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The impact of IT capabilities on firm performance: The mediating roles of absorptive capacity and supply chain agility

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ABSTRACT

Researchers and practitioners regard information technology (IT) as a competitive tool. However, current knowledge on IT capability mechanisms that affect firm performance remains unclear. Based on the dynamic capabilities perspective and the view of a hierarchy of capabilities, this article proposes a model to examine how IT capabilities (i.e., flexible IT infrastructure and IT assimilation) affect firm performance through absorptive capacity and supply chain agility in the supply chain context. Survey data show that absorptive capacity and supply chain agility fully mediate the influences of IT capabilities on firm performance. In addition to the direct effects, absorptive capacity also has indirect effects on firm performance by shaping supply chain agility. We conclude with implications and suggestions for future research.

1. Introduction

Leveraging information technology (IT) to derive competitive advantage is emerging as a top priority for firms [17,33,34,81]. IT capabilities are required for efficient and effective knowledge management and change management in a firm's supply chain [42,54,58,79]. However, previous empirical studies report mixed findings about the effects of IT capabilities on firm performance [54,79]. "The role and articulation of 'the underlying mechanisms' through which IT capabilities improve firm performance remain unclear" ([81], p. 238). As such, scholars have called for more empirical studies on the influential mechanisms of IT capabilities especially in the supply chain context [54,79].

The current study is an effort toward this research direction. In particular, this study explores the roles of two IT capabilities that affect firm performance, namely, (1) flexible IT infrastructure, which is a carefully planned and developed technological foundation on which present and future IT applications are built [9,54,60], and (2) IT assimilation, or the ability to diffuse and routinize IT applications in business processes [3]. Previous studies indicate that both flexible IT infrastructure and IT assimilation are valuable, rare, and imperfectly imitable IT capabilities that firms must acquire to prosper in a rapidly changing business environment [6,54,74].

Specifically, firms continue to make significant investments in IT infrastructure, facilitating the flow of knowledge and information across supply chains that, in turn, helps them maintain competitive advantage [14,33,61]. Given that the market has become increasingly uncertain, managers now consider creating flexible IT infrastructure as a critical capability that allows firms to achieve superior performance [56]. Thus, greater attention is given to the business value of a flexible IT infrastructure [9,54,56,60]. Furthermore, previous works report that a flexible IT infrastructure alone is insufficient — it simply cannot enable firms to maintain competitive advantage [19,48,81]. For example, Devaraj and Kohli [19], indicate that the performance benefits of IT infrastructure investment may not be fully realized unless IT applications are actually assimilated. Practically, as an increasing number of organizational processes are becoming IT-enabled, IT assimilation is becoming essential in supporting business processes within and across organizational boundaries, thereby determining the value realized from IT applications [3,40,74].

Recent literature question the direct effects of IT capabilities on firm performance by contending that the effects are mediated by other capabilities [45,49,52,58,79]. For example, Wade and Hulland [74], state that "information systems exert their influence on the firm through complementary relationships with other firm assets and capabilities" (p.109). Sambamurthy, Bharadwaj, and Grover [58] posit that knowledge management and agility are two important mediators that help establish the nomological network for IT capabilities' impact on firm performance. Mithas et al. [45] further argue that IT capabilities normally affect firm performance by enabling higher-order business capabilities. Following

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this notion, we draw upon the dynamic capabilities perspective and investigate the underlying influencing mechanisms of IT capabilities. In particular, we follow Grant [24] and Rai et al. [52] in conceptualizing IT capabilities as fundamental capabilities that shape higher-order capabilities (i.e., absorptive capacity and supply chain agility) that, in turn, affect firm performance.

Absorptive capacity refers to a firm's ability to value, assimilate, and apply new knowledge received from external sources, such as customers, suppliers, or alliance partners [18,42,82]. Supply chain agility is defined as a firm's ability to effectively collaborate with channel partners to respond to market changes in a rapid manner [7,65]. Both absorptive capacity and supply chain agility are viewed as the critical, direct sources of superior firm performance in the competitive market [15,58,66,82]. A flexible IT infrastructure provides the platform that can help firms exchange knowledge, align processes, and achieve operation flexibilities, whereas IT assimilation affects the efficiency and effectiveness of business processes within and across organizational boundaries through embedding IT applications into business processes [52,59,79]. As such, we propose that IT capabilities (i.e., flexible IT infrastructure and IT assimilation) support the development of absorptive capacity and supply chain agility, thereby influencing firm performance. The research model is supported by data collected from senior executives in China.

The rest of the paper is organized into sections. Section 2 presents the theoretical background and hypotheses development of this study. Section 3 describes the research methodology employed. Section 4 discusses our data analysis and research findings. Finally, Section 5 presents our discussion and conclusion.

2. Conceptual framework and hypotheses development

The dynamic capabilities perspective is a widely applied paradigm to explain variance in performance across competing firms [5,68,77,83,84]. With its roots in resource-based view, this theoretical perspective argues that superior firm performance comes from two types of organizational capabilities, namely, dynamic capability and operational capability [12,20,29,83]. The literature formulated the basic difference between dynamic capability and operational capability [29,31,76,80]. Scholars refer to the former as the means by which a firm achieves new resource conditions as market changes; by contrast, the latter is the means by which the firm functions or operates to make a living in the present [80]. Specifically, operational capability refers to a firm's ability to execute and coordinate the various tasks required to perform operational activities, such as distribution logistics and marketing campaigns [12,29,49,80]. This capability reflects a high-level routine or a collection of routines that can be used to respond to market changes [5,12,29,49]. Due to the growing need for a timely and cost-effective manner of product and service delivery, supply chain agility is considered a critical type of operational capability required for superior firm performance [46,47]. It also reflects the complex coordination and integration among different channel members, which enable firms to change supply chain practices and be responsive to market changes [7,65,66]. Therefore, supply chain agility is regarded as a critical source of superior firm performance [46,47].

Dynamic capability refers to a firm's ability to integrate, build, and reconfigure internal and external competencies [68,77]. Dynamic capability is regarded as a higher-level routine that is used to adapt operational routines and capabilities to develop new value-creating strategies [12,20,29,57,83]. In the existing literature, absorptive capacity is widely proposed as a critical type of dynamic capability that enables knowledge management [42,75,82]. Malhotra et al. [42] suggest that a firm's absorptive capacity reflects "the set of organizational routines and processes by which organizations acquire, assimilate, transform, and exploit knowledge" (p. 145). Hence, absorptive capacity enables the firm to sense and seize business opportunities that can directly affect firm performance [12,68,77].

On the other hand, based on the theoretical notion of higher-order capabilities and a hierarchy of capabilities, scholars suggest that organizational capabilities can be conceptualized as a hierarchy, with a higher-order capability being developed through a series of lower-order capabilities [24,26,35,64]. In this view, both absorptive capacity and supply chain agility are widely defined as higher-order capabilities that enable firms to exploit existing lower-order capability [26,80]. Accordingly, in current IT business value research, scholars increasingly regard IT capabilities as lower-order capabilities that enabling the development of higher-order capabilities, such as agility [58], knowledge management [67] as well as new product development dynamic and operational capabilities [49], rather than higher-order capabilities in themselves [4]. Rai et al. [52] contend that a firm's IT capability "represents a lower-order capability that can be leveraged to develop a higher-order process capability (i.e., supply chain process integration), which is a source of significant and sustained performance gains for the firm" (p. 227). Similarly, Sambamurthy et al. [58] propose that IT capabilities are antecedents of higher-order business capabilities, including knowledge management and agility capabilities. Following this logic, the current study proposes that both flexible IT infrastructure and IT assimilation are lower-order capabilities that can be leveraged to develop higher-order capabilities (i.e., absorptive capacity and supply chain agility) that, in turn, directly affect firm performance. Fig. 1 shows the research model.

2.1. Supply chain agility

Supply chain agility, as a type of operational capability, refers to a firm's ability to perform operational activities together with channel partners in order to adapt or respond to marketplace changes in a rapid manner [7,65,66]. A supply chain normally involves a series of linked activities, including design, manufacture, and delivery of products or services, among channel members. The firm needs to collaborate with partners to perform these linked activities efficiently and jointly manage marketplace volatility to achieve competitive advantage [73]. Under this condition, supply chain agility, which is all about customer responsiveness in the uncertain market [73], is essential in ensuring the firm's competitiveness because it enables effective and efficient responses to operational changes, such as procurement, manufacturing, delivery, and market promotion [1,58,65].

The concept of supply chain agility reflects a complex philosophy, which is not about rules and procedures which can be easily implemented or imitated, but about coordination and integration among different channel members across the supply chain [7,46,65,66]. This agility requires the firm "to supervise closely the legally separate but operationally interdependent parties, such as suppliers, manufacturers, and distributions, to maintain a close and coordinating relationship" [46]. This requirement means that supply chain agility can define how well the firm collaborates with channel partners in building complementary resources and developing knowledge sharing routines, thereby jointly managing market changes [1,7,15,73]. Therefore, supply chain agility could act as a rare, valuable, and imperfectly imitable operational capability, which is critical to improving firm performance [46,66].

In particular, supply chain agility can help a firm achieve high customer responsiveness and master marketplace changes through information integration [11,23,73]. This integration improves the visibility of the supply chain and enables the firm to sense marketplace changes in real time, thereby reducing the cost of demand uncertainty [7,27,37,79]. Furthermore, supply chain agility enables the firm to coordinate with channel partners with a shared vision on planning and business processes [1,7]. This coordination decreases potential conflicts and opportunistic behaviors within the supply chain, and motivates the firm to pool and deploy resources with channel partners to enhance the efficiency of products and service delivery [27]. Hence, supply chain agility not only enables the firm to

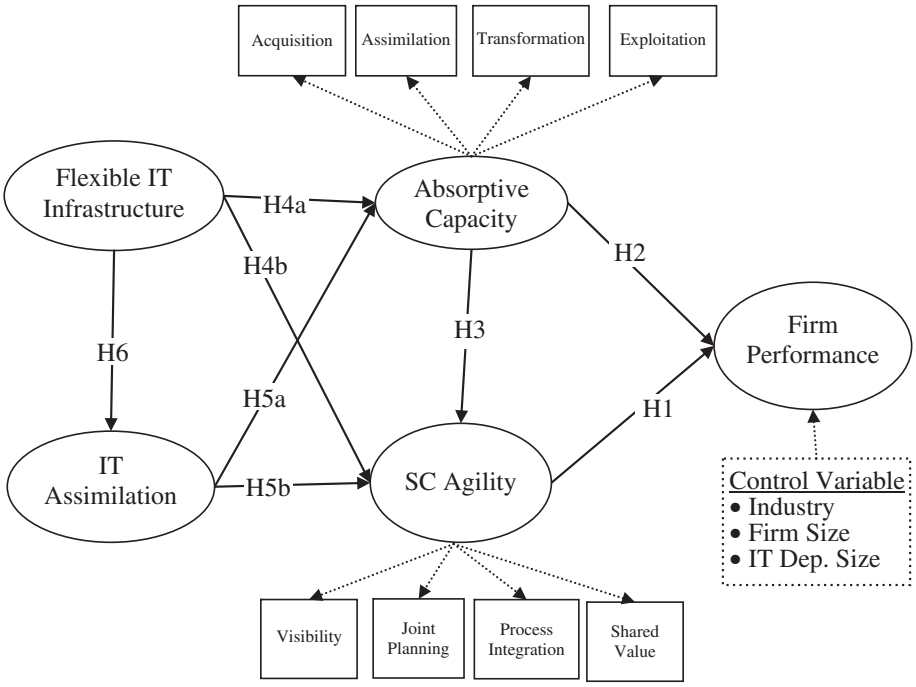


Fig. 1. Hypothesized model.

improve its daily operations, but also helps it reduce costs and increase profitability [1,58,65].

H1. A firm's supply chain agility is positively related to the firm's performance.

2.2. Absorptive capacity

Absorptive capacity refers to a firm's ability to recognize the value of new external knowledge as well as assimilate and commercialize it [10,18,71,82]. Absorptive capacity involves a collection of routines to manage knowledge and the cumulative influences of continuous learning in the firm [10,18,71]. It also enables market knowledge creation based on a firm's prior related-knowledge, effective learning routines, and rich communication [10,42,71]. Recently, scholars characterized absorptive capacity as a crucial dynamic capability pertaining to knowledge creation and utilization in knowledge-based competition, which can help the firm gain and sustain competitive advantage [42,49,82]. By effectively redefining and deploying the firm's knowledge-based assets, the firm with high absorptive capacity would be amenable to change, thus reshaping its operational capabilities to improve performance [49,82].

Based on the dynamic capabilities perspective, we propose absorptive capacity as an important source of superior firm performance. Specifically, a firm with a high level of absorptive capacity is likely to harness new knowledge obtained from external sources (e.g., customers, suppliers, competitors, and other channel partners) and to apply the new knowledge to identify business opportunities in the market [18,42,82]. For example, with absorptive capacity, a firm can effectively acquire new external knowledge about customer preferences, technology innovation, emerging markets, and so on. This acquisition would then help the firm sense environmental uncertainties, understand market tendencies, and catch market opportunities, which would be critical to increasing market share and improving profitability. Furthermore, absorptive capacity ensures efficient internal knowledge processing [10,18,69,71,82]. It also facilitates the establishment of formal and informal networks within the firm to transfer knowledge extensively across different functional departments [69,82]. Thus, the firm can effectively learn how to apply the new knowledge to reengineer its processes and improve its products and services.

H2. A firm's absorptive capacity is positively related to the firm's performance.

The literature indicates that a firm's operational capability can be fostered by its dynamic capability [12,29,49,83]. Pavolou and Sawy [49] proposed that the firm's dynamic capability can act as the strategic options which enables the firm to shape the existing operational capability when the opportunity or need arises. In the existing absorptive capacity research, scholars further propose that utilizing external knowledge is a major determinant of the firm's operational capability [42,82]. Agility research also posits that the firm's agility is determined by the degree of knowledge reach and richness the firm can achieve [58]. This capability indicates that the foundation of the firm's competitive advantage is to make use of absorptive capacity to develop a unique operational capability, such as agility [49,71].

Accordingly, we propose that a firm's absorptive capacity is positively related to its supply chain agility. Specifically, a firm with superior absorptive capacity is adept at sensing market changes and learning from experiences [42]. This ability helps the firm establish rich communications with channel partners using an enriched knowledge base, thus increasing the visibility of the supply chain. Furthermore, absorptive capacity helps the firm develop a shared understanding with channel partners by transforming and exploiting newly acquired knowledge. Such insight can help synchronize partners' tasks, resources, and channel administration [42,71]. Finally, the renewed knowledge base would help the firm understand the market and partners' opinions and values better, thereby enhancing shared values across the supply chain to ensure the supply chain agility [71].

H3. A firm's absorptive capacity is positively related to its supply chain agility.

2.3. IT capabilities

2.3.1. Flexible IT infrastructure

Flexible IT infrastructure refers to a firm's ability to establish a complete set of technological resources, which provides the foundation for the development of IT applications [9,54,59]. In particular, IT infrastructure includes the computing platform, communication networks, critical shared data, and core data processing applications. IT flexibility reflects the extent to which these elements are connective, compatible, and modular [54]. Specifically, a flexible IT infrastructure is characterized by (1) connectivity, or the connections between any IT component and other components within the firm or with channel partners; (2) compatibility, or the ability to share any type of information, such as data, video, image, text, and audio, among others, across any IT component within the firm or with channel partners; and (3) modularity, or the ability to add, modify, and remove any element of the infrastructure with ease and without major overall effects [8,9,16,46,50].

A flexible IT infrastructure can improve absorptive capacity via enhancing knowledge reach and richness [54,86]. In particular, this capability helps the firm standardize, update, and connect IT components, thereby facilitating the integration of data sources within and across organizational boundaries [36,54]. More specifically, the connectivity of IT components enables the firm to communicate and exchange knowledge efficiently with channel partners, thereby expanding the firm's knowledge reach [42]. Moreover, IT connectivity breaks the organizational silos and enables the firm to transfer and recombine knowledge across functional units. In addition, compatibility of IT components enables the firm to share knowledge with rich data format within the firm and with channel partners. With compatible IT, the firm shares explicit knowledge by document, text, and data, as well as exchanges tacit knowledge through picture, video, and audio, thus enhance its knowledge richness [42,58]. Furthermore, modularity of IT components enables the firm to modify the infrastructure to meet various knowledge management requirements (e.g., in e-business), and ensures that the firm can exchange and process knowledge with low technologic constraints.

H4a. A firm's flexible IT infrastructure is positively related to its absorptive capacity.

A flexible IT infrastructure also leads to a high level of supply chain agility. First, the connectivity of IT components helps the firm consolidate information flow with channel partners using an integrated technological interface. This consolidation enables the firm to have a smooth flow of information concerning products, orders, and inventory across the supply chain to increase channel visibility [52,86]. Furthermore, IT compatibility helps the firm span organizational boundaries and make data, information, and knowledge readily available in the firm [16]. This compatibility would facilitate the firm's collaboration with channel partners as they perform complex activities (e.g., joint planning, on demand forecast, and new product/service development) that facilitate the development of supply chain agility. Finally, a high degree of modularity enables interoperability among various IT components to facilitate the rapid development of new applications [16,50]. Such modularity also helps the firm adapt its IT applications and integrate these with channel partners' systems, thus allowing them to jointly respond to marketplace changes to increase supply chain agility.

H4b. A firm's flexible IT infrastructure is positively related to the firm's supply chain agility.

2.3.2. IT assimilation

IT assimilation refers to the ability to diffuse and routinize IT applications in business processes within and across organizational boundaries [3,40,74]. Specifically, this ability facilitates a firm's use of advanced IT applications (e.g., e-business technologies) in coordinated business activities, such as communication, marketing, procurement, logistics, and inventory, among others [44]. Meanwhile, IT assimilation ensures that the firm pays strong attention to IT applications when making strategy decisions on interorganizational collaborations, such as customer relationship management and supply chain integration [3,39,44]. Scholars suggest that IT assimilation can help bridge the traditional gaps between functions within the firm or with channel partners, thus leading to the development of dynamic capability and operational capability [49,53,74].

IT assimilation can facilitate knowledge management using advanced IT applications to support interorganizational communication and information processing [42]. For example, the firm can extend its channel partner base from a narrow and proprietary network to a broad and open network by using e-business tools, such as e-procurement and Internet-enabled supply chain management systems [41,86]. This capability extends the firm's knowledge reach and richness within the supply chain. In addition, IT assimilation helps the firm bridge the traditional relationship gaps that exist between functions within the firm. The diffusion of IT applications also helps departments work together to assimilate, transform, and commercialize newly acquired external knowledge [42]. For example, using an internal virtual community or electronic knowledge repositories, different functional units can efficiently exchange, recombine, and create knowledge [32]. Therefore, IT assimilation would help a firm improve the flow of knowledge, its access to stored knowledge, and the assimilation and commercialization of the acquired knowledge [37,42,49].

H5a. A firm's IT assimilation is positively related to the firm's absorptive capacity.

Similarly, IT assimilation improves supply chain agility because diffusing advanced IT applications enables a firm to effectively connect with its customers, suppliers, and other significant business partners [3,44,51,79,81]. In particular, assimilating advanced IT applications, such as e-business tools, helps the firm develop an integrated information flow with channel partners through an integrated technological platform with open standards [86]. This integrated information flow enables the firm to achieve rich content as well as reliable, and real-time information across the supply chain to improve the supply chain's transparency. Such transparency allows the firm to immediately identify qualified products that are suitable for its requirements [44]. The firm can also locate competent suppliers and respond to market changes efficiently and effectively through the use of advanced IT applications [37,44,66]. Furthermore, firms with a better ability to use interorganizational systems, such as supply chain management and customer relationship management systems, can achieve better synchronization and coordination with channel partners [37,41,62]. Assimilating these systems into business processes enables real-time analysis and insights that provide support for operational, tactical, and strategy decisions [81]. Meanwhile, IT assimilation helps the firm design metrics and analytics to estimate the real-time status of business processes, integration between processes, and advance warnings of performance degradation in the processes [81]. Such information facilitates the building of shared interpretation, consensus, and values required for supply chain agility [41,49].

H5b. A firm's IT assimilation is positively related to the firm's supply chain agility.

In addition, previous works indicate that a flexible IT infrastructure is essential for a firm attempting to develop a high level of IT assimilation [3,9]. Specifically, a flexible IT infrastructure provides an efficient platform that supports advanced IT applications such as e-business tools [85]. For example, the connectivity of IT infrastructure enables the integration between different IT components within and across organizational boundaries. Infrastructure connectivity also helps the firm diffuse IT applications to different departments and

channel partners [59]. Such compatibility enables the firm to easily migrate data between new IT applications and old information systems that, in turn, facilitates the implementation of new systems [3,9,59]. Furthermore, the modularity enables fast development and deployment of new IT applications, because it enables the firm to recombine existing IT components.

H6. A firm's flexible IT infrastructure is positively related to the firm's IT assimilation.

3. Method

3.1. Sample and data collection

We conducted a survey in China to test the research model. China has become the world's manufacturing center of consumer products and a global economic power. However, the present study requires the respondents to have specific knowledge of information systems and supply chain management, which makes data collection through a survey questionnaire difficult. Under this condition, we worked with a Chinese educational institution to make our survey feasible. This institution is well known for its executive training programs, especially the training on supply chain management and information systems concepts. With the help of the institution, we communicated with the Chamber of Commerce, whose members were executives who received education or training from this institution. Through the Chamber of Commerce, we obtained a list of 1000 firms located in the industrial parks of the Yangzi River Delta in China.

From each of these firms, one senior executive (e.g., the vice president of IT, chief technology officer, and chief operations officer) who obtained training from the institution was selected to serve as the key informant. Although the use of a single respondent may not be ideal for firm-level studies, this approach is common among recent empirical studies such as those investigating IT and supply chain management [11,33,43]. Specifically, these senior executives were knowledgeable about the related issues being examined in this research, such as supply chain management and IT. Furthermore, senior or middle management executives have the power and opportunity to either make executive decisions that affect their firms' operations, such as those regarding IT investment and supply chain relationships. We required the respondents to select their company's most significant channel partner, and to answer all questions based on their understanding of their companies and their relationships with the selected channel partner. A significant channel partner was defined as a dominant partner who commands a significant proportion of the focal firm's primary product(s) or product line(s) [52].

To encourage response, follow-up emails and telephone calls were made to non-respondents after we sent out the questionnaires. Finally, we received 293 returned questionnaires, seven of which were incomplete and thus discarded. A total of 286 completed questionnaires provided the study with a response rate of approximately 28.6%. Following Armstrong and Overton [2], we tested for the potential non-response bias. Comparing the chi-squares of the key measures of the responses from the first 25% of the respondents and those of the final 25%, we found that there were no significant differences between these two groups on these items. This result indicated that non-response bias was not serious in this study. Table 1 shows the demographic information of the sample.

Furthermore, a one-way ANOVA was employed to test the potential difference between data collected from the informants in the IT function and from those in the non-IT function, as well as between data collected from the manufacturing and service industries. The results showed no significant differences at the 0.01 significance level for all constructs (i.e. two IT capabilities, absorptive capacity, supply chain agility, and firm performance) both between the two functional groups and between the two industries. This result indicates that it is appropriate to combine these sets of data as a single sample in the following data analysis.

3.2. Measures

We developed the structured questionnaire in the following stages: (1) literature review to identify previously validated measures, (2) development of a draft version, (3) review of draft by invited academics and practitioners, (4) pilot test, and (5) refinements to the questionnaire. To form a translation committee of bilinguals [72], we invited three native Chinese speakers who were fluent in English to help translate the English questionnaire into Chinese. Then, we translated the Chinese questionnaire back into English to ensure that there were no semantic discrepancies between the Chinese and the original English versions. All measures were assessed with five-point Likert scales, ranging from “strongly disagree” to “strongly agree.” The Appendix A shows the items in the questionnaire.

3.2.1. IT capabilities

We measured flexible IT infrastructure on a four-item scale adapted from Ray et al. [54] and Saraf et al. [59]. These measures asked each respondent to evaluate the connectivity, compatibility, and modularity of the firm's IT infrastructure. IT assimilation was measured on a four-item scale adapted from Liang et al. [40]. These measures asked respondents to evaluate the extent to which IT applications were used in the companies' business processes, functional areas, and management and operations at high levels.

3.2.2. Absorptive capacity

According to the existing literature (see, e.g.,[30,42,82]), absorptive capacity is a second-order construct with the dimensions of acquisition, assimilation, transformation, and exploitation. Acquisition focuses on the ability to identify and acquire new relevant knowledge, which is critical to operations; assimilation reflects the ability to absorb and understand the newly obtained knowledge; transformation focuses on the ability to combine the existing knowledge and the newly obtained knowledge; and exploitation refers to the ability to use the new knowledge to achieve a firm's objectives. We adapted 12 items from Pavlou and El Sawy [49] and Jansen et al. [30] to measure the four dimensions, with three items each for acquisition, assimilation, transformation, and exploitation.

Table 1
Sample demographic (n = 286).

	N	Percentage
Industry		
Manufacturing	137	48.02%
Service	149	51.98%
Ownership		
State owned	98	34.27%
Privately owned	75	26.22%
Foreign controlled	113	39.51%
Number of employees		
≤100	52	18.18%
100–500	68	23.78%
500–1000	41	14.34%
1000–2000	22	7.69%
More than 2000	103	36.01%
Number of employees		
≤5	116	40.56%
6–10	50	17.48%
11–25	21	7.34%
More than 25	99	34.62%

3.2.3. Supply chain agility

Drawing upon the existing literature (see, e.g., [1,7,15,73]), we defined supply chain agility as a second-order construct encompassing the dimensions of visibility, joint planning, process integration, and shared values. Visibility reflects the integration of information across the supply chain. It is measured on a three-item scale based on Braunscheidel et al. [7] and Christopher [15]. Respondents were asked to evaluate the degree to which their firms provided useful information, exchanged timely information, and kept each other informed about critical events or changes with channel partners. Joint planning, or the cooperation in operational planning across the supply chain, was measured by four items adapted from Simatupang and Sridharan [63]. It is measured by the extent to which their firms jointly plan on demand forecasts, inventory requirements, new product or service introduction and rollover, and service support with channel partners. Process integration reflects the streamlining and automation of business processes across the supply chain. Based on the work of Lee and Whang [37], we measured it on a four-item scale, which tested the degree to which the firms and their key partners coordinated (1) workflow activities systematically, (2) workflow activities extensively, (3) procurement, and (4) order execution. Shared values reflected the agreement on the joint strategy goals of the supply chain, and was measured based on Li and Lin [38]. Four items measure the extent to which the focal firm and the key partners (1) share the same business values for the supply chain, (2) have a similar understanding of the aims and objectives, (3) work together to improve mutual quality in the long run, and (4) work together to improve the supply chain as a whole.

3.2.4. Firm performance

In order to measure firm performance, we used six items adapted from Rai et al. [52] and Chen, Paulraj, and Lado [13], including the firm's performance related to business, operations, and customer service. Specifically, performance of the focal firm is operationalized by items indicating the extent to which it performs better than its key competitors in (i) return on investment (ROI), (ii) profits as a percentage of sales, (iii) decreasing the product or service delivery cycle time, (iv) rapid response to market demand change, (v) rapid confirmation of customer orders, and (vi) increase in customer satisfaction.

3.2.5. Control variables

This study considered three control variables, namely, the industry, the size of the firm, and the size of the firm's IT department. Specifically, manufacturing and service firms may have significant differences in management and strategies [23]. Thus, we treated industry type as a dummy variable, such that 1 indicates the manufacturing industry and 0 represents the service industry, based on whether the firm manufactured physical products or provided services. The firm size may be crucial to a firm's ability and performance [84], so we treated firm size as the control variable and measured it by the number of full-time employees. Finally, given that this study focuses on IT capabilities, we controlled the factor of the IT department size, which was assessed based on the number of full-time IT employees. In the following analysis, we used the log of both firm size and IT department size.

4. Data analysis and results

Given that all data were perceptual and collected from a single source at one point in time, we checked the possible common method bias using Harman's one-factor test. The results showed that the test can categorize the items into seven constructs with eigenvalues greater than 1.0, thus accounting for 64.49% of the variance. The first construct did not account for the majority of the variance (15.60%), indicating that the common method bias was not a serious concern in this study. Furthermore, we compared the fit between the one-factor model and the measurement model by using LISREL. The results showed that the fit of the one-factor model ($\chi^2 = 4546.64$, d.f. = 779) was considerably worse ($p<0.01$) than that of the measurement model ($\chi^2 = 1477.48$, d.f. = 724), which further indicated that the common method bias was not an issue in this study.

4.1. Measurement model

We employed confirmatory factor analysis (CFA) to assess the validity of the scales. The CFA results indicated that the fit between the measurement model and the dataset was satisfactory ($\chi^2 = 1477$ on 724 d.f., RMSEA = 0.060, CFI = 0.98, IFI = 0.98, NFI = 0.95, NNFI = 0.97). The loadings of all items were higher than the suggested benchmark of 0.70. We also assessed Cronbach's alpha, composite reliability of constructs, and average variance extracted (AVE) to test convergent validity. As Table 2 reports, Cronbach's alpha ranged from 0.81 to 0.90, well above the benchmark value of 0.70. The values of composite reliability ranged from 0.88 to 0.93 and were above the benchmark value of 0.70. The AVE scores ranged from 0.55 to 0.77 and were above the benchmark value of 0.50 [22]. These results indicated that the measurement model had satisfactory convergent validity. In addition, as Table 3 shows, the square roots of the AVEs for all constructs were greater than the correlations between constructs, which confirmed the discriminant validity of the measurement model.

We also conducted a multicollinearity test, because several inter-construct correlations in Table 3 were higher than the benchmark value of 0.60. The rule of thumb to judge the existence of multicollinearity is if variance inflation factors (VIFs) are greater than 10 or if tolerance values are less than 0.10. The results of this study showed that the highest VIF was 2.24 and the lowest tolerance value was 0.45. Thus, multicollinearity did not appear to be a significant problem in our dataset.

In this study, absorptive capacity and supply chain agility were treated as second-order reflective constructs. To assess whether all first-order dimensions reflected the second-order construct, we employed a second-order CFA by using the extracted first-order dimensions. The results indicated that the higher-order measurement model had an acceptable fit ($\chi^2 = 124$ on 50 d.f., RMSEA = 0.07, CFI = 0.98, IFI = 0.98, NFI = 0.98, NNFI = 0.98 for absorptive capacity; and $\chi^2 = 290$ on 86 d.f., RMSEA = .09, CFI = .97, IFI = .97, NFI = .96, NNFI = .97 for supply chain agility). Although the RMSEA value of supply chain agility was slightly above the suggested cut-off value of 0.08, this value could be accepted according to the criterion proposed by Hair et al. [28] (i.e., RMSEA ≤ 0.10). The results showed that the loadings (ranging from 0.70 to 0.92) of each dimension on supply chain agility were positive and significant ($p<0.001$). Their correlations were significant at $p<0.001$, indicating that these

Table 2
Results of confirmatory factor analysis.

	Items	Cronbach's alpha	Composite reliability	AVE
Flexible IT infrastructure	4	0.83	0.89	0.66
IT assimilation	4	0.84	0.89	0.68
Second-order absorptive capacity		0.90	0.93	0.77
Acquisition	3	0.79	0.88	0.70
Assimilation	3	0.84	0.90	0.76
Transformation	3	0.81	0.89	0.73
Exploitation	3	0.82	0.89	0.74
Second-order SC agility		*0.86*	*0.90*	*0.70*
Visibility	3	0.81	0.89	0.73
Joint planning	4	0.85	0.90	0.68
Process integration	4	0.85	0.90	0.70
Shared values	4	0.90	0.93	0.75
Firm performance	6	0.84	0.88	0.55

Table 3
Means, standard deviation, and correlations.

	Means	SD	1	2	3	4	5	6	7	8
1. Flexible IT infrastructure	3.54	0.93	0.81							
2. IT assimilation	3.89	0.86	0.66	0.82						
3. Absorptive capacity	3.54	0.70	0.52	0.55	0.88					
4. Supply chain agility	3.39	0.77	0.52	0.56	0.69	0.84				
5. Firm performance	3.71	0.69	0.34	0.42	0.52	0.54	0.74			
6. Industry	–	–	−0.08	−0.04	−0.06	−0.08	−0.13	1.00		
7. Firm size	–	–	0.34	0.26	0.12	0.09	0.06	-0.05	1.00	
8. IT dep. size	–	–	0.42	0.36	0.21	0.18	0.13	−0.12	0.70	1.00

Note: Means are assessed based on average factor scores; standard deviations (SD) and correlations are from the second-order CFA output. The diagonal elements are the square root of the AVE.

dimensions converged on the common underlying construct of supply chain agility. Finally, we used the average scores of the first-order dimensions to construct the values for absorptive capacity and supply chain agility as well as to test the structural model [70,78].

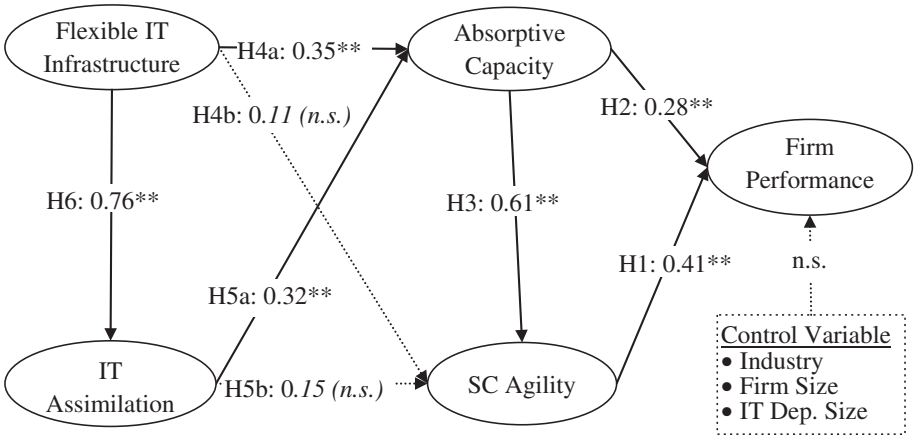
4.2. Structural model

Fig. 2 presents the results of the structural model. The results showed a good fit between the model and the dataset ($\chi^2 = 633.87$ on 261 d.f., RMSEA = 0.07, CFI = 0.97, IFI = 0.97, NFI = 0.94, NNFI = 0.96). The results indicated that the control variables (namely, industry, firm size, and IT department size) did not significantly influence firm performance. This may be attributed to the fact that this study measured firm performance by comparing a firm's performance with that of its key competitor. The low differences in the control variables between the firm and its key competitor may limit their ability to explain the variance of firm performance.

The results demonstrated that most of the hypotheses were supported, except H4b and H5b (on the relationship between IT capabilities and supply chain agility). The results also indicated that both flexible IT infrastructure ($\beta = 0.36$, $p<0.01$) and IT assimilation ($\beta = 0.32$, $p<0.01$) had a positive effect on absorptive capacity, as anticipated in H4a and H5a. Consistent with H6, a flexible IT infrastructure had a significant influence on IT assimilation ($\beta = 0.76$, $p<0.01$). Moreover, the greater the supply chain agility ($\beta = 0.47$, $p<0.01$) and absorptive capacity ($\beta = 0.27$, $p<0.01$) were, the better the firm performance was, thereby supporting H1 and H2, respectively. In addition, absorptive capacity was positively related to supply chain agility ($\beta = 0.61$, $p<0.01$), thus supporting H3.

4.3. Mediating effect testing

We followed the procedures proposed by Gregory, Harris, Armenakis, and Shook [25] to test the mediating effects of absorptive capacity and supply chain agility. We compared three alternative models (direct, indirect, and saturated) in terms of their fit indices and path coefficients. As shown in Table 4, the chi-square difference between the direct and saturated models was 83.86 with 2 d.f., which was significant ($p<.001$). This difference indicated that both absorptive capacity and supply chain agility can mediate the influences of IT capabilities on firm performance. In addition, the non-significant chi-square difference of 5.22 with 2 d.f. between the indirect and saturated models suggested that the more complicated saturated model could not improve the fit over the indirect model. The results for the individual structural paths in the saturated model suggested that neither of the direct paths from IT capabilities to firm performance was significant, although their links with absorptive capacity and supply chain agility remained significant ($p<.01$). In summary, the results indicated that the relationships between IT capabilities (i.e., flexible IT infrastructure and IT assimilation) and firm performance were fully mediated by absorptive capacity and supply chain agility. The results in the saturated model also showed that the direct path from absorptive capacity to firm performance was still significant, indicating that the relationship between absorptive



Note: * shows significance at the 0.05 level, and ** shows significance at the 0.01level.

Fig. 2. Results of the structural equation modeling.

Table 4
Statistics and standardized path coefficients of structural models.

Measure	Direct	Indirect	Saturated
χ^2	788.22	709.58	704.36
d.f.	259	256	257
RMSEA: Root Mean Square Error of Approximation (<0.08) [a]	0.085	0.078	0.078
CFI: Comparative Fit Index (>0.90)	0.95	0.96	0.96
IFI: Incremental Fit Index (>0.90)	0.95	0.96	0.96
NFI: Normed Fit Index (>0.90)	0.93	0.94	0.94
NNFI: Non-Normed Fit Index (>0.90)	0.95	0.95	0.95
Flexible IT infrastructure → Supply chain agility	0.43**	0.40**	0.42**
Flexible IT infrastructure → Absorptive capacity	0.44**	0.41**	0.42**
Flexible IT infrastructure → Firm performance	0.25*		-0.19
IT assimilation → Supply chain agility	0.29**	0.30**	0.29**
IT assimilation → Absorptive capacity	0.29**	0.30**	0.29**
IT assimilation → Firm performance	0.33**		0.16
Supply chain agility → Firm performance		0.39**	0.40**
Absorptive capacity → Firm performance		0.34**	0.35**

* $p<0.05$; ** $p<0.01$.
[a] The benchmark value of the fit indexes was adopted from [27].

capacity and firm performance was partially mediated by supply chain agility.

To obtain more information on the mediating effects, we further followed the process outlined by Rai et al. [52]. First, we examined the changes in R^2 to understand the additional contribution of the paths. Accordingly, an f^2 statistic was computed based on the difference in R^2 between the full mediation model and the partial mediation model (with additional direct paths from IT capabilities to firm performance), and then a pseudo F-statistic was calculated by multiplying the f^2 statistic by $(n-k-1)$. As Table 5 shows, the additional direct paths from the flexible IT infrastructure to firm performance and from the IT assimilation to firm performance did not explain the additional variance and contributed significantly to the explanatory power of the overall model.

We further assessed the significance of the mediating effect of absorptive capacity and supply chain agility on the relationship between IT capabilities and firm performance. This analysis was conducted based on the path coefficients and standard errors between the independent variables (IVs) and mediating variables (MVs), and between the MVs and dependent variable (DV). Next, we computed the magnitude of mediation by multiplying the standardized path coefficients between the IVs and MVs, and between the MVs and DV. The results, shown in Table 6, suggest that the positive impact of IT capabilities on firm performance are mediated by absorptive capacity and supply chain agility.

5. Discussion, limitations, and implications

The purpose of this study is to investigate the influence of IT capabilities on firm performance in the supply chain context. By applying the dynamic capabilities perspective and the view of a hierarchy of capabilities, this study proposes a conceptual model in which IT capabilities, as lower-order capabilities, exert influence on firm performance through higher-order capabilities, namely absorptive capacity and supply chain agility. Our empirical findings on the effects of IT capabilities, absorptive capacity, and supply chain agility are not only consistent with prior studies, but also offer new findings on the association between IT capabilities, absorptive capacity, and supply chain agility in improving firm performance.

Table 6
Significance of mediated paths from IT capabilities to firm performance (n = 286).

Indirect Effect	Mediated paths	Path	Z stat
Flexible IT Infrastructure → Performance	FITI → ABC → Per	0.139	4.776**
	FITI → SCA → Per	0.156	5.366**
IT assimilation → Performance	ITA → ABC → Per	0.102	3.181**
	ITA → SCA → Per	0.102	3.352**

FITI: Flexible IT Infrastructure; ITA: IT Assimilation; ABC: Absorptive Capacity; SCA: Supply Chain Agility; Per: Firm Performance.
** $p<0.01$.

Along the line of evidence for the relationship between higher-order capabilities and firm performance (see, e.g., [42,46,49,66,82]), this study has provided empirical evidence of the performance implications of both absorptive capacity and supply chain agility. Consistent with the dynamic capabilities perspective, the findings have highlighted the critical role of dynamic capability and operation capability in achieving firm performance. The results strongly support the claim that a firm's IT capabilities – both flexible IT infrastructure and IT assimilation – can help the firm improve its absorptive capacity. From a hierarchical perspective, a firm's specialized lower-order capabilities can be combined to generate higher-order ones. This finding is consistent with prior studies that proposed the notion that IT capabilities can help the firm develop dynamic capabilities (see, e.g., [49,58]). The current study responds to the calls of scholars who have stressed the need for empirical research that examines the relationship between IT capabilities and absorptive capacity [55]. The research results have highlighted the amplifying role of IT capabilities in developing absorptive capacity.

However, the results of this study do not support the hypothesis on the association of IT capabilities and supply chain agility. A possible explanation is that the effects of IT capabilities on supply chain agility are fully mediated by absorptive capacity. The results of the mediating effect test (see Table 4 and Fig. 2) indicate the full mediation of absorptive capacity on the relationship between IT capabilities and supply chain agility. Indeed, Pavlou and El Sawy [49] suggest that the direct impact of IT capabilities is on the firm's ability to manage *general* knowledge rather than on its capability to manage *operation-specific* knowledge. This notion indicates that the influence of IT capabilities on supply chain agility may be indirect.

The current study further finds that both absorptive capacity and supply chain agility can fully mediate the impact of both flexible IT infrastructure and IT assimilation on firm performance. This finding reinforces the view of a hierarchy of capabilities, which proposes that the lower-order capabilities can help a firm develop higher-order ones [24]. This view is consistent with that of previous studies, which posited that the impacts of IT capabilities, as lower-order capabilities, on firm performance are mediated by dynamic and operational capabilities, as higher-order capabilities (see, e.g., [49,52,58,79]).

Nevertheless, it is necessary to evaluate the contributions of this study in light of certain limitations. First, there may be other IT or organizational capabilities that can influence firm performance. Future research may extend the scope of this study by examining the effects of manufacturing, marketing, and managerial capabilities on firm performance. Meanwhile, future research can also investigate how IT capabilities may facilitate the development of new types of contracts, which would enhance the efficiency of capacity investment, allocation decision and contracting [21]. Second, all major constructs in this study are measured by the perceptions of individual respondents,

Table 5
Nested model comparison.

Direct Path	R^2 in mediated model (no direct path)	R2 with direct path	f^2 value	Pseudo F (F 1, 278)	Conclusion
Flexible IT infr. → firm performance	0.345	0.346	0.001	0.424	Not significant
IT assimilation → firm performance	0.345	0.353	0.012	3.425	Not significant

which are inherently subjective. Although our analysis results do not show that the common method bias is a serious problem, we urge future researchers to use objective data or collect data from multiple informants. Third, the generalizability of our findings may be limited by the demography of the respondents. Specifically, we conducted the study only within the context of China. We chose informants who obtained training from the same institution. Although doing so may have enhanced the internal validity of this study, it has also limited the external validity of this particular work. Scholars and practitioners should, therefore, exercise caution in generalizing our findings to firms located in different economic, political, and cultural environments. Fourth, this study only considers three control variables. Future research should examine other possible control variables, such as the firm's embeddedness in a supply chain, which may influence firm capabilities and performance. Finally, considering the unsatisfactory RMSEA value of supply chain agility, future research should develop an instrument with better psychometric validity for this construct.

This study makes three major theoretical contributions. First, it bridges separate studies on IT, dynamic capabilities, supply chain, and firm performance. It empirically tests their relationships in the supply chain context. Our findings help address the controversial issue of the value of IT capabilities [34,58,81]. The results demonstrate that, although IT capabilities do not have a direct impact on firm performance, they do have an indirect effect through absorptive capacity and supply chain agility.

Second, this study investigates how absorptive capacity affects firm performance directly and indirectly by shaping supply chain agility. The extant literature has examined either the direct or indirect effects of dynamic capability on firm performance (see, e.g., [12,49]). However, limited studies have examined these two types of effects simultaneously. The findings of this study thus lend empirical support to the idea that dynamic capability may exert both direct and indirect influence on firm performance.

Third, this study enriches our understanding of supply chain agility. Specifically, we provide empirical support for conceptualizing supply chain agility as a second-order construct. Meanwhile, consistent with prior studies (see, e.g., [7,15,66]), our findings confirm that supply chain agility is critical to firm performance. The results of the present study also extend our current understanding of the impact of IT capabilities on supply chain agility (see, e.g., [66]). Our findings indicate that supply chain agility can be shaped by absorptive capacity rather than affected by IT capabilities directly.

This study also has major practical implications for managers. Firms have invested millions of dollars in IT to help achieve superior firm performance, especially in supply chain management. However, these investments may not reach their highest level of efficiency if firms do not leverage their IT capabilities to achieve superior operational and dynamic capabilities, and to derive competitive advantage. Therefore, it is critical for managers to apply their firms' IT capabilities to improve higher-order organizational capabilities, such as absorptive capacity and supply chain agility, to improve firm performance. Our study provides the necessary guidance and knowledge.

Managers have to realize that justifying IT investments based on the immediate impacts of IT capabilities on firm performance is not appropriate. Rather, they should be aware of the interrelationships among IT capabilities, absorptive capacity, supply chain agility, and firm performance. Our findings indicate that the effects of IT capabilities on firm performance are mediated by absorptive capacity and supply chain agility. Thus, managers should focus on the effects of IT capabilities on enhancing the efficiency and effectiveness of information and knowledge intensive processes in the supply chain, rather than on improving firm performance directly. Managers should also pay attention to the different effects of IT capabilities on absorptive capacity and supply chain agility. This study indicates that IT capabilities do not influence supply chain agility directly. The firm should apply IT capabilities to improve absorptive capacity first, and then enhance supply chain agility with superior absorptive capacity, which could then lead to superior performance.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.dss.2012.12.016.

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