses are clustered by firm. Significance levels are denoted as: *10%, **5%, ***1%.