The Role of ERP Implementation in Enabling Digital Options: A Theoretical and Empirical Analysis

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The Role of ERP Implementation in Enabling Digital Options: A Theoretical and Empirical Analysis

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ABSTRACT: Many firms are transforming themselves from vertically integrated organizations into digitally enabled organizations. As firms become more innovative in their technical infrastructures and more competitive in their respective industries/verticals, their extended enterprise models include using their previous enterprise resource planning (ERP) investments as foundations for prioritizing additions and for longer-term strategies. The key issue for many firms is how to leverage their ERP implementation to become better partners and collaborators by enabling digital options to exploit business opportunities. This paper ascertains the contextual conditions under which ERP system implementations have the greatest impact on intention to adopt digital options. Using empirical data, it finds that the impact of ERP implementation on digital-options adoption intention is moderated by a firm’s digital-resource readiness. For information systems (IS) practice, the study suggests that firms should view ERP divisibility as an option value generator for supporting new customers and revenue opportunities. For IS research, it relates digital-options theory to specific measurable constructs and to the firm’s digital-resource readiness. Theoretical and practical implications are discussed.

KEY WORDS AND PHRASES: Customer-relationship management, digitally enabled extended enterprise, extent of ERP implementation, knowledge reach/richness, process reach/richness, resource readiness, supply-chain management.

Many firms today are transforming themselves from vertically integrated organizations into digitally enabled organizations to take advantage of business-to-consumer (B2C) and business-to-business (B2B) e-commerce opportunities [28, 42, 54, 80, 94]. Digitally enabled organizations are agile, multi-enterprise recombinant entities executing core-competency-based strategies [54, 91]. They coordinate their activities and interact with their stakeholders through the exchange of information over electronic networks and markets [28, 80]. The dominant business configuration for digitally enabled organizations is a network, Web, or hub connected via IT wherein suppliers, customers, complementors, and alliance partners engage in collaboration via alliances and compete via coalitions [28, 54, 91]. According to this perspective, successful digitally enabled organizations operate within the equilibrium of ongoing interactions of technical competence and capabilities, and technology strategy-experience forces.

To improve revenue and profits in today’s fast-paced and competitive business environments, traditional firms must implement digitally enabled initiatives and develop competencies to form, maintain, and optimize partnerships with other firms for long-term value creation [9]. While some firms have cultivated the digitally enabled extended-enterprise model for business innovations, others have found doing so a serious struggle [54, 91]. As firms become more innovative in their technical infrastructures and more competitive in their
respective industries/verticals, their extended-enterprise model includes using their previous ERP investments as a foundation for prioritizing additions and for longer-term strategies. Since the traditional ERP’s technical focus is internal on transaction processing, it is insufficient for sharing information and collaborating commerce. Consequently, the vast majority of today’s ERP applications are inadequate not only from an architectural standpoint, but also from a business-relevance perspective [2, 13, 44]. The key issue now facing most firms is how to leverage their ERP implementation to become better partners and collaborators. The combination of evolving business drivers, changing customer demands, and the evolution of the business model for the extended enterprise have changed the way firms transact with partners, making it critical to optimize business processes across enterprises rather than just within an enterprise.

Digitally enabled organizations continually invoke organizational routines for IT adoption and reconfigure their internal and external resources to enable digital networks (digital options) to exploit business opportunities [91]. However, as suggested recently, “there has been a limited theoretical understanding as well as limited empirical grounding regarding how IT can be leveraged to design and govern the extended enterprise and how IT-enabled process capabilities across the extended enterprise enables [sic] firms to leverage resources, exploit competencies, manage partner relationships, and explore opportunities” [54, p. 233]. The present paper proposes a theoretical viewpoint, supported by empirical evidence, on how the extent of ERP implementation affects a firm’s digital-options adoption intentions. An investment in extending the scope of ERP implementation can create growth options for future investments in customer-relationship management (CRM) and supply-chain management (SCM) systems that could not be exercised by firms that have a less modern integrated architecture [83]. Since each follow-on project enabled by the initial ERP implementation is viewed as an option, the vital question for many firms in dynamic and diversified environments becomes: Should extending the scope of ERP implementation be viewed as enhancing rigidities or as generating option value for enabling digital options? The extent to which ERP implementation results in enhancing a firm’s knowledge and process reach and richness provides insights into digital-options adoption intentions. This is captured in the research model shown in Figure 1. The model suggests that extending the scope of a firm’s ERP implementation has a direct impact on the extent of its digital-options adoption intention and that such impact can be positively moderated by its digital-resource readiness.

**Theoretical Framework**

Digital options are a set of digitally enabled organizational processes (e.g., customer capture, order fulfillment, supply chain, product innovation, manufacturing, logistics and distribution networks) for automating, informing, and integrating the activities of an extended enterprise [30, 47]. In digital-option theory, IT adoption is also viewed as an option. Accordingly, an initial investment in new IT creates “growth” options [10, 40, 86, 88], especially in the first
phase of a multiphase implementation [81, 82]. Growth options refer to the opportunity to grow the project’s scope beyond what was initially anticipated by creating one or more additional related assets through follow-on investments [86]. Growth options are most likely to be present on more innovative projects and those that implement a platform for future applications [40]. Subsequently, a firm may apply its capabilities to emerging opportunities or let them remain unused. However, “for those things that a firm may do, value is created by actively structuring those elements as an option” [40, p. 78].

According to Fichman, the option value of an IT platform investment can be predicted based on four types of determinants: (1) strategic factors, such as the strategic importance of affected products or processes, radicalness of process improvements, and innovative capabilities/endowment, (2) organizational learning factors, such as learning-related endowments and exploitable absorptive capacity, (3) technology bandwagon factors, such as network dominance of technology class or technology instance, and (4) adaptation factors that yield increased payoffs over time, such as divisibility [38]. Although the quantitative value of a real option for determining the value of IT investments is not always intuitively obvious, nevertheless real options provide a new way of thinking (i.e., options thinking) about how projects can be structured and managed. The essence of options thinking is more a philosophy for project management than a science of precise quantification [40]. “Significantly, real option theory, in fact, does not dictate use of any particular pricing models. It is simply an approach that recognizes the value of management flexibility in investment evaluation” [25, p. 16]. Therefore, IT managers do not necessarily need to acquire arcane option-quantification skills or use option-pricing models (e.g., Black-Scholes, Binomial) to put option thinking to work [38], since

![Figure 1. Hypothesized Research Model](image-url)
“the bigger win comes from using real options concepts to actively create and extract the value of embedded options that can otherwise be difficult to see” [40, p. 75]. When quantification is not feasible, the above determinants could be used with qualitative methods, such as decision tree analysis, qualitative scoring models, or general project management heuristics, for valuing IT platform options [38]. Over time, firms learn and gain experience in strategic processes associated with capability building as they launch digital options to support competitive actions [74]. Organizational learning is seen as a purposive quest to retain and improve competitiveness and innovation in uncertain technological and market conditions [33]. It is, therefore, contingent upon path dependency and cannot occur without appropriate preconditions [35, 83]; that is, “where a firm can go is a function of its current position and the paths ahead” [84, p. 522].

**Extent of ERP Implementation**

The extent of ERP implementation defines the type of benefits that can be derived from ERP systems and specifies the degree to which ERP systems will change process integration in the business units of the enterprise [57]. ERP implementation is divisible to the extent that it can be divided up for sequential or incremental implementation by functions, departments, the entire company, multiple companies, locations, or regions. Each incremental segment positions the firm for positive payoffs even if no further implementation segments are pursued [38]. ERP divisibility, allows managers the flexibility to change the scope of the implementation, which in turn can reduce the potential for losses or increase the potential for gains in response to external and internal events.

In the present research, the extent of ERP implementation is defined as ERP functional scope (system range), organizational scope (system reach), and geographic scope [15, 51]. ERP functional scope refers to the range of business functions (accounting, manufacturing, sales, etc.) that share the ERP implementation. Greater ERP functional scope is achieved through the implementation of multiple or cross-functional ERP modules. It (1) provides data and process integration across functions and ensures more benefits than a single function implementation [17], (2) facilitates the exchange of data between applications for monitoring and managing business activities across the extended enterprise, and (3) enables end-to-end automation of business processes, thereby allowing firms to react more quickly to changes in business conditions. ERP organizational scope describes the organizational locations that the ERP implementation can reach (link), such as departments, divisions, an entire company, and multiple companies. ERP geographic scope refers to the regional, national, and global reach of the ERP implementation. Recent research has shown that ERP projects with greater functional, organizational, or geographic scope result in positive, higher shareholder returns [71]. The largest increase in returns (3.29%) is found for ERP purchases with greater functional, organizational, and geographic scope, and negative returns are found for projects with lesser scope.
**ERP Divisibility as Option-Value Generator**

The full potential of an ERP system cannot be realized if its integration and coordination capability is confined within the walls of a firm [4, 5, 81]. ERP divisibility provides for *stage options*, where value is created in providing the opportunity to alter or terminate an implementation before each new stage of funding, based upon the receipt of updated information about costs and benefits. Although stage options overlap with other operational options, such as options to abandon, defer, change scale, and grow [10], the growth option is often exercised in the case of an ERP implementation [86]. Since ERP divisibility offers a variety of embedded growth opportunities (options), it tends to be more complex, more innovative, with high uncertainty and path dependencies, which can result in a longer time frame for an overall positive payoff [40].

A firm can derive value from its ERP implementation through a strategy of continuous business improvement both within its enterprise and beyond by (1) extending the scope of ERP implementation to create the capability to compete [75] and (2) integrating its ERP systems with those of its trading partners to collaborate effectively by reducing costs and improving business processes, data integrity, and customer service [67]. This can lead to a platform for real (growth) options, an escalation of a commitment to a full-scale ERP implementation, and a future investment in e-business applications [71, 86].

The most important categories of e-business applications are considered to be the sell-side (CRM) and buy-side (SCM) of e-business applications [9, 42, 56]. SCM and CRM systems support the external part of the extended enterprise, while an ERP system comprises the internal portion [65]. Further investments to extend the ERP system by linking it to CRM and SCM systems can significantly improve business-process integration for the extended enterprise, and result in enterprise-applications integration [13, 60]. Enterprise-applications integration is often required to achieve business-process integration for the extended enterprise, since CRM and SCM systems will offer an ERP-based firm the opportunity to build interactive relationships with its business partners [4, 5, 56]. Others have argued that such enterprise applications integration might produce greater benefits than ERP, SCM, or CRM systems alone [8, 58, 63]. For example, when middleware and a standardized software infrastructure are used, the information generated by the ERP system can be shared via the Internet directly with the supplier’s ERP systems [94]. Inventory levels, production planning, and material purchasing can be exchanged between the focal firm and suppliers via ERP and SCM systems to support B2B integration. The focal firm can also exchange valuable business data, such as order status, invoice, and on-line order fulfillment, with its customers using CRM’s B2C applications.

**Digital-Options Adoption Intentions**

Prior research in invocation diffusion suggests that assimilation of innovation starts by a firm’s initial awareness and evaluation of innovation. Innovation
adoption decision occurs in the initiation stage. In this stage, the firm collects information, builds knowledge of the innovation, examines its relevance and appropriateness to the organization, and makes a decision whether to adopt the innovation. This initiation stage “amounts both to identifying and prioritizing needs and problems on one hand and to searching the organization’s environment to locate innovations of potential usefulness to meet the organization’s problems” [72, p. 391]. According to Fichman, even though an organization may exhibit a high propensity to innovate, it can still lag in its intention to adopt innovations that do not fit with its needs, strategies, resources, or capabilities [37]. Likewise, a less innovative organization may still choose to be an early adopter of innovation when it perceives it as a good fit. The degree to which an innovation fits the problem to be solved and the potential of the innovation to enhance a firm’s performance in value chain activities are significant motivators for the firm to adopt the innovation [3]. Therefore, the intention to adopt an innovation will be affected by its functional fit to the firm’s needs and its requirement fit to the firm’s current resource base.

In collaborative trading communities, ERP’s role in serving information across the supply chain becomes more critical, and erroneous data (e.g., about inventories) become more costly. Integrating ERP with SCM and CRM is complex. Business processes such as procurement and fulfillment are inherently complex, and enabling these transactions over electronic networks is even more challenging [78]. Firms need to avoid large B2B or B2C projects until they have a consistent interpretation of the data that are shared with multiple users, applications, business units, and trading partners [92]. Serious data inconsistency problems occur in disparate and fragmented systems spread across organizational boundaries, such as the supply chain [70]. Semantic reconciliation of reference data (e.g., product, services, employees, assets, ledger accounts, customers, suppliers) becomes increasingly important as the established business applications become more integrated and business processes span entire companies. In this environment, adjusting ERP data and processes to serve the needs of one customer will negatively affect all trading partners as well as the enterprise’s ability to execute within the trading community [93]. Data consistency can enable both enterprise-application integration (systems integration) and business-process integration [56], since “having common data definition and data consistency not only enables connectivity across the supply chain, but also enables the exchange of complementary information between a firm and its supply chain partners” [70, p. 237]. The enterprise-applications integration depends on the fit between data and applications supported by a firm’s internal ERP system and the data and applications that are supported by the external CRM and SCM systems [94]. This fit is necessary for both enterprise-application integrations and business-process integration [56, 62]. A firm’s ERP data need to be combined with external sales forecasts and customer data to provide business intelligence that purchasing activities can use to react to rising demand and to obtain a better price from a single supplier. Any inconsistency, however, can result in a performance gap and a lower satisfaction level with the firm’s existing ERP systems.

Data consistency (quality, integrity, and standardization) is often a key issue in SCM implementation because SCM systems receive much of their data from
other applications and legacy systems with multiple data sources and varying quality [55, 70, 76]. Data consistency in supply chains will be enabled by common data definitions for the reference data as well as automated systems for data capture. For organizations to benefit from SCM systems, they must ensure that their ERP systems are implemented correctly beforehand. Without properly functioning ERP systems, SCM systems may do nothing more than create upstream and downstream problems at Internet speed [65]. Allowing all the partners in the supply chain to view and dynamically manage both demand and capacity data raises opportunities for simultaneous improvement in customer-service levels and reduction in both overall inventory levels and associated costs [47, 52].

Similarly, CRM-adoption intentions depend on the fit between the data of ERP and CRM systems. CRM systems help firms to continually refine insights into customer needs, behaviors, and economics. ERP systems contain vast amounts of data about customers. CRM efficiency can be maximized by integrating it with ERP systems to differentiate the way firms treat each and every customer. By developing cross-functional integration, supported by data warehousing and ERP systems, firms can create a customized view and a deeper understanding of each customer, which allows them to respond to sales opportunities or impending support issues [49]. This will result in greater customer value, improved retention, and lower support costs. Furthermore, it leads to the elimination of outdated processes and redesigned activities that in the past have failed to deliver customer value.

The more a firm’s resources meets its performance needs, the less likely it is to perceive a need to alter the status quo and the less likely it will try a new IT innovation, even though it may, in fact, be useful for its needs. Since strategic decisions are tied to an awareness of some real or anticipated performance gap, if a firm’s strategic needs can be fulfilled by the current business practices, there will be little incentive for the firm to adopt innovations. However, a gap, in turn, will provide the firm the impetus to find new ways to improve performance via adaptation and strategic actions (plans) [72]. As a firm perceives more performance gaps, it will be under urgency to take action to close those gaps [34]. Achieving strategic fit requires alignment of organizational resources, capabilities, and competencies with environmental opportunities and threats, and an internal consistency (fit) with regard to the firm’s overall activities, operations, and plans [14]. The managerial challenge is, therefore, to reconcile innovative aspects of strategy with existing resource endowments, capabilities, and organizational routines, all of which reflect prior strategic choices. Barriers to innovation are likely to reflect such strategic choices and plans [11].

**Digital-Resource Readiness**

A firm’s resource readiness is considered to be a major factor affecting its intention to adopt Internet business strategies [2, 48]. It also explains the extent of e-business use in U.S. firms [48]. Digital options are created through enhancements to the reach and richness of firm’s knowledge and processes.
Knowledge reach refers to the comprehensiveness and accessibility of codified knowledge that is available to a firm, and knowledge richness relates to the quality of information. High digital process reach is the implementation of digitized processes that tie activity and information flows across departmental units, functional units, and geographical regions as well as between value network partners (including suppliers, customers, and vendors). High digital process richness is associated with the quality of the information collected about transactions in these processes. Process richness improves the quality of information available to process participants by making it timelier, accurate, relevant, and customized [66].

ERP remains at the center of an organization’s information-management strategy even as the business becomes more complex and distributed. ERP implementation can create digital options by extending the knowledge and process reach and richness of a firm so that it is integrated internally and digitally extended to external customers, suppliers, and partners. Traditional ERP applications are clustered in two major groups: enterprise-support modules (accounting and finance, human resources and payroll), and value-chain modules (operations, manufacturing and material management applications, distribution and logistics, etc). The better the quality of the information obtained from value-chain modules, the higher the quality of planning and forecasting, which in turn will reduce the frequency of demand-and-supply mismatches. Therefore, the firm’s digital knowledge and process richness (its digital-resource readiness) will be higher because of its capabilities to collect and access high-quality information about its internal processes. Recent research has suggested that single-site projects that support administrative functions (enterprise-support modules) rather than value-chain activities are much less likely to be able to exploit the growth options from future initiatives that leverage an ERP platform [71]. Multi-site projects are likely to generate greater returns than single-site ERP projects involving the same modules. However, the greatest benefits accrue from ERP platform investments for multiple sites that also involve purchase of two or more value-chain modules. The higher a firm’s digital-resource readiness in terms of the value-chain modules, the higher is the firm’s digital knowledge and process reach and richness because of its capabilities to link processes and information flows across departmental units, functional units, and geographical regions. From an options-value perspective, value-chain modules can generate greater options value because of (1) their potential for more radical improvements in strategically important processes, (2) innovation-related capabilities and endowments, and (3) the organizational learning associated with the implementation of cross-functional processes [38, 71]. The options value of an ERP implementation that involves higher functional, organizational, and geographic scope will, therefore, be higher because of the increased future options for digital knowledge and process reach and richness [74].

Further, SCM and CRM systems can extend the ERP digitized process reach and richness to suppliers, customers, and vendors by supporting cascading transactions. A new on-line sales order, for example, triggers factory work orders, claims inventory, reserves manufacturing capacity, schedules labor, and leads to automated generation of invoices and credit evaluations of customers
and purchase orders for suppliers [46]. Process reach and richness support the firm’s responding capabilities by improving the coordination internal and external to the firm in product development, supply chain, and production.

**Hypothesis Development**

As the extent of ERP implementation increases, the resources made available by the IT infrastructure and its ability to support a wide range of strategic initiatives increase as well [16]. Firms with greater process reach can co-opt more customers or business partners with their value-chain activities [89]. However, only firms that have acquired or developed the precursory resources can begin to build up a resource over time because of the interconnectedness of asset stocks [32]. For example, prior research on predicting intention to adopt Financial Electronic Data Interchange (FEDI) has suggested that the extent of EDI application implementation has a positive impact on FEDI adoption intentions because it provides complementary benefits and greater confidence to the decision-makers to assimilate FEDI more effectively [84]. Similarly, the initial experience with digital options often results in additional IT investment in similar technologies, which are likely to enable learning-by-doing and thus shape management insight about IT complementarities and the firm’s IT capability [74]. Through the increasing investment and its associative learning, firms can both expand their knowledge and skill base and improve their ability to assimilate external information and its application to commercial ends [27, 38]. This absorptive capacity is widely understood to enhance a firm’s innovative capabilities, and it is related to the firm’s ability to assimilate and adopt new IT—a low absorptive capacity can limit investment in strategic options that have path dependencies [85]. Path dependence is important to organizational learning and often influences the firm’s locus of search for new technologies [73]. The knowledge to be gained during deployment of extended ERP systems will contribute to technological development that occurs in the vicinity of the absorptive capacity being acquired today by enabling future digital options with long-lasting strategic relevance. Therefore, the ability to integrate SCM or CRM systems with ERP systems is predicated on the availability of precursory ERP and on the firm’s ability to learn from its ERP implementations and identify areas where additional system, process, and business training, as well as organizational realignment, are necessary, since implementation fundamentals (regarding product, process training, and change management) do not change [68]. Missed opportunities during ERP implementation become risks in implementing SCM/CRM and linking it to the ERP system. The option value for CRM/SCM adoption increases with the increased organizational learning gained from implementing process changes across distinct organizational units, which are likely to require technology adaptations to accommodate exogenous and endogenous “misfits” [77]. This exploitable absorptive capacity, will therefore (1) give the firm the capability to become a better partner and collaborator at a lower cost, more quickly, and with less inherent risk than competitors, (2) increase the managerial flexibility to pursue currently unforeseen investments, (3) increase the option value of
positioning investments in IT platforms, and (4) have a positive impact on the firm’s intention to adopt SCM/CRM [38, 70, 74]. Hence the following hypothesis is proposed:

**H1:** The higher the extent of ERP implementation, the higher will be the extent of a firm’s digital-options adoption intentions.

Resource readiness is the necessary condition for a firm to adopt new IT innovations, since a lack of the necessary resources would limit its ability to fully use the innovation. Firms that possess innovation-related capabilities and endowments will have a greater ability to recognize and exploit a larger array of immediate follow-on projects and more managerial flexibility in the structuring and executing of options—they can innovate more economically with higher expected value of returns and probability of success from the investment [38]. Digital options are enabled when existing resources and capabilities allow preferential access to future opportunities for growth. They can broaden the original value proposition of ERP by enhancing the reach and richness of a firm’s knowledge and processes [66]. Process-oriented IT is more directly supportive of a firm’s responding ability, whereas knowledge-oriented IT is more supportive of its sensing ability. Sensing and responding capabilities are both necessary to ensure a firm’s agility [66]. Enhancements of the breadth of resources (reach) and the quality of information (richness) available to the firm improve its ability to sense and respond to environmental changes, thereby making it more agile [66]. However, deficiencies in either knowledge or process-oriented IT create an imbalance in the digital-options “platform,” making it an unsteady base from which to launch agile moves by adopting new IT innovations. Therefore, it is reasonable to suggest that the impact of the extent of ERP implementation on the extent of digital-options adoption intentions is positively moderated by a firm’s digital-resource readiness, that is, its digital knowledge and process reach and richness. The following hypothesis is proposed next:

**H2:** Greater extent of ERP implementation in conjunction with greater digital-resource readiness is positively associated with greater digital-option adoption intentions.

**Research Methodology**

**Measurement of Constructs**

In order to develop scales to measure the constructs, the underlying domain was identified and items were created accordingly. As some measures were developed for the first time, past literature was reviewed and constructs were carefully defined to specify the domain and ensure content and face validity [23, 62]. The model, shown in Figure 1, is represented by first- and second-order formative and reflective constructs. The guidelines of Jarvis, MacKenzie, and Podsakoff were followed in determining this choice because
they provide several decisive factors that cogently differentiate reflective and formative constructs [50]:

1. Direction of causality. If the direction of causality is from the construct to the indicators, and changes in the underlying construct are hypothesized to cause changes in the indicators, the measures are referred to as reflective [41]. In contrast, with formative indicators changes in the measures are “assumed to cause changes in the latent variable” [12, p. 65] and “assumed to be defined by, or to be a function of its measurements” [6, p. 34].

2. Expectation of correlation. Reflective indicators are expected to be correlated and have high internal consistency reliability. Conversely, with formative indicators, there is no expected a priori pattern of association among the dimensions. Formative indicators are not assumed to reflect the same underlying construct, that is, they can be independent of one another and measure different factors. It is possible for formative indicators of the same construct to have a positive, negative, or no correlation with one another. Internal consistency measures do not apply to formative indicators.

3. Consequences of removing an indicator. For reflective indicators, removal of an indicator from the measurement model does not change the meaning of the construct or its construct validity. The measures are assumed to be equally valid, reliable, and interchangeable. Consequently, the remaining indicators can adequately represent the construct. Since formative indicators define the concept, there must be dimensions covering the domain of the construct for the construct to be properly defined. The removal of an indicator can be critical, as it may change the meaning of the construct.

4. Nomological net of the construct indicators. Since reflective indicators reflect the same construct and are interchangeable, they should have the same antecedents and consequences. Formative indicators are not expected to have the same antecedents and consequences because the measures do not necessarily capture the same aspects of the construct’s domain, nor are they interchangeable.

Based on these criteria, the constructs were modeled as follows: (1) extent of ERP implementation was modeled as a first-order construct with formative indicators, and (2) digital-resource readiness and digital-options adoption intentions were both modeled as second-order formative constructs, each with two first-order constructs. The scale items are listed in Appendix A and described next.

A minimum of three indicators were selected to measure each of the constructs [12]. The extent of ERP implementation (ERPEX) is measured by three formative indicators, the functional, organizational, and geographic scope of the implementation. ERP functional scope (ERPFS) was measured as the range of the implementation project and as a summation of the business functions covered by the ERP implementation. ERP organizational scope (ERPOS) was measured by the number of locations (departments, divisions, entire
company, multiple companies, etc.) targeted for ERP implementation, and ERP geographic scope (ERPGS) was measured by the geographic reach of the implementation (i.e., single site, multiple sites, national, worldwide). Extent of digital-options adoption intentions (EDOAI) is a second-order construct formed by SCM- and CRM-adoption intentions. The SCM-adoption intention (SCMAI) was measured with three items describing the extent of ERP/SCM fit (SCMFT) and the four items indicating the extent to which a firm is actively planning to use SCM applications for improving information and workflows among suppliers, customers, and partners. The CRM-adoption intention (CRMAI) was measured with three items describing the extent of ERP/CRM fit (CRMFT) and the four items that assessed the extent to which a firm is actively planning to implement CRM applications for improving customer interactions, sales force automation, and improving customer service. Digital-resource readiness (DRR) was assessed by ten items measuring the extent of a firm’s digital knowledge and process reach and richness. It is appropriately modeled as a formative second-order construct formed by two first-order facets that measured digital-knowledge reach/richness (KRR) and digital-process reach/richness (PRR). The constructs, with the exception of ERPEX, were assessed using five-point Likert scales anchored between “strongly disagree” and “strongly agree.”

To help provide a better explanation for the moderating effects of DRR on the relationship between ERPEX and EDOAI, a control was used for firm size (as a proxy for firm financial resources) to partial out organizational size effects. Firm size was measured by the total number of employees. Prior research suggests that firm size can have a positive influence on adoption behavior and on implementing radical innovations [59, 72, 87]. Larger firms, which may have larger operating budgets, technology base, and resources, are generally able to implement more extensive ERP systems. Conversely, large firms tend to be less flexible than smaller firms because they need more communication, coordination, and support to effect radical innovations [64].

**Data Collection**

The survey design was supported by (1) semi-structured interviews with knowledgeable executives to assess content validity, and (2) a pilot random sample. The purpose of the interviews was to evaluate each measure for comprehensibility, consistency of meaning, and respondents’ ability to respond accurately. The interviews helped to clarify questions and improve instructions and scale items. The study built on the use of interviews with experts. The individuals included were a chief information officer (CIO), an ERP project leader, a senior ERP consultant, and three business group managers in charge of overseeing ERP implementation in procurement, marketing, and planning/budgeting areas (in two manufacturing firms in, respectively, the generic drugs and disk drive industries).

After their review, the instrument was pilot-tested with a sample of Fortune 1000 firms to assess the face and content validity of the measures. The purpose of the pilot study was threefold: to assess the internal and external validity
of the scale items, to estimate potential participation rates for the subsequent study, and to provide insight into blind spots and oversights needed to plan the research study. The survey was sent to one of four key executives. Although only 123 surveys were returned after two rounds of follow-up requests, yielding a response rate of 12.3 percent, it was nonetheless possible to glean important information. As shown in Table 1, a large percentage (36%) were manufacturing firms, suggesting that it would be appropriate to focus on this industry to test the research model. The pilot study also made it possible to confirm that the psychometric properties of the measures were robust across both samples.

Empirical data for hypothesis testing were collected via a field survey of firms that had recently implemented ERP systems. The respondent population was chosen using a stratified sample of U.S.-based manufacturing firms drawn from the Harris Nationwide Manufacturing database. Manufacturing firms were selected because ERP implementation is particularly prevalent among these firms, since the sales of ERP systems were originally targeted to large manufacturing companies. This was also observed from the pilot data of Fortune 1000 firms. Consequently, the survey was restricted to manufacturing firms to minimize the potential confounding effects of industry variations on firm digital-option adoption intentions and digital-resource readiness.

The stratified sampling technique helped in avoiding biases due to firm size. For this purpose, the total population of 22,700 firms in the Harris database were stratified into four categories based on employee counts (3,000 and over, 1,000–2,999, 500–999, and 200–499), and the survey questionnaire was mailed to a random sample of firms within each strata (the fourth stratum was underweighted because ERP implementation is less prevalent among smaller firms).

The survey questionnaire was mailed to the senior-most IS executive in each firm (e.g., chief information officer, vice president in charge of IS), along with a letter outlining the purpose of the research and a pre-addressed stamped envelope for mailing back completed responses. Firms received no specific incentive for completing the survey, beyond a copy of the aggregated survey results. A total of 550 firms were contacted. Of these, 104 firms declined participation, citing reasons such as corporate policy and departure of the contact person from the firm. Two surveys were dropped (both from the 200–499 employee range) because they were incomplete. After two follow-up mailings for nonrespondents, conducted two and four months after the original mailing, a total of 148 usable responses were obtained, for a reasonable response rate of 27 percent (148/550). Response rate by firm strata is reported in Table 2. Chi-square analysis indicated that the nonrespondents did not differ systematically from the respondents on two criteria: firm revenue and number of employees.

As shown in Table 3, the manufacturing organizations in the survey typically were using systems that had been rolled out for 18 months. Their implementation projects took an average of almost 15 months to complete, with an average of 55 internal employees devoted to the implementation, and an average of 25 firms hired external consultants. The number of ERP users ranged from 50 to 5,000, with an average of 350 users.
Number and percentage of firms responding | Characteristic | $M$ | $Mdn$ | $Max$ | $Min$ | $SD$
---|---|---|---|---|---|---
Manufacturing 44 (35.8) | Number of months system has been used since rollout | 19.10 | 19.00 | 48 | 5 | 7.49
Banking 10 (8.1) | | | | | | 
Business services 6 (4.9) | | | | | | 
Retail 15 (12.2) | Length of time (in months) to complete e-project | 16.00 | 15.00 | 60 | 6 | 7.15
Healthcare 6 (4.9) | | | | | | 
Financial services 3 (2.4) | Number of full-time-equivalent employees (internal) devoted to ERP implementation | 57.56 | 45.00 | 250 | 10 | 42.51
Petroleum chemicals 8 (6.5) | | | | | | 
Pharmaceuticals 2 (1.6) | | | | | | 
Transportation 4 (3.3) | | | | | | 
Utilities 8 (6.5) | Number of full-time-equivalent consultants (external) hired for ERP implementation | 30.37 | 20.00 | 300 | 5 | 37.07
Other 17 (13.8) | | | | | | 

Table 1. Descriptive Statistics for Pilot Test Data from Fortune 1000 Firms ($N = 123$).
Partial least squares (PLS) using PLS-Graph, v3.00 software was used to test the hypothesized relationships shown in the model of Figure 1 [21]. PLS is appropriate for studies that have formative constructs, a relatively small sample size, and an emphasis on theory development [22]. It is widely used in IS research [53, 90]. Further, it is more appropriate for analyzing moderating effects because traditional techniques cannot account for measurement error in exogenous constructs [19, 20]. The PLS model is evaluated in two steps: (1) assessment of the reliability and validity of the measurement model, and (2) assessment of the structural model [8].

Exploratory Factor Analysis

The measures for EDOAI were factor analyzed to determine the factors that would form the underlying dimensions of the construct. As seen in Table 4, two factors emerged that explained 77 percent of the variance. Factors were named based on the inherent construct identified from the items that loaded onto each factor. Factor 1 contained items that measure CRM-adoption intentions.
<table>
<thead>
<tr>
<th>Code</th>
<th>CRM-adoption intentions (CRMAI)</th>
<th>SCM-adoption intentions (SCMAI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRMAI</td>
<td>CRMFT1: There is a good fit between ERP implementation and customer relationship management initiatives. 0.916 -0.075</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMFT2: Data provided by ERP match well with data required for customer relationship management. 0.927 -0.058</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMFT3: Our ERP implementation will help us take advantage of our current/future customer relationship management programs. 0.929 -0.022</td>
<td></td>
</tr>
<tr>
<td>CRMAP</td>
<td>CRMAP1: We plan to integrate our e-mail, phone, paper documents, and Web interfaces for improved customer interaction. 0.928 0.061</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMAP2: We plan to use sales force automation to improve and track our sales processes. 0.903 0.057</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMAP3: We plan to use the Internet for handling sales transactions and improve customer service. 0.923 -0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMAP4: We plan to automate customer responses and profiles, track marketing campaigns across different media and channels, and manage quotes and proposals from negotiations to closing. 0.941 0.030</td>
<td></td>
</tr>
<tr>
<td>SCMFT</td>
<td>SCMFT1: There is a good fit between ERP implementation and supply chain management initiatives. 0.015 0.701</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCMFT2: Data provided by ERP match well with data required for supply chain management. 0.053 0.752</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCMFT3: Our ERP implementation will help us take advantage of our current/future supply chain management programs. -0.051 0.751</td>
<td></td>
</tr>
</tbody>
</table>
SCM-adoption plan (SCMAP)

SCMAP: We plan to use the Internet or extranets to improve information flow among our suppliers, customers, and partners. 0.039 0.917

SCMAP: We plan to improve lead time, quality, and customization by sharing data with our business partners. -0.028 0.890

SCMAP: We plan to use our own database information and suppliers’ pipeline processes to forecast demand more accurately and create viable scheduling applications. -0.007 0.874

SCMAP: We plan to reduce overall production cost by streamlining our workflow and information flow to and from business partners. -0.038 0.896

Table 4. Exploratory Factor Analysis Results for SCM- and CRM-Adoption Intentions.

Notes: Extraction Method—Principal Axis Factoring; Rotation Method—Promax with Kaiser Normalization. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy: 0.873; Barlett’s test of sphericity: chi-square = 2,552.86; df = 91; p = .000. Boldface figures show which factor items load onto.
(CRMAI), and factor 2 consisted of measures of SCM-adoption intentions (SCMAI). For convergent validity, it was expected that items belonging to the same scale would have factor loadings exceeding 0.60 on a common factor and factor cross-loadings less than 0.30 for all other factors, demonstrating acceptable discriminant validity. Table 4 shows that items loaded high and uniformly on their expected factor and that cross-loadings were small. Reliability was assessed using Cronbach’s alpha. There was a high degree of reliability for each factor, with both exceeding 0.90.

Once an interpretive structure for EDOAI was established, confirmatory factor analysis was applied to further assess the measurement properties of the constructs. Table 5 provides the mean values and standard deviation of all constructs.

Measurement Model Analysis

In order to focus on the psychometric properties of the measurement model, the study examined the composite reliability, convergent validity, and discriminant validity of the constructs. Formative indicators are not assumed to measure the same construct, nor are they expected to be correlated or to demonstrate internal consistency. Consequently, measures of internal consistency do not apply for ERPEX [19, 20, 43]. Moreover, there are no definitive criteria for the validation of formative variables. However, the general practice is to examine item weights, which will usually have smaller absolute values than item loadings [24].

Convergent validity can be assessed by an examination of the measurement model loadings (and weights). The loadings, once deemed consistent with the underlying construct, were used to assess internal consistency and average variance extracted (AVE). Convergent and discriminant validity is adequate for constructs modeled using two or more reflective indicators when (1) the square root of the AVE by a construct from its indicators is at least 0.707 (AVE > 0.50), and (2) item loadings exceed 0.70 and load more highly on the constructs they are intended to measure [1].

Table 6 provides the measurement model results. All AVEs exceeded 0.50, providing evidence that measures in the constructs are more closely aligned with themselves than with other constructs [43]. Convergent validity is also evident from the high loadings of reflective measure items on their associated constructs. Moreover, all item loadings were significant at the 0.05 level, and were above the 0.70 suggested benchmark noted above [41]. An evaluation of the formative measurement model for ERPEX is based on the weights of the indicators. The weights for the formative construct (ERPEX) were significant at the $p < 0.05$ level. The weights provide information about the make-up and relative importance for each indicator in the creation/formation of the component [20, p. 307]. For example, the ERPOS is more important in determining the construct than the ERPGS or ERPF. Reliability measures are reported in Table 6. Since a measure may have unacceptable convergent validity and still be reliable, the reliability was assessed after the convergent validity was determined [79]. All composite reliability measures were above the suggested
minimum value of 0.70. Collectively, the measures provide strong evidence of item reliability and convergent and discriminant validity.

Second-Order Constructs

PLS can be used to approximate second-order factors using two procedures [22]. One approach is to use a direct item to construct approach, where the second-order construct is measured by the items of the first-order constructs. Another approach, which we use here, models the path coefficients from the first- to second-order constructs using the weights of the formative constructs.
Thus, to estimate the proposed second-order constructs, DRR and EDOAI, the coefficients (γ_i) of each first-order factor were modeled to the latent second-order factor following the procedure of Diamantopoulos and Winklhofer [31, p. 270]:

\[ DRR = \gamma_1 \times KRR + \gamma_2 \times PRR \] (1)

\[ EDOAI = \gamma_1 \times SCMAI + \gamma_2 \times CRMAI \] (2)

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Factor Loading</th>
<th>Critical Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent of ERP implementation (ERPEX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERPS</td>
<td>0.486*</td>
<td>3.06**</td>
</tr>
<tr>
<td>ERPOS</td>
<td>0.629*</td>
<td>4.13*</td>
</tr>
<tr>
<td>ERPGS</td>
<td>0.423*</td>
<td>2.56***</td>
</tr>
<tr>
<td>CR; AVE = N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRM-adoption intentions (CRMAI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRMT_1</td>
<td>0.915</td>
<td>45.24*</td>
</tr>
<tr>
<td>CRMT_2</td>
<td>0.927</td>
<td>53.41*</td>
</tr>
<tr>
<td>CRMT_3</td>
<td>0.929</td>
<td>42.82*</td>
</tr>
<tr>
<td>CRMAP_1</td>
<td>0.927</td>
<td>47.77*</td>
</tr>
<tr>
<td>CRMAP_2</td>
<td>0.902</td>
<td>36.56*</td>
</tr>
<tr>
<td>CRMAP_3</td>
<td>0.922</td>
<td>44.13*</td>
</tr>
<tr>
<td>CRMAP_4</td>
<td>0.941</td>
<td>47.33*</td>
</tr>
<tr>
<td>CR = 0.976; AVE = 0.854</td>
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<td></td>
</tr>
<tr>
<td>SCM-adoption intentions (SCMAI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCMFT_1</td>
<td>0.704</td>
<td>10.03*</td>
</tr>
<tr>
<td>SCMFT_2</td>
<td>0.752</td>
<td>13.27*</td>
</tr>
<tr>
<td>SCMFT_3</td>
<td>0.753</td>
<td>13.44*</td>
</tr>
<tr>
<td>SCMAM_1</td>
<td>0.917</td>
<td>47.84*</td>
</tr>
<tr>
<td>SCMAM_2</td>
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<td>26.62*</td>
</tr>
<tr>
<td>SCMAM_3</td>
<td>0.873</td>
<td>28.20*</td>
</tr>
<tr>
<td>SCMAM_4</td>
<td>0.896</td>
<td>39.50*</td>
</tr>
<tr>
<td>CR = 0.939; AVE = 0.689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital resource readiness (DRR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge reach/richness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KRR_1</td>
<td>0.729</td>
<td>7.91*</td>
</tr>
<tr>
<td>KRR_2</td>
<td>0.778</td>
<td>9.25*</td>
</tr>
<tr>
<td>KRR_3</td>
<td>0.830</td>
<td>16.61*</td>
</tr>
<tr>
<td>KRR_4</td>
<td>0.776</td>
<td>11.31*</td>
</tr>
<tr>
<td>KRR_5</td>
<td>0.700</td>
<td>6.72*</td>
</tr>
<tr>
<td>CR = 0.873; AVE = 0.581</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process reach/richness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRR_1</td>
<td>0.820</td>
<td>16.21*</td>
</tr>
<tr>
<td>PRR_2</td>
<td>0.848</td>
<td>23.08*</td>
</tr>
<tr>
<td>PRR_3</td>
<td>0.746</td>
<td>15.10*</td>
</tr>
<tr>
<td>PRR_4</td>
<td>0.781</td>
<td>16.02*</td>
</tr>
<tr>
<td>PRR_5</td>
<td>0.719</td>
<td>11.84*</td>
</tr>
<tr>
<td>CR = 0.888; AVE = 0.615</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Measurement Model Results.

Notes: Standard errors for all indicators ranged from 0.01 to 0.10. * Weights; Composite Reliability, CR; Average Variance Extracted, AVE. *** p < 0.05; ** p < 0.01; * p < 0.001.
The results in Figure 2 indicate that the weights are significant for both second-order factors.

**Structural Model**

PLS does not provide summary statistics to assess the overall “fit” of the model. However, the variance explained by the path model (multiple $R^2$ for the endogenous construct, EDOAI) and the sign and significance of path coefficients are typically used to assess model fit. A bootstrapping approach was used to generate 500 random samples of the original sample size from the data set by sampling through replacement. This was necessary to obtain estimates of standard errors to test the statistical significance of the path coefficients. Such an approach provides valid estimates of the significance of the path coefficients in the PLS models [61].

The empirical testing and validation of the theorized causal links are shown in Figure 3. The estimated path effects, associated $t$-values, and standard errors are provided. As observed, all coefficients are in the appropriate direction and are statistically significant (except for the control variable size). For the main effect, the results reveal that ERPEX has a direct and significant relationship to EDOAI ($\beta = 0.240; t = 3.33, p < 0.01$), providing support for hypothesis H1.

Moreover, the standardized path coefficients exceed the suggested minimum standard of 0.20 [19, 20]. The predictive power of the model can be assessed by examining the explained variance. The model explained 42 percent of the variance in EDOAI.

As seen in Table 7, the correlations between ERPEX and EDOAI (0.43), ERPEX and DRR (0.26), and DRR and EDOAI (0.38) were all significantly related.
Tests for Moderation

Chin, Marcolin, and Newsted note that it may be desirable to model formative moderator constructs differently from reflective constructs [22] (see the on-line supplement to their article, www.informs.org/Pubs/Supplements/ISR/1526-5536-2003-02-SupplA.pdf). They suggest creating centralized or transformed composite scores using PLS weightings, then using these composites rather than product-item indicators [22]. All items were standardized or centered consistent with recommended strategies for assessing interactions [22]. Further, to ensure that the moderating effects are tested and interpreted correctly, the study followed the guidelines reported by Carte and Russell [18]. The moderating effects, if found to be significant, will provide a strong indication of the lack of common method bias [36]. Although the respondents may anticipate the linear relationships and answer accordingly, they are not likely to predict the moderating relationships. Second, the correlation matrix (see Table 7) did not indicate any highly correlated variables, while evidence of common method bias usually results in extremely high correlations (r > 0.90) [7].

The strength of the relationship between ERPEX and EDOAI is significantly dependent upon DRR (β = 0.512; t = 7.16; p < 0.001), confirming hypothesis H2. Although a control was applied to EDOAI to partial out the effects of firm size, it was not significant (β = 0.123; t = 1.87; p > 0.05). In addition, to examine whether the hypothesized interaction effect added any significant explanatory power over and above the main effect of ERPEX on EDOAI, the $R^2$ values of the dependent variable, EDOAI, were compared. Accordingly, the effect size $f^2$ was computed to compare the $R^2$ values between the main and interaction effect models as a gauge for whether the interactions had a small (0.02), medium (0.15), or large effect (0.35) on EDOAI [26]. The model was examined with and without the significant interaction effect, an approach consistent with the guidelines recommended by Carte and Russell [18]. The model without the interaction explained less variance (0.189) in EDOAI than the model that included DRR as a moderator (0.419). Based on the results of the two competing models, the formative effect size was considered large.

Figure 3. Model Results
<table>
<thead>
<tr>
<th>Constructs</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPEX</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRR</td>
<td>0.26</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KRR</td>
<td>0.11</td>
<td>0.30</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRR</td>
<td>0.23</td>
<td>0.41</td>
<td>0.28</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDOAI</td>
<td>0.43</td>
<td>0.38</td>
<td>0.19</td>
<td>0.27</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCMAI</td>
<td>0.24</td>
<td>0.56</td>
<td>0.16</td>
<td>0.29</td>
<td>0.38</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>CRMAI</td>
<td>0.29</td>
<td>0.14</td>
<td>0.12</td>
<td>0.07</td>
<td>0.28</td>
<td>0.22</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 7. Correlations of Structural Model Constructs.
\( f^2 = 0.39 \), indicating that the models are different in terms of their ability to explain EDOAI. This analysis, consistent with the path significances reported earlier, confirmed that the hypothesized interaction effect of DRR provides a better explanation of the variance in EDOAI relative to the main effect and that DRR must be considered along with ERPEX.

**Discussion and Conclusions**

This study addresses a central question in the innovation field in the context of complex organizational technologies: Under what circumstances should a firm take the lead as an innovator with emerging technologies [38]? It is based on the argument that positioning investments in a multiphase implementation creates real (growth) options for the subsequent implementation and use of the platform [33]. The study provides theoretical arguments for the role of ERP implementations in enabling digital options and measures the impact of the extent of ERP implementation on the extent of digital-options adoption intentions. The study draws on unique data sets collected from two surveys. These provided evidence of the scales’ robustness and generalizability across two populations. The scales in this study exhibited good validity and should provide a useful tool for further inquiry into factors that can lead to differential digital-options adoption intentions as the result of extending ERP implementation. By relating digital-option theory to specific measurable constructs, it enabled testing of the hypotheses. The results validated the expectations and provided strong support for the theoretical predictions, confirming that the effects of extending ERP implementation on the extent of a firm’s digital-options adoption intentions are positively moderated by its digital-resource readiness. This research also suggests that the digital-adoption decisions of a firm are linked to its digital-resource readiness, and that a firm’s knowledge and process reach and richness can be powerful explanatory variables that account for important differences in digital-options adoption intentions among firms.

This study offers further empirical research into IT platform adoptions and factors that predict digital-options adoption intentions. It demonstrates that extending a firm’s ERP implementation can affect its digital-options intentions. Therefore, firms should view ERP divisibility and extending ERP implementation as an option-value generator and as having the potential to create growth options for future SCM/CRM adoptions rather than as enhancing rigidities. These growth options will be dependent on the firm’s digital-resource readiness (its knowledge and its process reach and richness). In addition, the increased extent of ERP implementation will result in exploitable absorptive capacity needed for assimilating SCM/CRM. Although, SCM/CRM-adoption intentions represent a firm’s future plans, and confer the right, but not the obligation, to obtain benefits from future deployments of these technologies, there is a general link between the motivations of early adopters and the technology options [38, 39]. That is, those firms that defer the adoption of new IT platforms may (1) not have quite the same claim on future benefits because of time-compression diseconomies, (2) suffer a general
loss of innovative capabilities, (3) lose the ability to appreciate new technologies, and (4) find themselves “locked out” of future opportunities as well as current ones [32, 40]. Factors leading to high option value (e.g., extent of ERP implementation, organizational learning, innovation-related capabilities and endowment, resource readiness, absorptive capacity, divisibility) should be predictive of early adoption. A meta-analysis of innovation research found that the same variables that predicted adoption also predicted implementation [29]. An evaluation of these factors should help to direct managerial attention to the most promising options and could provide insights into the structuring of options [38].

Implications for Research

Recent research suggests that a firm’s ability to enhance its existing IT-dependent strategic initiatives and deploy new ones is dependent on its development of strong IT infrastructure resources and relationship assets [69]. Digital-options theory suggests that IT directly and indirectly supports agility by enabling firms’ digital options [74]. SCM/CRM adoption will enhance a firm’s knowledge and process reach and richness and, therefore, its agility [66]. Firms possessing higher levels of agility are better positioned to detect and exploit market opportunities in order to meet changing environmental conditions [66]. It is hoped that this research will trigger a series of related investigations. For example, future studies need to test whether ERP value-chain modules influence CRM- and SCM-adoption intention in different ways, and test for the direct and independent roles of SCM- or CRM-adoption on enterprise agility. Future studies need to test the research model longitudinally and test the sustainability of the effects of SCM/CRM adoption on enhancing a firm’s sensing and responding abilities, and for the effects of building strong IT infrastructure and relationship assets using both competing and complementary IT platforms. Prior research has suggested that institutional pressures, such as mimetic, coercive, and normative pressures, have the potential to influence the intent to adopt interorganizational systems [85]. Future research needs to include these pressures along with the constructs in the present study to provide the theoretical linkages to institutional environment in which a firm is situated. This can provide greater insight into the factors that enable adoption of digital options.

Implications for Practice

A firm’s IT competence is based on the readiness of its stock of IT resources and capabilities and determines its capacity for IT-based innovation by converting its IT assets into strategic applications. A firm has the option to use its ERP capabilities as a dominant enterprise-application model to enable its Net-enabled business-innovation cycle for collaborate commerce [91]. This can be done by extending its internal business process and system integration to enterprise-application integration and by including its suppliers and
customers. Digital-option creation via SCM and CRM systems allows for both integrated and complementary (e.g., best-of-breed) approaches. However, a fully integrated platform (e.g., Oracle e-business suite, www.oracle.com/applications/e-business-suite.html) allows for better data consistency and semantic reconciliation of reference data and thereby provides better business information for effective decision-making and optimal responsiveness. Prior research has also suggested that by providing collaboration platforms based upon data and process standardization, B2B markets can foster a higher level of interorganizational integration [28]. A fully integrated platform can also increase the prospects for network dominance of the technology class, which is defined as the extent to which an IT innovation class is likely to achieve a dominant position relative to competing technology classes. Such an increase will subsequently increase the option value of positioning investments in the IT platform [38].

Firms should position their ERP investment to not only scale up internal operations, but also to trade electronically with customers, suppliers, and other business partners [71]. They should seek growth opportunities rather than cost cutting, turnaround, and sustaining strategies when it comes to ERP implementation. Although the benefits from extending the scope of ERP implementation can be more indirect than basic cost-cutting measures, firms can still maximize the return on their investment in the long run. Firms that extend the scope of their ERP implementation today can leverage the economies of scale to support new customer and revenue opportunities that simply were not feasible before. However, overhauling business processes to operate horizontally across a firm will not be effective unless the installed applications are frequently improved and, when appropriate, retirement strategies are identified based on changing business requirements and emerging technologies [66]. Without these a firm may not have flexibility in adoption or implementation and may have to defer the decision to invest for some period.

Effective option thinking requires managers to (1) recognize and enhance opportunities to create options with IT, (2) value those options (in the same way), and (3) manage projects to fully extract this value [40]. Although the extent of ERP implementation can directly and significantly influence a firm’s digital-options intentions, the study found that the effect can vary based on the readiness of the firm’s digital resources. This suggests that the impact of extending the scope of ERP implementation on digital-options intentions can be strengthened (or weakened) when (or under the conditions of) firms have a superior (vs. inferior) knowledge and process reach and richness. Firms need to evaluate the readiness of their digital resources and to find out how they compare with the best-in-practice with respect to (1) the frequency and variety of digitally enabled competitive actions, and (2) the actions of industry leaders in the same industry or other industries. In collaborative environments, firms need to optimize their internal processes for mutual benefit and to exchange accurate and up-to-date information to share best practices. The lack of a perceived performance gap of current business practices, perceived potential benefits, or perceived resource readiness is a major reason for not enabling digital options.

Technology leaders have the capacity necessary for IT-based innovation to be first movers. To be a leader, a firm must evaluate the strategic importance of
different capabilities and be willing to patiently and persistently build them, even though it may be less expensive or more efficient in the short term to rely on outsiders for procurement. Prior research suggests that beside resource readiness, institutional pressures have a significant influence on organizational intention to adopt [24, 85]. While CRM-adoption decisions may be viewed as one-sided organizational decisions, supply-chain integration involves the integration of information flows, physical flows, and financial flows between a firm and its supply-chain partners [70]. Firms wishing to extend their internal processes, therefore, must develop trusting and collaborative relationships with their partners, and focus their efforts on organizational capabilities and strategic processes that contribute to the creation of customer value for their extended enterprises. Not only must they develop supply-chain process-integration capabilities, but they must also develop capabilities to quickly select similar digitally enabled partners to share information and create virtual organizations, and then to dissolve these partnerships just as quickly [45]. Therefore, they must develop new competencies for adding or removing partners, and for raising the level of partnerships to increase their capabilities for long-term value creation. They must be able to leverage the relationships with partners so that each can focus on its own core competencies.

Limitations

Like any empirical research effort, this study has a number of methodological strengths and limitations, and specific issues warrant caution in interpreting the results. The breadth of the sample included in the study suggests that the findings are fairly generalizable to many manufacturing industries. However, the findings are limited in some important ways. The study did not consider the institutional effect of focusing on a single industry. Compared to other industries, it is conceivable that SCM has a greater impact than CRM in manufacturing industries. Although the respondents possessed a high degree of relevant knowledge, all of the measures are self-reported and therefore subject to hindsight and other biases. Reliance on the report of a single informant is also a limitation. The extent to which the findings are consistent or dissimilar across different sectors represents an avenue for future research. Another limitation is the cross-sectional nature of the study and the fact that it captured only a snapshot of the firms’ digital resources. Finally, the firms in the survey had only recently implemented ERP systems, and it was assumed to be unlikely that they would have implemented SCM and CRM. Thus, the respondents were asked about their post-ERP expectations with a series of statements that asked about their firm’s future plans regarding SCM and CRM. Although it seems doubtful, nonetheless it is still possible that some of the firms had already implemented CRM and SCM.

Concluding Remarks

This study integrated theoretical perspectives and empirical findings on when (or under what conditions) extending the scope of ERP implementation can be
leveraged for adopting digital options. It theoretically derived valid and reliable scales for measuring the extent of ERP implementation, digital-resource readiness, and SCM-/CRM-adoption intentions. It shows that extending the scope of a firm’s ERP implementation can have a direct and significant impact on the firm’s digital-options adoption intentions and that such impacts are moderated by the firm’s knowledge and process reach and richness.

**NOTE**

1. Computed as $F = f^2 * ([n - k] - 1)$, with $1, (n - k) df$, where $n$ = sample size, $k$ = number of constructs in the mode, and $f^2 = (R^2_{interaction} - R^2_{main})/(1 - R^2_{interaction})$.

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Appendix A

Extent of ERP Implementation (ERPEX)

**ERPFS:** Functional scope of implementation of your selected ERP (select all that apply): Accounting/Finance | Manufacturing | Planning/Scheduling | Human Resources | Sales/Distribution | Logistics/Inventory Control | Other (please specify): ___________

**ERPOS:** Scope of implementation of your selected ERP: Department | Division | Entire company | Multiple Companies | Other: ___________

**ERPGS:** Geographical extent of implementation: Single site | Multiple sites | National | Worldwide

Extent of Digital-Options Adoption Intention (EDOAI)

**ERP/CRM fit (CRMFT)**

**CRMFT₁:** There is a good fit between ERP implementation and customer-relationship management initiatives.

**CRMFT₂:** Data provided by ERP match well with the data required for customer-relationship management.

**CRMFT₃:** Our ERP implementation will help us take advantage of our current/future customer-relationship management programs.

**CRM-Adoption Plan (CRMAP)**

**CRMAP₁:** We plan to integrate our e-mail, phone, paper documents, and Web interfaces for improved customer interaction.

**CRMAP₂:** We plan to use sales force automation to improve and track our sales processes.

**CRMAP₃:** We plan to use the Internet for handling sales transactions and improving customer service.

**CRMAP₄:** We plan to automate customer responses and profiles, track marketing campaigns across different media and channels, and manage quotes and proposals from negotiations to closing.

**ERP/SCM fit (SCMFT)**

**SCMFT₁:** There is a good fit between ERP implementation and supply-chain management initiatives.

**SCMFT₂:** Data provided by ERP match well with the data required for supply-chain management.

**SCMFT₃:** Our ERP implementation will help us take advantage of our current/future supply-chain management programs.
SCM-Adoption Plan (SCMAP)

SCMAP₁: We plan to use the Internet or extranets to improve information flow among our suppliers, customers, and partners.

SCMAP₂: We plan to improve lead time, quality, and customization by sharing data with our business partners.

SCMAP₃: We plan to use our own database information and suppliers’ pipeline processes to forecast demand more accurately and create viable scheduling applications.

SCMAP₄: We plan to reduce overall production cost by streamlining our workflow and information flow to and from business partners.

Digital-Resource Readiness (DRR)

Knowledge Reach/Richness (KRR)

KRR₁: ERP implementation has reduced error rates in our operational processes

KRR₂: ERP implementation has significantly improved our forecasting accuracy

KRR₃: ERP implementation has improved the flexibility of our decision-making

KRR₄: ERP implementation has made us more adaptive to changing business environment

KRR₅: ERP implementation has made our company more agile

Process Reach/Richness (PRR)

PRR₁: ERP implementation has given us more ways to customize our processes

PRR₂: ERP implementation has improved our efficiency of operations

PRR₃: ERP implementation has reduced the amount of rework needed for data-entry errors

PRR₄: ERP implementation has improved our quality of operations

PRR₅: ERP implementation helps us complete more transactions in less time

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