Resource co-specialization in outsourcing of enterprise systems software

Impact on exchange success and firm growth

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Abstract

Purpose – Enterprise systems are commonly implemented by firms through outsourcing arrangements with software vendors. However, deriving benefits from these implementations has proved to be a challenge, and a great deal of variation has been observed in the extent of value generated for client and vendor firms. This research examines the role of co-specialization as a strategy to make the most out of outsourced enterprise systems. The authors develop hypotheses relating resource co-specialization with two indicators of success for implementation of enterprise software: (1) exchange success and (2) firm growth.

Design/methodology/approach – The hypotheses are tested using a unique panel data set of 175 firms adopting Advanced Planning and Scheduling (APS) software, a type of enterprise system used for managing manufacturing and logistics. The authors identify organizational factors that support co-specialization and then examine how co-specialization is associated with enterprise software implementation success, controlling for the endogenous choice to co-specialize.

Findings – The empirical results suggest that resource co-specialization is positively associated with implementation success and that the two resource co-specialization pathways that are examined complement each other in providing performance benefits.

Originality/value – This paper contributes to the research literature on outsourcing. The study also provides a new empirical test using a unique data set of 175 firms adopting APS Software.

Keywords Enterprise systems, Firm growth, Advance planning and scheduling (APS), Exchange success, Resource co-specialization, Strategic commitment

Paper type Research paper

1. Introduction

The worldwide market for enterprise systems is expected to exceed $500B by 2022 (Orbis Research, 2017). Enterprise systems consist of software for integrating transactions and processes across the firm and supply chain; types of enterprise systems include Enterprise

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Resource Planning (ERP) and Advanced Planning and Scheduling (APS) systems (Bendoly *et al.*, 2009; Tenhiälä *et al.*, 2018; Vidoni and Vecchietti, 2015). Despite widespread popularity of enterprise systems, deriving benefits from these systems remains a challenge (Lorenzo *et al.*, 2009; Rettig, 2007), and evidence of the effectiveness of such systems has been mixed with reports of positive impacts (Cotteleer and Bendoly, 2006; Tenhiälä and Helkiö, 2015) as well as negative (Langenwalter, 2000; Xue *et al.*, 2005) and neutral effects (Devaraj and Kohli, 2003; Hendricks *et al.*, 2007). Enterprise systems frequently involve at least some outsourcing, and the outsourcing has implications for generating value from their implementations (Anderson and Parker, 2002; Brynjolfsson *et al.*, 1994; Liang *et al.*, 2016). On the one hand, such outsourcing calls for additional efforts for coordination between the vendors and clients (Cezar *et al.*, 2017; Han and Mithas, 2013). On the other hand, outsourcing provides opportunities for generating benefits for the clients and vendors that may not be realized through clients' in-house development of the enterprise systems (Bettencourt *et al.*, 2002; Mudambi and Tallman, 2010).

Past research has investigated outsourcing of information technology (Gorla and Somers, 2014; Narayanan *et al.*, 2011; Susarla *et al.*, 2010) and enterprise systems (Agrawal *et al.*, 2006; Kalaignanam *et al.*, 2013). Outsourcing of enterprise systems presents additional challenges for clients and vendors, compared to outsourcing of information technology in general (Volkoff *et al.*, 2007), because such systems are intended for "seamless integration of all the information flows through a company" (Davenport, 1998, p. 121). To achieve such integration, technical knowledge about the systems' software needs to be combined with knowledge of the business processes across the enterprise (Ba and Nault, 2017; Ravichandran and Lertwongsatien, 2005). It follows that client employees need to learn about ongoing use of the software and the vendor employees need to understand the business processes of the client (Ko *et al.*, 2005). Extant research has focused on the diffusion of enterprise systems software and the extent of its usage across the client enterprise as drivers of implementation success (Gattiker and Goodhue, 2005; Purvis *et al.*, 2001). However, the specific mechanisms by which vendors and clients can combine their efforts, and the extent to which such joint efforts can explain differential performance, have not been examined. In this research, we consider resource co-specialization as a strategy for implementation of enterprise systems, and the impact of co-specialization on the performance of enterprise systems implementations.

Co-specialization describes a strategy where the vendor and the client are locked into a relationship of bilateral specialization. Co-specialization is more than an outsourcing relationship. It requires ongoing specialization from both sides, and the accompanying sustained mutual commitment to the relationship. Co-specialization joins the resource-based notion of creating specialized combinations of resources that are valuable and difficult to imitate (Barney, 1986; Teece, 2007) and the transaction cost economics perspective of developing such combinations through joint efforts of vendor and client instead of in-house development or purchasing (Grahovac *et al.*, 2015; Handley, 2017; Holcomb and Hitt, 2007; Lajili and Mahoney, 2006). By requiring asset-specific investments by both exchange parties and going beyond contractual arrangements and transactional relationships, co-specialization serves as a middle ground between purely integrated and transactional relationships and provides implicit economic safeguards for both exchange parties (Jayaraman *et al.*, 2013; Kim and Mahoney, 2006; Sjödin *et al.*, 2019; Ulrich and Ellison, 2005). Implementation of outsourced enterprise systems provides a context where co-specialization as mutual commitment is a compelling governance choice that can help to ensure a successful relationship and enable firm growth.

Enterprise systems are a long-term investment and, as such, their performance should be assessed by including aspects of post-implementation performance over time (Ram *et al.*,

2013). Especially for co-specialization, vendors and clients have opportunities to work together beyond the initial deployment of the enterprise system, not only for maintenance but also for technical enhancements of software and changes to business processes (Cao *et al.*, 2013; Somers and Nelson, 2004). It is imperative that the success of such joint efforts be assessed using measures such as continuation of the vendor–client relationship (Gable, 1996; Koh *et al.*, 2004) and the financial performance of the client firm (Lee *et al.*, 2004; Mithas *et al.*, 2012). Although past research recognized the importance of longer-term performance measures (Schwarz, 2014), there is a dearth of empirical studies that investigate post-implementation performance (Claybaugh *et al.*, 2019; Gattiker and Goodhue, 2005). Our research examines the impact of co-specialization on measures of post-implementation performance success related to strength of the relationship and client-firm growth.

Our research differs from existing studies on outsourcing of enterprise systems in four ways. First, we consider characteristics of client–vendor relationships that make them suitable for choosing co-specialization as a mutual commitment strategy for outsourcing their enterprise systems. Second, we examine two different pathways of co-specialization, each aimed at convergence of knowledge among vendors and clients about use of the software and the business processes that they impact. Third, while existing studies have used perceptual measures of relationship strength collected using surveys of implementing firms, we use an independent assessment of exchange success, and archival data to capture growth of the firm. Our measure of exchange success provides an assessment of the first-order impact of resource co-specialization, while our measure of firm growth considers the secondary performance impact. Fourth, by including antecedent factors to control for the choice to co-specialize we account for the endogenous choice in assessing the impact of co-specialization on success of the implementation. We test our hypotheses using a unique panel data set of 175 firms adopting APS applications, which are a type of enterprise software used for managing manufacturing and logistics. Overall, our research offers insights to practitioners on implementing enterprise systems, and contributes to the academic literature on co-specialization.

The paper is organized as follows. We start by briefly reviewing the extant literature and providing theoretical background related to our research. Supported by theory, we present our hypotheses in the subsequent section. Next, we describe our methods for empirical examination. We then present our analyses and describe the results. We provide conclusions concerning the implications of the results, indicate some of the limitations of this research and suggest opportunities for further research.

2. Existing literature and theory

2.1 Fit between outsourced software and business processes

Enterprise systems implementation through outsourcing involves a vendor firm that specializes in software and a client firm seeking to coordinate its business processes using the enterprise system that it purchases from a vendor. In the market for enterprise systems, significant externalities such as a large existing user-base network provide incentives for competing firms to purchase the most widely used product (Chellappa *et al.*, 2010). Because client firms often have access to and prefer to use the same enterprise systems as their competitors, competitive advantage cannot occur solely by purchasing enterprise systems in strategic factor markets (Barney, 1986; Clemons and Row, 1991). Large scale implementations such as those for enterprise systems also call for a *fit* between systems and processes (Strong and Volkoff, 2010). Fit in this context is matching the software with the organization and processes that the system supports (Benjamin and Levinson, 1993).

2.2 Two principal pathways toward fit

Developing fit between the vendor's generic software and the client's existing business processes can be accomplished by organizational restructuring (Guha *et al.*, 1993). Examples of organizational restructuring include process redesign of multiple functional areas, and modifications of routines and roles to complement the vendor's systems software. Fit between software and processes can also be generated by adaptive customization – adding exclusive features and generating customer-specific variants of the software (Subramanyam *et al.*, 2012). Examples of adaptive customization include investing in firm-specific codified interfaces, and customized software to complement the client's business processes. When either the vendor or the client unilaterally develops such *specialized resources* through either pathway to fit the needs and features of the other, the vendor and/or client are vulnerable to potential economic holdup problems (Williamson, 1985).

However, by choosing to make bilateral and ongoing mutual commitments (Brinkhoff *et al.*, 2015; Mahoney and Pandian, 1992), the vendor and client can gain the benefit of specialization and the ensuing fit while simultaneously safeguarding each of their investments. Mutual and ongoing commitments to customize the systems (adaptive customization) or alter existing business processes (organizational restructuring) align economic incentives and thus reduce the likelihood of holdup problems. With bilateral and ongoing mutual commitments, the vendor and the client specialize their employees to match the requirements of the new processes of the client, and/or the vendor and client continually cooperate to support the custom features of the system. Such bilateral specialization and mutual commitment in an outsourcing relationship is called co-specialization (Teece, 2007). Figure 1 provides a description of co-specialization applied to the two pathways of organizational restructuring and adaptive customization.

2.3 Resource co-specialization

Resource co-specialization originated in the idea of balancing competition and cooperation between firms to achieve innovation (Klein *et al.*, 2007; Teece, 1986, 1992). Resource co-specialization requires continuing mutual adjustments by both exchange partners to create idiosyncratic bilateral synergy (Mahoney and Pandian, 1992). The mutual sunk cost commitments that ensue also work to safeguard these investments, thus resulting in continuation of the exchange relationship in business and technology ecosystems (Kay *et al.*, 2018; Wareham *et al.*, 2014). These mutual commitments provide a safeguard against

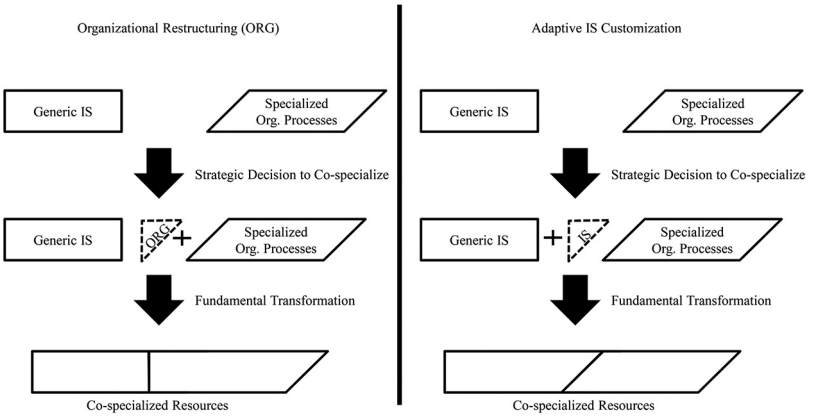


Figure 1.
Enterprise systems co-specialization pathways

economic holdup problems, which enables the resource co-specialization to increase economic value creation (Jacobides *et al.*, 2018; Kim and Mahoney, 2006). Furthermore, extant theory suggests that co-specialized resources can be drivers of sustainable competitive advantage (Coff and Kryscynski, 2011; Teece, 1986, 2018). However, co-specialized resources and activities can also affect a firm's adjustment and opportunity costs in innovation adoption, competitive imitation, supply chain design, and strategic repositioning (Argyres *et al.*, 2019; Bigelow *et al.*, 2019; Saeed *et al.*, 2019). As such, it requires proper governance arrangements and managerial capabilities that collectively determine economic profits and social benefits (Barney, 2018; Luo and Kaul, 2019).

In the context of implementing outsourced enterprise systems, resource co-specialization occurs when a vendor and a client make irreversible commitments to modify systems or organizational processes to adjust to the requirements of the other exchange parties on an ongoing basis (Cao *et al.*, 2013; Wareham *et al.*, 2014). It results in the creation of resource bundles that enable exchange partners to create value in new markets (Cennamo *et al.*, 2018; Sirmon *et al.*, 2007). Such resource co-specialization and its management are key potential sources of competitive advantage (Powell and Dent-Micallef, 1997) and firm growth (Mitra, 2005) resulting from enterprise systems implementation.

2.4 Capability for resource co-specialization

The value of co-specialized resources is a function of the joint use by vendor and client, and co-specialization efforts can result in combinations that are idiosyncratic and unique to the partnerships that combine them (Teece, 2007, 2018). However, resource co-specialization requires management "to identify, develop, and utilize, in combination specialized or co-specialized assets" (Teece, 2007, p. 1338) including human resources (Sevcenko and Ethiraj, 2018). Firms have disparate capabilities to succeed at such efforts of combining different assets and capabilities (Jansen *et al.*, 2005; Kogut and Zander, 1992; Todorova and Durisin, 2007). Factors impacting the choice of co-specialization can exist at the levels of firm, transaction and industry and would be similar to factors known to impact other governance modes such as alliances (Cabral and Pacheco-de-Almeida, 2018; Tafti *et al.*, 2013) and outsourced enterprise system implementations (Hendricks *et al.*, 2007) that call for joint and complementary efforts (Strong and Volkoff, 2010).

2.5 Impact on success of outsourced enterprise systems

The mechanism of resource co-specialization and its performance implications have not been fully addressed in the resources and capabilities literature (Adegbesan, 2009; Bharadwaj *et al.*, 2013). Prior research on resource co-specialization in enterprise systems implementation has mainly focused on knowledge transfer from vendor to client (Ko *et al.*, 2005) and on co-specialization needs in alliances and equity joint ventures across firm boundaries (Klein *et al.*, 2007; Rai and Tang, 2014). However, there has been little theoretical and empirical analysis concerning the possibility of idiosyncratic bilateral synergy, which results from co-specialization and mutual commitment in on-going exchange relationships (Mahoney and Pandian, 1992; Teece, 2007).

Strategic pricing practices of enterprise systems vendors and associated support services make it difficult to measure accurately the actual costs and benefits of outsourced enterprise systems. Because the immediate effects of enterprise systems are manifest in process improvements, more conclusive results are expected when enterprise systems investments are related directly to process outcomes and organizational learning measures (Ray *et al.*, 2005; Tippins and Sohi, 2003). For resource co-specialization in enterprise systems implementation, the direct outcome is the success of the exchange between the parties.

Exchange success is defined as a continuation of the exchange relationship by both the client and the vendor (Kim and Chung, 2003; Koh *et al.*, 2004). Further, by supporting new or modified business processes, the enterprise system can catalyze growth of the firm. Thus, another outcome of resource co-specialization in outsourced enterprise systems is firm-level growth (Kor, 2003). Exchange success and firm growth, are outcomes considered by transaction cost economics (Teece, 1986; Williamson, 1985) and the resource-based approach (Kor *et al.*, 2016; Penrose, 1959), respectively.

3. Hypotheses

Firms considering resource co-specialization must decide when it is appropriate to engage in bilateral commitment to specialize resources to fit the vendor–client relationship. In other words, does the firm choose no specialization, unilateral specialization or bilateral specialization? As a result of managerial differences, firms vary in their strategic choice to participate in co-specialization. The firm must choose the appropriate situation to engage in co-specialization and be willing to mutually commit to a relationship to safeguard such co-specialization. This firm heterogeneity is anticipated to result in differential performance outcomes from co-specialization.

3.1 Impact on exchange success

Resource co-specialization requires mutual commitment, and results in reducing the transaction costs of working with an exchange partner. By increasing the economic incentives for both exchange parties to act in a mutually beneficial manner, resource co-specialization should result in both exchange parties being satisfied with the relationship. Resource co-specialization implies that more efforts will be put toward cooperating with each other to create greater shared opportunities. The resulting incentive alignment gives both parties confidence in increasing the scope of their joint activities. Thus, firms making a strategic commitment to co-specialization should achieve greater levels of exchange success.

One way in which resource co-specialization may be achieved is by applying it to organizational restructuring. Firms that choose resource co-specialization through organizational restructuring benefit as each organization is designed to fit their exchange partner's requirements. An implicit understanding of how shared business processes work is developed over time. The incentive to stay with their exchange partner is high and the incentive to move to a different transactional partner is low.

A second way in which resource co-specialization may be achieved is by adaptive customization of the software. Adaptive customization means that customized software results in greater fit to the business needs and ultimately greater satisfaction in the exchange relationship. The rollout of new versions of the software is more likely to be compatible with the client's existing software and their business needs. The joint work of client and vendor for adaptive customization provides learning opportunities for the vendor, which increases the general market value of their software.

H1. Controlling for the heterogeneity of firms explaining their strategic choice to co-specialize:

H1a. Organizational restructuring is positively associated with exchange success.

H1b. Adaptive customization is positively associated with exchange success.

3.2 Impact on firm growth

Bilateral specialization of assets by the vendor and client means that the firm will retain processes in-house rather than going to the market to obtain specialized resources to do the required processes. Resource co-specialization means that the products of those resources will closely fit with the business requirements of the client. This close fit will enable the business to thrive and produce increased sales volume. Further, resource co-specialization results in creating and using new resource bundles that can enable the exchange partners to discover and take advantage of new market opportunities that would fuel firm growth. Thus, firms making a strategic commitment to resource co-specialization should achieve better firm growth.

While organization restructuring often means reduction in employees and decreased firm size, when done with mutual commitment to the shared business process of client and vendor, it increases the likelihood that business scope will expand. This shared commitment to specific business processes indicates that the firms regard the business processes as beneficial and will support their continued existence and expansion. Further, organizational restructuring with mutual commitment aligns economic incentives and is designed to ensure that the work being done through the business processes is directed in a productive way. This heightened quality results in increased productivity, improved demand for the firm's products and services, and resultant sales, while maintaining or even increasing employee headcount.

Adaptive customization by both vendor and client will ensure that the functionality of enterprise systems is aligned with the requirements of the client. Given that the client's requirements are designed to create capabilities valued by the client's own customers, the client firm can expect increased sales from adaptive customization. Superior information systems built through resource co-specialization increase the productivity of firm resources. They enable a firm to grow more efficiently by helping the firm to manage the increase in complexity introduced by firm growth. Further, by customizing the existing system, the client does not require other specialists for work on newer products and services and would be able to more easily offer a broad portfolio of products and/or services resulting in sales growth.

H2. Controlling for the heterogeneity of firms explaining their strategic choice to co-specialize:

H2a. Organizational restructuring is positively associated with firm growth.

H2b. Adaptive customization is positively associated with firm growth.

4. Methods

4.1 Research setting and data sources

We examine the performance and growth effects of resource co-specialization using a unique data set on implementation projects of widely adopted APS applications that are used to manage the supply chains of client firms[1]. APS covers a range of decision support applications that facilitate coordination of supply chain activities of the client and their customers and suppliers. APS applications use hierarchical optimization techniques that capture business strategies and production priorities in constraint-based planning (Günther and van Beek, 2003). Automated decision support by APS can improve customer service and enhance operational efficiency by accounting for the latest information across firm boundaries (Dehning *et al.*, 2007). APS applications extend ERP systems, which have been

deployed by almost all large manufacturers to provide a backbone for data storage and transaction tracking (Banker *et al.*, 2006; Hendricks *et al.*, 2007). APS applications seek plans that are feasible and high-performing across the supply chain (Tiwana and Konsynski, 2010) by enabling the sharing of information among supply chain partners (Patnayakuni *et al.*, 2006). This information sharing benefits supply chain customers and suppliers in terms of fewer inventory issues, improved resource utilization, tighter connection between operational measures and financial outcomes and improved digital capabilities.

In our empirical models, the posited causal relationship is based on the use of two co-specialization pathways, organizational restructuring and adaptive customization, which can improve exchange success and firm growth. Although research finds that APS systems likely contribute to superior financial performance by providing improved visibility of supply chain operations (Dong *et al.*, 2009), the magnitude of such effects is expected to vary due to the uniqueness of each APS system implementation, and differential organizational capabilities across firms. Exchange success and firm growth differences are driven by the firm's strategy of whether to pursue resource co-specialization. Our analysis controls for supply-side factors related to a single dominant enterprise systems vendor and thus avoids the confounding effect caused by multiple enterprise systems vendors (Levina and Su, 2008). This approach also addresses potential issues of ex-post bargaining for value appropriation between enterprise systems vendors and adopting firms, which may arise in the context of co-specialization.

A large APS vendor (hereafter referred to as ITSTAR) provided us access to the company's database. The rich bilateral firm-level data regarding all client exchanges with this market-leading vendor, combined with other firm-level data for the clients, are used to test our theory-driven hypotheses. The software sales and exchange relationships on which the analyses are based are taken from a historical context and comprise a sufficiently long period (i.e. 1990-2001). Resource co-specialization is ongoing and applies generally over a broad period. The data enable us to follow a full cycle of industry evolution from inception to growth and maturity. The study period, 1990-2001, includes the beginning of the APS industry through significant consolidation.

ITSTAR offers a variety of APS solutions designed for intra- or inter-firm client activities. ITSTAR products can cost millions of dollars, and sometimes take years to be integrated with existing information systems. In addition to APS software licensing, ITSTAR and its partner companies (e.g. consulting and platform providers) offer additional fee-based services such as APS-specific organizational consulting, employee training and technical support for customization. The sales records show a wide variation in the purchasing of these services, affording empirical analysis based on those variations. ITSTAR products are modular, so that each product can be installed separately. ITSTAR audits each project, tracks the enterprise systems implementation process and keeps records in its sales database about which modules are installed and repurchased by each client with license extension agreements. The data are drawn from the sales records of the software licensing, organizational consulting and technical support contracts between ITSTAR and its client firms since 1990. We matched ITSTAR's sales data to *SDC Platinum* data for mergers and acquisitions (M&A) and to firm-level *Compustat* data, which provides the number of employees, sales, capital intensity and additional firm-level control measures.

The sales data are used for management's strategic decision-making at ITSTAR and represent a significant portion of the APS implementation population among US firms since ITSTAR maintained a dominant share of the US APS industry during the observation period. The ITSTAR database is maintained for each business unit account. Thus, all ITSTAR data were aggregated to the available firm-level *Compustat* data. The data-

matching process results in 175 unique firms consisting of multiple business units and includes all ITSTAR enterprise systems projects. The final sample consists of publicly traded firms in the USA as we exclude all private or foreign clients of ITSTAR.

4.2 Variable measurement

4.2.1 Dependent variables. Exchange success is measured as an index of the level of overall vendor reference-ability of each client's project transactions (*REFER*) reflecting the comprehensive, objective rating by a third-party value measurement company, Miller-Williams Inc. The company assesses each vendor-client transaction using its customer value scorecard including key performance indicators of costs, customer responsiveness and revenue (Eccles *et al.*, 2002). This measure of case reference-ability ranges from "negative" (with the lowest rating of 1) to "promoter" (with the highest rating of 5) as a reference case for future implementation and training project transactions. As such, it is a direct, objective measure of the success of the relationship between vendor and client undertaken to implement enterprise systems.

As an alternative exchange success measure, we examine whether each client firm has repurchased the same APS application from ITSTAR by license extension (*EXTEND*). We review the sales history of each client firm in the sample to find if there is a record of repeat purchase of the ITSTAR application as an observable measure of the success of exchange relationship between vendor and client (Susarla *et al.*, 2010). Whereas *REFER* represents a comprehensive assessment by a third-party, *EXTEND* captures actual behaviors by the client firms based on their experience with ITSTAR and its APS applications.

Our first measure of firm-level growth is the number of employees (Brush and Vanderwerf, 1992; Penrose, 1959). The second growth measure is the firms' sales growth (Tambe, 2014). We create an unmatched panel with different starting years for each client depending on their first ITSTAR implementation (between 1990 and 1998). We monitor all client companies until a common ending year of 2001. Specifically, we assess changes over time in two measures to enable an assessment of firm growth from the *Compustat* database: the logarithm of the number of employees (*LABOR*) and net sales (*SALES*)[2]. The definitions and measurement details of all variables used in our estimation are provided in the Appendix.

4.2.2 Independent variables. Organizational restructuring: ITSTAR partners with professional business consulting companies to provide organizational consulting services, which enable the client firms to redefine and adjust their business processes prior to the deployment of APS applications. APS-specific organizational restructuring is often recommended by ITSTAR for the client firms to better integrate the new APS applications into their restructured business processes. To drive integration and avoid a disruption to current business routines, supply chain planners of client firms are included in the taskforce from the early stages of organizational restructuring. The resulting business processes are often costly and difficult to reverse. Organizational restructuring also requires the vendor to hire specialized employees, which often means the employees build specialized skills fundamental to the client's business. Organizational restructuring is therefore a mechanism in which both client and vendor make mutual commitments to specialize their resources to fit the needs of the shared relationship. Accordingly, we use the attainment of organizational restructuring consulting services (*ORG*) as a measure of resource co-specialization effected through organizational restructuring.

Adaptive customization: Many client firms engage ITSTAR to customize the software to accomplish firm-specific requirements. Clients use technical support services from ITSTAR by purchase of an annual software support contract to customize and configure purchased

APS applications (*CUST*)[3]. The client firms need the vendor's APS-specific knowledge and support for the customization of the APS products they purchase to fit their existing organizational processes. The measure of adaptive customization, *CUST*, is a binary measure of annual membership subscription by client firms for additional technology services beyond software warranty or training. Adaptive customization addresses the following issues: customizing the user interface to provide better flow; changing the security settings; configuring the system to address the business requirements; redesigning the APS solution; and integrating the solution with pre-existing systems. Adaptive customization results in a substantially modified enterprise system, tailored to a client's unique processes and requirements. Therefore, adaptive customization renders it difficult and costly for the firm to replace the enterprise systems in the future. Adaptive customization also implies that the vendor makes commitments to specialize the software to the requirements of existing clients and bears the added burden of maintaining multiple versions of software among its clients. This mutual commitment represents resource co-specialization through adaptive customization in the context of enterprise systems implementation.

4.3 Control variables

Strategic commitment to resource co-specialization may vary with a host of characteristics of firms or industries. We control for several drivers of co-specialization strategy and performance. First, we control for capital's cost share (*KCS*) because capital-intensive firms may expect greater benefits by employing specialized systems. Second, because APS applications cover a range of value chain activities within and between firms (Hendricks *et al.*, 2007), the vertical scope of client firms may affect the costs and benefits of resource co-specialization. To control for the influence of a firm's vertical scope on resource co-specialization, we use a value-added-to-sales measure of vertical scope (*VS*) (D'Aveni and Ravenscraft, 1994). Third, to address an alternative explanation for resource co-specialization, we control (in Table II only) for value-added, which is defined as multi-factor productivity (*MFP*) (Van Leeuwen and Klomp, 2006). Because of potential confounding effects, *MFP* is not included in the second-stage (in Tables III and VI), as it could be correlated with exchange success and firm growth and could also be reasonably interpreted as an enterprise systems implementation outcome. Fourth, prior accumulated knowledge is a key determinant of the success of enterprise systems implementation. To capture vendor and client relationship history and associated relational learning (Klein *et al.*, 2007; Mani and Barua, 2015), we measure the duration in months from the first ITSTAR software purchase by the client until 2001 (*DURATION*). Fifth, because a firm can significantly increase its employees and sales through a business combination with another firm, we control for M&A activity (Penrose, 1959) by using M&A transaction value, scaled by operating income *(MERGAQ)* (Xue *et al.*, 2011). Sixth, we include a dummy variable for companies in the manufacturing sector (*MANUFACT*) and four-digit SIC codes (*SIC*) to remove variations that are due to idiosyncratic characteristics across different industry environments (Xue *et al.*, 2012). Seventh, while there are over 20 different systems solutions available from ITSTAR, solutions were identified by ITSTAR as belonging into one of two broadly categorized groups (*INTRA_IS* and *INTER_IS*), depending on their primary functions – i.e. within a firm (e.g. plant management) and between firms (e.g. inventory management). Eighth, we control for advertising intensity because it may impact the benefits of resource co-specialization *(ADI)* (Sutton, 1992). Ninth, some ITSTAR applications are purchased and deployed at domestic or foreign plants (*ABROAD*). We expect that implementing in a foreign country presents cultural, logistic and language barriers that might influence the ability of the client and vendor to co-specialize. Tenth and finally, ITSTAR classifies all

client firms into several account types (Red, Yellow or Green) which reflect overall scale, priority, and urgency of the client's projects (*ACCOUNT*) to ITSTAR. We control for the potential effect that these unique implementation circumstances might have on resource co-specialization.

4.4 Estimation methods

The estimation approach involves two stages of analyses. We first examine what factors prompt the choice of using a co-specialization strategy applied to each of the two pathways of organizational restructuring and adaptive customization. We then examine the impacts of co-specialization implemented through the two pathways on exchange success in terms of project case reference-ability and license extension measures, as well as on firm growth in terms of the number of employees and sales. Lastly, we examine whether co-specialization implemented through the two pathways results in complementary or substitution effects on exchange success and firm growth. However, an endogeneity problem arises in testing the causal effect of a co-specialization strategy because strategic choices to invest in enterprise systems may be endogenous since unobservable factors relating to performance may also be correlated with unobservable factors predicting resource co-specialization. In particular, firms possessing superior organizational capabilities may have a different propensity to seek resource co-specialization, and therefore a different propensity to achieve exchange success and firm growth. As a result, empirical models that do not account for this process are potentially mis-specified, and conclusions drawn from them are potentially misleading (Hamilton and Nickerson, 2003; Ketokivi and McIntosh, 2017).

To avoid this endogeneity problem of biased and inconsistent estimates, we use endogenous switching regression with Heckman (1979) correction and two-stage instrumental variable (IV) regression. First, in the case of endogenous regression, the inverse Mill's ratio is calculated for the strategic choice of co-specialization applied to the two pathways. The intuition behind this procedure is that the estimates need to be corrected by controlling for the propensity of the sample firm to purposefully adopt a particular strategy driven by often unobservable characteristics. This procedure differentiates firms undertaking organizational restructuring from other firms (and separates firms choosing adaptive customization from others) in the sample. An advantage of separate estimations for the selected and non-selected cases is that they do not restrict the independent variable coefficients to be the same for the entire sample (Shaver, 1998). The use of the correction procedure is justified if the inverse Mill's ratio coefficients are statistically significant. The coefficients would indicate if there are advantages (or disadvantages) for resource co-specialization firms over the remainder of the sample. Existing applications of this procedure are readily found in the literature (Bharadwaj *et al.*, 2007; Mani *et al.*, 2010; Salvador *et al.*, 2014; Wan *et al.*, 2012).

Second, when the specification test suggests potential endogeneity problems but the coefficients of the correction terms are not statistically significant, we estimate and report the alternative two-stage IV regression. We use instrumental variables, in the first stage for identification purposes, which we anticipate might affect resource co-specialization choices, but that exert little impact on exchange success and firm growth measures after controlling for other covariates. We use a vector of exogenous variables including *ABROAD* (i.e. the new enterprise system is implemented at a foreign location), *INTER_IS* (i.e. the new enterprise system is implemented between the client and its partner firms to support external transactions) and *ACCOUNT* (i.e. ITSTAR's classification of client firms' implementation circumstances into three types based on the scale, urgency, and priority of each client's projects)[4]. We expect this vector of exogenous variables to impact the choice

to use co-specialization, but only affect the performance outcomes through resource co-specialization. The common feature of these three instrumental variables is uncertainty and complexity beyond the control of the client and the vendor (and is thus exogenous) due to differing foreign contexts, the client's relationship with partners outside its firm boundary, and the client's implementation circumstances assessed by the vendor.

Another concern regarding attempts to establish causality is time precedence (i.e. resource co-specialization must occur before exchange success and firm growth). Accordingly, we specify the resource co-specialization choice as a function of the lagged values at the time of enterprise system implementation along with other known characteristics.

5. Results

5.1 Sample characteristics and descriptive statistics

Table I provides summary statistics and correlation coefficients for the variables in the model. We examined the regression assumptions for serial correlation, heteroscedasticity, multicollinearity, normality of the residuals and outliers. The average firm in the sample is large and growing, with median net sales (*SALES*) of $4.33B and employment (*LABOR*) of 22,050 in 2001. The median annual employment growth during the observation period is 1,088 employees per firm (or 3.01 per cent), and the median annual sales growth is $98.76M (or 2.56 per cent). About 79 per cent (138 firms) of the sample firms are classified as operating in the manufacturing sector (*MANUFACT*), and 26 per cent (46 firms) implement APS in foreign locations (*ABROAD*).

There are key differences in the measures of enterprise systems implementations across the sample firms. About 62 per cent (109 firms) purchased inter-firm enterprise systems (*INTER_IS*) and the average duration of contractual relationship with ITSTAR (*DURATION*) is 93.45 months (or 7.79 years). Regarding the use of restructuring services, 31 per cent (54 firms) undertook organizational restructuring as part of enterprise systems deployment (*ORG*). About 23 per cent (40 firms) purchased annual technology support membership to receive support services for adaptive customization (*CUST*). Whereas 21 per cent of the firms are classified as promoter cases, 12 per cent are classified as negative ones (*REFER*). Finally, 21 per cent (37 firms) have repurchased software licenses to extend their use of the enterprise systems (*EXTEND*).

5.2 Determinants of resource co-specialization strategy

Results of the *first-stage* analyses about determinants of a resource co-specialization strategy to account for endogeneity in strategic choices to co-specialize are presented in Models 1 and 3 of Table II, the set of baseline models that will be used in the second-stage estimation discussed below. The Wald χ^2 statistic is significant ($p < 0.01$) for an ordered or a binary logit model, which examines the determinants of organizational restructuring *(ORG)* and adaptive customization (*CUST*). The results of instrumental and lagged variables in the resource co-specialization models are largely consistent with our theoretical expectations. The coefficients for *ACCOUNT* and *INTER_IS* are positive and statistically significant in all baseline models, and identify strategic choices of resource co-specialization pathways. The third instrumental variable, *ABROAD*, is positive but not statistically significant. These results indicate that the types of client firms (*ACCOUNT*) classified by ITSTAR impact the firms' resource co-specialization choices. Also, firms deploying enterprise systems across firm boundaries (*INTER_IS*) are more likely to undertake organizational restructuring and to adaptively customize the enterprise systems alongside implementation. The coefficient for vertical scope (*VS*) is negative and significant (β =

Table I. Descriptive statistics and correlation coefficients

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. REFER	1.00																
2. EXTEND	*0.29*	1.00															
3. LABOR	0.11	0.06	1.00														
4. SALES	0.12	0.10	*0.88*	1.00													
5. ORG	*0.19*	0.14	0.02	0.06	1.00												
6. CUST	*0.32*	*0.28*	0.13	0.07	*0.34*	1.00											
7. KCS	−0.08	0.00	0.03	0.07	−0.13	−0.06	1.00										
8. VS	0.02	−0.02	−0.07	−0.06	0.02	0.05	*−0.44*	1.00									
9. DURATION	0.00	0.04	0.01	0.07	−0.12	−0.07	0.01	−0.08	1.00								
10. MERGAQ	0.10	0.03	−0.03	−0.05	0.13	0.05	0.04	−0.09	0.00	1.00							
11. MANUFACT	0.01	0.06	−0.15	−0.05	0.00	0.08	*0.16*	−0.07	0.15	−0.03	1.00						
12. SIC	−0.05	−0.07	0.11	0.10	0.12	0.00	−0.01	0.04	*−0.18*	0.07	*−0.70*	1.00					
13. INTRA_IS	0.09	0.11	0.03	0.02	0.09	0.12	−0.01	0.09	−0.07	*−0.17*	0.02	0.03	1.00				
14. INTER_IS	*0.33*	*0.41*	0.14	0.13	*0.27*	*0.29*	0.01	0.06	*−0.16*	0.10	0.01	0.02	−0.12	1.00			
15. ADI	−0.13	−0.11	−0.14	−0.12	−0.04	−0.11	0.03	0.06	0.11	−0.06	0.06	−0.12	−0.12	−0.04	1.00		
16. ABROAD	*0.23*	*0.23*	0.01	0.05	*0.19*	*0.20*	0.14	−0.03	−0.01	0.14	0.11	0.00	0.01	*0.18*	−0.06	1.00	
17. ACCOUNT	*0.36*	*0.29*	0.06	0.11	*0.31*	*0.30*	−0.05	0.02	−0.05	0.08	0.07	−0.01	0.14	*0.27*	−0.14	*0.27*	1.00
Mean	3.37[a]	0.21	55K	15B	0.31	0.23	0.87	0.12	93.45	1.76	0.79	3648	0.95	0.62	7.51	0.26	0.68
SD	1.44	0.41	123K	29B	0.46	0.42	0.23	0.10	25.08	10.88	0.41	1179	0.21	0.49	5.99	0.44	0.86
Minimum	0.00	0.00	36.00	15M	0.00	0.00	0.19	0.01	27.98	−15.20	0.00	1011	0.00	0.00	0.09	0.00	0.00
Maximum	5.00	1.00	1.38M	217B	1.00	1.00	1.43	0.74	167.84	93.70	1.00	8731	1.00	1.00	60.55	1.00	2.00

Notes: $N = 175$; Statistically significant correlations are marked as italic ($p < 0.05$). [a]REFER is an objective, third-party reference-ability score which ranges from "negative" (with the lowest rating of 1) to "promoter" (with the highest rating of 5). The mean score presented here is an average of the sample reference scores

Table II.
Determinants of adaptive customization and organization restructuring: first-stage ordered and binary logit instrumental variable approach

Model components	CUST		ORG	
	Model 1	Model 2	Model 3	Model 4
ORG		1.29*** (0.45)		
CUST				1.25*** (0.44)
lagged_KCS	0.10 (0.94)	0.20 (0.92)	−1.59 (1.02)	−1.74 (1.07)
lagged_VS	1.50 (1.93)	2.72 (2.03)	−4.57** (1.96)	−5.18** (2.03)
lagged_MFP	0.18 (0.38)	0.18 (0.40)	0.14 (0.33)	0.12 (0.32)
lagged_LABOR (log)	−0.10 (0.34)	−0.02 (0.36)	−0.26 (0.30)	−0.22 (0.32)
lagged_SALES (log)	−0.13 (0.33)	−0.22 (0.35)	0.23 (0.31)	0.24 (0.33)
MANUFACT	0.23 (0.57)	0.32 (0.57)	−0.38 (0.46)	−0.43 (0.47)
INTER_IS	1.35** (0.57)	1.18** (0.57)	1.07** (0.45)	0.88* (0.46)
ABROAD	0.38 (0.48)	0.26 (0.46)	0.49 (0.45)	0.43 (0.45)
ACCOUNT = 1	1.93** (0.75)	1.74** (0.80)	1.20** (0.58)	0.81 (0.62)
ACCOUNT = 2	1.39** (0.54)	1.17** (0.57)	1.20*** (0.45)	0.95** (0.47)
CONSTANT	−1.51 (1.72)	−2.27 (1.78)	0.72 (1.63)	0.49 (1.69)
N (firms)	175	175	175	175
Wald χ^2	30.11	33.83	30.50	40.69
McFadden's R^2	0.18	0.22	0.16	0.20

Notes: Positive coefficients indicate a greater probability of pursuing resource co-specialization in enterprise systems implementation; *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$ (Robust standard errors in parentheses)

−4.57, $p < 0.05$) in Model 3, which implies that a greater vertical scope prior to enterprise systems implementation decreases the likelihood of choosing organizational restructuring. Capital intensity (*KCS*), multi-factor productivity (*MFP*) and whether the client firm is a manufacturer (*MANUFACT*) are controlled for, but are not significant predictors of either resource co-specialization mechanisms.

Models 2 and 4 in Table II add the other resource co-specialization pathway as a covariate, which provides a preliminary empirical test for complementarity between the two pathways. Both models present an improvement in fit over their baseline models. As expected, there exists a positive relationship between organizational restructuring and adaptive customization. The result in Model 2 indicates that the use of organizational restructuring significantly increases the likelihood of pursuing adaptive customization (*CUST*, $\beta = 1.29$, $p < 0.01$). The result in Model 4 also indicates that the firms that adaptively customized enterprise systems, are more likely to have also pursued organizational restructuring in their business processes (*ORG*, $\beta = 1.25$, $p < 0.01$). Though not the key finding of the paper, improved fit of Models 2 and 4 compared to Models 1 and 3 suggests that firms pursue a second co-specialization pathway to complement the first.

5.3 Impacts of resource co-specialization strategy on exchange success

We first examine the exchange success effect of resource co-specialization (*H1a* and *H1b*) by estimating its impact on a case reference-ability index (*REFER*) and license extension (*EXTEND*). Table III reports the corrected estimates for *REFER* and *EXTEND* using endogenous switching regressions. The results for the two measures of exchange success (*REFER* and *EXTEND*) are similar and consistent in the direction and statistical significance of the coefficients. The Wald χ^2 statistic is significant ($p < 0.01$) for each model. The McFadden's R^2 in the *EXTEND* equations (Models 5-8) is higher than those in the *REFER* equations (Models 1-4). The first-stage models in Table II are used to calculate the inverse Mill's ratio into each resource co-specialization pathway to achieve consistent and

Table III. Performance effects of organizational restructuring and adaptive customization: Ordered and binary logit of reference-ability index and license extension

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	REFER				EXTEND			
	ORG	ORG	CUST	CUST	ORG	ORG	CUST	CUST
Model components	YES	NO	YES	NO	YES	NO	YES	NO
CORRECTION (λ) for Selection (YES)	1.55* (0.82)		2.32** (1.08)		8.02** (3.10)		3.26** (1.50)	
CORRECTION (λ) for Non-selection(NO)		−2.72*** (0.81)		−2.23*** (0.84)		−4.44*** (1.10)		−4.79*** (1.23)
ORG			0.10 (0.91)	0.30 (0.39)			−0.90 (1.26)	−0.76 (0.73)
CUST	1.55** (0.71)	1.42*** (0.48)			2.00** (0.94)	0.95 (0.76)		
LABOR (log)	0.57 (0.48)	0.14 (0.19)	0.23 (0.31)	0.08 (0.17)	0.47 (0.71)	−0.26 (0.35)	0.07 (0.65)	−0.54 (0.36)
SALES (log)	−0.58 (0.51)	0.06 (0.22)	−0.43 (0.39)	0.20 (0.19)	−0.15 (0.75)	0.52 (0.39)	0.48 (0.56)	1.00** (0.40)
DURATION	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.01)	0.09*** (0.03)	−0.02* (0.01)	0.02 (0.02)	−0.03 (0.02)
MANUFACT	−1.40 (1.10)	−0.07 (0.47)	0.75 (1.33)	−0.63 (0.43)	−3.44* (1.89)	−0.86 (0.98)	1.21 (2.18)	−1.47* (0.76)
SIC	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00* (0.00)	0.00* (0.00)	0.00** (0.00)	0.00 (0.00)	0.00* (0.00)
INTRA_IS	−4.85 (4.60)	1.02** (0.40)		0.99** (0.39)				
ADI	−0.21 (0.17)	−0.02 (0.02)	−0.27 (0.22)	−0.03** (0.01)	−0.02 (0.14)	−0.01 (0.04)	0.05 (0.14)	−0.06 (0.10)
CONSTANT	−12.50 (6.93)	0.16 (1.88)	−6.32 (5.37)	−0.95 (1.39)	2.46 (6.23)	−0.39 (3.08)	−5.69 (5.82)	−1.46 (2.75)
	−11.29 (6.74)	1.67 (1.88)	−5.59 (5.02)	0.60 (1.40)				
	−11.10 (6.73)	1.99 (1.89)	−5.13 (4.79)	0.93 (1.41)				
	−10.20 (6.66)	3.27 (1.92)	−1.69 (4.48)	2.20 (1.43)				
	−7.52 (6.45)	5.46 (1.93)		4.28 (1.47)				
N (firms)	54	121	40	135	53	114	40	127
Wald χ^2	18.20	34.16	9.42	32.33	23.44	34.22	11.06	25.57
McFadden's R^2	0.12	0.11	0.15	0.08	0.49	0.35	0.26	0.31

Notes: Positive coefficients indicate a greater probability of achieving exchange success. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (Robust standard errors in parentheses)

unbiased estimates in the second-stage estimation. We estimate the exchange success equations separately for the sub-samples of observations dependent on the pursuit of each resource co-specialization pathway (*ORG* and *CUST*), which provides unrestricted estimates for each covariate across resource co-specialization choices. We also estimate the models using the two-stage IV regressions and find similar results, which are not reported for brevity. Because the coefficients of the correction term are highly significant, we report in Table III the results of endogenous switching regressions with Heckman (1979) correction specified by the correction variable λ.

The results for the dependent variable *REFER* in Table III suggest that the observed influence of resource co-specialization choices on exchange success is also driven in part by endogenous selection. The estimated coefficients for the correction terms (λ) are statistically significant in all models, with positive coefficients for λ with the sub-sample of resource co-specializing firms (i.e. the columns of *ORG* = YES or *CUST* = YES) and negative coefficients for the correction terms for the sub-sample firms that did not adopt a resource co-specialization strategy (i.e. the columns of *ORG* = NO or *CUST* = NO). These results together suggest that there are absolute advantages for firms choosing to use a resource co-specialization strategy and firms using neither organizational restructuring nor adaptive customization in implementation are impacted adversely in terms of exchange success.

The results for the dependent variable *EXTEND*, shown in Table III, allow us to assess how much firms that pursue resource co-specialization perform better by using organizational restructuring than *if they avoided such co-specialization*. The predicted probability in a logit model is $\Pr(y_j = 1) = F(x_j b)$ where x_j are the independent variables in the jth observation and b is the estimated parameter vector. The expected probability of exchange success is obtained by multiplying the coefficient estimates of resource co-specialization (e.g. via organizational restructuring or *ORG* in Models 5 and 6) in Table III by the vector of firm attributes for the relevant sub-sample groups (Shaver, 1998). For instance, the predicted probability of exchange success for the firms that chose to co-specialize via organizational restructuring ($n = 53$) is calculated by multiplying the coefficient estimates in Model 5 and this subgroup's mean values of the variables included in logit estimation (i.e. *ORG* logit estimates × *ORG* subgroup means). We can also calculate the predicted probability of exchange success for these firms *if they have not used organizational restructuring* by multiplying the coefficient estimates in Model 6 with this subgroup's mean values of the variables in the logit model representing the vector of firm attributes (i.e. cross-multiplication of Non-*ORG* estimates × *ORG* subgroup means). We verified the values of these predicted probabilities by using Stata's post-estimation commands "predict" and "margins" to calculate and contrast the predicted probabilities of exchange success for different treatment groups by using the estimated parameters from the models in Table III. As presented in Table IV, the estimates for exchange success show that the expected

Table IV.
Predicted probabilities from logit models of license extension (EXTEND) with and without organizational restructuring (ORG)

Details	Firms that chose to undertake ORG ($n = 53$)	Firms that chose not to undertake ORG ($n = 114$)
Predicted probability of license extension with ORG: estimates from the Model 5 in Table III	0.44	0.18
Predicted probability of license extension without ORG: estimates from the Model 6 in Table III	0.30	0.11

probability of license extension (*EXTEND*) for the 53 firms that implemented *ORG* is 0.44, and the probability if they would have not pursued *ORG* is 0.30. While the expected probability of license extension for the 114 firms that did not use *ORG* is 0.11, it would be 0.18 if they had pursued *ORG*.

It is also possible to assess the predicted probabilities of exchange success measured by license extension in the same manner from the coefficient estimates of resource co-specialization via adaptive customization (Models 7 and 8 for *CUST*) in Table III. As shown in Table V, the probability for the 40 firms that pursued adaptive customization is 0.43, but it would only be 0.30 if they would have pursued a different strategy. Finally, while the probability for the 127 firms that did not customize enterprise systems is 0.16, it would be 0.24 if they would have pursued adaptive customization. These estimates allow the comparison of the predicted probabilities of exchange success between firms that choose different resource co-specialization strategies – i.e. use or no use of the two mechanisms of organizational restructuring and adaptive customization. The left columns and top rows of Tables IV and V show higher probabilities in comparison. These results of absolute advantages indicate that the sample firms' resource co-specialization with organizational restructuring or adaptive customization are more likely to be successful than if they had chosen otherwise regardless of their observable and unobservable characteristics.

We further examine the coefficients for the variables in Table III and find that, in the presence of the correction term, the coefficients for within-firm enterprise systems are statistically significant and positively related with *REFER* only for the sub-samples of firms that did not adopt either organizational restructuring (*INTRA_IS*, $\beta = 1.02$, $p < 0.05$) or adaptive customization (*INTRA_IS*, $\beta = 0.99$, $p < 0.05$). We also find that advertising intensity is significant only in the sub-sample in which firms do not choose adaptive customization (*ADI*, $\beta = -0.03$, $p < 0.05$). These results indicate that the performance difference between intra- and inter-firm enterprise systems would disappear as the firms pursue either resource co-specialization strategy, while any performance difference due to advertising also disappears after choosing adaptive customization. Meanwhile, several of the control variables are significant predictors of contract extension (*EXTEND*), after controlling for the selection of resource co-specialization. Client firms with higher sales volumes are more likely to extend their contract with the software vendor (*SALES*, $\beta = 1.00$, $p < 0.05$) when they do not choose adaptive customization. Client firms that have worked with the vendor for a longer period of time, are more likely to extend if they pursue organizational restructuring (*DURATION*, $\beta = 0.09$, $p < 0.01$), but less likely to extend if they do not pursue organizational restructuring (*DURATION*, $\beta = -0.02$, $p < 0.10$). Manufacturing firms are less likely to extend the contract with vendor in sub-samples in which firms choose organizational restructuring and in which firms choose not to pursue

Table V. Predicted probabilities from logit models of license extension (EXTEND) with and without adaptive customization (CUST)

Details	Firms that chose to undertake CUST ($n = 40$)	Firms that chose not to undertake CUST ($n = 127$)
Predicted probability of license extension with CUST: estimates from the Model 7 in Table III	0.43	0.24
Predicted probability of license extension without CUST: estimates from the Model 8 in Table III	0.30	0.16

adaptive customization. The sub-sample results also indicate that there are industry differences regarding contract extension.

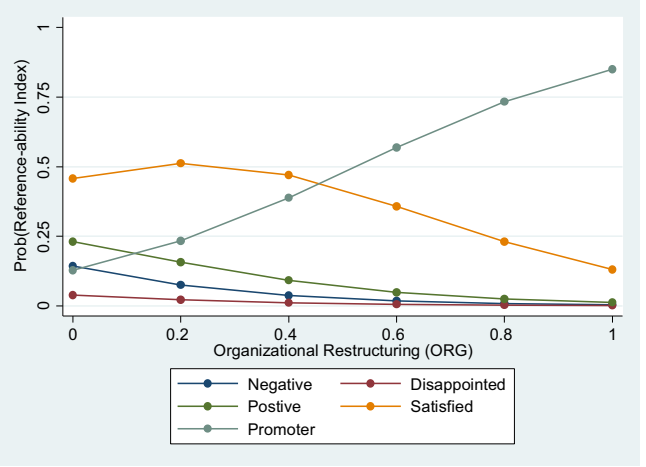
The interpretation of the effects in logit models requires special caution. Unlike OLS models, the marginal effect of an interaction between two variables in a logit model is not simply the coefficient of their interaction term because the magnitude and the sign of the marginal effect can differ across observations (Hoetker, 2007). As graphing the results of the logit model enables a more intuitive understanding of the impacts of explanatory variables and their interactions, we provide graphical presentations of selected results in Figures 2(a) and 2(b). As depicted in Figure 2(a), the main effects are not monotonic with respect to case reference-ability index (*REFER*). A positive relationship between *ORG* and *REFER* is observed only in the highest level of the reference-ability index – i.e. promoter cases. Organizational restructuring yields positive returns to reference-ability (*REFER*) when the client is considered a strong promoter. In other cases, organizational restructuring has no effect or a negative effect on reference-ability. As shown in Figure 2(b), the probabilities of license extension (*EXTEND*) increase with organizational restructuring (*ORG*) and are consistently higher in the presence of adaptive customization (*CUST*).

To further examine their complementarity, we also include *CUST* as a covariate in Table III while estimating performance effects in *ORG* and non-*ORG* sub-samples. The coefficients for adaptive customization (*CUST*) remain positive and statistically significant in reference to *REFER* in the case of organizational restructuring (*CUST*, $\beta = 1.55, p < 0.05$) and not (*CUST*, $\beta = 1.42, p < 0.01$) and *EXTEND* in the case of organizational restructuring (*CUST*, $\beta = 2.00, p < 0.05$). Overall, these results indicate that there exists a weak complementarity between organizational restructuring and adaptive customization on exchange success (*REFER* and *EXTEND*). This finding is illustrated in Figure 2(b) as a gap between the two lines of the impact of *ORG* contract extension (*EXTEND*) with and without adaptive customization. However, the coefficients for organizational restructuring alone are not statistically significant when we include the correction term. Together, these results provide support for *H1b*, and corroborate that firms choosing resource co-specialization through adaptive customization surpass the exchange success of those that do not pursue co-specialization. However, organizational restructuring, while contributing to exchange success if it is accompanied with adaptive customization, did not significantly improve exchange success after controlling for the influence of the endogenous selection on resource co-specialization.

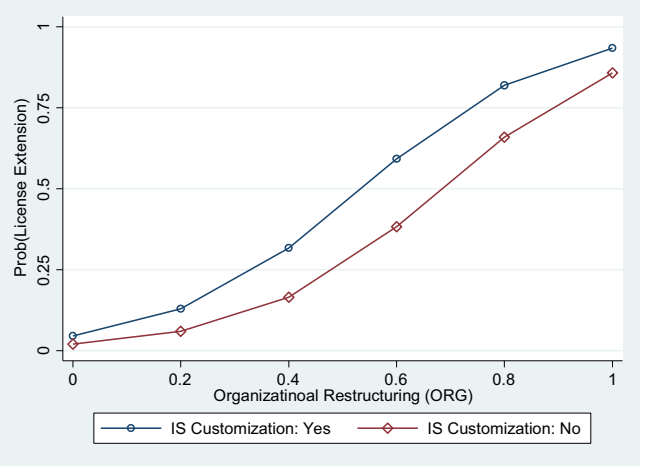
5.4 Impacts of resource co-specialization strategy on firm growth

Table VI presents the results of the growth effect estimation from the two-stage regressions using the instrumented resource co-specialization variables (*ORG* and *CUST*) – individually (Models 1, 2, 4 and 5 to test the individual effect of *ORG* and *CUST*) and in combination (Models 3 and 6 – to test their interactive effect). We control for lagged values of labor and net sales at the time of implementation. We also estimate the growth effect of resource co-specialization using the Heckman (1979) correction for each sub-sample.

H2a and *H2b* examine the impact of resource co-specialization on firm growth. First, the results in Table VI show positive and statistically significant relationships between the instrumented variable organizational restructuring (*ORG*) and the *ex post* firm size measures of *LABOR* in Model 1 (*ORG*, $\beta = 0.68, p < 0.01$) and *SALES* in Model 4 (*ORG*, $\beta = 0.49, p < 0.05$) while controlling for the impacts of industry-level and firm-level covariates and *ex ante* firm size at the time of enterprise systems implementation. This finding is consistent with the logic that the use of resource co-specialization increases productivity and supports the efficient growth of the firm. We also find positive and statistically significant



(a)



(b)

Notes: (a) Reference-ability Index as a function of Organizational Restructuring (ORG); (b) license extension as a function of organizational restructuring and adaptive customization

Figure 2.
Performance effects of organizational restructuring and adaptive customization

relationships between the instrumented variable adaptive customization (*CUST*) and firm growth as measured by *LABOR* in Model 2 (*CUST*, $\beta = 0.57$, $p < 0.01$) and as measured by *SALES* in Model 5 (*CUST*, $\beta = 0.59$, $p < 0.01$). The coefficients for the interaction of organizational restructuring and adaptive customization in the *LABOR* growth model, Model 3 (*ORG*CUST*, $\beta = 0.91$, $p < 0.01$), and in the *SALES* growth model, Model 6 (*ORG*CUST*, $\beta = 0.81$, $p < 0.01$) are positive and statistically significant, which indicate a complementary relationship on firm growth.

Table VI. Growth effects of organizational restructuring and adaptive customization: second-stage instrumental variable OLS for the number of employees and net sales

Model components	Model 1	LABOR Model 2	Model 3	Model 4	SALES Model 5	Model 6
ORG (IV)	0.68*** (0.27)			0.49** (0.24)		
CUST (IV)		0.57*** (0.24)			0.59*** (0.22)	
ORG*CUST (IV)			0.91*** (0.38)			0.81*** (0.33)
lagged_LABOR (log)	0.95*** (0.03)	0.96*** (0.02)	0.96*** (0.02)			
lagged_SALES (log)				0.97*** (0.02)	0.97*** (0.02)	0.98*** (0.02)
KCS	0.16 (0.17)	0.10 (0.16)	0.12 (0.16)	−0.32 (0.21)	−0.36* (0.19)	−0.34* (0.20)
VS	0.60 (0.44)	0.19 (0.47)	0.36 (0.45)	−1.50** (0.74)	−1.83*** (0.69)	−1.65** (0.70)
DURATION	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01*** (0.00)	0.00*** (0.00)	0.01*** (0.00)
MERGAQ	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00* (0.00)	0.00 (0.00)
MANUFACT	0.05 (0.23)	0.04 (0.22)	0.03 (0.23)	−0.05 (0.12)	−0.08 (0.12)	−0.08 (0.12)
SIC	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
INTRA_IS	−0.13 (0.46)	−0.12 (0.46)	−0.13 (0.46)	−0.06 (0.35)	−0.06 (0.35)	−0.07 (0.35)
ADI	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01** (0.01)	0.01** (0.01)	0.01** (0.01)
CONSTANT	0.01 (0.55)	0.16 (0.56)	0.16 (0.56)	0.25 (0.47)	0.34 (0.46)	0.36 (0.47)
N	171	171	171	171	171	171
Model F	275.73	266.63	269.55	324.50	326.62	318.77
R^2	0.88	0.88	0.88	0.93	0.93	0.93

Notes: Positive coefficients indicate a positive growth effect; $*p < 0.1$, $**p < 0.05$, $***p < 0.01$ (Robust standard errors in parentheses)

Based on the estimates in Table VI, we can also assess how much firms that pursue resource co-specialization have grown in terms of the number of employees and sales with their use of the two resource co-specialization mechanisms. Calculation of the growth effects requires the exponential function to convert natural-logged values of the number of employees (*LABOR*) and the sales (*SALES*) in estimation. First, as an example, the predicted value of 0.68 from the estimates in Model 1 in Table VI indicates a growth effect of $exp(0.68) = 1.974$ thousand additional employees. This growth effect of organizational restructuring (non-zero instrumented value of *ORG* for 53 firms that chose to undertake *ORG*) is estimated to be an additional 1,974 employees from the year of enterprise systems implementation to 2001 (Model 1 in Table VI) while controlling for the past number of employees and other fixed effects. Similarly, the growth effect of adaptive customization (non-zero instrumented value of *CUST* for 40 firms that chose to undertake *CUST*) indicates a net increase of 1,768 employees (Model 2). Second, in terms of the sales growth of the firms using either organizational restructuring or adaptive customization, the effect of ORG is a net increase of $1.63M (Model 4) and the effect of *CUST* is $1.80M (Model 5) while controlling for their past sales and other fixed effects. Finally, when both organizational restructuring and adaptive customization are adopted, their combined growth effects are estimated as an additional 2,484 employees (Model 3) and additional sales of $2.25M (Model 6).

None of the control variables are significant predictors of firm growth in terms of *LABOR*. Control variables for capital intensity (*KCS*), vertical scope (*VS*), time since first client implementation with vendor (*DURATION*), mergers and acquisitions activity (*MERGAQ*)[5] and advertising intensity (*ADI*) affect firm sales growth. Overall, after controlling for those important alternative explanations for growth in the model specification provided in Table VI, we find empirical corroboration for *H2a* and *H2b*.

6. Discussion

We examined two common resource co-specialization pathways in enterprise systems implementation, organizational restructuring and adaptive customization. Our analysis suggests that the two pathways complement each other in their effect on both exchange success and firm growth. In other words, the benefit of resource co-specialization with organization restructuring is greater when also pursuing adaptive customization, and vice versa. There may be two main explanations. First, there is the technical explanation that customization of the software is more useful when the organization processes are also modified. In the complicated context of enterprise systems, pursuing one pathway of co-specialization may not be adequate to obtain the full benefit of that pathway. Most firms may require both pathways to achieve a close fit between the organizational processes and the enterprise system. A second explanation is that by simultaneously pursuing both pathways of co-specialization, the vendor and client firm make mutual commitments through multiple means. By doubling-down on the mutual commitment between parties, firms create additional lock-in, with each firm receiving greater work effort from their partner. The effect of this mutual commitment across multiple means may exceed what is expected when the effect of each pathway is additive. With mutual commitments, economic value creation for the firm may come from a partner vendor willing and able to support both organizational restructuring and adaptive customization.

Our research design enables tests of the effect of resource co-specialization in the direct, short-term context of exchange success and in the secondary, long-term context of firm growth. In this way, we provide a broad view of the relationship between resource co-specialization and performance. This view suggests that vendors and clients may choose to pursue co-specialization to build strong partner relationships, and then benefit from those

relationships in terms of growing the firm. This design affords reliable empirical evidence on the role of resource co-specialization as a facilitator of performance improvements.

While there may be explicit benefits inherent in the specialization of the resources by vendor and client (Lawrence *et al.*, 2016), the aspect of resource co-specialization that we have emphasized in this research is the mutual commitment, subsequent lock-in, and the staying power created in the relationship between vendor and client. Mutual commitment between vendor and client may supplement other contractual or governance mechanisms to provide stability and align incentives to encourage both firms to act in the best interest of their sourcing partner (Cao and Lumineau, 2015). While organizational restructuring and adaptive customization are expensive pathways for firms to pursue, this research indicates that the bottom-line benefit of avoiding expensive transaction costs associated with contracting and the top-line benefit of aligning incentives appears sufficient to push firms to make the strategic choice of resource co-specialization and reap benefits in terms of relationship success and firm growth.

Numerous opportunities exist for researchers interested in the context of enterprise systems and the contribution of resource co-specialization to a successful vendor-client relationship. The limitations inherent in the current paper suggest multiple promising avenues for future research. First, we use observations of enterprise systems implementation for ITSTAR products. ITSTAR has maintained a dominant share of the APS market during the observation period and therefore our data set represents a large portion of the population of firms implementing APS. However, the strategic choice of resource co-specialization may have different implications under different industry conditions (Tenhiälä and Helkiö, 2015). Researchers may study how the dynamics of industry competition and consolidation play a contingent role in moderating the effect of resource co-specialization. It is possible that vendors in highly competitive industries may benefit more or less from relationships with high levels of mutual commitment. Second, the current paper considers the overall success of the vendor-client relationship, but stops short of addressing value appropriation by vendor and client due to price effects or profitability. We believe that our sample firms had equal access to APS applications in the factor market at competitive input prices as we have witnessed increased competitive entries into the APS industry; however, firms may differ in their ability to appropriate value from the relationship. Third, our developed theory suggests that the bulk of impact on exchange success and firm growth depends on co-specialized investments, and that drilling down into the details of the types of co-specialization is not anticipated to explain much more of the variance. That conjecture may be challenged by future research that provides and empirically tests a typology of co-specialized investments. Researchers may go beyond the enterprise systems context to consider how organizations engage in resource co-specialization in retail supply-chain partnerships, real estate leasing contracts and private–public partnerships to name just a few. Even within a given context, the specific types of resources that are being co-specialized may provide important strategic consequences. Fourth, our model focuses on firm-specific complementarity between enterprise systems and human resources, but does not include the relationships between enterprise systems and other strategic resources and capabilities. Unique production technologies or other strategic choices such as product market diversification may offer additional pathways of resource co-specialization and it remains unclear what the impact of resource co-specialization is when pursuing unique pathways. Finally, we focus on a firm's resource co-specialization strategy, but do not directly measure the alternative strategy of retaining real options and managerial flexibility. Not all firms need to pursue resource co-specialization for every enterprise systems implementation, especially as it entails substantial coordination efforts

and risky irreversible organizational changes. The drivers of resource co-specialization strategy that we found may reflect the nature of highly sophisticated APS applications, which would require a deep involvement of client firms and greater vendor–client firm interactions. When implementing other technologies, vendors and clients may benefit from retaining flexibility in sourcing.

Research in enterprise systems has offered various explanations for the consequences of technology adoption over the past 50 years (Karimi *et al.*, 2007; Wade and Hulland, 2004). These perspectives direct research attention toward human resources, social contexts, and organizational processes that influence technology-mediated changes. Such changes are not simply the result of new technology itself, but of the combination of innovative technology features and organizational capabilities that support the use of the new technology. For example, research suggests the role of human agency as an explanation for a variety of observed outcomes from the use of enterprise systems in organizations such as users' improvised re-invention and information delivery, which shape the enactments of an integrated enterprise system (Boudreau and Robey, 2005; Kettinger *et al.*, 2013), and informal advice networks that activate the informational capabilities of enterprise systems for organizational change (Leonardi, 2007). We expect continued research to explore new organizational practices that are created from the intense interactions of innovative technologies and human resources within and between firms, enriching our theoretical and empirical understanding of the management of enterprise systems.

7. Conclusion

In the context of strategic sourcing and enterprise systems implementation, we examine resource co-specialization hypotheses that exchange success and firm growth depend on the firm's strategic use of resource co-specialization pathways (i.e. organizational restructuring and adaptive customization) by which idiosyncratic bilateral synergy and mutual commitment are created between the vendor and the client. The empirical results from analyses of our unique panel data set in the APS industry corroborate the resource co-specialization hypotheses and provide new insights about how firms may choose resource co-specialization to align the incentives of vendor and client. In such situations, both the vendor and the client specialize their product or organizational capabilities to fit the needs of the other party. This mutual commitment serves to strengthen the relationship between the partners and promote exchange success. Resource co-specialization also enables firms to grow in terms of revenue and employees. These new strategic insights suggest that resource co-specializing firms possess advantages over firms that do not co-specialize.

Our analysis also finds that resource co-specialization is an important managerial choice of firms. Prior research studies using the amount of investment in information systems as a determinant of various performance outcomes have offered mixed results. We maintain that to accurately evaluate information systems capability and its impact on performance, it is critical to look beyond information systems investment and examine strategic choices that lead to heterogeneous outcomes. A mutual commitment to choosing a resource co-specialization strategy can benefit both the outsourcing relationship and the firm's prospect for growth. Empirical models should simultaneously address a firm's strategic choices as well as their drivers and consequences. We adopt econometric methods that address potential endogeneity problems. Broadly, we find that economic value creation varies depending on management's strategic choices and organizational capabilities in implementation. A firm's strategic imitation of successful rival firms' enterprise systems adoption and resource co-specialization (by pursuing organizational restructuring and adaptive customization) will not lead to similar performance or growth effects without

consideration of its own endogenous choices and organizational capabilities for resource co-specialization. Such difficult-to-observe capabilities make resource co-specialization resilient to the threat of replication.

Notes

1. This unique data set is original, and the results from it have not been previously published. The data enable a close examination of co-specialized enterprise systems investments by client and vendor.
2. Yearly financial measures (LABOR, SALES, capital's cost share [KCS], vertical scope [VS], mergers and acquisitions [MERGAQ] and advertising intensity [ADI]) are converted to 2001 dollar values.
3. An alternative specification of adaptive customization uses ITSTAR's tiered support service levels to capture the extent to which the vendor and client firms customize the software for use in the specific relationship. An ITSTAR senior executive confirms that both measures represent software customization when undertaken by ITSTAR and its client as opposed to other support-related activities that may be common in the software industry. The results using tiered support service levels are qualitatively similar and not reported for brevity.
4. The suitability of the components of the vector of exogenous variables as instrumental variables is based on the premise that each variable affects the extent of resource co-specialization, but only affects exchange success or firm growth through resource co-specialization. ABROAD reflects the unique challenges of co-specializing in a foreign context (e.g. cultural and regulatory barriers) and creates inefficiencies for the client and vendor in the process of resource co-specialization, yet the effect is limited to the impact on the focal enterprise system implementation accounted for by the resource co-specialization. INTER_IS is the degree of freedom that the client and the vendor have in terms of co-specializing in both the software and their organization when they are working closely with multiple partners. This variable directly impacts the level of resource co-specialization that the client and vendor can undertake, but the behavior of other exchange partners is unlikely to affect the success of the focal vendor relationship and the growth of the client firm. ACCOUNT is the level of attention given by the vendor to the client. This level of attention influences the amount of resource co-specialization that the vendor is willing to undertake and provides a signal to the client that specialization to fit the vendor might be useful in practice and would be reciprocated by the vendor. Together, these attention- and signaling-effects impact the level of resource co-specialization, but this assessment by the vendor itself is unlikely to affect client performance except through the resource co-specialization activities around the APS implementation. For these instrumental variables for organizational restructuring and adaptive customization, we have undertaken a series of robustness tests for endogeneity of resource co-specialization, strength of the instruments and over-identifying restrictions. All test results in the LABOR and SALES growth models (either 2SLS or GMM; with or without heteroscedasticity-robust standard errors) are consistent in supporting the use of instrumental variables.
5. In addition to being statistically significant using a measure of the transaction value of mergers and acquisitions scaled by operating income (Wong *et al.* 2011), the main results were robust to using alternative measures (e.g. the log of transaction value of M&As, the count of M&As and the transaction value of M&A scaled by sales).

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Appendix

Table AI.
Definition and measurement of variables

Name	Definition	Measurement
REFER	Project case reference-ability	1-5 (negative, disappointed, positive, satisfied, and promoter) assigned for firm i in year 2001
EXTEND	Software license extension	1 if firm i has extended the license by repeat purchasing the same enterprise system application as of 2001
LABOR	Employees	The number of employees for firm i in year *t* and 2001
SALES	Sales	Net sales for firm i in year *t* and 2001
ORG	Organizational restructuring	0 or 1 if firm i used organizational restructuring consulting services for enterprise systems implementation in year *t*
CUST	Adaptive customization	0 or 1 if firm i purchased annual membership service to customize the software in year *t*
KCS	Capital intensity	Capital's cost share in relative to Labor's cost share for firm i in year *t* and 2001
VS	Vertical scope	[Total value added - (Net income + Income taxes)/[Net sales-(Net income + Income taxes] in year *t* and 2001
MFP	Multi-factor productivity	Value-added, total-factor or multi-factor productivity
DURATION	Enterprise system vendor and client firm history	Months from the year of first enterprise system implementation with ITSTAR to 2001 regardless of co-specialization
MERGAQ	Merger and acquisition activity	Transaction merger and acquisition value, scaled by operating income
MANUFACT	Manufacturing industries	1 for manufacturing industries
SIC	Industry group	4-digit SIC codes
INTRA_IS	Within-firm enterprise systems solutions	1 if firm i has purchased within-firm APS solutions designed for internal activities
INTER_IS	Between-firm enterprise systems solutions	1 if firm i has purchased between-firm APS solutions designed for external transactions
ADI	Advertising intensity	Advertising intensity (%) for firm i in year *t* and 2001 Advertising expenditures/Net sales in year *t* and 2001
ABROAD	Foreign location	1 if implemented at foreign location
ACCOUNT	Account type	1-3 client firm's account type

Note: Yearly financial measures (LABOR, SALES, KCS, VS, MFP, MERGAQ, and ADI) are converted to 2001 dollar values

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