Joining Supply and Demand Conditions of IT Enabled Change: Toward an Economic Theory of Inter-Firm Modulation

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Abstract

This paper examines emergent information systems and technologies and explains under what supply and demand conditions inter-firm modularization of information-based products and services and subsequent vertical de-integration of organizations is more likely. Research in organizational economics identifies transactional attributes such as coordination costs, asset specificity, and the economic non-separability problem to help explain and predict vertical de-integration. We extend this perspective by considering the modularization of information-based products and services that is noticeable to the customer to develop a framework that joins the four cornerstones of (1) transaction-related efforts; (2) commitment-related contractual risks; (3) measurement-related contractual risks; and (4) modularization-related impacts on value.
1. **Introduction**

This research seeks to explain the differential impact across industries of the modularization of information-based products and services as a result of the application of modern IT and Internet-based standards for data and communication. In particular, we consider contemporary information systems and technologies and the firm-level supply-side and consumer-level demand-side conditions that will likely influence the modularization of information-based products and services, and the vertical de-integration of organizations.

Extant theoretical and empirical literature considers the impact of changes in information technology on organizational scope and structure (Afuah, 2003; Hitt 1999). In some cases, information technology has been shown to reduce organizational scope and increase vertical de-integration (e.g., Brynjolfsson et al., 1994; Malone, Yates, & Benjamin, 1987), while in other cases information technology has led to greater organizational scope and vertical integration (e.g., Clemons, Reddi, & Row, 1993; Gurbaxani & Wang, 1991).

Traditionally, research has considered the decision making of one organization responsible for various parts of its value chain and final product, be it as part of internal operations or through external procurement and outsourcing. An important—albeit typically implicit—assumption is that the final product and scope of the product portfolio remain unchanged from the point of view of the end-buyer even as the product itself may become increasingly modular, and the value chain may become increasingly vertically de-integrated. Thus, the current paper seeks to build upon and extend the organizational economics approach to product modularization and vertical de-integration (e.g., Lajili & Mahoney, 2006; Mukhopadyay & Kekre, 2002), which focuses primarily on supply-side factors, and to highlight the decisions by individual buyers of end-products or services, as is often the case with information-based and –enabled products and services. In so doing, we join organizational economics (e.g., Mahoney, 2005; Williamson, 1985), which emphasizes value chain decisions from a
focal firm’s point of view, with consumer economics with its emphasis on individual consumer’s decisions and their responses to bundling and pricing (Bakos & Brynjolfsson, 2000; Bakos et al., 2005), and mass customization (Priem, Li, & Carr, 2012; Stremersch et al., 2003).

Information systems research that builds on organizational and consumer economics has considered the conditions and implications of modular versus integrated designs of products (Baldwin & Clark, 2000; Staudenmeyer, Tripsas, & Tucci, 2005). In the context of information technology, this research has identified two key changes: (1) many products and services are now based on information, and use data standards to enable readily available combinations of individual modules to be organized as an integrated whole (Bakos, et al., 2005; Shapiro & Varian 1999); and (2) this shift towards product modularization and the re-combination of modules into an integrated whole often shifts decision making from the firm to the individual end-consumer (Schilling, 2000).

The current paper thus considers changes in information technology (Lanzolla & Suarez, 2010; Orlikowski & Iacono, 2001) that impact the modularization of information-based products and services that is noticeable to end-customers, and thereby impact organizational scope and the extent of vertical de-integration. In the next section, we provide a value-based research framework that combines three transactional attributes—i.e., coordination costs, asset specificity, and economic non-separability—that influence the design and modularization of information-based products and services, and hence the extent of vertical de-integration (Park & Ro, 2013; Zaheer & Venkatraman, 1994). We extend this value-based framework by combining the four cornerstones of (1) transaction-related efforts; (2) commitment-related contractual risks; (3) measurement-related contractual risks; and (4) modularization-related impacts on value. The third section extends this value-based framework to incorporate a consumer (demand-side) perspective. The final section offers a discussion and conclusions.
2. Supply-Side: A Value-Based Framework to Explain and Predict Modularization and Vertical De-Integration of Information-Based Products and Services

Product modularization refers to changes in the internal structure of products and services from an integrated entity to a structure that allows for the clear distinction of separate parts that can be traded efficiently in a market. Product modularization can be planned and coordinated centrally within an organization, or can be emergent, which often occurs in decentralized settings through the actions of many (quasi-independent) participants and without central coordination (Langlois, 2002). This current paper largely focuses on emergent (i.e., market-based) modularization processes that are supported or enabled by IT (Zammuto et al., 2007).

Modularity has been described as the “degree to which a system’s components can be separated and recombined” (Schilling, 2000: 315), which is often related to the degree to which a system conforms to interface standards (Sanchez & Mahoney, 1996; Wilson, Weiss, & John, 1990). The extent of product modularization is thought to be influenced by economic factors such as market size, inter-firm diffusion of technology, and the evolution of interface standards (Christensen, Verlinden & Westerman, 2002; Stigler, 1939; Wilson, Weiss, & John, 1990) in particular in combination with concepts such as information hiding, which have long been used in computer science (Parnas, 1972).

IT plays a key role as it allows for the separation of physical products and services on the one hand and information on the other hand, and results in differing requirements of economic value-adding activities in physical versus virtual business environments (Hagel & Singer, 1999). There is considerable evidence of product modularization in industries that are manufacturing-related (Baldwin & Clark, 2000). However, even though many information-based products and services are now available electronically and can be offered as distinct components, for example via Internet-based web service platforms, inter-firm product modularization has not followed a uniform
and predictable pattern in terms of speed and quality (Cacciatori & Jacobides, 2005) across industries where information is a major part of the product or service, such as real estate (Sawyer, et al., 2003), financial services (Markus, Steinfield, & Wigand, 2006), music (Anand & Cantillon, 2004), software (Demirkan & Goul, 2006), and travel (Chircu, Kauffman, & Keskey, 2001). Among the suggested reasons that hinder the diffusion of product modularization and greater vertical de-integration are: organizational inertia and path dependencies (Argyres & Liebeskind 1999), continued economic benefits for organizations and individuals associated with product bundling (Bakos, et al., 2005), a lack or immaturity of adequate component interfaces (Shapiro & Varian, 1999), and various countermeasures by incumbents to preserve an existing competitive advantage (Schilling, 2000).

Organizational economics has traditionally been concerned with the scope of the firm (Coase, 1937; Williamson, 1975) based on a discriminating alignment of transaction characteristics and governance structures to achieve comparative efficiency (Williamson, 1996), which can then lead to competitive advantage (Kim & Mahoney, 2006; Lado & Zhang, 1998). Consistent with a majority of empirical findings, we posit a fit between modular products and services and modular organizations (Sanchez & Mahoney, 1996; Sosa, Eppinger, & Rowles, 2004), in the sense that modular products and services tend to be more vertically de-integrated (Hoetker, 2005; Jacobides, 2005; Jacobides & Billinger, 2006). The current paper extends this framework to also consider the scope of the product portfolio that an organization produces, and the opportunity for new firms to enter a market with a focus on producing and selling one or several modules, and for consumers to obtain a formerly integrated product or service through multiple separate transactions.

Organizational economics generally seek to explain and predict changes in governance structures and the boundaries of the firm based on transaction-related characteristics, such as asset specificity (Williamson, 1985) and the non-separability problem (Alchian & Demsetz, 1972). The next section builds on the efficiency perspective and extends this framework to consider that inter-
firm product modularization can also impact transactional value (Zajac & Olsen, 1993). For each of the four cornerstones, we discuss the role IT might play for developments towards modularization.

2.1 Cornerstone 1: Transaction-Related Efforts (Coordination Costs) and the Role of IT

Business transactions are defined as the exchange of goods and services in a business environment, which typically include search, negotiation, exchange, and post-transaction activities that require certain efforts and costs (Coase, 1937; Williamson, 1975). Even when incentives are aligned, substantial coordination costs are typically still to be expected (Foss, 2011; Kim & Mahoney, 2005). Effective coordination requires the management of interdependencies (Malone & Crowston, 1994; Schepker, et al., 2013) and can be achieved through the exchange of information (e.g., based on written documents or verbal communication) and data transfer (e.g., based on structured reports).

Internal coordination costs represent the economic costs incurred for various activities intended to manage interdependencies within a firm. Internal coordination typically requires establishing internal management procedures, hierarchical protocols, and routines (Becker & Murphy, 1992; Leiblein, 2003), as well as operational activities for administration and planning (Im, Grover, & Teng, 2013). In contrast, external coordination costs stem from the complexity and efforts associated with the management of modular organizational structures, sales, and market procurement, and result in the need to establish and maintain relationships with business partners, customers and suppliers, and to conduct multiple market transactions, including activities, such as search, negotiation, and exchange (Gurbaxani & Wang, 1991; Schepker, et al. 2013). Efforts to coordinate a system, such as an organization, tend to increase with the size and complexity of the system as a result of the increasing numbers of both the elements that are part of the system and the relationships between the elements (Simon, 1962). The efficient level of product modularization and thereby the efficient boundary of the firm (i.e., the efficient level of vertical de-integration) are
affected by trading off external and internal coordination costs (Clemons, Reddy, & Row, 1993; Malone, Yates, & Benjamin, 1987).

**The Role of IT:** IT can help reduce costs of both internal and external coordination, and some forms, such as electronic mail, instant messaging, or video conferencing, are so generic in their support of primarily unstructured communication that they seem to support internal and external forms of coordination equally well (Hinds & Kiesler, 1995; Markus, 1994). Internal coordination costs in particular can be reduced by improving the quality and speed of information processing and managerial decision making within the firm, thus improving the efficiency of centralized management structures (Malone, Yates, & Benjamin, 1987). Notable forms of IT applied in integrated organizational settings, include enterprise resource and planning (ERP) systems as comprehensive transaction management applications that join many kinds of information processing abilities into a single data-base (Akkermans *et al*., 2003; Maybert, Soni, & Venkataramanan, 2003). ERP systems can improve operational efficiency (Jasperson, Carter, & Zmud, 2005; McAfee, 2002), as they facilitate the management and transparency with which resources flow through the organization, including production material, financial information (accounting), and human resources. In addition, internal coordination is also enabled by IT systems that focus on collaboration and problem solving, including intranet-applications, knowledge management, and group support systems (Alavi & Leidner, 2001; Nunamaker *et al*., 1996; Sambamurthy & Subramani, 2005). To date, the various technologies that support internal coordination have reached a remarkable level of maturity and diffusion within modern organizations.

In terms of reducing external coordination costs, IT can reduce efforts required to conduct market transactions. Among many examples are systems to facilitate cost-effective access to market information, such as search engines, supplier directories (Österle, Fleisch, & Alt, 2001), and online markets (Bakos, 1991); and interactive systems to enable inter-organizational data exchange, supply
management, and online collaboration (Markus, Majchrzak, & Gasser, 2002). In addition, applications such as online auctions and bidding platforms enable negotiations and transaction settlement (McIntyre & Subramaniam, 2009; Pinker, Seidmann, & Vakrat, 2003).

The net effect of IT on coordination costs has long been discussed in the information systems literature. Gurbaxani and Whang (1991) suggest that the net effect of IT on firm size varies depending on the cost structure of the firm and the modes of synergy generated by integration, and Sahaym, Steensma, and Schilling (2007) emphasize the need to include additional organizational variables to analyze coordination costs. Legner and Schemm (2008) note that substantial IT supports internal coordination (e.g., ERP systems, internal reporting). However, overall the more specific prediction is that of Malone, Yates, and Benjamin (1987), which predicts that because IT systems generally reduce coordination costs associated with search and communication with transacting parties, they favor external procurement over vertical integration. Other research predicts more outsourcing as part of long-term relationships with a reduced set of suppliers (Ang & Straub, 1998; Loh & Venkatraman, 1992; Steinfield, Kraut, & Plummer, 1995). In a recent longitudinal study, Im, Grover, & Teng (2013) largely corroborate these predictions, and find a bi-directional association between organizational size and information technology. As organizations grow in size, information technology spending increases, but is later followed by a reduction in organizational size, likely indicative of increased outsourcing activities. In Im, Grover, & Teng’s (2013) study, a large part of the interaction was mitigated and explained by coordination costs that first increase as a result of organizational size, but later decrease as a result of increased spending on information technology.

We suggest that a close look at the specific systems and technologies that are available to support coordination and the decisions associated with their development, implementation, and operation can offer important, additional insights: Despite the potential benefits, information technology that targets external coordination has in fact been much more difficult to implement
than internal systems, largely because of the more decentralized nature of required decision making (Gebauer & Buxmann, 2000). The added complexity might explain the longstanding comparative advantage of *intra-*organizational systems over *inter-*organizational counterparts in terms of technological sophistication and actual use. Still, the focus on systems that explicitly support external coordination is strong and continues to grow for data exchange, electronic market platforms, and to satisfy security concerns and legal requirements, such as Sarbanes-Oxley (Branza & Desouza, 2006; Phillips & Meeker, 2000). Recent technology frameworks and platforms such as service-oriented architectures have enabled and supported inter-organizational information-based modular products and services (Legner & Scherm, 2008). For example, sophisticated collaboration and trading platforms, such as Covisint and SupplyOn have made continued progress in the automotive industry; and innovative, cloud-based and service-oriented architectures enable cost-efficient combinations of software modules from various sources (Gerst & Bunduchi, 2005; Papazoglou & Georgakopoulos, 2003). Our theory development, which builds on and extends previous predictions (Malone, Yates, & Benjamin, 1987), thus leads to our first proposition.

**Proposition 1:** Ongoing developments in IT will lower the costs of external coordination relative to internal coordination, which will lead to an increase in the inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

2.2 Cornerstone 2: Commitment-Related Contractual Risks due to Asset Specificity and the Role of IT

Besides the costs to coordinate complex relationships within and between organizations, costs result from the management of different types of contractual risk that occur when agents act opportunistically (Mahoney, 2001; Williamson, 1975). Transaction costs theory maintains that contractual difficulties can be anticipated when at least some opportunistic agents engage in transactions of sufficient demand uncertainty and/or technological uncertainty to surpass bounded rationality capabilities (Leiblein, 2003; Simon, 1982). The contractual risk of some opportunistic
agents utilizing asymmetric information to their advantage—and thus potentially leading to adverse selection, moral hazard, and economic hold-up problems—is high in such business environments and vertical financial ownership is an adaptive response to this potential inadequacy of market contracting (Mahoney, 2005; Williamson, 1985).

Transaction costs theory emphasizes contractual risks that are associated with commitments that a firm makes when investing in various forms of transaction-specific assets, including human, physical, and site asset specificity (Williamson, 1985). Human asset specificity involves uniquely related learning processes and often involves teamwork (Brouthers & Hennart, 2007; Masten, Meehan, & Snyder, 1989). Physical asset specificity includes requirements for specialized machine tools and equipment (Caves & Bradburd, 1988; Leiblein, 2003). Site specificity occurs when unique locational advantages exist, as, for example, when a power plant is located near a coal mining area to save on transportation costs (Dyer & Singh, 1998; Joskow, 1985).

Commitment in the form of unilateral investments in relationship-specific assets can leave a firm vulnerable to an opportunistic business partner. The unified and integrated solution of vertical financial ownership (Lajili & Mahoney, 2006; Mahoney, 1992) is viewed as an organizational choice to mitigate the small-number bargaining problem, since it entails a hierarchical authority relationship and residual rights of control from an incomplete contracting perspective (Bakos & Brynjolfsson, 1993a; Brynjolfsson, 1994; Grossman & Hart, 1986) that is more likely to reduce economic hold-up problems under conditions of asset specificity.

As an alternative, mutual commitments in the form of relationship-specific investments can serve as economic safeguards to substitute for vertical integration in mitigating economic holdup problems (Williamson, 1996). Alternative forms of mutual commitment related to IT include the voluntary limitation of the number of suppliers in exchange for relationship-specific investments (Bakos & Brynjolfsson, 1993b), and mutual relation-specific investments in IT systems (Kim &
Mahoney, 2006). Indeed, the efficient level of product modularization, and thereby the efficient level of vertical de-integration, is affected by the level of asset specificity in the exchange relationship.

**The Role of IT:** To the extent that IT systems reduce transaction risks through reduced relationship-specific investments, theory suggests that higher levels of product modularization and vertical de-integration can be expected (Clemons, Reddi, & Row, 1993; Gurbaxani & Whang, 1991). Generic (non-asset-specific) forms of IT correspond with off-the-shelf components for hardware and software, and open standards for data interchange, such as what is commonly applied in connection with the public internet (e.g., XML-based open standards) (Shapiro & Varian, 1999). With increasing maturity of technology and users, and development and diffusion of open standards, specificity is less prominent, even for advanced and sophisticated IT systems (Legner & Schemm, 2008). One current limit seems to be posed by recent developments, as some vendors, such as Salesforce.com, Microsoft, and Amazon have been promoting technology-platforms (force.com, Axure, EC2, respectively) that despite their inherently modular architecture are not necessarily compatible with the offerings of the competition. In comparison with older technologies, however, modern applications tend to be web-based, easier to install, often hosted externally (e.g., cloud-based); easier to learn and use (e.g., graphical user interfaces); and allow for more efficient set up of new business connections across time and space, which leads to our second proposition.

**Proposition 2:** Ongoing developments in IT will lower the level of asset specificity, which thus lowers the contractual risks in the supply chain, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

2.3 Cornerstone 3: Measurement-Related Contractual Risks due to Non-Separability and Quality Assessment, and the Role of IT

Another type of contractual risks results from problems in measuring output due to asymmetric information among various transactional parties. Organizational economics identifies the problem of non-separability in team production (Alchian & Demsetz, 1972), and of quality-
assessment in multi-stage production (Ouchi, 1979). Mahoney (1992) joins elements of transaction costs and agency theory to show that reductions in asset specificity and in measurement problems in team production can play an important role in explaining increased vertical de-integration. Here, we focus on reductions in measurement problems. In cases of non-separability, the productivity of an individual team member can be difficult to measure by simply observing the output of the entire team (Coff & Kryscynski, 2011). Vertical integration is suggested as a solution to the extent that it allows for adequate effort (input) control. Vertical de-integration and product modularization is expected to become more prominent to the extent that it becomes easier to assess individual contributions from observing the output of team production, a prediction that has been corroborated empirically (Poppo & Zenger, 1998). In addition to the metering problem, the efficient level of vertical de-integration is also related to the difficulty of assessing the quality of intermittent products in multi-stage production (Eisenhardt, 1985; Ethiraj & Levinthal, 2004). Vertical de-integration and product modularization are more likely to occur in cases where the quality of intermittent products is comparatively easy to assess or becomes easier to assess over time, which is the case for many information-based products and services offered as distinct modules on common platforms. The economic value of integrated products may be considered partly a function of the risks and challenges associated with the correct measurement of the value and quality of individual modules. Agency theory suggests that non-separability and measurement problems can be mitigated cost-efficiently if individual efforts are monitored closely via vertical integration (Alchian & Demsetz, 1972; Barzel, 1982).

**The Role of IT:** IT has the potential to reduce risks associated with market transactions in situations of high non-separability, most notably through improved information sharing, mutual monitoring, and evaluation schemes that can be implemented for both inter-firm and intra-firm collaboration (DeSanctis & Gallupe, 1987; Gurbaxani & Wang, 1991). For example, Argyres (1999)
describes a case where digital design tools and agreed upon ways to transmit and store data electronically allowed four separate firms to successfully collaborate on the design of a complex military aircraft. The problems of non-separability and quality assessment were mitigated with a product definition system that served to “codify pieces of design data that would have otherwise left tacit and hence open to interpretation, [whereas the system] provided unambiguous measures of data quality” (Argyres, 1999: 173). More recent developments include the emergence of web-based and social media tools that support and enable collaboration between the members of a dedicated team or general online community (O’Reilly, 2005); as well as various forms of web services and virtualized IT applications that allow for the combination of individual components into complex offerings of comprehensive services, such as in real estate (owners.com), travel (kayak.com), or retail (amazon.com). While advanced collaboration tools can allow for a more granular assessment of the contributions of individual team members than what was possible before, the use of self-contained applications generally makes it easier to measure the value of individual components as part of more comprehensive offerings. For many products and services, the separation of individual components of a formerly integrated product, and their individual assessment will become easier as a result of the use of innovative technologies that have increasingly become available (Jacobides & Billinger, 2006).

These ongoing developments in IT lead to our third proposition.

**Proposition 3**: Ongoing developments in IT will lower contractual risks associated with non-separability and measurement problems, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

**2.4 Cornerstone 4: Modularization-Related Impacts on the Quality and Value of Products and the Role of IT**

For the final cornerstone, we suggest that outcome-related aspects help to explain and predict developments of product modularization to the extent that they offset transaction-related cost and risks, and thus contribute to a positive net benefit of modularization. For example, from
the perspective of the supply-side, modular designs and design rules enable clear architectures, clean interfaces (Parnas, 1972), and a set of well-specified functional tests of module performance can enhance the quality of physical products (Baldwin & Clark, 2000). Adhering to design rules based on product platforms can support markets for specialized components that can further increase the overall level of product quality (Robertson & Ulrich, 1998; Schilling, 2000) and opens the possibility of innovative combinations through mixing and matching (Baldwin & Clark, 2000; Brusoni & Prencipe, 2001). Such product modularization is expected to dominate the market to the extent that the resulting level of product quality exceeds the level of quality that is obtained from an integrated design that allows for intricate interaction of individual components (Schilling, 2000), and to the extent that the benefits outweigh the increased complexity associated with the added number of interfaces between components (Ethiraj & Levinthal, 2004; Gill & Kemerer, 1991; Parnas, 1972).

Role of IT: Macher, Mowery, and Simcoe (2002) show how well-defined links between specialized applications impact higher production quality in the semiconductor supply chain. Shapiro and Varian (1999) consider how clean and standardized data interfaces support interactions between individual product modules to maintain high overall quality. Legner and Schemm (2008) provide empirical evidence for the continued emergence of standards for product data interchange in the supply chains of retail and consumer goods industries that are expected to increasingly meet inter-organizational coordination requirements. Companies, such as Owners.com and Kayak.com provide web-based access to services in real estate and travel, respectively. Both industries have traditionally been dominated by agents that provide integrated offerings. In contrast, the new web-based platforms strive to allow access to specialized service modules by a network of business partners to provide comprehensive and high-quality service and value to customers. In both cases (and many others), the IT platform replaces the role of the agent as an integrator of various service activities into one comprehensive offering. These developments lead to our fourth proposition.
**Proposition 4:** Ongoing developments in IT will increase the quality and value of modularized information-based products and service, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

Figure 1 summarizes our developed framework, which provides the four cornerstones for explaining—and the four propositions for predicting—when and to what extent there will likely be a development from integration to inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

Figure 1 illustrates in its inner-most layer four economic **issues** that are associated with developments towards modularization, namely transaction-related effort, commitment and asset-specificity, non-separability, and outcome (product quality and value). The second layer lists four areas of research (**theory bases**) that we suggest are particularly well suited to address developments toward modularization in relation with each of the four issues, namely the areas of coordination costs, transaction cost economics, agency theory, and product/design quality. The third, outer-most layer depicts the **role of IT** by depicting the types of systems and technologies that we suggest to be particularly supportive of a move toward modularization. Propositions 1 through 4 each summarize the expected interplay between an issue, a related theory base and the role of IT for one of the four cornerstones. We suggest that the extent of modularization in a particular industry results in sum from the extent to which each of the propositions 1 through 4 apply.
3. Extending the Value-Based Framework to Include a Consumer-Perspective (Demand-Side)

In the canonical vertical coordination problem there is a given product or service of a given quality and the task is to minimize the sum of production and transaction costs via a comparative assessment of imperfect governance alternatives (Williamson, 1985). Here we build on and extend this supply-side approach by considering cases where consumers have different preference-orderings across vertical coordination arrangements (Adner & Snow, 2010; Priem, et al., 2012). On the one hand, heterogeneous consumer groups may value “mix and match” product and service options (Adner & Levinthal, 2001; Adner & Zemsky, 2006) that become available from vertical de-integration and therefore tend to increase the demand of such modularization (Sanchez & Mahoney, 1996; Wilson, Weiss, & John, 1990). On the other hand, some product and services modularization results in consumers becoming “co-producers” in the production process (Vargo & Lusch, 2004), which can increase the effort required to obtain a complex, modularized product or service, and subsequently dampen demand. Therefore, we suggest that the analysis of recent developments in IT impacting product modularization and vertical de-integration requires a value-based approach that extends organizational economics theories of cost minimization to consider maximizing transactional value (Zajac & Olsen, 1993).

For example, we expect a comparatively slow diffusion of modularization to occur when the benefits from specialization for the supply-side are offset to a large extent by an increased effort required by customers (demand-side) to obtain and recombine individual components into a comprehensive product or service. This section revisits our four cornerstones from the perspective of the demand-side, whereby we join our framework (Figure 1) with concepts from consumer economics and marketing (for a summary see Figure 2 at the end of Section 3).
3.1 Cornerstone 1: Transaction-Related Efforts (Opportunity Costs) and the Role of IT

An increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration can require the end-consumer to conduct multiple transactions with several vendors, followed by the need to combine the components into an integrated whole. This change could substantially increase transaction-related efforts on the part of a consumer who now effectively takes on the role of a co-producer (Lusch, Vargo, & O’Brien, 2007; Vargo & Lusch, 2004). The question then arises of how this increase in transaction-related efforts will affect consumer behavior and revenues. Besides potential differences in market power between firms and individual consumers as buyers (Dewan, Michael, & Min, 1998) that can occur with vertical de-integration, a comparative analysis also must take into account the efforts associated with the combination (assembly) of individual modules into an integrated whole (Sheth, Newman, & Gross, 1991). In particular for complex offerings, such as computer systems (Steffens, 1994) or real estate services (Levitt & Syverson, 2005), it can be difficult for individual consumers to fully recreate the added value of an integrated system or service offering by interfacing individual modules (Schilling, 2000).

Consumer economics emphasizes the concept of opportunity costs to explain and predict consumer decision making, and consider the economic value of allocating alternate resources, such as financial assets and time (Becker, 1965). For example, Fox and Hoch (2005) applied the concept of opportunity costs to explain consumer searches for low prices across several grocery stores. Among the factors identified were the value of time, household wealth, travel time to a store, and storage costs in relation to home-ownership. Research on mass customization, a concept related to our notion of customer-led configuration and component combination, suggests that the complexity associated with custom configuration during the purchasing process is an important factor to explain and predict consumer behavior (Dellaert & Stremersch, 2005). Transaction-related efforts and
opportunity costs associated with increased consumer involvement and multiple transactions can impact consumer behavior as they potentially limit the economic attractiveness of modularized products and services from an end-consumer’s perspective (Bendapudi & Leone, 2003; Kivetz & Simonson, 2003).

**The Role of IT:** The impacts of IT on transaction-related efforts (e.g., cognitive, physical, financial) and end-customer behavior have been considered in business-to-consumer electronic commerce (Bailey & Bakos, 1997), behavioral decision making (Todd & Benbasat, 2000), consumer marketing (Bechwati & Xia, 2003), and consumer-focused markets and auctions (Alba et al., 1997). For example, advances in IT have led to so called long-tail marketing, where online retailers, such as Amazon and Ebay, provide consumers with a broader range of products and services than what can typically be accommodated in a physical store. From the individual buyer’s perspective, transaction-related efforts can be reduced to the extent that the online store covers a larger variety of individual preferences, thus limiting the need to shop at different places (Brynjolfsson, Hu, & Simester, 2011 Brynjolfsson, Hu, & Smith, 2006).

IT is also applied to business models that include some form of assembly-related effort, such as in mass customization and the use of self-service tools that are often offered online (Dellaert & Stremersch 2005; Meuter et al., 2005). Buyers of mass-customized products configure and price a product or service in terms of functions, features, and scope. The available range of customizable products is substantial and growing, including personal computers, cars, backpacks, clothes, and shoes. Research shows that the level of complexity that is associated with mass-customization and self-service offerings can impact consumer behavior (Dellaert & Stremersch 2005), which is likely to differ between customer groups (Fox & Hoch, 2005; Meuter, et al., 2005).

When assessing the impact of IT on coordination and opportunity costs, one key aspect to consider is the extent to which IT provides common interfaces between individual modules. The
efforts required for reconfiguration and assembly can be substantially reduced when information about characteristics and module prices, and possibly even the modules themselves (Bhattacharjee et al., 2006), are offered via a unified, e.g., web-based, platform featuring reciprocal links and references to a wide range of suitable components and expert information (Bakos, 1997; Brynjolfsson, Hu, & Smith, 2006). Examples can be found in advanced online platforms, such as what is available in the real estate (Levitt & Syverson, 2005) and travel service sectors (Chircu, Kauffman, & Keskey, 2001) where data that are used for one service (e.g., home search, flight reservation) are automatically transferred to another service (e.g., school information, car rental). IT in general and the internet in particular can limit overall transaction costs from the perspective of the customer, even in the case of multiple transactions, which leads to our fifth proposition.

**Proposition 5:** Changes in IT are expected to lower opportunity costs associated with the acquisition and combination of modules by consumers, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

3.2 Cornerstone 2: Commitment-Related Contractual Risks (Switching Costs)

Similar to the impact of asset specificity on the relationships between firms, high switching costs can sometimes unexpectedly lock individual consumers in with a particular seller (James, Leiblein, & Lu, 2013; Peteraf, 1993). These customer switching costs have been classified as procedural, financial, and relational (Burnham, Frels, & Mahajan, 2003). Procedural switching costs involve the expenditure of time and effort, and consist of economic, risk, evaluation, learning, and setup costs as a result of the changed business relationship. Financial switching costs involve the loss of financially quantifiable resources, and consist of benefits-loss and financial-loss costs. Relational switching costs involve psychological costs due to personal- and brand-relationship loss.
Switching costs can be especially high for consumers when switching from one integrated product or service and market relationship to several distinct (and comparatively smaller) modules and relationships that each require separate initiation, set up, and development.

**Role of IT:** In cases where users lack the knowledge required to combine modules, intermediaries, such as general contractors or agents, typically emerge and offer individualized help. However, the same role can also be performed by IT that enables quick access and lowers specificity and that can therefore, on net, reduce consumers’ contractual hazards and switching costs (Shapiro & Varian, 1999; Steinfield, Kraut, & Plummer, 1995). Examples are generic online commerce platforms (e.g. Amazon, Ebay) and data exchange standards (e.g., XML) that support a multitude of potential transactional relationships. Sophisticated and powerful search engines, tools, and consumer portals, have effectively allowed for a unified transaction environment that gives users access to a wide variety of information, products, and services, while limiting the specificity of individual transactions and exchange relationships, which limits switching costs between vendors (Floyd *et al.*, 2007), and supports modularized product offerings in an online environment. These developments have increased consumers’ bargaining power (Porter, 1980, 2001), and lead to our sixth proposition.

**Proposition 6:** Changes in IT are expected to lower switching costs and contractual risks from commitments related with the purchase and combination of modules by consumers, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

### 3.3 Cornerstone 3: Measurement-Related Contractual Risks (Quality Assessment and Value Determination)

The ability to assess and assure product quality contractually concerns not only firms on the supply-side, but also individual end-consumers on the demand-side. The organizational economics literature emphasizes risk-mitigating mechanisms, such as product and service warranties and the use of brand names (Barzel, 1982; Mosakowski, 1993), to reduce the risks associated with the correct
assessment of quality. To extend this literature, we consider consumer-oriented research on how product modularization and subsequent vertical de-integration influence the ability to assess and assure product quality. For example, a vertically integrated firm often provides product and service bundling by offering multiple products or services in a single package for a single price (Schmalensee, 1984). Modularization and vertical de-integration often leads to unbundling (Wilson, Weiss, & John, 1990) in which the boundaries between individual organizational and product components are initially ill-defined, possibly overlapping, and only are resolved over time (Schilling, 2000). The likely result in such situations in the short-run is an increase in uncertainty about product and service quality.

Additional uncertainty results when individual components need to interact and function well with each other, meaning that the value of service and product components may be different when assessed as stand-alone components than when obtained as an integrated whole (Guiltinan, 1987; Wilson, Weiss, & John, 1990). Uncertainty in value determination can make it difficult for consumers to substitute modularized service models for traditional full-service (integrated) models. However, as we discuss next, changes in IT can help to reduce consumers’ quality uncertainty on net, and therefore play a role in developments towards product modularization and vertical de-integration.

**Role of IT:** The risks associated with quality assessment of consumer goods and services also apply to online environments (Malone, Yates, & Benjamin, 1987). Despite limitations and perceived risks in an online trading environment (Teo & Yeoung, 2003), research results show that IT often has a strong positive effect on market transparency, and thus reduces measurement-related contractual risks. End-user-oriented technology innovations have increased market transparency and alleviated the quality assessment problem for products and components that had previously been difficult to describe and evaluate (Lajili & Mahoney, 2006). For example, Levitt and Syverson
(2005) show the information advantage held by real estate agents over their clients to be notably reduced as a result of available internet-based information.

Based on the various developments in user-generated content (e.g., reviews) and participation, there is a continuous increase in the range of products and services that can be measured and traded economically in a market at a risk that is acceptable to buyers. A case in point is provided by services, such as real estate, where formerly comprehensive and integrated offerings have been dissected into separate modules that are offered online by new competitors, such as Zillow.com and Owners.com. Individual users now have more choices regarding which part(s) of the formerly comprehensive service offerings they want to buy into, whereby the online platform and online community can help with measurement and metering problems. These developments lead to our seventh proposition.

**Proposition 7:** Changes in IT are expected to lower the risks associated with the assessment and valuation of individual modules by consumers, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

### 3.4 Cornerstone 4: Modularization-Related Impacts on Value (Preciseness)

Consumer choice theory emphasizes the positive association between the effort that a buyer makes in the purchasing process, such as the search for information on the quality of various product offerings, and the precision of the resulting purchasing decision in satisfying individual preferences (Johnson & Payne 1985; Stigler, 1961). Product modularization is considered a likely result in situations where an increase in the preciseness with which consumer preferences are met coincides with an increase in customer-perceived value of the product or service (Alba et al., 1997).

Buyer heterogeneity can therefore be considered an important driver for modularization since it allows buyers to substitute individual modules and to choose the scope of the product according to individual preferences (Wilson, Weiss, & John 1990). To the extent that buyer preferences vary, modularization provides more buyers the opportunity to obtain a product that
more precisely matches individual preferences regarding components and scope than what may be possible with a limited number of pre-configured, integrated product offerings (Prahalad & Krishnan, 2008).

**Role of IT:** IT can play an important role to help increase the preciseness with which customer preferences are met, especially in cases of high customer heterogeneity (Alba et al., 1997). Online platforms can make it convenient for individual consumers to mix and match modular offerings of even complex products and services, and to accommodate a wide variety of tastes without compromising product quality, effort, or cost (Dellaert & Stremersch, 2005). Similarly, Internet-based long-tail retail arrangements intend to let heterogeneous customer groups obtain product and service modules that reflect more closely individual tastes and preferences, and thus enable increased precision with which demand is met (Brynjolfsson, Hu, & Smith, 2005). Personalization technologies also play a role, such as Amazon’s collaborative filtering and recommendation system, and Netflix’s algorithmic tool for movie preference rankings. These developments thus lead to our eighth, and final, proposition.

*Proposition 8:* Changes in IT are expected to increase the preciseness with which modularized products and services can meet heterogeneous buyer preferences, which will lead to an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.

Similar to Figure 1 for the firm, Figure 2 summarizes the four cornerstones and propositions to analyze modularization from the perspective of the individual consumer, and illustrates the connections between four economic issues (inner-most layer), theory bases (middle layer), and the role of IT (outer most layer) that we suggest play a role in developments from integration to modularization, as they are relevant to the demand-side. A key point of our framework is that considering both the supply- and demand-sides promises a fuller picture for explaining and predicting the conditions under which there will likely be an increase in inter-firm modularization of information-based products and services with a subsequent increase in vertical de-integration.
4. Discussion and Conclusions

This paper develops a framework for explaining and predicting the conditions under which there will more likely be an increase in inter-firm modularization of information-based products and services and a subsequent increase in vertical de-integration. Our developed framework joins the perspective of the firm (see Figure 1) with the perspective of the individual consumer (see Figure 2) to explain and predict an increase in product modularization and vertical de-integration as a result of recent and expected developments in IT.

In addition to extending and joining extant consumer and organizational economics theory, the current paper’s developed framework is intended for practitioner use. In particular, this framework highlights important supply-side and demand-side tradeoffs for decision makers to consider: For example, a positive effect from the perspective of the supply-side in terms of savings and advantages from modularization and specialization can correspond with a negative effect for the demand-side in the form of additional required efforts and costs. In order to determine the net effect, decision makers should consider developments with respect to all eight propositions provided here simultaneously.

In summary, this paper presents a value-based approach that joins supply-side and demand-side factors to explain and predict the differential diffusion of product modularization and vertical de-integration across industries. We suggest that current developments toward modularization often coincide with changes in IT capabilities and interface standards and are thus particularly applicable to information-based products and services that are often offered via web-based platforms.

The current paper identifies four distinct issues considered in both organizational and consumer economics, namely: transaction-related efforts, commitment-related contractual risks,
measurement-related contractual risks, and impacts on the value of products and services. We propose that the combination of each of the issues and their resulting impacts on modularization from the perspectives of both the firm and the consumer play important roles in shaping the overall developments in a particular market.

This paper should prove fruitful for not only empirical testing of the corresponding eight falsifiable hypotheses of our theory-based propositions, but also could be extended by applying formal modeling and possibly simulation techniques in order to improve our understanding about the multitude of interactions and resulting developments of IT and the impacts on inter-firm modularization of information-based products and services.

In summary, this paper contributes to both management theory and practice in the context of management information systems. It provides a number of theory-driven propositions that appear promising for further analysis, formal modeling, and empirical testing. We suggest that both explanatory and predictive powers are improved in maintaining a value-based approach that joins supply and demand-side factors. We anticipate that the next generation of research examining IT change and organizational governance will continue to contribute significantly to the advancement and integration of organization and consumer economics.
Figure 1: Four cornerstones of product modularization and vertical de-integration (firm perspective, supply-side)
Figure 2: Four cornerstones of product modularization and vertical de-integration (consumer perspective, demand-side)
References


