07-046

Electronic Hierarchies and Electronic Heterarchies: Relationship-Specific Assets and the Governance of Interfirm IT

Electronic Hierarchies and Electronic Heterarchies: Relationship-Specific Assets and the Governance of Interfirm IT

Andrew McAfee (corresponding author)
Harvard Business School
Morgan 491, Soldiers Field
Boston, MA 02163
617.495.6547
617.496.4059 fax
amcafee@hbs.edu

Marco Bettiol
University of Padua
Via del Santo 28, 35123 Padova, Italy
marco.bettiol@unipd.it

Maria Chiarvesio
University of Udine
Via Tomadini 30/a, 33100 Udine – Italy
chiarvesio@uniud.it

Electronic Hierarchies and Electronic Heterarchies: Relationship-Specific Assets and the Governance of Interfirm IT

Author Biographies

Andrew McAfee is an associate professor in the Technology and Operations Management Area at the Harvard Business School. He obtained his doctorate from Harvard Business School in 1999. His research investigates how information technologies from ERP systems to prediction market facilitate structured and unstructured multi-party interactions, and the roles that general managers play in extracting the maximum value from their firms' IT investments.

Marco Bettiol is assistant professor in Business Economics at the University of Padua (Italy) and researcher at the TeDIS Center of Venice International University. He obtained his Ph.D. in Economic Sciences at the University of Udine. His research is focused on innovation processes and on the role of information and communication technologies in sustaining the competitiveness of small and medium enterprises.

Maria Chiarvesio is assistant professor in the Business Economics and Management Area at the University of Udine (Italy) and researcher at the TeDIS Center of Venice International University. She got a Ph.D. in Business Economics at the University of Venice in 1998. Her research activity is focused mainly on the impact of information and communication technologies on SMEs and industrial districts; her interest is to investigate how industrial districts SMEs and local development systems are taking advantage of network technologies to face the challenges of internationalization and innovation in the new global competitive scenario.

The authors gratefully acknowledges the support of the Harvard Business School's Division of Research and the TeDIS Center at Venice International University

Electronic Hierarchies and Electronic Heterarchies: Relationship-Specific Assets and the Governance of Interfirm IT

Abstract

This paper uses concepts from the theory of the firm and MIS research to argue that some types of information technology (IT) will be deployed only within hierarchical governance structures. This argument introduces a contingency into the 'electronic markets hypothesis,' which holds that greater use of IT is unidirectionally associated with reduced use of hierarchies. We revisit the assumption that interfirm IT is never a relationship-specific asset. While many types of interfirm IT are highly redirectable others are not, and become relationship-specific assets once configured for a particular context; these assets are referred to here as *enterprise information technologies*. Because complete contracts over IT assets are not possible, relationship specificity is an important consideration; scholarship on the theory of the firm yields a consistent prescription that when assets are relationship specific and contracts incomplete, the single decision-making authority of a hierarchy is optimal. The paper therefore argues that when enterprise IT is required, so is an electronic hierarchy: a collaboration in which one member has all required decision rights over jointly used IT. This contingent theory yields three hypotheses, which are tested using data gathered from firms in Italian industrial districts. Because of this paper's focus on governance rather than price-setting, electronic hierarchies

are contrasted not with electronic markets, but instead with electronic heterarchies.

Keywords: asset specificity, theory of the firm, electronic markets hypothesis, EDI, XML, incomplete contracts, information technology, electronic marketplaces, enterprise information technology, electronic hierarchy

Electronic Hierarchies and Electronic Heterarchies: Relationship-Specific Assets and the Governance of Interfirm IT

INTRODUCTION

Scholars have long been concerned with IT's impact on the organization of work. Some of this research has focused within the firm, and has considered whether greater computerization leads to increased or decreased centralization of decision-making and standardization of work processes (see, for example, Leavitt and Whisler 1958, Attewell and Rule 1984, and Zuboff 1988) Another important stream of research has focused on the boundary of the firm, analyzing whether greater diffusion of IT makes it more or less attractive to distribute economic activity across markets rather than within a hierarchy.

This latter stream of work has largely converged to the conclusion that "By reducing the costs of coordination, IT will lead to an overall shift toward proportionately more use of markets – rather than hierarchies – to coordinate economic activity." (Malone, Yates et al. 1987). This has come to be known as the electronic markets hypothesis (EMH), and is broadly accepted; one review (Sampson 2003) found only a single conference proceeding that "queried the myth of diminishing firms." Variants of the EMH were articulated both before and after the explosion in business use of the Internet.

This paper aims neither to reinforce the EMH nor to refute it, but instead to introduce a contingency into consideration of IT's impact on the organization of work. The argument presented here focuses on the governance of IT-facilitated multifirm collaborations, and on the *ex ante* decisions that must be made about jointly used information technologies. In contrast to previous work, which has treated IT as a unitary construct, this paper distinguishes between "enterprise information technologies" such as Electronic Data Interchange (EDI) and eXtensible Markup Language (XML), which require collaborators to reach substantial *ex ante* agreements, and "network information technologies" such as email and instant messaging, which do not.

The appropriate governance mechanism for an IT-facilitated collaboration, we argue, is contingent on the type of IT being deployed; when an enterprise technology is required, so is an electronic hierarchy. Briefly stated, this is because hierarchies have well-understood advantages when assets are relationship-specific and complete contracts are not possible. Both of these conditions apply to enterprise technologies, but not network technologies. So as enterprise IT becomes important, electronic hierarchies become the norm.

This paper uses the term *electronic hierarchy* rather than simply *hierarchy* to convey that collaborators in such an arrangement do not surrender all (or even most) of their decision rights to a central authority. Instead, they surrender only a small subset, namely decisions about the configuration of jointly used enterprise information technologies. And to emphasize that this paper concentrates on governance rather than price-setting, electronic hierarchies are contrasted not

with *electronic markets* but with *electronic heterarchies*, which are collaborations in which decision rights over jointly used technologies are not vested with any single party.

The first section of this paper after this introduction describes the EMH, its theoretical underpinnings, and a variant known as the 'move to the middle' hypothesis. This is followed by a presentation of the empirical support for some aspects of the EMH as well as some anomalies. The issue of relationship specificity of IT assets is then explored. The next two sections propose a categorization of information technologies based on their levels of relationship specificity, then use this categorization to provide definitions of 'electronic hierarchy' and 'electronic heterarchy.' The paper then offers a contingent theory about the governance of interfirm IT and three hypotheses derived from this theory. These hypotheses are tested with data gathered from firms in 41 Italian industrial districts. Discussion and conclusion sections end the paper.

THE ELECTRONIC MARKETS HYPOTHESIS

Predictions about IT's impact on markets and hierarchies have often been based within economics literature on the theory of the firm. IT scholars have drawn differentially on agency theory (Ciborra 1983, Gurbaxani and Whang 1991), transaction cost economics (Ciborra 1983, Gurbaxani and Whang 1991, Clemons, Reddi et al. 1993, Malone, Yates *et al.* 1987) and property rights theory (Brynjolfsson 1994) when formulating their propositions. These propositions, however, have been largely consistent. For the present purposes, it is useful to

present them as a set of reasons that IT favors markets, and a set of exceptions, or circumstances under which IT favors hierarchies. Interestingly, literature on the EMH has not to date offered a clear definitions for 'electronic market' or 'electronic hierarchy.'

According to this literature, IT increases the comparative attractiveness of using markets for coordinating economic activity because:

IT reduces coordination costs. (Clemons, Reddi *et al.* 1993, Brynjolfsson 1994, Malone, Yates *et al.* 1987, Malone and Rockart 1991). Gurbaxani and Whang 1991 observe that IT can reduce both internal and external coordination costs, and are thus unable to offer an unambiguous prescription about whether IT favors markets or hierarchies. Malone, Yates *et al.* 1987, however, maintain that "An overall reduction in the 'unit costs' of coordination would reduce the importance of the coordination cost dimension (on which markets are weak) and thus lead to markets becoming more desirable in some situations where hierarchies were previously favored. In other words, the result of reducing coordination costs without changing anything else should be an increase in the proportion of economic activity coordinated by markets." In addition, IT's information sharing capabilities make it easier and less costly to communicate the required large volumes of information about complex products across firm boundaries (Malone, Yates *et al.* 1987, Clemons, Reddi *et al.* 1993).

IT assets have low relationship specificity since IT is highly 'redirectable.' This reduces the threat of hold-up and opportunism risk that is a component of interfirm transaction cost. (Clemons, Reddi *et al.* 1993, Brynjolfsson 1994,

Clemons and Row 1992, Grover and Ramanlal 1999, Helper and MacDuffie 2002).

In contrast, the circumstances under which IT favors hierarchies over markets, as articulated by previous research, seem comparatively limited. They include situations where:

Network externalities exist (Gurbaxani and Whang 1991, Brynjolfsson 1994). This has proved to be the case for person-to-person auctions and some products such as used books (Rayner 2002, McAfee 2002), but IT-based network externalities are not yet evident in many other non-communications industries.

Monitoring is valuable (Gurbaxani and Whang 1991, Brynjolfsson 1994). Better monitoring can be valuable both within hierarchies and across markets. However, the increase in monitoring capabilities brought by IT is an improvement along a dimension where hierarchies are comparatively weak. All other things being equal, then, this improvement thus makes hierarchies comparatively more attractive. Baker and Hubbard 2004 found that US trucking firms became more likely to own trucks and employ drivers, as opposed to contracting with individual truck owners, after improved driver monitoring technologies became available.

The 'Move to the Middle' Hypothesis

Some scholarship on the impact of IT has concluded that while information technologies themselves generally lead to greater use of markets for the reasons listed above, other considerations intervene and lead to organizational forms that are less fluid than spot markets. Clemons and colleagues (Clemons and Row

1992, Clemons, Reddi *et al.* 1993) highlight the risks inherent in transacting with many partners in a market and predict a 'move to the middle' where firms will use IT to build close relationships with a relatively small number of partners. Bakos and Brynjolfsson 1993 concentrate on suppliers' incentives to make 'non-contractible investments' to ensure attributes such as quality and responsiveness, and conclude that the optimal structure is a buyer linked to a small group of suppliers. Wang and Seidmann 1995, analyzing suppliers' incentives to form EDI links with a single buyer, reach a similar result.

The 'move to the middle' hypothesis concerns the size and stability of IT-based multi-firm collaborations, and does not address their governance. This paper, meanwhile, focuses on governance, in particular the allocation of decision rights within IT-enabled multi-firm collaborations. This focus appears to be unique in the literature on inter-organizational IT.

EMPIRICAL SUPPORT FOR THE EMH

The EMH implies that parties will adopt IT to help them match supply and demand via the price mechanism, and to organize in novel ways to accomplish work previously done within firms. Both of these phenomena are occurring. In the Internet era a number of popular IT-facilitated price setting forums have emerged. They include sites for auctions (eBay, Google AdWords), reverse auctions (Freemarkets, now part of the software vendor Ariba), name-your-price (Priceline), and 'prediction markets' where traders can monetize their beliefs about election outcomes (Iowa futures market), movie box office receipts

(Hollywood Stock Exchange), and world events (tradesports.com) (for a discussion of prediction markets, see Wolfers and Zitzewitz 2004).

The emergence of the Linux operating system is perhaps the clearest example that complex and economically significant products no longer need to be developed within single firms or traditional industrial alliances. They can instead result from the collaborative, voluntary, and minimally directed efforts of individuals around the world who use IT both to execute their work and to discuss it. The success of Linux and other 'open source' products such as the Apache web server and has helped spark interest in open and distributed communities of production (Lerner and Tirole 2000).

At the intersection of online markets and open communities, spot markets for knowledge work, from document formatting (OfficeTiger) to solving scientific problems (InnoCentive), have appeared. These markets match supply and demand for human capital in a way that was not possible before the advent of the Web (Malone 2004, Davenport and Prusak 1998, Sawhney, Prandelli et al. 2003).

The years after the birth of the Web also saw the emergence of eMarketplaces, businesses that were predicated on the validity of the EMH. eMarketplaces, also called B2B exchanges, were Web-based forums, usually intra-industry, where members could find new trading partners and execute transactions with them. More than 1500 eMarketplaces were founded, 92% of them independent of any incumbent firms (Day, Fein et al. 2003). More than 20 of these businesses went public, with a combined market capitalization of over $100 billion at one point (Anonymous 2000). Analysts predicted that digitally mediated trade would reach

$2.7 trillion (or 17% of total trade) by 2004, with over half of this flowing through exchanges (Kafka 2000), and that the Internet would reduce input prices by as much as 40% in some already competitive industries (Brookes and Wahhaj 2000). These and other forecasts seemed to take their cue from the assertions by Kaplan and Sawhney 2000 that eMarketplaces would "exert enormous influence over the way transactions are carried out, relationships are formed, and profits flow."

Empirical anomalies

Not all electronic markets, however, have been successful. The most visible failures have been the many eMarketplaces that went out of business in the wake of the 'tech wreck;' the sharp decline in the share prices of Internet companies beginning in the spring of 2000. Of the more than 1500 B2B exchanges founded, the great majority no longer exist (Day, Fein *et al.* 2003; see also Doyle and Melanson 2001, Ince 2002 Kafka, Temkin et al. 2000,). In the wake of widespread eMarketplace failures, some observers have become skeptical about IT's market-fostering abilities. One reporter concluded that "… the potential of e-markets to change the habits and processes of companies, improve trading efficiencies, cut costs for traders, and raise revenue for those who run the markets, is much more limited than originally thought" (Frew 2002). Another concluded "So much for the dream of friction-free capitalism leveling the

playing field between large and small firms. Contrary to expectations, the lesson of B2B seems to be that big is beautiful" (Anonymous 2001).

The failure of public eMarketplaces could be interpreted as support for the move to the middle hypothesis. This hypothesis, however, does not explain the paucity of some kinds of electronic link between customer firms and their small, stable supply networks. Clemons and Row 1993 found that many firms in the consumer packaged goods industry had not adopted EDI, even though there was a widespread belief that the industry as a whole would be better off if they did. Many investigations of EDI have found that suppliers need to be forced by buyers to adopt the technology (Prekumar and Ramamurthy 1995, Truman 2000). Many of these suppliers have presumably already made all required non-contractible investments (in quality, responsiveness, etc.) and EDI has been shown to offer benefits to both buyers and suppliers (Mukhopadhyay, Rajiv et al. 1997, Kekre and Mukhopadhyay 1992, Bensaou 1997), so the need for coercion is puzzling.

Finally, a dedicated empirical evaluation of the EMH yielded equivocal results. Hess and Kemerer 1994 studied the impact of computerized loan origination systems and concluded that "despite a decade of experience with these systems… the industry has not been fundamentally changed" and conclude that "the [electronic markets] hypothesis will require augmentation in order to fully explain [our] results…"

THE IMPLICATIONS OF RELATIONSHIP SPECIFICITY

Data that do not support the EMH are puzzling because the hypothesis does appear to rest on sound underlying economics. Modern information technologies clearly reduce coordination costs, and it is well accepted that markets have higher coordination costs than do hierarchies. Greater penetration of IT (which is clearly taking place; see Stiroh 2002 and Gordon 2003) should therefore lead to greater reliance on markets unless there is some mitigating or countervailing phenomenon.

This paper argues that the mitigating phenomenon is the relationship specificity of some types of interfirm information technology. While certain technologies are easily redirectable from one use to another, others are not. The relationship specificity of information technologies is an important consideration, and is proposed here as the required augmentation of the EMH, because it appears to be impossible to write complete contracts over IT.

High rates of innovation among IT producers and high levels of IT investment among rivals combine to create a complex, dynamic, and uncertain environment (Prahalad and Krishnan 2002). Within such an environment it would be prohibitively difficult to enumerate all the possible future use scenarios for a given IT asset, especially one that spanned multiple groups, let alone to specify *ex ante* the rights and responsibilities of all involved parties in each scenario. Previous research applying the theory of the firm to IT has not focused on complete contracting (Bakos and Nault 1997 are an exception in this regard. They

included incomplete contracting in their analysis of optimal network ownership structures in the presence of network externalities). This lack of attention to complete contracting is perhaps related to the assumption, discussed above, that IT assets are easily redirectable ones. If a shared asset is redirectable complete contracts are not required; the asset's owner simply puts it to a different use whenever conditions merit doing so.

If a shared asset is *not* redirectable, however, the theory of the firm holds incomplete contracting to be a critical consideration, and has a clear prescription. As Hart 1989 says "One thing I can be sure of is if .. assets are sufficiently complementary, and initial contracts sufficiently incomplete, the two sets of assets should be under common control." Asset complementarity and asset specificity are, for the present purposes, equivalent concepts. An EDI connection between two firms, for example, is a relationship-specific asset. Equivalently, the configured hardware and software required at each end of the connection are complementary assets. The link as a whole, in other words, is a specific asset; the endpoints are complementary assets.

The prescription articulated by Hart is widely accepted (see, for example, Williamson 1985, Grossman and Hart 1986, Hart 1988, Hart and Moore 1990, and Klein, Crawford et al. 1978) because scholars have identified failings in both the formation and the adaptation of non-hierarchical organizational forms when both asset specificity and incomplete contracting apply.

Formation

Initial scholarship on the theory of the firm (Coase 1937) highlighted that complex transactions among peers in a market were characterized by high levels of haggling and learning. When negotiating about a relationship-specific asset peers might attempt to define a complete contract even when one is not possible, or might engage in extra-contractual 'side bargaining.' Extensive haggling and learning delay the point at which a shared asset is put to productive use.

Some productive collaborations might not form at all due to the combination of a relationship-specific asset and incomplete contracting. If one party feels that a potential partner will exploit the relationship specificity of the asset by appropriating *ex post* rents in a way that cannot be contracted against *ex ante*, that party might not enter into the collaboration. As Hart 1989 puts it, in these circumstances "a far sighted agent thus chooses his investment inefficiently, from the point of view of the group as a whole, because he realizes that part of his investment will be appropriated by others at the ex-post stage."

Adaptation

If a group of peers overcomes the obstacles to forming a collaboration that makes use of a shared IT asset, they face another set of challenges as they attempt to adapt it over time to disturbances in the environment. Williamson 1991 segments such disturbances into two categories: those for which prices serve as sufficient statistics, and those that "… require coordinated responses, lest the individual parts operate at cross-purposes or otherwise suboptimize."

According to Williamson, hierarchies are better at adaptations where price is not a sufficient statistic: "As compared with the market, the use of formal organization to orchestrate coordinated adaptation to unanticipated disturbances enjoys adaptive advantages as the condition of [multilateral] dependency progressively builds up… [and] … dependency builds up as asset specificity deepens."

The unambiguous prescription from the theory of the firm is that if an inter-group information technology is a relationship-specific asset over which complete contracts cannot be written, it should be governed by a hierarchy with a single decision-making authority.

A TECHNOLOGY CATEGORIZATION

So which inter-group information technologies, if any, are relationship specific? Email, instant messaging, and Web browsers seem to their users to be almost infinitely redirectable – which technologies aren't?

An answer to this question emerges from considering the extent of *ex ante* agreement required before collaborators can begin jointly using a given information technology. Table 1 segregates these agreements into three levels: network, data, and process (this three-level framework is similar to the one used by Chari and Seshadri 2004 for discussing systems integration efforts; see also McAfee 2005).

Table 1 about here

The rightmost column of Table 1 arranges collaborative technologies by the level(s) of agreement that must be in place before they can be used (This categorization differs from previous typologies of interorganizational information systems, which have been based on whether they have a bilateral or multilateral 'footprint' (see, for example, Bakos 1991 and Choudhury 1997). 'Level 1' technologies require the pre-existence only of a common network, and with the Internet such a network is in place around the world. These technologies, referred to here as *network information technologies* (NITs), include email, instant messaging, Web sites, and Web browsers. (Web sites are included in this list because the owner of a site does not need to reach agreement with all of its users before initiating the site or making changes to it.). Because level 1 technologies require no *ex ante* agreements among their users, they are completely redirectable.

The same is not true for the technologies listed at levels 2 and 3 in Table 1. They require complete and precise *ex ante* agreements about the data that will be exchanged and, if a multi-step process is to be executed, the 'flowchart' of the tasks, sequence, and possible branches and termination points of the process. These complete agreements are required because the technologies at levels 2 and 3, which are referred to here as *enterprise information technologies* (EITs), involve the exchange of data between information systems or modules. As the mythologist Joseph Campbell remarked, "Computers are like Old Testament Gods: all rules and no mercy." If the information system at one end of an EDI

link receives a transmission that differs even slightly, in format or content, from what it has been programmed to accept, the transmission will fail. The same does not happen with NIT because network technologies are employed not to exchange data between computers, but instead between humans (email, instant messaging) or between a human and a computer (Web browsing) (McAfee 2005)

Practitioners use the term *configuration* to describe the work of reaching required agreements about EITs and embedding these agreements within the technologies themselves. Configuring an EDI or XML link means determining the family of transmissions that will be sent across the link and the exact syntax and structure of each. Configuring ERP involves defining the data the system will contain and the business processes it will facilitate, then 'populating' the system to reflect these choices. Configuration is detailed and time-consuming work. A study found that ERP implementations required an average of 21 months (Hitt, Wu et al. 2002), and a case study revealed that 19 months were required to establish a single XML link between a large manufacturer and its distributors (McAfee 2004).

Configuring an EIT converts it from a general purpose asset to a context-specific one. The EDI link established to transmit purchase orders and invoices between an automobile assembler and its battery supplier, for example, cannot readily be redeployed to send electronic loan payments to the supplier's bank. In all probability, it also can't be quickly redeployed to transmit purchase orders and invoices to another auto manufacturer. This is because the two carmakers are virtually guaranteed to have very different internal information systems and data

structures, a phenomenon referred to as the ‘corporate household problem’ (Hansen, Madnick et al. 2002, Chen, Funk et al. 2001. Some scholarship on technologies such as EDI appears to assume that the definition and promulgation of level 2 standards by industry-level and inter-industry bodies will eliminate or at least reduce the household problem, thereby allowing redirectability. Detailed investigations of how EDI is actually implemented, however, reveal high levels of standards fragmentation and idiosyncratic configuration (Swatman, Swatman et al. 1991, McAfee 2003) and the exercise of power to force compliance with a convenient, rather than a universal, standard (McNurlin 1987).

Technologies like ERP that embed level 2 *and* level 3 agreements are even less redirectable once configured. Even though these technologies have initial templates for data and processes these templates are heavily modified during configuration to support the particular requirements of each implementation (for case studies of this work, see McAfee and Herman 2000, McAfee, McFarlan et al. 2004, Ross 1999, and Austin, Nolan et al. 1999). The lack of redirectability in configured EIT is so pronounced that in the event of a troubled adoption effort some firms have scrapped a partially-configured system rather than restarting ‘from scratch’ with it (Sirkin and Dickel 2000, Worthen 2002).

Both network and enterprise information technologies facilitate multi-party collaboration. For the present purposes, the salient difference between them is that network technologies are trivially easy to redirect from one context or relationship to another, while enterprise technologies, once configured, are not redirectable.

ELECTRONIC HIERARCHIES AND ELECTRONIC HETERARCHIES

Table 1 provides a basis for defining an electronic hierarchy:

An electronic hierarchy *is group of participants desiring collaboration, one of which has enforceable level 2 and/or level 3 decision rights.*

Much of the research on the impact of IT on the boundary of the firm has contrasted hierarchies with markets. In this work, the term 'market' appears to have two meanings: a *forum in which buyers and sellers come together and the forces of supply and demand affect prices* (the primary meaning of the word in many dictionaries) and a *group of peers without any controlling authority*. The first definition stresses mechanisms for exchange and price setting; the second concerns governance and decision rights, which are the focus of this paper. Given this focus, it is more appropriate to compare hierarchies not with markets, but instead with heterarchies, which are groups in which all members have the same level of authority. The definition of electronic hierarchy given above suggests a definition for electronic heterarchy:

An electronic heterarchy *is a group of participants desiring collaboration in which level 2 and level 3 decision rights are not vested with any single party.*

By these definitions, some common arrangements are clearly electronic heterarchies, while others are clearly electronic hierarchies. A single firm, whether centralized or decentralized, is an electronic hierarchy. Executives

within the firm have level 2 and level 3 decision rights by virtue of their authority, just as they have the right to decide on other aspects of firm infrastructure such as office and factory locations, capital expenditures, etc. It might be more organizationally difficult for executives in a decentralized firm to make and enforce level 2 and level 3 decisions (Worthen 2002), but it is within the scope of their authority.

A group of peer firms transacting on a spot basis, or the set of firms that make up an industry, on the other hand, constitute an electronic heterarchy. No single actor has enforceable level 2 and level 3 decision rights. Of course, a firm in either situation could propose a set of level 2 or level 3 parameters, but would not necessarily have effective mechanisms for propagating or enforcing them.

This does not imply, however, that all multi-firm arrangements are electronic heterarchies. Using the definitions presented here, an electronic hierarchy could span multiple firms if one of them possessed enough power to enforce its level 2 and level 3 preferences on the others. This definition is consistent with Malone, Yates *et al.* 1987, who state that "In many cases the hierarchy… span[s] legally separate firms in a close,… electronically mediated… relationship." This could be the case for a vertical value chain with a dominant player. Wal-Mart and Dell, to take two examples, are both dominant in their value chains (or at least large portions of them), and both have established IT-based private exchanges in which all participants abide by their level 2 and level 3 decisions. Private exchanges like these are considered here to be electronic hierarchies. This definition differs slightly from the standard view of the theory of the firm, in which

"…ownership determines the disposition of an asset in conditions not covered by a contract" (Bakos and Nault 1997). This paper asserts that IT asset disposition rights can also derive from power.

Finally, an intra- or inter-industry body dedicated to proposing level 2 and level 3 standards is considered here to be an electronic heterarchy, as long as neither the body itself nor any of its participants has enough power to force compliance. These standards bodies, which include the multi-industry ebXML effort and high tech manufacturing's RosettaNet, lack both *de facto* and *de jure* decision rights over their participants.

It is important to stress that these definitions for electronic heterarchy and electronic hierarchy concern *only* decision rights over level 2 and level 3 IT. Dell, for example, does not typically make human resources or financing decisions for its suppliers, nor does it specify what operating systems must be used on their servers. Nonetheless, these suppliers are considered here to be members of an electronic hierarchy with Dell as the central authority, because Dell sets the level 2 and level 3 parameters for its private exchange.

THEORY AND HYPOTHESES

Taken together, prescriptions from the theory of the firm, awareness of the differences between NIT and EIT, and the definitions of electronic hierarchy and electronic heterarchy yield a contingent theory about the impact of IT on the organization of work. This theory is summarized in Table 2. It holds that when an enterprise information technology such as EDI or XML is required, an

electronic hierarchy is necessary and an electronic heterarchy is insufficient. When network IT alone is required, an electronic heterarchy is sufficient and an electronic hierarchy is not necessary (but neither is one harmful). A single decision making authority is required for enterprise IT because it is a relationship-specific asset over which complete contracts cannot be written. Network IT is highly redirectable instead of being relationship specific, so decision rights over it can be distributed among peers in a heterarchy without adverse effect.

Table 2 about here

This theory helps to explain why, as one 2003 study concluded, "In spite of the significant potential benefits, only a few large businesses have implemented inter-organizational e-business processes so far." (Segev, Patankar et al. 2003). Links and processes that require *ex ante* level 2 and/or level 3 agreements also require the creation of relationship-specific assets over which complete contracts cannot be written. The predicted result in this situation, according to the theory of the firm, is 'Williamsonian underinvestment' (Clemons and Row 1993).

This contingent theory of the governance of IT-facilitated collaborations yields three hypotheses:

H1: Network information technologies will be deployed both within electronic hierarchies and across electronic heterarchies.

H2: Enterprise information technologies will be deployed primarily within electronic hierarchies, and rarely across electronic heterarchies.

H3: Within a two-party electronic hierarchy that deploys Enterprise IT the party with greater power will exercise decision rights over that technology.

Hypothesis 2 does not state that electronic heterarchies will *never* deploy Enterprise IT. Members of an electronic heterarchy with particularly high levels of trust or effective joint decision-making mechanisms might be able to successfully deploy such technologies. These heterarchies would be examples of hybrid forms (Williamson 1991) with non-hierarchical governance mechanisms over jointly-used IT. According to the theory proposed here, however, most electronic heterarchies will not deploy enterprise information technologies.

HYPOTHESIS TESTING

Our hypotheses are tested with data from a survey of firms within Italian industrial districts. These firms typically have deep and longstanding relationships with each other, supporting their ability to closely coordinate activities and remain responsive to market needs. There is a strong tradition of research on Italian industrial districts (see, for example, Piore and Sabel (1984), Pyke, Becattini et al. (1990), Whitford (2001), and Chiarvesio, Di Maria et al. (2004)),including a study that found scant uptake of pre-Internet era IT for interfirm communication (Kumar, van Dissel et al. (1998)). Micelli and De Pietro (1997) characterized Italian districts as 'networks without technologies.'

Such districts provide a stern environment for testing our hypotheses because their member firms typically have close ties, both horizontal and vertical, and

have historically worked in close collaboration with each other. These firms therefore could be expected to have relatively high levels of trust and long histories of collaboration, making them more likely to adopt Enterprise IT even in the absence of a decision rights hierarchy. The advent of useful network and enterprise IT after the mid 1990s provides an opportunity to study which technologies were widely employed by members of these districts, and which ones were not.

DATA

Since 1999, the Center for Studies on Technologies in Distributed Intelligence Systems (TeDIS) at Venice International University has conducted an annual telephone survey of the IT endowments of firms in Italy's districts. A core set of questions has remained constant across surveys, but others have been added and dropped. TeDIS also surveyed different districts each year from among the 199 recognized by ISTAT, the Italian National Institute of Statistics.

In 2005, TeDIS surveyed 668 firms in 41 districts, concentrating on the home furnishings, engineering, and fashion industries. The 2005 survey asked firms if they had email and corporate web sites (both network technologies) and if they had EDI and XML links (both enterprise technologies) with external partners. 77 companies responded that they had EDI or XML, or both. These firms were then contacted by phone to complete a follow-up survey that asked further questions about these links. Data from the initial and follow-up surveys were used to evaluate hypotheses 1-3.

Of the 77 firms that reported having an EDI/XML link, 41 responded to the follow-up survey, yielding a response rate of 53.2%. Table 3 below shows that respondents and non-respondents to the follow-up on EDI/XML were similar along most dimensions captured by the initial TeDIS survey, with the exception that a marginally significantly higher percentage of respondents described themselves as having a 'competitive position' in their markets.

Table 3 about here

This table also shows that firms with EDI/XML links were on average larger, more likely to be part of an industrial group, more likely to be in the home furnishings industry, and less likely to be in the fashion industry than those without such links. These differences perhaps merit exploration and explanation in future work, but they are not of interest for the present purposes. This paper seeks not to explain what causes an EDI/XML link to form, but instead to characterize the governance modes of whatever links are in existence.

To do this, we used the initial 2005 TeDIS survey to identify a population of extant EDI/XML links, then conducted the follow-on survey to assess their governance. Most previous research on EDI, in contrast, has examined the set of links connecting a single large customer firm with members of its supplier network (see, for example, Mukhopadhyay, Kekre et al. (1995), Hart and Saunders (1998), Son, Narasimhan et al. (2005)). These links could be expected

to have largely similar decision right allocations. Our approach to identifying a population of links, in contrast, contains no *ex ante* biases toward a particular governance mode. Our survey incorporated both EDI *and* XML, a more recent and flexible technology for exchanging electronic documents between information systems (for explanations of XML, see Hagel and Seely Brown (2001, Hagel (2002), and McAfee (2005)).

HYPOTHESIS 1

99.7% of respondents to the original 2005 TeDIS survey used email, and 84.2% maintained publicly visible corporate websites. The survey did not specifically ask if these technologies were used for interfirm (as well as intrafirm) information sharing, but it is extremely unlikely that they were not. There appear to be no documented cases, for example, in which a company with an Internet-compliant email system did *not* use that system for interfirm communications.

The survey also did not ask whether email and websites were used only with external firms to which the respondent had ceded IT-related decision rights (or firms over which the respondent had these rights). In other words, the survey did not attempt to discern whether interfirm email and Web browsing were conducted only within electronic hierarchies. Common sense and accumulated experience, however, strongly indicate that this is not the case. The only prerequisite to using email is an email address, and the only prerequisite to accessing a public website is knowledge of its URL. There appears to be no evidence that any firms

have confined their email and web traffic only to external partners to whom they have surrendered IT decision rights, or who have surrendered these rights to them. If firms in Italian districts were using email and the Web only under these circumstances, they would almost certainly be unique among the world's adopters of these technologies. Furthermore, it is highly likely that many of these companies are *not* part of a multi-firm electronic hierarchy. If such companies are using external email, they are by definition using it across an electronic heterarchy.

The near universality of email and deep penetration of corporate websites among TeDIS survey respondents, combined with common-sense assumptions about how these technologies are used among firms, provides support for our first hypothesis, that network technologies are used across all IT governance modes. The near ubiquity and heavy use of these two technologies across virtually any population of corporations in the developed world is further support for our first hypothesis.

HYPOTHESIS 2

The follow-on survey asked respondents how many external EDI/XML links they maintained. The 41 respondents maintained a total of 363 links, but 17 firms had only one connection. These technologies are used mainly with customers: on average, firms have 8.6 connections with them and only 0.9 with suppliers, and 27 firms have no EDI or XML connections with suppliers at all. Since the survey also asked respondents for their total number of customers, we can calculate a

“connection ratio”: 72% of respondents are connected by EDI with 1% or less of their customers; another 15% with less of 10% of them, and none with more than 50%.

The follow-on survey also asked each respondent to provide governance information on up to three EDI/XML links. 5 firms reported on 3 links; 18 on two links, and 18 on one link, for a total of 69 links. Of these, 17 are XML (24.6%) and 52 are EDI (75.4%). 54 are links with customers, and 15 are with suppliers. Half of the links are recent: 18.8% were established less than one year ago, 21.8% are between one and two years old, and 11.6% are between two and three years old. 27.5% of the links are at least five years old. 58% of links are equally used to send and receive information; 18.8% are used primarily to send information, and 23.2% primarily to receive information.

Each of these links spans a firm dyad, but there are no cases in which the follow-on survey by coincidence captured information from *both* firms in the dyad. This is not surprising, since 36.2% of respondents reported that the other firm in the EDI/XML dyad was outside their district (but within Italy), and 42.0% reported that the other firm was outside Italy.

For each EDI/XML link, the survey asked three questions about governance of the link; two of these questions were quantitative, and one was qualitative. The two quantitative questions were:

Who initiated the link?

Who defined which transmissions would be used?

For each of these, three answers were possible:

The respondent did

The partner / the other firm in the dyad did

Both firms did

Responses to these two questions are summarized below in Table 4.

Table 4 about here

We used these responses to categorize dyads as electronic hierarchies or electronic heterarchies as follows:

If the same firm was wholly responsible for initiating the link and configuring it, the dyad

was considered an electronic hierarchy.

If both firms were jointly responsible for initiating and configuring the link, the dyad was considered an electronic heterarchy.

If one firm was wholly responsible for one decision while the two firms were jointly responsible for the other one, the dyad was considered a 'partial electronic hierarchy'.

As Table 4 shows, there were no cases in which one firm was wholly responsible for one decision while the other firm was wholly responsible for the other one.

Table 4 reveals that 76.8% of links (53 total links) existed within electronic hierarchies, 10.2% (7 total) existed within partial electronic hierarchies, and 13% (9 total) existed within electronic heterarchies.

If hypothesis two is incorrect and decision rights over the EDI/XML link are in fact irrelevant in dyads with such links, then a null hypothesis is that each of Table 4's nine cells should contain approximately the same number. In other words, the two sets of decision rights over the link should be unrelated and equally distributed across the three possible outcomes. A chi-square test reveals that this null hypothesis can be rejected with a high degree of confidence (χ^2 (8, N=69) = 21.96, p = 0.000).

Qualitative data provide additional support for hypothesis two. For each link we asked the open-ended question "Why did you choose this technology?"

25 responses to this question (representing 46.3% of all links with customers) indicated that a customer imposed the link, and another 10 responses (18.5%) indicated that a customer suggested the link in order to make transactions more efficient, to extend the partner's existing EDI/XML infrastructure, or to have a standard communication language. These customers include large national and international manufacturers like Fiat, Volkswagen, Electrolux, Enel (the national Italian electricity supplier), or worldwide distributors like Brico, Castorama, Bloomingdale's, and Wal-Mart.

HYPOTHESIS 3

Our third hypothesis is that in dyads that are electronic hierarchies the more powerful party with be the party with IT decision rights. Previous studies of EDI adoption have indicated that the customer firm holds decision rights. In these studies, however, customer firms have also typically been comparatively large, so it is possible that power derives from relative size.

To evaluate these two variants of hypothesis three, we asked respondents to the follow-on survey whether they were the customer or supplier in the dyad, and whether they were the larger or smaller firm.

Of the 53 electronic hierarchies identified within the sample, the customer firm held decision rights over the link in 41 cases (77% of cases). In the other 12 cases the supplier firm held decision rights over initiating the link and defining its uses.

In the 7 partial electronic hierarchies, the customer firm held the singly vested decision rights in all but one case. Of the 60 instances of full or partial electronic hierarchies, therefore, the supplier held all solely vested decision rights in 13 cases, or 21.7% of cases.

Across the 53 electronic hierarchies, the smaller firm held both sets of decision rights in only 7 cases, while the larger firm held both sets in 44 cases. In one of the two remaining cases the firms were the same size; in the other case the respondent did not indicate relative firm size. Including partial electronic hierarchies, in the 58 cases where relative firm size data is available, smaller firm

held all fully vested decision rights in only 8 cases, or 13.8% of cases. While decision rights were less often vested with the smaller firm than with the supplier, the difference between 8 and 13 cases is not statistically significant for the sample size of 60 ($p = .117$). We therefore cannot say with statistical confidence that relative firm size is a better predictor of decision right allocation than status as a customer or supplier in our sample.

In five of the seven partial electronic hierarchies the singly vested decision rights were the *later stage* ones, in other words the decision defining the transmission set to be carried by the link, rather than the initial decision to establish a link. In four of these five cases the party assuming the later stage decision right was the customer, who is presumed to be the more powerful. This pattern is consistent with the prediction from property rights theory that parties with decision rights over a relationship-specific asset will be likely to exercise these rights at the *ex post* stage. Because the asset is in place at this stage it is problematic to walk away from the relationship, and so the other party's bargaining power is reduced, leaving it vulnerable to the progressive assumption of extra-contractual decision rights.

An alternative to hypothesis three is that the more technically sophisticated firm assumes decision rights over the EDI/XML link. The follow-on survey asked respondents whether the other member of the dyad was more technically sophisticated. Of the 32 electronic hierarchies where the other dyad member held decision rights over the link, this other firm was assessed as being more technically sophisticated in only 43.7% of the cases. This indicates that firms are

not simply allocating EDI/XML link decision rights to the more sophisticated member of the dyad.

DISCUSSION

The theory presented here also offers an explanation for some anomalies within the EMH, as well as some current trends in the use of inter-organizational IT.

eMarkeplace Failures

Substantial variation in the revenue models, services offered, and funding sources of these businesses appeared to have little effect on outcomes; very few public exchanges attracted a large membership. When eMarketplaces are viewed as *de novo* electronic hierarchies, their widespread failure becomes less surprising. These startup businesses made level 2 and level 3 decisions on behalf of an industry, then expected members to accede to them by joining the eMarketplace. When prospective members are viewed as Williamson's 'far sighted agents' their reluctance to join, and so to subsume themselves within an electronic hierarchy, becomes easy to understand.

Private exchanges

Large firms such as Dell, Wal-Mart, HP, and Cisco have sponsored 'private exchanges,' which use level 2 and/or level 3 technologies to facilitate interactions among the sponsor and its suppliers (private exchanges are described in Sawhney 2002, Young 2001, and Harris 2001; for case studies of private exchanges in operation see Perman 2001, Anonymous 2000, Hoffman, Keedy et

al. 2002). In fact, several firms founded with the goal of building public eMarketplaces have explicitly repositioned themselves as providers of software and services for private exchanges (Harris 2001, Anonymous 2001, Parker 2001, Weinberg 2001, Day, Fein et al. 2002). Private exchanges are electronic hierarchies that make use of the power of a large firm. Private exchange sponsors have the leverage to force their suppliers to comply with the level 2 and level 3 decisions they make about these enterprise technologies.

Amazon and eBay's publication of level 2 and 3 standards for application integration with merchants (Schonfeld 2005) is a similar phenomenon. These standards are 'take it or leave it' propositions; they are not renegotiated with each merchant. Because of the power of the two eCommerce giants, many merchants have adopted one or both of them (Amazon and eBays standards are not interchangeable), and thereby subsumed themselves within an electronic hierarchy.

Private exchanges can support a 'move to the middle,' but the Amazon and eBay examples highlight a distinction between the move to the middle hypothesis and the theory presented here. An electronic hierarchy is not necessarily composed of a small, stable network; it can instead consist of an authority with level 2 and level 3 decision rights, such as Amazon or eBay, and a large and fluid set of actors who interact with them. Conversely, not all small and stable networks that use IT are electronic hierarchies; some such networks appear to be characterized by Williamsonian underinvestment in level 2 and level 3 IT because actors are not willing become part of an electronic hierarchy.

Web Services

XML is part of a larger set of technologies often labeled 'Web Services' that, according to some analysts, can significantly ease the challenges of inter-company systems integration (Hagel and Seely Brown 2001, Hagel 2002)). While Web Services are both more powerful and more flexible than previous technologies such as EDI, they cannot yet be used to create linkages that are *not* relationship-specific, and there is reason to doubt that this will change (McAfee 2005). As a result, if the theory presented here has validity, then Web Services will continue to be deployed primarily within electronic hierarchies.

Standards bodies

A number of standards bodies, some governmental and some industry-financed, propose level 2 and/or level 3 standards. If such a standard were to be widely accepted with 100% fidelity, than at least some enterprise technologies could move from relationship-specific to redirectable. Two factors, however, mitigate against this vision. First, standards bodies are themselves fragmented, overlapping, and proliferating (Chari and Seshadri 2004) so a single 'pure' standard is unlikely to emerge. Second, firms in practice appear to take the work of standards bodies as a starting point for their integration work, modifying proposed standards as required to suit their idiosyncratic needs (for a case study of this, see McAfee 2004). As long as this is the case, configured enterprise technologies will continue to be relationship-specific investments.

CONCLUSION

This paper presents a contingent theory of the impact of IT on the organization of economic activity. In contrast to the EMH, the theory holds that in some circumstances electronic hierarchies will predominate.

The theory, however, is silent about when enterprise IT is required. It is not yet clear when, if ever, electronic heterarchies using network IT alone are at a competitive disadvantage vis-à-vis electronic hierarchies using both NIT and EIT. Clear examples of competition between the two organizational forms are lacking. Also lacking are comparisons of the benefits or capabilities provided by the two technology categories. It seems unlikely that the recent massive investments in enterprise technologies (McAfee 2003) would have taken place if they offered no advantages over NIT alone, but these advantages have not yet been delineated.

Another potentially fruitful stream of research suggested by the theory presented here is examination of the processes by which multi-firm electronic hierarchies form and EIT is deployed. Large firms are apparently able to convince their suppliers to adopt EDI, XML, and private exchange software, but it is not yet clear if they do so primarily via fiat or consensus building. The early histories of successful online markets such as eBay (Cohen 2002) and the bookseller Alibris (McAfee 2004) suggest that they started by defining few level 2 or level 3 standards for their participants. They did not attempt, in other words, to become electronic hierarchies immediately. Only after they accumulated significant power did they begin to require their members to make relationship-specific

investments. Future research could reveal if this is a general pattern, and how entities other than powerful incumbent firms can successfully build electronic hierarchies.

The financial services and travel industries appear to be anomalies within the theory presented here because both make heavy use of level 2 and level 3 enterprise technologies, yet neither is an electronic hierarchy: there does not exist in either industry a single authority with decision rights over level 2 and level 3 parameters. It could be that the need to exchange huge amounts of frequently-changing data forced firms in both these industries to agree on universal interaction standards, and then to refrain from subsequently deviating from them. Governmental intervention could also have played a role. Early airline reservation systems received antitrust scrutiny in the US (see, for example, Friedman and Nissenbaum 1996) prompting their owners to open them to competitors, and financial services firms have faced regulations about the speed with which transactions must be executed. Future research could help clarify whether these were the dominant pressures leading to the current deep and broad IT linkages in these two industries, or whether there are other explanations for them.

The two categories of electronic hierarchy and electronic market clearly do not capture all of the existing modes of governing IT-based collaborations. Consortia, for example, exist in industries including electronics (Converge) and health care (the Global Healthcare Exchange). Consortia are typically founded, funded, and jointly governed by several large firms within the industry and have as a goal the

propagation of level 2 and level 3 standards to facilitate trade among members. Other hybrid forms also exist, such as multi-firm IT infrastructures that exist for the duration of a single large project (Argyres 1999). Further research could help define the full spectrum of IT-based interactions and the appropriate governance mechanisms for each. Scholars working on these topics would do well to heed Williamson 1991 admonition that “market-favoring predispositions need to be disputed, lest the study of economic organization in all of its forms be needlessly and harmfully truncated.”

Table 1: Levels of *ex ante* agreement required for IT-facilitated collaboration. This table divides required agreements into three levels, gives examples of the *ex ante* agreements required at each, and lists examples of information technologies that can be used once these agreements are in place (neither set of examples is exhaustive). The levels of agreements are cumulative; the technologies listed at level 2, for example, cannot be used unless both level 1 and level 2 agreements are in place.

	Definition	**Examples of *ex ante* agreements required**	**Technologies available once agreements exist**
Level 1: Transport	Agreement about link/network used to transmit data between machines	Network choice, encryption, encoding, transmission integrity mechanisms	Email, instant messaging, websites, groupware
Level 2: Data	Agreement about contents and structure of data sent between modules	Data definitions, document syntax, acceptable values	Electronic data interchange (EDI), extensible markup language (XML)
Level 3: Process	Agreement on parameters of business process(es) facilitated by multi-module information systems.	Sequence of steps, possible branches, possible endpoints, authorizations required	Enterprise resource planning (ERP), customer relationship management (CRM)

Groupware is “application software that integrates work on a single project by several concurrent users at separated workstations.” EDI is “the computer-to-computer exchange of structured information, by agreed message standards, from one computer application to another by electronic means and with a minimum of human intervention.” XML is a computer language “capable of describing many different kinds of data. Its primary purpose is to facilitate the sharing of data across different systems, particularly systems connected via the Internet.” ERPs are “management information systems that integrate and automate many of the business practices associated with the operations or production aspects of a company.” CRM is software intended “to enable organizations to better serve their customers through the introduction of reliable processes and procedures for interacting with those customers.” All definitions from Wikipedia, www.wikipedia.org, accessed October 22, 2005.

Table 2: Information technology categories and governance mechanisms.

The table summarizes the theory presented in this paper of the appropriate governance mechanisms for different categories of interaction-facilitating IT. Because network IT is not a relationship-specific asset it does not require a hierarchical governance structure; a heterarchy is sufficient. Enterprise IT, on the other hand, is a relationship-specific asset once configured. It therefore must be governed within a hierarchy.

	Governance mechanism	
Technology Category	**Electronic Heterarchy**	**Electronic Hierarchy**
Network IT	Sufficient	Unnecessary
Enterprise IT	Insufficient	Necessary

Table 3: Comparison of Respondents and non-Respondents to 2005 TeDIS follow-on survey. This table also compares follow-on respondents and non-respondents to firms participating in the original survey who did *not* report having an EDI or XML connection to another firm.

	EDI/XML respondents (N=41)	Non respondents to EDI survey (N=36)	EDI/XML non adopters (N=591)
Turnover (average)	64.3	44.8	18.8 ***
Turnover (median)	35.0	19.0	9.2
Employees (average)	218	282	78 ***
Employees (median)	160	100	45
Export ratio (% on turnover)	44.2	54.6	46.2
Competitive position (leadership or relevant role in the market)	90.0	83.3 *	75.3 ***
Belonging to a group (%)	53.7	50.0	29.3 ***
Main production: products for final market (%)	58.5	50.0	50.7 *
Industry: engineering (%)	34.2	41.6	31.6
Industry: home-furnishings (%)	34.1	30.6	25.4 **
Industry: fashion (%)	31.7	27.8	43.0 **

*Note: Differences from EDI/XML respondents significant at: * 90%; ** 95,5%, *** 99%*

Table 4: Summary of responses to questions about decision rights over EDI/XML links

		The transmissions were defined by :			
		company	partner	both	total
The link was initiated by:	company	21	0	2	23
	partner	0	32	0	32
	both	0	5	9	14
	total	21	37	11	69

REFERENCES

Anonymous. 2000. Business: Seller Beware. *The Economist, 354*. Mar 4 2000. 61-62

Anonymous. 2000. Supply-chain software: Hewlett Packard. *Business 2.0, 2002*. June 5. 236

Anonymous. 2001. Business: Time to rebuild. *The Economist, 359*. May 19. 55-56

Argyres, N. S. 1999. The Impact of Information Technology on Coordination: Evidence from the B-2 "Stealth" Bomer. *Organization Science,* **10**(2). 162-180.

Attewell, P., Rule, J. 1984. Computing and Organizations: What We Know and What We Don't Know. *Communications of the ACM,* **27**(12). 128-136.

Austin, R., Nolan, R., Cotteleer, M. 1999. *Cisco System, Inc.: Implementing ERP* (Case study No. HBS No. 699-022). Boston: Harvard Business School Publishing.

Baker, G. P., Hubbard, T. N. 2004. Contractability and Asset Ownership: On-board Computers and Governance in US Trucking. *Quarterly Journal of Economics,* **119**(4). 1143.

Bakos, J. Y. 1991. Information links and electronic marketplaces: The role of interorganizational information systems in vertical markets. *Journal of Management Information Systems,* **8**(2). 31-52.

Bakos, J. Y., Brynjolfsson, E. 1993. From vendors to partners: Information technology and incomplete contracts in buyer-supplier relationships. *Journal of Organizational Computing,* **3**(3). 301-328.

Bakos, J. Y., Nault, B. 1997. Ownership and Investment in Electronic Networks. *Information Systems Research,* **8**(4).

Bensaou, M. 1997. Interorganizational cooperation: The role of information technology an epirical comparison oif US and Japanese supplier relations. *Information Systems Research,* **8**(2). 107-124.

Brookes, M., Wahhaj, Z. 2000. *The Shocking Economic Impact of B2B* (Global Economics Paper No. 37). New York: Goldman Sachs.

Brynjolfsson, E. 1994. Information assets, technology, and organization. *Management Science,* **40**(12). 1645-1662.

Chari, K., Seshadri, S. 2004. Demystifying Integration. *Commumications of the ACM,* **47**(7). 59-63.

Chen, X., Funk, J., Madnick, S., Wang, R. 2001. *Corporate Household Data: Research Directions.* Paper presented at the Proceedings of the Americas Conference on Information Systems, Boston. August

Choudhury, V. 1997. Strategic Choices in the Development of Inter-Organization Information Systems. *Information Systems Research,* **8**(1). 1-24.

Ciborra, C. U. 1983. Markets, bureaucracies and groups in the information society: An institutional appraisal of the impacts of information technology. *Information Economics and Policy,* **1**. 145-160.

Clemons, E. K., Reddi, S. P., Row, M. C. 1993. The impact of information technology on the organization of economic activity: The "move to the middle" hypothesis. *Journal of Management Information Systems: Jmis,* **10**(2). 9-35.

Clemons, E. K., Row, M. C. 1992. Information technology and industrial cooperation: The changing economics of coordination and ownership. *Journal of Management Information Systems,* **9**(2). 9-28.

Clemons, E. K., Row, M. C. 1993. Information, power, and control of the distribution channel. *Chief Executive,* **85**. 64-67.

Clemons, E. K., Row, M. C. 1993. Limits to interfirm coordination through information technology: Results of a field study in consumer packaged goods distribution. *Journal of Management Information Systems: Jmis,* **10**(1). 73-95.

Coase, R. H. 1937. The nature of the firm. *Economica, New Series,* **4**(16). 386-405.

Cohen, A. 2002. *The Perfect Store: Inside eBay*. New York: Little, Brown.

Davenport, T. H., Prusak, L. 1998. *Working knowledge: how organizations manage what they know*. Boston, Mass: Harvard Business School Press.

Day, G., Fein, A., Roppersberger, G. 2002. *Shakeouts in Digital Markets: Lessons from B2B Exchanges* (Working paper). Philadelphia, PA: The Wharton School.

Day, G. S., Fein, A. J., Ruppersberger, G. 2003. Shakeouts in Digital Markets: Lessons from B2B Exchanges. *California Management Review,* **45**(2). 131-150.

Doyle, T., Melanson, J. 2001. B2B Web Exchanges: Easier Hyped than Done. *Journal of Business Strategy,* **22**(3). 10-13.

Frew, W. 2002. The Trouble with E-Markets. *Business Review Weekly*. May 2. 58

Friedman, B., Nissenbaum, H. 1996. Bias in Computer Systems. *ACM Transactions on Information Systems,* **14**(3). 330-347.

Gordon, R. J. 2003. Exploding Productivity Growth: Context, Causes, and Implications. *Brookings Papers in Economic Activity*(2). 207-298.

Grossman, S. J., Hart, O. D. 1986. The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy,* **94**(4). 691-719.

Grover, V., Ramanlal, P. 1999. Six myths of information and markets: Information technology networks, electronic commerce, and the battle for consumer surplus. *MIS Quarterly,* **23**(4). 465.

Gurbaxani, V., Whang, S. 1991. The Impact of Information Systems on Organizations and Markets. *Communications of the ACM,* **34**(1). 59-73.

Hagel, J. 2002. *Out of the Box*. Boston: Harvard Business School Publishing.

Hagel, J., Seely Brown, J. 2001. Your Next IT Strategy. *Harvard Business Review*. 105.

Hansen, M., Madnick, S., Siegel, M. 2002. *Data Integration Using Web Services* (Working Paper No. 4406-02). Cambridge, MA: MIT Sloan School of Management.

Harris, N. 2001. `Private Exchanges' May Allow B-to-B Commerce to Thrive After All*. The Wall Street Journal.* p. B1

Hart, O. 1988. Incomplete Contracts and the Theory of the Firm. *Journal of Law, Economics, and Organization,* **4**(1). 119-139.

Hart, O. 1989. An economist's perspective on the theory of the firm. *Columbia Law Review,* **89**. 1757-1774.

Hart, O., Moore, J. 1990. Property Rights and the Nature of the Firm. *Journal of Political Economy,* **98**. 1119-1158.

Helper, S., MacDuffie, J. P. 2002. B2B and Modes of Exchange: Evolutionary and Transformative Effects. In B. Kogut (Ed.), *The Global Internet Economy* (pp. 1-68).

Hess, C. M., Kemerer, C. F. 1994. Computerized loan origination systems: An industry case study of the electronic markets hypothesis. *MIS Quarterly*. 251-275.

Hitt, L. M., Wu, D. J., Zhou, X. 2002. Investment in enterprise resource planning: Business impact and productivity measures. *Journal of Management Information Systems,* **19**(1). 71.

Hoffman, W., Keedy, J., Roberts, K. 2002. The Unexpected Return of B2B*. Mckinsey Quarterly.* p. 97

Ince, J. F. 2002. B2B phase II. *Upside,* **14**(4). 48-54.

Kafka, S. J. 2000. *eMarketplaces Boost B2B Trade* (The Forrester Report). Cambridge, MA: Forrester Research.

Kafka, S. J., Temkin, B. D., Doyle, B., Brown, T. O., Martin, P. 2000. *The eMarketplace Shakeout* (The Forrester Report). Cambridge, MA: Forrester Research.

Kaplan, S., Sawhney, M. 2000. E-Hubs: The New B2B Marketplaces. *Harvard Business Review,* **78**(3). 97-104.

Kekre, S., Mukhopadhyay, T. 1992. Impact of electronic data interchange technology on quality improvement and inventory reduction programs: A field study. *International Journal of Production Economics,* **28**(3). 265-282.

Klein, B., Crawford, R. G., Alchian, A. A. 1978. Vertical integration, appropriable rents, and the competitive contracting process. *Journal of Law and Economics,* **21**(2). 297-326.

Leavitt, H. J., Whisler, T. L. 1958. Management in the 1980s. *Harvard Business Review,* **36**. 41-48.

Lerner, J., Tirole, J. 2000. *The Simple Economics of Open Source* (NBER Working Paper No. 7600). Cambridge, MA: National Bureau of Economic Research.

Malone, T. W. 2004. *The Future of Work*. Boston: Harvard Business School Press.

Malone, T. W., Rockart, J. F. 1991. Computers, networks and the corporation. *Scientific American*. 128-136.

Malone, T. W., Yates, J., Benjamin, R. I. 1987. Electronic Markets and Electronic Hierarchies. *Communications of the ACM,* **30**(6). 484-497.

Malone, T. W., Yates, J., Benjamin, R. I. 1989. The Logic of Electronic Markets. *Harvard Business Review,* **67**(3). 166-172.

McAfee, A. 2003. When Too Much IT Knowledge is a Dangerous Thing. *Sloan Management Review,* **44**(2). 83-89.

McAfee, A. 2004. *Alibris in 2004* (Harvard Business School case study No. 605-035). Boston: Harvard Business School.

McAfee, A. 2005. Will Web Services Really Transform Collaboration? *Sloan Management Review,* **46**(2). 78-84.

McAfee, A., McFarlan, F. W., Berkley Wagonfeld, A. 2004. *Enterprise IT at Cisco (2004)* (Case No. 9-605-015). Boston: Harvard Business School.

McAfee, A. P. 2002. *Alibris (A)* (Case study No. 601-111). Boston: Harvard Business School.

McAfee, A. P. 2003. *Dubai Ports Authority (A)* (Case No. 9-603-061). Boston: Harvard Business School.

McAfee, A. P. 2004. *IBM: Ordering Midrange Computers in Europe* (Case No. 9-605-022). Boston: Harvard Business School.

McAfee, A. P., Herman, K. 2000. *IBM Technology Group* (Case study No. 600-010). Boston: Harvard Business School.

McNurlin, B. C. 1987. The Rise of Co-operative Systems. *EDP Analyzer, 25*. June. 1-16

Mukhopadhyay, T., Rajiv, S., Srinivasan, K. 1997. Information Technology Impact on Process Output and Quality. *Management Science,* **43**(12). 1645-1659.

Parker, R. 2001. Component suppliers shun online trading exchanges. *Supply Management*. May 24, 2001. 10

Perman, S. 2001. Automate or Die. *eCompany*.

Prahalad, C. K., Krishnan, M., S. 2002. The dynamic synchronization of strategy and information technology. *MIT Sloan Management Review,* **43**(4). 24-33.

Prekumar, G., Ramamurthy, K. 1995. The Role of Interorganizational and Organizational Factors on the Decision Mode for Adoption of Interorganizational Systems. *Decision Sciences,* **26**(3). 303-336.

Rayner, R. 2002. An Actual Internet Success Story. *The New York Times Magazine*. June 9.

Ross, J. 1999. Dow Corning Corporation: Business Processes and Information Technology. *Journal of Information Technology,* **15**(3).

Sampson, G. 2003. The Myth of Diminishing Firms. *Commumications of the ACM,* **46**(11). 25-28.

Sawhney, M. 2002. Putting the Horse First; B2B exchanges failed because they got their business models backward. *CIO, 15*. May 15. 38-40

Sawhney, M., Prandelli, E., Verona, G. 2003. The Power of Innomediation. *Sloan Management Review,* **44**(2). 77-82.

Schonfeld, E. 2005. The Great Giveaway. *Business 2.0*. April. 28-32

Segev, A., Patankar, A., Zhao, J. L. 2003. e-Business Process Interleaving: Managerial and Technological Implications. *Information Systems and e-Business Management,* **1**(4). 331-423.

Sirkin, H., Dickel, K. 2000. *Getting Value from Enterprise Initiatives*.Boston: Boston Consulting Group.

Stiroh, K. J. 2002. Information Technology and the U.S. Productivity Revival: What do the Industry Data Say? *The American Economic Review,* **92**(5). 1559-1576.

Swatman, P. M. C., Swatman, P. A., Fowler, D. C. 1991. *The Urgent Case for EDI Standards.* Paper presented at the Australian Computer Conference (MOSAIC '91), Adelaide, South Australia. October

Truman, G. E. 2000. Integration in Electronic Exchange Environments. *Journal of Management Information Systems,* **17**(1). 209-244.

Wang, E. T. G., Seidmann, A. 1995. Electronic data interchange: Competitive externalities and strategic implementation policies. *Management Science,* **41**(3). 401-418.

Weinberg, N. 2001. B2B grows up. *Forbes, 168*. September 10, 2001. S18-S21

Williamson, O. E. 1985. *The economic institutions of capitalism: Firms, markets, relational contracting*. New York: The Free Press.

Williamson, O. E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly,* **36**. 269-296.

Wolfers, J., Zitzewitz, E. 2004. Prediction Markets. *Journal of Economic Perspectives,* **18**(2). 107-126.

Worthen, B. 2002. Nestle's ERP Odyssey; Nestle USA's costly and protracted struggle with its SAP project is a cautionary tale for any company intent on an enterprisewide implementation. *CIO Magazine, 15*. May 15, 2002. 1

Young, E. 2001. Web Marketplaces that Really Work: The best new online exchanges are difference from the old public B2Bs - they're private and they're profitable. *Fortune*. Nov 19. 78

Zuboff, S. 1988. *In the Age of the Smart Machine: The Future of Work and Power*. New York: Basic Books.