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How the Interaction of Big Data Analytics Capabilities and Digital Platform Capabilities Affects Service Innovation: A Dynamic Capabilities View

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ABSTRACT The emergence of big data analytics capability (BDAC) and the development of service innovation have aroused the interest of scholars and practitioners in exploring the mechanism of BDAC–service innovation value chain from the inside. The current study adopts the dynamic capabilities view to examine the effects of the different types of BDAC on service innovation. Our findings from a survey of 175 organizations in China provide empirical evidence of two positive effects of big data analytics technical capabilities (BDAT) and big data analytics personnel capabilities (BDAP) on service innovation via dynamic capabilities. Furthermore, this study illuminates the significant and different quasi-moderating roles of digital platform capabilities. Such capabilities positively enhance dynamic capabilities and strengthen the effects of BDAT on dynamic capabilities but weaken the effects of BDAP on dynamic capabilities. Introduced environmental dynamism aims to examine how the influence of environmental factors negatively moderates the relationship between dynamic capabilities and service innovation. Our study offers theoretical and practical contributions.

INDEX TERMS Big data analytics capabilities, service innovation, digital platform capabilities, dynamic capabilities, environment dynamism.

I. INTRODUCTION

The relationship between big data analytics (BDA) and service innovation is gradually becoming a pivotal issue for service practice and research. BDA is regarded not only as a new engine for economic growth and firm development [1], [2] but also as an important academic area in the border field of digital innovation [3]. Nowadays, BDA technology is attracting considerable attention in the service-dominant logic, 75% of firms and 91% of Fortune 1000 firms have been investing in big data and related projects [4], [5], and its approbated value is expected to support additional service innovation [6]– [8]. However, not all firms that apply BDA can gain the success of service innovation. Most big data investments or projects have not acquired benefits because of the failure to take proper actions to react to the opportunities of extracting value from data [9]. Moreover, many firms still struggle with the dilemma of the shift to service orientation and digital transformation [10]. The rapid development of digital technology has engendered opportunities for service innovation, and harnessing quality data to design and deliver state-of-the-art services will enable novel business models [11], [12], but the role of digital platforms in the whole BDA value chain is lacking [13]. Therefore, the internal mechanisms of how BDA performs within digital platforms must be identified to generate valuable service innovations.

In consistent with Mikalef [9], the current study views big data analytics capabilities (BDAC) as the firm's competence to utilize data management, infrastructure, and talent to create competitive advantages and tries to fill several gaps in the

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literature. First, prior studies provide evidence of the positive effects of BDAC on performance and innovation [12], [14]–[16], but few scholars have attempted to discover the inner mechanism. The manner by which different types of BDAC affect service innovation remains unknown. On the basis of the resource-based view, different types of resources may lead to distinctly varied outcomes. Dynamic capabilities view notes the necessity for an organization to steer various types of operational capabilities to adapt to the external environment [17]. Thus, the need for highlighting the influence of different types of BDAC should be in line with these significant theories. Moreover, the different types of BDAC—big data analytics technical capabilities (BDAT) and big data analytics personnel capabilities (BDAP)—have many different characteristics that may lead to various effects on service innovation. Though many firms jumping on the bandwagon of big data and BDA, the unclear issues, such as unfocused input, could result in the misunderstanding or hype around BDA [18], the pressure burden on BDA application [15], and the low yield of big data investment portfolio [19]. The undesirable aftermath will severely hamper firm growth and the development of related theories. Thus, this article aims to bridge this gap by examining the relationships between BDAT/BDAP and service innovation.

Second, existing studies suggest that the direct driving role of information technology (IT) capabilities on performance may diminish due to the absence of an intermediate mechanism [20]. Therefore, a specific perspective must be urgently drawn to investigate the linkage bridging BDAC and service innovation. Although technology-push innovation (e.g., BDAC-push service innovation) can generate excellent outcomes, firms have to endure long and complicated development processes and stages [21]. The BDAC value chain may be excessively long that its positive effect is no longer evident or even diminishes in value delivery, which may result in service failure. Specifically, BDAT and BDAP are insufficient for firms to improve their performance automatically and directly [22]. Scholars have stated that the dynamic capabilities view, which emphasizes the integration of operational capabilities, can reasonably redeploy BDAP and BDAT to produce service innovation [17]. Furthermore, whether the effects of different types of BDAC on service innovation are mediated by dynamic capabilities remains untapped in prior literature, and only a few studies have provided empirical results [20], [23]. Therefore, the present work adopts the dynamic capabilities view to address these significant issues and bridge the literature gap by studying the effects of BDAT and BDAP on service innovation.

Third, although service innovation is undergoing shifts in service logic and driving engine and is becoming increasingly digital technology-enabled [24], the role of digital platform capabilities in the BDA–innovation value chain remains unexplored. Several firms fail to extract value from BDA to support service innovation because of deficiencies in digital platform building. For instance, remote specialists, whose expertise knowledge could be regarded as BDAP, cannot promptly offer and transmit consult reports (analysis solution) without a tele-picture archiving communication system, a customized digital platform with high performance (in place of an old system with low efficiency), thereby decreasing the value of the target service [25]. Furthermore, firms eager for rapid development should focus on their customers' real preferences and demands instead of becoming overdependent on big data market analytics because digital technology and BDAC are insufficient to be the center of service innovation [21]. Thus, the value of a digital platform that identifies customer demands in real-time is embodied in value/insight extraction, but the dearth of generic digital platforms remains a problem [26].

Fourth, the boundary effect of environmental dynamism on the dynamic capabilities–service innovation linkage remains unclear. The nature of the view of dynamic capabilities and the limits of the resource-based view call for considering exogenous variables and their effects [27], such as environmental dynamism, which is a key situational parameter that should be underscored in the dynamic capabilities view in business practice [3]. Ignorance of environmental dynamism could collapse the service innovation mechanism, given that the innovation may be unlikely to succeed in a highly dynamic or turbulent external environment [3]. Moreover, theoretical debates and even contradictory conclusions exist about whether dynamic capabilities are valuable and effective only in turbulent environments [28]. Few articles have been published on the external factors in the BDAC value chain and introduced environmental dynamism to examine its moderating role in the big data environment. Therefore, the current study intends to address this gap by exploring how environmental dynamism influences the relationship between dynamic capabilities and service innovation.

This research aims to investigate the specific inner mechanism between BDAC and service innovation by addressing the following research questions:

1) How do interactions between BDAC and digital platform capabilities affect service innovation via dynamic capabilities?

2) What is the role of environmental dynamism in this mechanism?

II. THEORETICAL BACKGROUND

A. BDAC AND SERVICE INNOVATION

On the basis of the service-dominant logic, service innovation is a rebundling of existing resources to create novel, beneficial resources [8], [11], and it aims to improve existing services and create new value propositions or service systems during resource (e.g., information, knowledge, skills) delivery [1], [6]. Customers participate in the value co-creating mechanism by approving propositions during these processes [29]. Service innovation covers a large number of digital technology-enabled and process-oriented materials [24]. Digital technology plays a significant role in service innovation not only by enabling resource allocation, new

resource introduction, and access to resources required for service exchange [11] but also by allowing firms to understand customer behaviors deeply and commercialize service innovations [30]. Scholars believe that the huge volumes of data and information relevant to customers are key sources to general innovation and create tremendous opportunities for service innovation [31], [32]. Moreover, the integration between data and BDA may create novel ways for supporting customer-oriented service innovation [6], [11]. Firms with BDA applications allow abundant and accurate ways of gathering, processing, and analyzing large amounts of trace data from different sources to identify potential customers' needs that can be induced and transformed into ultimate customer purchase behaviors [6].

However, BDA is limited in shaping high levels of capabilities because of difficulties in unstructured data-processing and business value extraction [15], [19]. The concept of BDAC, which refers to the ability to provide business insights in the big data environment by using BDAP, BDAT, and BDA management capabilities, has been proposed [14]. Most studies focus on the effect of BDAC on firm performance or innovativeness and confirm the positive effect via anecdotal evidence or case studies [14], [16], [23], [33], but the literature focus on specific innovativeness outcomes, such as service innovation, has not been discussed deeply, and the internal mechanism remains unknown [6]. These problems continue to perplex firm executives, decrease investment returns on BDA projects, and hinder BDAC development. Moreover, previous studies generally adopt a holistic perspective and regard BDAC as a second-order construct. Exploring the effect of specific types of BDAC on service innovation seems necessary to understand how BDAC contributes to superior innovation. Table 1 demonstrates the effects of BDA on performance or innovation in previous studies, showing that the research on the mechanism between BDAC and service innovation remains limited.

In line with the prior research classification of firm resources [34], we use two dimensions of BDAC, namely, BDAT (physical capital: technology resource) and BDAP (human capital: human resource), to conduct further study. BDAP refers to an analyst's ability to perform assigned tasks in the big data environment, which consists of managerial skills (including business and relational knowledge) and technical skills (including technical and technology management knowledge) [6], [14]. BDAT refers to the flexibility of the BDA infrastructure, which includes the connectivity, compatibility, and modularity within or among differently sourced data and infrastructures [14]. BDAP and BDAT have varied characteristics. Compared with BDAP, BDAT is the only inherent physical feature of the BDA infrastructure that has a certain degree of stability, and it is a tangible resource with ready availability for firms [16]. BDAP is the innate nature of personnel knowledge with human uncertainty and complexity, which have no clear and visible boundaries, similar to intangible resources, and it is rare and insufficient for firms in general [16], [35]. In addition, BDAP may become increasingly complex in the value-creating process; for instance, the effectiveness and efficiency of personnel knowledge may be affected by the external atmosphere, internal experience, and mood. Therefore, the effect of BDAT and BDAP on service innovation is worth studying separately. Furthermore, resource and operational abilities cannot directly create value, and the dynamic capabilities view can properly bridge the BDAC value chain and service innovation. The interplay of BDAP or BDAT and other digital capabilities also remains untapped; for instance, the dearth of digital platform capabilities may be another significant internal factor in the failure of BDAC building.

B. DYNAMIC CAPABILITIES

Dynamic capabilities refer to an organization's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments [41]. Scholars regard dynamic capabilities as a bridge to link BDAC and firm-level outcomes and to offer a valuable explanation of BDAC's influence on innovation [20], [23]. As the extension of the resource-based view, the dynamic capabilities view emphasizes purposeful modification not only on tangible and intangible resources but also on operational capabilities [17], [42]. In particular, operational capabilities refer to the competence to execute and coordinate assigned tasks for performing operational activities [17]. In this view, BDAP and BDAT can be regarded as a firm's operational capabilities governed by dynamic capabilities to derive service innovation. However, a resource base and operational capabilities cannot provide value extraction alone [43]. Thus, the current study aims to integrate BDAT and BDAP into a dynamic capabilities framework to improve service innovation effectively. Prior literature notes that BDAC is the antecedent of dynamic capabilities, but only a few studies have explored the specific types of BDAC and discussed the effect of digital platform capabilities [20], [44], [45]. Furthermore, BDAC has been confirmed as the valuation of firm performance and innovation improvement generally by dynamic capabilities [20], [23], [40]. Tracking the indirect relationship between BDAP/BDAT and service innovation via dynamic capabilities seems necessary to clear the BDAC value chain and disclose its inner mechanism.

C. DIGITAL PLATFORM CAPABILITIES

Digital platform capabilities refer to the competence to collect customer information and acquire user-generated content from digital channels, which offer standards, connectivity, rules, and IT competence to coordinate customer big data production, search, and delivery [13], [44]. Specifically, such capabilities include two types of platform: one for connecting to customers to collect customer experience, opinion, and derived knowledge and another for connecting to businesses to learn information from institutions around customers and conducting marketing activities directly to targeted customer groups [4]. Digital platform capabilities are vital for firm performance and innovation as an

TABLE 1. Representative literature on BDA.

Author	Type	Independence	Mediator	Moderator	Dependence
[36]	Conceptual (Review)	BDA	----	----	Digital Service Innovation
[6]	Empirical, Case Study, Interview (n=4)	BDA	----	----	Service Innovation
[15]	Conceptual (Research Framework)	BDAC	Value Creation Mechanisms	Technology and Industry Context Competitive Dynamics	Strategic Value
[37]	Empirical, Case Study, Interview (n=3)	BDA Implementation	Agility	BDAC	Manufacturing Performance
[38]	Empirical, survey (n = 161)	Top Management Support	BDA Use	Environmental Dynamism	Asset Productivity; Business Growth
[16]	Empirical, survey (n = 232)	BDAC (formative)	----	----	Market and Operational Performance
[14]	Empirical, survey (n = 152)	BDAC (reflective)	----	Analytics Capability-Business Strategy Alignment	Firm Performance
[20]	Empirical, survey (n = 297)	BDAC (reflective)	Process-Oriented Dynamic Capabilities	----	Firm Performance
[39]	Empirical, survey (n = 212)	BDA Management Capabilities (reflective)	----	Technology Orientation	Tourism Supply Chain Performance
[40]	Empirical, survey (n = 202)	BDAC (formative)	Dynamic and Operational Capabilities	----	Competitive Performance
[23]	Empirical, survey (n = 175)	BDAC (formative)	Dynamic Capabilities	Environment Dynamism & Heterogeneity & Hostility	Incremental and Radical Innovation

essential resource for survival in the digital era; these capabilities offer opportunities for new service, technology development, and increased processing capability with low cost [45], [46].

In the context of big data, digital platforms enable firms to develop complementary technologies and services. For example, user participation is an effective way for organizations to mitigate innovation challenges, but they must face the problems of high costs and uncertainty of customer acceptance; the connectivity of internal technical platforms can resolve these issues by improving the effectiveness of identifying opportunities of service innovation [10]. Although digital platforms are permeating mainstream information systems (IS) research and are viewed as a critical study area for future studies related to organization innovation, the evidence of its specific role, such as its direct or indirect effects, or its moderating role is unclear [13], [44], [45]. The interaction between BDA and digital platforms may trigger innovation. For instance, firms can perform a real-time perception of customer sentiment and then provide demand-oriented service with the efficient utilization of BDA resource and third-party digital social media platforms, such as Twitter and Facebook [47]. BDAC is different from digital platform capabilities; the former highlights fundamental connectivity and high-level bridges, whereas the latter emphasizes a firm's inherent analysis function. Digital platform capabilities may also produce different effects when interacting with BDAP and BDAT, which have different natures [16]. However, to date, few studies have discussed the relationship between platform generativity and big data in the context of service innovation, and the interaction among various antecedents of dynamic capabilities calls for research [45]. Accordingly, the current study adopts a holistic approach to fill these gaps by investigating the effects of digital platform capabilities and the interaction between BDAT and BDAP on dynamic capabilities.

D. ENVIRONMENTAL DYNAMISM

Environmental dynamism refers to environmental volatility (rate and amount of change) and unpredictability (uncertainty of change) [48]. An ongoing core debate exists on whether dynamic capabilities are valuable only in dynamic environments [49]. On the one hand, scholars argue that dynamic capabilities contribute value in relatively stable environments when facing threats and opportunities [41]. On the other hand, dynamic capabilities are meaningless in stable and moderately stable environments and they may even harm firm performance [28]. Environmental dynamism has been introduced as a boundary condition to investigate the role of dynamic capabilities in the firm outcome on the basis of the dynamic capabilities view to clarify this issue. First, the interaction is insignificant to a competitive edge; that is, dynamic capabilities are not effective in the Chinese business atmosphere [50]. In addition, dynamic capabilities cannot directly influence market performance regardless of whether the level of environmental dynamism is high or low [51]. Second, environmental dynamism positively moderates the effect of dynamic capabilities strategy on new venture performance [52]. Finally, a complex nonlinear effect is emerging in an increasing number of studies. Dynamic capabilities can produce a marked effect in relatively stable and highly dynamic environments (U-shaped) [42], and the dynamic capabilities–performance relationship shows the strongest positive correlation when environmental dynamism stays at a medium level (reverse U-shaped) [48]. In our research, dynamic capabilities in an environment with various degrees of dynamism

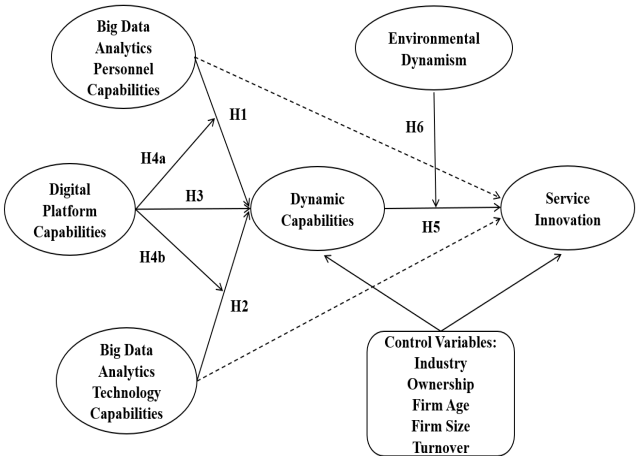

FIGURE 1. Proposed research model.

may lead to different outcomes. Therefore, the moderating role of environmental dynamism in the relationship between dynamic capabilities and service innovation should be clarified.

III. HYPOTHESIS DEVELOPMENT

This study proposes that BDAC, namely, BDAP and BDAT, has significant effects on service innovation by dynamic capabilities. Digital platform capabilities are an antecedent of dynamic capabilities and are introduced as a quasi-moderator of the relationship between BDAP/BDAT and dynamic capabilities. Furthermore, environmental dynamism acts as a moderator of the relationship between dynamic capabilities and service innovation. Fig. 1 presents the hypotheses and research model.

A. EFFECT OF BDAP AND BDAT ON DYNAMIC CAPABILITIES

Current literature highlights the facilitating effect of the existing resource base and operational capabilities on dynamic capabilities [17]. In line with dynamic capabilities view, resources and capabilities are antecedents of dynamic capabilities and dynamic capabilities can govern the changes in ordinary capabilities [53]. Scholars also emphasize that companies are leveraging BDA to utilize the knowledge generated from massive data in order to guide and improve the sensing, seizing and transforming ability of organizations [15], [20], [23], [40]. Thus, BDAT and BDAP, as the resource and capabilities of BDA, may positively influence dynamic capabilities.

BDAP refers to the technical and managerial skills of BDA human resources and it can be viewed as a firm's mobile information base or knowledge set [14], [16]. Scholars note that firms must combine endogenous and exogenous knowledge to acquire dynamic capabilities [54]. Therefore, knowledge processes could be regarded as an antecedent of successful dynamic capabilities and BDAP may be helpful in the creation of dynamic capabilities [20], [54]. Specifically, BDAP enables analysts or decision-makers to choose the proper data sources and processing tool effectively, further promoting agile operations on the three dimensions of dynamic capabilities. The knowledge and skills relevant to managerial aspects, enables firms to sense external opportunities accurately, generate the customer profile clearly, and accelerate the business process transforming efficiently [27]. Thus, we propose that:

H1: BDAP positively affects dynamic capabilities.

Furthermore, IT infrastructure flexibility allows firms to improve their sensing and responding performance by enhancing their capabilities, such as those of detecting, processing, and communicating [55], [56]. In this view, BDAT provides firms opportunities to apply their knowledge in addressing changing business conditions with analysis results and optimal decisions and choices, thus improving dynamic capabilities. For example, a firm can utilize a flexibility analytics infrastructure to recognize potential needs by drawing and visualizing customer data derived from diverse sources, such as digital platforms, of which they may sometimes not be aware [6]. Scholars propose that BDAT initially improves the customer sentiment analysis and non-customer potential needs (sensing), then drives the dynamic resource allocation and decision-making processes (seizing), and finally, the marketing approaches transforming (transforming) [33], [55]. Therefore, we propose that:

H2: BDAT positively affects dynamic capabilities.

B. QUASI-MODERATING ROLE OF DIGITAL PLATFORM CAPABILITIES

Digital platform capabilities provide the proper conditions for dynamic capabilities development; it offers the generation of digital information and collective wisdom, such as the experience, opinion, and knowledge among members, including individual customers or organizations, in digital platform ecosystems [4], and information is the basis or resource needed for quick response and timely decision-making capabilities. Digital platforms enable firms to recognize changes rapidly in the external environment and respond quickly to changing customer requirements and increased processing capabilities with low cost [45], [46]. For instance, Volvo Cars meet the demand to develop new decision-making capabilities by building a digital platform that collects external ideas from external developers, end-users, and public authorities [3]. Thus, we propose the following:

H3: Digital platform capabilities positively affect dynamic capabilities.

Scholars propose that the interaction between digital platforms and enterprise system platforms can trigger firm innovation, which shows the potential moderating role of digital platform capabilities [45]. For example, with a digital interactive platform, Apple Watch Nike Plus utilizes data analysis to offer a novel co-creating running course [57]. The digital platform allows personnel to interact with customers, provides additional support (e.g., customer profiling), and creates a harmonious atmosphere wherein the skill

sets, experience and given support jointly operate on innovative service offers [6]. Nevertheless, when a firm's digital platform capabilities rise to a high level, the contribution of BDAP to dynamic capabilities may diminish. Given the striking characteristics of the ease of connectivity to other technologies, a large amount of data or information and auto-analysis needed for a few specialized skills may minimize the necessity of human resources for market change-sensing [45]. Moreover, the introduction of digital platforms may change the way people think or work and fail to initiate synergies with people [58], [59]. Consequently, any established strategy or plan may encounter implementation problems because of the intimidating nature of collaboration. Meanwhile, abundant and complicated data may confuse personnel and result in difficulties in leveraging their knowledge and skill to discover truths and relationships among things [3]. When digital platform capabilities are at a low level, personnel have to rely on their current knowledge and skills to recognize changes, make decisions, and implement plans. The effect of BDAP on dynamic capabilities is therefore intensified. Thus, we propose the following:

H4a: Digital platform capabilities negatively moderate the relationship between BDAP and dynamic capabilities.

When digital platform capabilities rise to a high level (large amounts of data need to be processed rapidly), BDAT becomes particularly valuable, because it can ensure smooth data processing, decrease the possibility of interruption, and guarantee the timely improvement of dynamic capabilities. For example, an infrastructure with excellent compatibility can enable Amazon to improve collaboration, application development, and rapid analysis to address changing needs even when encountering massive data [60]. With good connectivity, firms can combine structured and unstructured data from various functions and platforms to explore customer characteristics deeply among transactions and then recognize potential needs [61]. Furthermore, BDAT not only provides human service actors with new opportunities to deploy existing resources rapidly but also fundamentally revamps practices for highly individualized customer needs. For example, a telecommunications company in Austria operates a flexible analytics infrastructure to collect and analyze customer behavior and interaction data on an advanced digital platform—an e-bank portal—to offer tailored content on user interfaces in a timely manner [6]. When digital platform capabilities are at a low level, BDAT cannot completely reflect its value because the BDA infrastructure is not operating at full or high capability. Thus, we propose the following:

H4b: Digital platform capabilities positively moderate the relationship between BDAT and dynamic capabilities.

C. EFFECT OF DYNAMIC CAPABILITIES ON SERVICE INNOVATION

Several scholars state that dynamic capabilities have the power to originate innovative behavior and innovation performance [62]. Innovative service delivery is a dynamic process that requires firms to adapt to evolving customer needs, and dynamic capabilities can provide firms with opportunities to evolve customer demands and market trends by adapting resources [10], [63]. The success of service innovation depends on specific dynamic capabilities, given that the identification and exploration of service innovation opportunities require firms to build new capabilities in rapidly changing business environments [64]. Firms with excellent dynamic capabilities can react effectively and decide promptly and accurately in ever-changing environments [2]. Existing literature also verifies this relationship; dynamic relational capabilities enable components of service innovation [65]. In healthcare, dynamic capabilities are the key to the development of the service innovation concept [66]. Thus, we propose the following:

H5: Dynamic capabilities positively affect service innovation.

D. MODERATING ROLE OF ENVIRONMENTAL DYNAMISM

The interaction between internal mechanisms and external environmental variables may moderate the processes within firms [67]. Firms are required to have the ability to capture effective customer/market information, analyze data collected from stakeholders in a dynamic environment, and convey updated information within firms quickly [38], [68], [69]. Dynamic capabilities can produce a marked effect on firm outcome by following a predictable and linear path in moderate environmental dynamism [17]. However, changes are usually nonlinear and unpredictable in markets [48]. A turbulent external environment may destroy a firm's critical capabilities and reduce the value of its dynamic capabilities [70]. In addition, changes that occur simultaneously and rapidly in an environment with a high level of dynamism may neutralize or render obsolete any generated benefits [27], and firms cannot readily conduct service innovation. The literature also shows the negative moderating role of environmental dynamism in the relationship between BDA use and asset productivity [38]. Thus, we propose the following:

H6: Environmental dynamism negatively moderates the relationship between dynamic capabilities and service innovation.

IV. RESEARCH DESIGN

A. CONSTRUCT MEASUREMENT

All constructs' measurement items, which were measured as reflective, were adopted from previous studies. Our questionnaire adopted a seven-point Likert scale with options ranging from 1 (''strongly disagree'') to 7 (''strongly agree'') to measure all variables, which included BDAP, BDAT, service innovation, dynamic capabilities, digital platform capabilities, and environmental dynamism. According to prior literature, industry, ownership, firm age, and firm size may influence service innovation and dynamic capabilities to different degrees. Thus, we included these variables as control variables in our model (Appendix F).

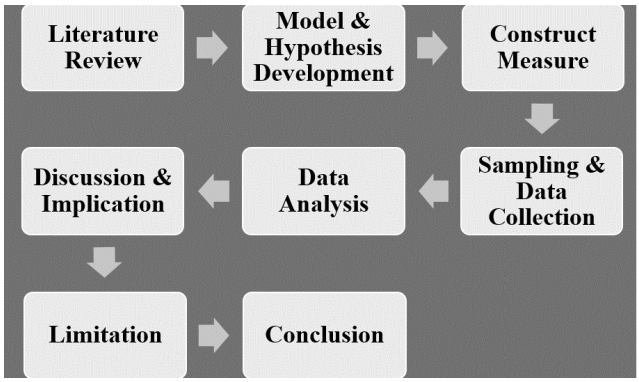

FIGURE 2. Research methodology.

The questionnaire was developed as follows: First, an English-language questionnaire was developed and then translated into a Chinese version by a team of three researchers from different fields [67]. Two team members are English majors and have a professional translation certificate and a professional English graded certificate. A professional translator (not part of the team) translated the current version back to the English version, and no semantic discrepancies were identified between the two versions. Second, a pre-survey was conducted to assess and refine the questionnaire preliminarily. Twenty-three MBA students from various industries were selected as the sample. We submitted the translated questionnaire to these students for additional feedback. Then, an interview was conducted after this pre-survey to collect their opinions. The questionnaire was then adjusted accordingly to meet the required reliability and validity. We made several modifications, such as the rearranging of the questions, the changing of the questionnaire format, and the deletion of some items. No improper elements remained in our questionnaire after these manipulations. Finally, the second version of the questionnaire was created in paper and digital forms to perform the following steps. Fig. 2 represents the research methodology used in current research:

B. SAMPLING AND DATA COLLECTION

We conducted a questionnaire survey to test the proposed hypotheses in China. This country is an important global manufacturing base [71] and a large digital market wherein firms actively engage for value-creating from big data [71], [72]. Furthermore, the wealth of data generated in China attracts researchers and practitioners. Thus, the data are representative for firm BDAC in China and the corresponding results are suitable not only for China but also for other countries [20]. With the help of government authorities in Big Data Industrial League and Big Data National Engineering Laboratory in China, we generated a contact list of 400 corporations. First, we made phone calls to get the permission of firms' owners or senior managers to participate in our research. Then we visited their companies and ask them to fill out the paper questionnaires. During this period, we collected 189 paper questionnaires. Second, we sent emails to the rest of the companies on our list with digital questionnaires attached. Another 110 digital questionnaires are collected. However, 124 questionnaires which didn't meet the requirement of our research were strictly deleted. Finally, we collected 175 valid questionnaires with a response rate of 43.8%. Table 2 shows the demographic characteristics of the respondents and their firms. We tested the normality of each scale item. The result showed the absolute values of skewness and kurtosis were all less than 1, indicating that all variables are normally distributed. Then, we conducted an independent-sample T-test to check for differences in the variables between the paper and digital questionnaires. The data show the following: BDAT ($p = 0.63$, $t = -1.77$), BDAP ($p = 0.43$, $t = -0.89$), digital platform capabilities ($p = 0.47$, $t = -1.20$), dynamic capabilities ($p = 0.92$, $t = -1.78$), environmental dynamism ($p = 0.64$, $t = -1.94$), and service innovation ($p = 0.22$, $t = -3.03$). These results indicate that no significant difference exists between most of the core variables collected by the two channels. As the digital questionnaire represents the late wave in our survey, there is also no significant difference between early and late responses. Thus, non-response bias is not a threat to this study. In addition, we statistically checked the severity and potential influence of common method bias (CMB) through partial least squares (PLS) [73], [74]. The results (Appendix C) show that most method factor loadings are insignificant; the average that substantively explains the variance of the indicators is 0.662; the average method-based variance is 0.024 (an approximate ratio of 28.2:1). Thus, CMB is not a serious problem for this study.

V. RESULT

A. MEASUREMENT MODE

The hierarchical research models were proposed as follow: the BDAP, BDAT, SI (service innovation), DC (dynamic capabilities), ED (environmental dynamism), DPC (digital platform capabilities), C1 (Industry), C2 (Ownership), C3 (Firm Age), C4 (Firm Size), C5 (Turnover), β (path coefficient), ε (error).

1) MAIN EFFECT TEST

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \varepsilon (M5)$$

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \varepsilon\ (M7)$$

Model 5 was conducted to estimate the effects of five control variables on service innovation. The effects of BDAP and BDAT on service innovation were evaluated in model 7.

2) MEDIATING ROLE TEST

$$DC = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \varepsilon (M1)$$

$$DC = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \varepsilon (M2)$$

TABLE 2. Sample characteristics.

Characteristic	Range	Frequency	Percentage
Industry	Software, Information Technology	19	10.9%
	Education, Training	18	10.3%
	Banking, Financial Service	25	14.3%
	Public Administration, Social Security	14	8.0%
	Organizations		
	Manufacturing	30	17.1%
	Wholesale and Retail	6	3.4%
	Construction Projects, Real Estate	14	8.0%
	Transportation, Warehousing and Postal Services	5	2.9%
	Resident Services, Repairs, and other services	16	9.1%
	Telecommunications, Electronic Products	8	4.6%
	Culture, Sports and Entertainment	4	2.3%
	Others	16	9.1%
	Total	175	100%
Ownership	State-owned or state-controlled enterprises	98	56.0%
	Private Enterprise	61	34.9%
	Sino-Foreign Joint Ventures	6	3.4%
	Wholly foreign-owned enterprises	2	1.1%
	Others	8	4.6%
	Total	175	100%
Firm Age	< 3	12	6.9%
	3-6	41	23.4%
	7-15	35	20.0%
	16-25	45	25.7%
	26-40	31	17.7%
	>40	11	6.3%
	Total	175	100%
Firm Size (Number of employees)	<100	20	11.4%
	100-500	64	36.6%
	501-1000	38	21.7%
	1001-5000	30	17.2%
	5001-10000	5	2.9%
	10001-30000	9	5.1%
	>30000	9	5.1%
	Total	175	100%
Turnover (in millions RMB)	≤100	86	49.1%
	100< Turnover ≤1000	42	24.0%
	1000< Turnover ≤10000	13	7.5%
	10000< Turnover ≤50000	29	16.5%
	>50000	5	2.9%
	Total	175	100%

Note: Others in Industry include travel, accommodation and catering, agriculture forestry, animal husbandry and fishing, healthcare, and electricity, heat, gas and water production and supply industries and so forth; Others in Ownership include collective ownership

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \beta_8 DC + \varepsilon (M8)$$

Model 1 was conducted to estimate the effects of five control variables on dynamic capabilities. In model 2, we added the BDAP and BDAT to evaluate their influence on dynamic capabilities. And in model 8, we added the dynamic capabilities to evaluate its effect on service innovation.

3) MODERATING ROLE TEST

$$DC = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \beta_8 DPC + \varepsilon (M3)$$

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \beta_8 DPC + \beta_9 DPC \times BDAP + \beta_{10} DPC \times BDAT + \varepsilon (M4)$$

Model 3 estimates the direct effect of digital platform capabilities on dynamic capabilities. Model 4 estimates the effect of interaction terms between digital platform capabilities and BDAP/BDAT on dynamic capabilities. Thus, model 3 and model 4 capture the quasi-moderating effect of digital platform capabilities.

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 DC + \beta_7 ED + \beta_8 ED \times DC + \varepsilon (M6)$$

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \beta_8 DC + \beta_9 ED + \varepsilon (M9)$$

$$SI = \alpha_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 BDAP + \beta_7 BDAT + \beta_8 DC + \beta_9 ED + \beta_{10} ED \times DC + \varepsilon (M10)$$

In model 6, we estimated the effect of an interaction term between environmental dynamism and dynamic capabilities on service innovation. Model 9 estimates the direct effect of environmental dynamism on service innovation. Model 10 also estimates the interaction terms between environmental dynamism and dynamic capabilities on service innovation under the addition of BDAP and BDAT.

The hierarchical research model in this study was estimated by PLS to improve the suitability and overcome the limits of multivariate normality, sample size, and model complexity, among others [75]. Thus, we used Smart PLS to estimate the related indicators of our research model. We perform higher-order confirmatory factor analysis to verify the convergent validity and the first-order hierarchical model of each construct because BDAP, BDAT, and dynamic capabilities are second-order hierarchical models. Appendix A presents the factor loadings, Cronbach's α, composite reliability (CR), and average variance extracted (AVE). The calculated results indicate that all item loadings exceed the threshold of 0.70 [76] at $p < 0.01$. The unidimensionality is supported by the high average of the item loadings (i.e., loadings > 0.808, $p < 0.01$) [77]. Each construct's Cronbach's α and CR exceed 0.70 [78]. The AVE for all constructs is greater than 0.50 and the lowest value is 0.644 [76]. Appendix B shows the cross-loading results. All items' cross-loading exceeds 0.707 [78], and the lowest value is 0.716. The difference between each item's loadings with its primary construct and those with other constructs exceeds 0.1 [79]. The square root of AVE for all constructs is greater than variable correlations [76], [77]. We also conducted the Heterotrait-Monotrait (HTMT) Ratio test of the first-order factors to assess the discriminant validity. Appendix E represents these results. The majority of our HTMT ratios of all first-order constructs are lower than 0.85. The exceptions are the ratios of pairs of the same second-order construct are above 0.85 but still below the threshold value 0.9. We conducted collinearity diagnostics to evaluate

multicollinearity. The highest variance inflation factor (VIF) value is 3.918, which falls below the acceptable common cut-off value of 5 [14], [20]. Therefore, multicollinearity is not a problem for this study. These results demonstrate not only the good discriminant and convergent validity but also the good measurement properties of our research model.

B. HYPOTHESIS TESTING

A hierarchical regression analysis was developed to examine the hypotheses in this study (Table 3). In model 1, four control variables—industry, ownership, firm age, and firm size—do not significantly affect dynamic capabilities. The data of model 2 show that BDAP and BDAT have significant and positive influences on dynamic capabilities ($\beta = 0.548$, $p < 0.01$; $\beta = 0.319$, $p < 0.01$, respectively). The explained variance in dynamic capabilities is 67.6%, $f^2 = 0.669$, and $F = 111.723$; the explanatory power is significant. Therefore, H1 and H2 are supported. Model 3 indicates that the direct effect of digital platform capabilities on dynamic capabilities is significant and positive ($\beta = 0.168$, $p < 0.05$), and the explanatory power is significant ($R^2 = 0.686$, $f^2 = 0.031$, $F = 5.146$). In model 4, the interaction terms of BDAP and digital platform capabilities are negative and significant ($\beta = -0.126$, $p < 0.01$), whereas the interaction terms between BDAT and digital platform capabilities are positive and significant ($\beta = 0.057$, $p < 0.05$). The explanatory power is also significant ($R^2 = 0.741$, $f^2 = 0.175$, $F = 28.7$). Fig. 3 and 4 display the analysis of simple slope for each interaction terms on dynamic capabilities. When the level of digital platform capabilities is high, a high level of BDAP will yield low dynamic capabilities while high BDAT results in high dynamic capabilities. H3, H4a, and H4b are hence supported. In model 5, four control variables have no effects on service innovation. In model 7, BDAP ($\beta = 0.388$, $p < 0.01$) and BDAT ($\beta = 0.296$, $p < 0.01$) have positive and significant effects on service innovation. In model 8, the influence of dynamic capabilities on service innovation is positive and significant ($\beta = 0.295$, $p < 0.01$). Thus, H5 is supported. The data of models 6, 9, and 10 indicate that the interaction term of environmental dynamism and dynamic capabilities is negative and significant ($\beta = -0.102$, $p < 0.05$). The explanatory power is also significant ($R^2 = 0.49$, $f^2 = 0.027$, $F = 4.428$). Fig. 5 presents a simple slopes analysis for service innovation growth, which indicates that varying in the high level of environmental dynamism, a low level of dynamic capabilities leads to high service innovation. Thus, H6 is supported.

We conducted a regression analysis to examine the mediating effect of dynamic capabilities [78]. The data from models 2, 7, and 8 show that the dynamic capabilities have mediating roles. We retained all settings for the PLS-SEM algorithm, selected 5,000 bootstrap samples, and selected the complete bootstrapping option. Appendix E shows the results. BDAP and BDAT exert significant effects ($t = 1.845$, $p < 0.05$; $t = 2.127$, $p < 0.05$) on service innovation, and both indirect effects are significant ($t = 2.292$, $p < 0.05$; $t = 1.86$, $p < 0.05$); neither of the 95% confidence intervals include zero. We concluded that dynamic capabilities perform partial mediating roles in two relationships (BDAP and service innovation; BDAT and service innovation). We implement the product of values of direct and indirect effects to examine the type of this partial mediation further. Given a positive product value ($0.228 \times 0.162 = 0.037$; $0.199 \times 0.094 = 0.019$), we concluded that dynamic capabilities represent a

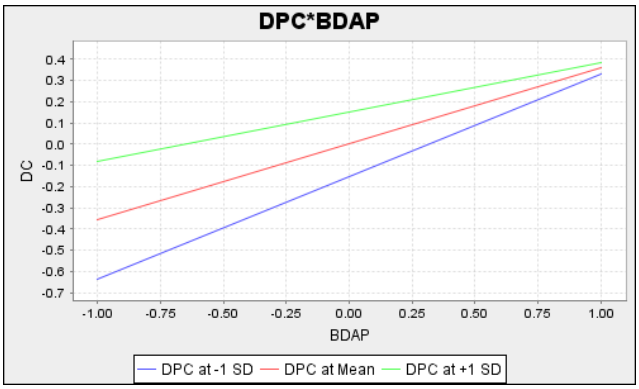

FIGURE 3. Plot for the interaction effect of digital platform capabilities and BDAP on dynamic capabilities.

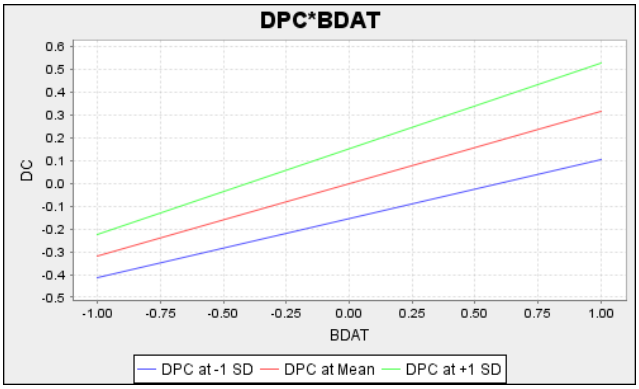

FIGURE 4. Plot for the interaction effect of digital platform capabilities and BDAT on dynamic capabilities.

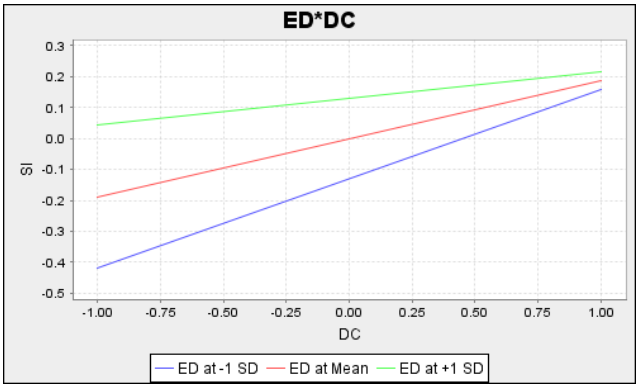

FIGURE 5. Plot for the interaction effect of environmental dynamism and dynamic capabilities on service innovation.

TABLE 3. Results of regression analysis.

Construct	Dynamic Capabilities				Service Innovation					
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Firm Age	-0.124	-0.024	-0.024	-0.032	-0.081	-0.002	0.008	0.015	0.008	0.009
Ownership	-0.040	-0.002	-0.007	-0.014	-0.085	-0.066	-0.052	-0.052	-0.061	-0.057
Industry	-0.051	0.055	0.071	0.067	0.023	0.049	0.111	0.095	0.075	0.089
Firm Size	0.035	0.002	0.008	0.019	0.047	0.042	0.019	0.018	0.024	0.033
Turnover	0.074	0.164	0.164	0.166	-0.141	-0.158	-0.064	-0.113	-0.100	-0.113
BDAP		0.548**	0.524**	0.359**			0.388**	0.228*	0.213*	0.190
BDAT		0.319**	0.205*	0.317**			0.296**	0.199*	0.160*	0.179*
Digital Platform Capabilities			0.168*	0.153*						
Dynamic Capabilities						0.405*		0.295**	0.223*	0.190
Environmental Dynamism						0.219*			0.152	0.128
Digital Platform Capabilities × BDAP				-0.126**						
Digital Platform Capabilities × BDAT				0.057*						
Environmental Dynamism × Dynamic Capabilities						-0.105*				-0.102*
R^2	0.020	0.676	0.686	0.741	0.039	0.455	0.440	0.467	0.476	0.490
ΔR^2		0.656	0.010	0.055		0.416	0.401	0.027	0.009	0.014
F^2		0.669	0.031	0.175		0.433	0.417	0.048	0.017	0.027
F-value		111.723**	5.146**	28.700**		71.878**	70.473**	8.016**	2.805**	4.428**
SRMR(EM)	0.083	0.069	0.068	0.068	0.047	0.067	0.072	0.068	0.067	0.067
Q^2	0.011	0.401	0.406	0.435	0.014	0.259	0.256	0.268	0.271	0.278
q^2		0.394	0.008	0.049		0.248	0.245	0.016	0.004	0.010

Note: *p<0.05, **p<0.01, one-tail test.

TABLE 4. Results of hypothesis testing.

Hypothesis	Results
H1: BDAP → Dynamic capabilities (Positive)	Supported
H2: BDAT → Dynamic capabilities (Positive)	Supported
H3: Digital platform capabilities → Dynamic capabilities (Positive)	Supported
H4a: Digital platform capabilities x BDAP → Dynamic capabilities (Negative)	Supported
H4b: Digital platform capabilities x BDAT → Dynamic capabilities (Positive)	Supported
H5: Dynamic capabilities → Service innovation (Positive)	Supported
H6: Environmental dynamism x Dynamic capabilities → Service Innovation (Negative)	Supported

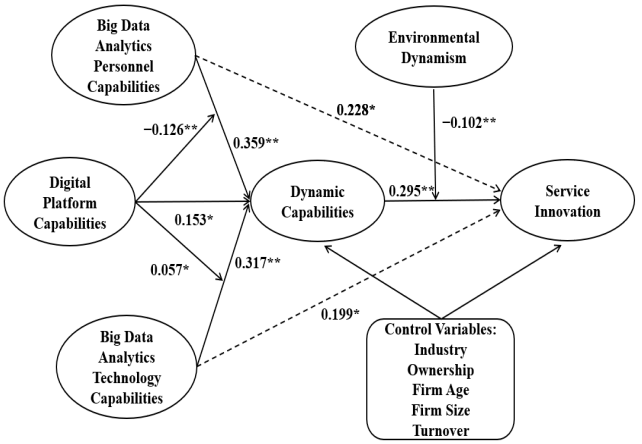

FIGURE 6. Result of research model with parameter estimates.

complementary mediation of the relationship. In addition, we adopted SPSS Process Procedure 2.13 with the bootstrapping of 5000 samples to test the mediating role and robustness. The results indicate the significant indirect effects of BDAT and BDAP on service innovation via dynamic capabilities ($Z = 4.11$, $p < 0.01$; $Z = 2.50$, $p < 0.05$). Thus, H7a and H7b are supported. Finally, Stone–Geissler's Q^2 was computed to examine the research model's predictive validity [14]. We applied the cross-validity redundancy approach (omission distance = 8) and gained $Q^2 = 0.435$ for dynamic capabilities and $Q^2 = 0.278$ for service innovation. These findings adequately demonstrate the predictive validity of BDAP and BDAT on dynamic capabilities and the predictive validity of BDAP, BDAT, and dynamic capabilities on service innovation, respectively.

Table 4 demonstrates the test results. H1, H2, H3, H4a, H4b, H5, H6, H7a, and H7b are supported. Fig. 6 shows the research results of PLS estimation (the data is from models 4, 8, and 10).

VI. DISCUSSIONS AND IMPLICATIONS

A. THEORETICAL IMPLICATIONS

This study draws on the dynamic capabilities view to discover the internal influence mechanism between different types of BDAC and service innovation through an empirical study. Digital platform capabilities as a quasi-moderator of the relationships between BDAT/BDAP and dynamic capabilities. Then, we introduce environmental dynamism as a moderator to investigate the effect of dynamic capabilities on service innovation. Finally, we examine the mediating effect of BDAP and BDAT on service innovation. Our research offers the following theoretical contributions.

First, this study enriches the existing empirical studies by assessing the direct and indirect effects of BDAT and BDAP, as two types of BDAC, on service innovation. As firms increasingly rely on big data and related analytics technology to drive performance and innovation, scholars have been calling for additional in-depth research to investigate the influence of BDAC [16]. However, few studies focus on innovation, especially service innovation. Therefore, the current empirical article enriches the relevant literature. Our study contributes to this part of the literature on digitally enabled service innovation and enriches the research perspective on service innovation from the different dimensions of BDAC. Current studies usually regard BDA as an aggregate factor (e.g., BDA technology or usage) [15], [38] or as a holistic view (e.g., third-order BDAC). However, each type of BDAC has distinct characteristics and effects on firm-level factors. We identify the direct positive effects of BDAT and BDAP on service innovation, thereby addressing the gap in the big data–innovation link. In addition, our empirical results demonstrate that the different dimensions of BDAC are the bases of service innovation, which enriches the resource-based view. The finding also provides evidence of the necessity and requirement of BDAP and BDAT for driving service innovation.

Second, our study responds to the call for examining the interactions among the antecedents of dynamic capabilities by introducing digital platform capabilities as a quasi-moderator. Scholars have set a research direction for dynamic capabilities and have emphasized the significance of fully developing the dynamic capabilities view by investigating the interaction among its antecedents, especially the unexplored ones [17], such as digital platform capabilities. However, only relatively few relevant studies offer empirical evidence. We enrich this part of the literature by identifying the different degrees of coordination of digital platform capabilities with BDAT and BDAP. On the one hand, our study reveals digital platform capabilities' direct and positive role in dynamic capabilities. This finding suggests that digital platform capabilities could act as a new antecedent to dynamic capabilities, filling the gap concerning unexplored antecedents [17] and extends the scope of dynamic capabilities enabler. On the other hand, the current study tests the different interaction effects of digital capabilities with BDAP and BDAT; specifically, digital platform capabilities positively moderate the relationship between BDAT and dynamic capabilities but negatively moderate the same with BDAP. This phenomenon shows that BDAT performs well at a high level of digital platform capabilities, but this high level does not strengthen the relationship between BDAP and dynamic capabilities.

These results may be attributed to the supplementary relationship or the synergism between digital platforms and BDAT/BDAP, which may affect the final benefit outcomes and be conducive to determining the inner mechanism. The positive moderation is ascribed to the fact that BDAT meets the requirement of a high level of digital platform capabilities (collected massive data and information), which guarantees smooth data processing and reduced interruption and downtime. Then, BDAT and digital platform capabilities jointly embody a synergistic effect on developing dynamic capabilities. However, the relation between BDAP and digital platforms tends to be substitutional. When digital platform capabilities rise to a high level, the contribution of BDAP to dynamic capabilities building may diminish. This finding is consistent with the opinion that an increasingly powerful platform does not require excessively many talents and skills to leverage firm dynamic capabilities [13], [45]. Furthermore, the progressiveness and auto-processing of digital platforms may modify personnel's mode of thinking and work, resulting in their high dependence on historical data and given solutions instead of their own knowledge; ultimately, the contribution to dynamic capabilities is reduced [58], [59]. Moreover, the excessively complicated unstructured data brought by a high degree of the digital platform may perplex big data analysts because the whole human resource relevant to BDA still stays at a relatively low level and infancy stage with limitations [16]. For instance, at the early stage of digital transformation, design engineers cannot utilize and coordinate with digital platforms and communities with customers or other design participants in the same platform ecosystem [3]. These phenomena show that the development of digital platforms requires managers to focus on the adverse effects and strive to diminish them promptly. Meanwhile, firms have to maintain and strengthen the existing favorable effects purposefully. This result may stimulate researchers' interest in further exploring the mechanism and relationship between digital platforms and human resources related to BDA.

Third, this study responds to the debate on the moderating role of environmental dynamism, that is, the interaction's influence between dynamic capabilities and environmental dynamism on service innovation, by introducing environmental dynamism as a moderator on the basis of the dynamic capabilities view. Prior literature shows different positive and nonlinear moderating roles, but only a few studies investigate the influence of the interaction on service innovation. Our research fills this gap in the dynamic capabilities–service innovation link and enriches the literature on dynamic capabilities and service innovation. Our findings demonstrate that environmental dynamism negatively moderates the relationship between dynamic capabilities and service innovation. When environmental dynamism is at a high level, dynamic capabilities perform poorly, and the possibility of enabling the role in service innovation decreases. This finding distinctly differs from that of mainstream literature that indicates a positive moderating effect of environmental dynamism. When a firm's external environment becomes acute and fluctuant, for firm-level innovation, even dynamic capabilities cannot maintain a stable contribution to service innovation because of the drastic, ever-changing environment and customer preference. This result reflects the intensive and dramatic influence of the China-US trade war on Chinese enterprises.

Fourth, the literature examining the mediating role of dynamic capabilities between various types of BDAC, such

TABLE 5. Reliability.

Factors	Reflective Construct	Items	Factor Loadings	t-value	Cronbach'α	CR	AVE	Second-order factor loading
Big Data Analytics Personnel Capability (BDAP)	Technical Knowledge (TK)	TK1	0.843	32.339	0.882	0.919	0.740	0.859
		TK2	0.902	33.612				
		TK3	0.810	57.299				
		TK4	0.882	19.358				
	Technology Management Knowledge (TM)	TM1	0.854	30.809	0.856	0.912	0.776	0.880
		TM2	0.916	36.258				
		TM3	0.871	88.177				
	Business Knowledge (BK)	BK1	0.846	32.198	0.739	0.851	0.658	0.808
		BK2	0.863	50.841				
		BK3	0.716	14.615				
	Relationship Knowledge (RK)	RK1	0.881	51.613	0.836	0.901	0.753	0.867
		RK2	0.844	24.417				
		RK3	0.877	44.516				
Big Data Analytics Technology Capability (BDAT)	Connectivity (CN)	CN1	0.893	55.623	0.882	0.927	0.809	0.899
		CN2	0.900	51.926				
		CN3	0.905	56.136				
	Compatibility (CM)	CM1	0.915	72.931	0.852	0.91	0.772	0.878
		CM2	0.831	20.988				
		CM3	0.888	45.257				
	Modularity (MD)	MD1	0.844	32.652	0.879	0.917	0.734	0.856
		MD2	0.860	35.372				
		MD3	0.875	45.984				
		MD4	0.847	29.789				
Dynamic Capabilities (DC)	Strategic-sensing (SSC)	SSC1	0.779	11.237	0.791	0.878	0.707	0.839
		SSC2	0.853	7.451				
		SSC3	0.886	23.500				
	Time-decision Making (TDC)	TDC1	0.905	68.838	0.858	0.914	0.780	0.883
		TDC2	0.867	44.835				
		TDC3	0.876	32.543				
	Change-implementation (CIC)	CIC1	0.887	44.320	0.860	0.915	0.782	0.884
		CIC2	0.894	23.211				
		CIC3	0.871	50.328				
Environmental Dynamism (ED)	Environmental Dynamism (ED)	ED1	0.766	19.392	0.867	0.904	0.654	----
		ED2	0.765	14.598				
		ED3	0.867	43.694				
		ED4	0.812	23.489				
		ED5	0.829	22.560				
Digital Platform Capabilities (DPC)	Platforms to Connect to Consumers	DPC1	0.848	24.729	0.912	0.932	0.695	----
		DPC2	0.846	25.535				
		DPC3	0.812	20.707				
	Platforms to Connect to Business	DPC4	0.872	44.156				
		DPC5	0.802	21.963				
		DPC6	0.821	27.194				
Service Innovation (SI)	SI	SI1	0.783	16.454	0.862	0.900	0.644	----
		SI2	0.825	23.838				
		SI3	0.833	26.481				
		SI4	0.791	24.362				
		SI5	0.779	19.518				

as BDAT and BDAP, on service innovation is scarce. Few studies explore these roles through empirical data and merely propose research frameworks or method case studies [6], [15], which require additional data verification. Hence, our study addresses this gap by introducing dynamic capabilities as a mediator to establish a linkage on the basis of data gathered from Chinese firms. Our results present that dynamic capabilities perform a partially mediating role in the relationship between BDAT and service innovation and in the relationship between BDAP and service innovation, thus further enriching the application range and scenarios of the dynamic capabilities view. With this connection of dynamic capabilities, the relationships between BDAP/BDAT and service innovation become further explicit and spur practitioners to place further attention on dynamic capabilities and then improve the whole competence for resisting uncertain risks.

B. PRACTICAL IMPLICATIONS

This study has several implications for business practitioners. First, practitioners should commit a sustainable investment in developing digital platform capabilities. Digital platform capabilities are an antecedent of dynamic capabilities, which directly affect organizations' dynamic capabilities. Hence, building a digital platform and shaping related capabilities, such as platforms for customers and businesses, will bridge the distance between firms and customers or businesses and will more clearly develop dynamic capabilities as an alternative option, which generally manifests as an abstract concept. Additionally, the absolutely reverse moderating role of digital platform capabilities in the effect of BDAT and BDAP on service innovation seems to contradict, given that organizations decide whether to build or further invest in digital platforms. Nonetheless, consistently investing is worthwhile and farsighted for firms

TABLE 6. Cross-loading.

	BK	CM	CN	MD	RK	TK	TM	DPC	SIC	SSC	TDC	ED	SI
BK1	**0.846**	0.602	0.557	0.584	0.621	0.651	0.629	0.526	0.518	0.572	0.545	0.530	0.433
BK2	**0.863**	0.593	0.533	0.654	0.713	0.671	0.663	0.592	0.616	0.569	0.614	0.605	0.530
BK3	**0.716**	0.421	0.407	0.463	0.452	0.482	0.464	0.378	0.401	0.418	0.397	0.479	0.442
CM1	0.633	**0.915**	0.752	0.707	0.605	0.668	0.556	0.659	0.551	0.630	0.585	0.553	0.494
CM2	0.518	**0.831**	0.629	0.636	0.467	0.510	0.421	0.578	0.525	0.400	0.475	0.465	0.416
CM3	0.615	**0.888**	0.708	0.720	0.583	0.668	0.541	0.667	0.567	0.645	0.650	0.543	0.501
CN1	0.568	0.677	**0.893**	0.713	0.599	0.716	0.583	0.685	0.533	0.586	0.593	0.490	0.466
CN2	0.503	0.713	**0.900**	0.693	0.513	0.628	0.463	0.613	0.497	0.493	0.483	0.472	0.454
CN3	0.603	0.753	**0.905**	0.698	0.593	0.651	0.593	0.690	0.591	0.608	0.629	0.532	0.513
MD1	0.585	0.656	0.647	**0.844**	0.481	0.595	0.495	0.631	0.543	0.531	0.536	0.574	0.538
MD2	0.600	0.674	0.677	**0.860**	0.526	0.597	0.469	0.644	0.535	0.553	0.560	0.603	0.481
MD3	0.625	0.697	0.705	**0.875**	0.637	0.749	0.603	0.704	0.513	0.620	0.582	0.641	0.579
MD4	0.613	0.657	0.641	**0.847**	0.540	0.655	0.578	0.603	0.470	0.560	0.590	0.612	0.390
RK1	0.680	0.552	0.597	0.591	**0.881**	0.721	0.642	0.553	0.590	0.573	0.655	0.587	0.510
RK2	0.614	0.489	0.466	0.508	**0.844**	0.635	0.636	0.427	0.552	0.509	0.543	0.506	0.363
RK3	0.645	0.600	0.579	0.561	**0.877**	0.652	0.577	0.520	0.639	0.586	0.656	0.488	0.504
TK1	0.550	0.578	0.600	0.605	0.621	**0.843**	0.575	0.500	0.477	0.501	0.512	0.492	0.468
TK2	0.654	0.626	0.687	0.695	0.704	**0.902**	0.702	0.578	0.544	0.569	0.596	0.511	0.552
TK3	0.679	0.634	0.614	0.636	0.650	**0.810**	0.682	0.650	0.559	0.652	0.642	0.578	0.552
TK4	0.688	0.582	0.637	0.668	0.678	**0.882**	0.703	0.557	0.534	0.624	0.618	0.586	0.577
TM1	0.578	0.497	0.538	0.508	0.614	0.648	**0.854**	0.464	0.432	0.512	0.509	0.381	0.396
TM2	0.705	0.531	0.549	0.581	0.695	0.742	**0.916**	0.531	0.562	0.569	0.600	0.493	0.443
TM3	0.641	0.501	0.518	0.564	0.569	0.656	**0.871**	0.578	0.500	0.493	0.555	0.481	0.485
DPC1	0.490	0.601	0.598	0.652	0.428	0.495	0.378	**0.848**	0.496	0.537	0.516	0.553	0.465
DPC2	0.484	0.585	0.597	0.663	0.454	0.558	0.433	**0.846**	0.451	0.473	0.482	0.528	0.513
DPC3	0.455	0.529	0.564	0.542	0.391	0.493	0.457	**0.812**	0.427	0.441	0.409	0.462	0.423
DPC4	0.582	0.632	0.683	0.631	0.531	0.556	0.559	**0.872**	0.510	0.555	0.534	0.506	0.465
DPC5	0.540	0.638	0.600	0.619	0.515	0.584	0.552	**0.802**	0.520	0.559	0.563	0.499	0.426
DPC6	0.560	0.623	0.635	0.652	0.551	0.629	0.583	**0.821**	0.590	0.584	0.585	0.513	0.479
CIC1	0.559	0.547	0.516	0.562	0.552	0.541	0.516	0.501	**0.887**	0.617	0.701	0.580	0.480
CIC2	0.576	0.548	0.524	0.508	0.662	0.546	0.530	0.548	**0.894**	0.627	0.711	0.569	0.474
CIC3	0.563	0.560	0.554	0.524	0.600	0.546	0.461	0.548	**0.871**	0.690	0.689	0.551	0.467
SSC1	0.423	0.433	0.445	0.446	0.440	0.469	0.438	0.495	0.562	**0.779**	0.564	0.464	0.402
SSC2	0.600	0.622	0.561	0.586	0.570	0.614	0.500	0.558	0.616	**0.853**	0.696	0.602	0.521
SSC3	0.595	0.553	0.564	0.622	0.596	0.629	0.560	0.543	0.657	**0.886**	0.737	0.626	0.496
TDC1	0.621	0.600	0.583	0.600	0.635	0.642	0.640	0.539	0.719	0.718	**0.905**	0.657	0.522
TDC2	0.571	0.564	0.541	0.575	0.665	0.576	0.536	0.547	0.709	0.682	**0.867**	0.563	0.494
TDC3	0.527	0.562	0.551	0.578	0.589	0.610	0.492	0.562	0.671	0.710	**0.876**	0.610	0.528
ED1	0.492	0.466	0.504	0.557	0.470	0.546	0.428	0.537	0.478	0.525	0.570	**0.766**	0.436
ED2	0.471	0.400	0.362	0.468	0.387	0.409	0.408	0.399	0.421	0.445	0.467	**0.765**	0.437
ED3	0.563	0.531	0.460	0.609	0.485	0.504	0.410	0.516	0.548	0.587	0.605	**0.867**	0.477
ED4	0.530	0.454	0.432	0.571	0.561	0.520	0.395	0.445	0.538	0.553	0.557	**0.812**	0.483
ED5	0.627	0.544	0.480	0.653	0.548	0.567	0.439	0.578	0.595	0.611	0.591	**0.829**	0.496
SI1	0.440	0.447	0.453	0.431	0.426	0.516	0.370	0.495	0.395	0.437	0.392	0.350	**0.784**
SI2	0.501	0.416	0.407	0.487	0.462	0.518	0.452	0.487	0.467	0.452	0.475	0.518	**0.825**
SI3	0.450	0.389	0.348	0.421	0.387	0.463	0.375	0.397	0.443	0.477	0.491	0.425	**0.831**
SI4	0.455	0.453	0.472	0.498	0.465	0.543	0.419	0.450	0.487	0.483	0.491	0.456	**0.790**
SI5	0.466	0.446	0.447	0.487	0.381	0.469	0.384	0.395	0.351	0.418	0.487	0.553	**0.781**

because of the improvement in dynamic capabilities and enhancement of the contribution of BDAT to dynamic capabilities. Personnel's knowledge and capabilities should be upgraded (e.g., equipment with competitive artificial intelligence knowledge, skill, and even AI capabilities). These areas are the future development directions that firms must develop and combat via successful staff training and corresponding knowledge or skills equipment considering their empiricism, dependence, and routinization to digital platforms. Human resources can be arranged to a position with creative requirements in order to acquire additional benefits.

Second, our research results provide executives with an explicit direction to implement BDAC building programs. Our finding demonstrates that BDAT and BDAP perform as a basis in developing dynamic capabilities, which are positively related to service innovation. Firms should focus on investment in technical infrastructure and staff training in the BDA field to improve the efficiency and effectiveness of their dynamic capabilities building. Specifically, the

TABLE 7. Common method bias analysis.

Construct	Second Order	Indicator	Substantive Factor Loading (R1)	R12	Method Factor Loading (R2)	R22
BDAP	TM	TM1	1.070**	1.143	-0.349*	0.122
		TM2	1.170**	1.362	-0.347**	0.120
		TM3	0.810**	0.654	-0.055	0.003
	TK	TK1	0.700**	0.493	0.039	0.002
		TK2	0.810**	0.656	0.031	0.001
		TK3	0.480**	0.230	0.339*	0.115
		TK4	0.770**	0.591	0.069	0.005
	BK	BK1	0.690**	0.477	0.065	0.004
		BK2	0.620**	0.383	0.191	0.036
		BK3	0.470**	0.220	0.114	0.013
	RK	RK1	0.770**	0.594	0.042	0.002
		RK2	1.030**	1.055	-0.298*	0.089
		RK3	0.610**	0.368	0.166	0.028
BDAT	CN	CN1	0.761**	0.579	0.064	0.004
		CN2	1.166**	1.360	-0.372**	0.138
		CN3	0.784**	0.615	0.063	0.004
	CM	CM1	0.849**	0.721	-0.004	0.000
		CM2	0.986**	0.972	-0.260	0.068
		CM3	0.731**	0.534	0.105	0.011
	MD	MD1	0.754**	0.569	0.033	0.001
		MD2	0.835**	0.697	-0.031	0.001
		MD3	0.559**	0.312	0.295**	0.087
		MD4	0.715**	0.511	0.075	0.006
DPC	DPC	DPC1	0.918**	0.843	-0.082	0.007
		DPC2	0.904**	0.817	-0.067	0.004
		DPC3	0.991**	0.982	-0.204**	0.042
		DPC4	0.876**	0.767	-0.002	0.000
		DPC5	0.683**	0.466	0.138	0.019
		DPC6	0.628**	0.394	0.220**	0.048
DC	CIC	CIC1	0.876**	0.767	-0.084	0.007
		CIC2	0.864**	0.746	-0.059	0.003
		CIC3	0.914**	0.835	-0.111	0.012
	TDC	TDC1	0.787**	0.619	0.072	0.005
		TDC2	0.832**	0.692	-0.013	0.000
		TDC3	0.810**	0.656	0.010	0.000
	SSC	SSC1	0.763**	0.582	-0.091	0.008
		SSC2	0.611**	0.373	0.187	0.035
		SSC3	0.755**	0.570	0.072	0.005
SI	SI	SI1	0.799**	0.638	-0.016	0.000
		SI2	0.797**	0.635	0.034	0.001
		SI3	0.924**	0.854	-0.116*	0.013
		SI4	0.724**	0.524	0.083	0.007
		SI5	0.764**	0.584	0.019	0.000
ED	ED	ED1	0.702**	0.493	0.083	0.007
		ED2	0.909**	0.826	-0.176*	0.031
		ED3	0.915**	0.837	-0.055	0.003
		ED4	0.812**	0.659	-0.006	0.000
		ED5	0.706**	0.498	0.150	0.023
Average	----	----	**0.800**	**0.662**	**0.000**	**0.024**

TABLE 8. Heterotrait–Monotrait ratio (HTMT) ratio of the first-order factors.

	BK	CM	CN	DPC	ED	MD	RK	SI	SIC	SSC	TDC	TK	TM
BK	--												
CM	0.775	–											
CN	0.699	0.895	–										
DPC	0.676	0.780	0.789	--									
ED	0.786	0.644	0.564	0.622	–								
MD	0.809	0.892	0.868	0.811	0.754	–							
RK	0.893	0.685	0.681	0.586	0.639	0.663	--						
SI	0.648	0.561	0.531	0.537	0.589	0.588	0.534	--					
SIC	0.741	0.661	0.636	0.604	0.679	0.613	0.758	0.500	–				
SSC	0.797	0.718	0.684	0.620	0.743	0.726	0.723	0.593	0.784	--			
TDC	0.750	0.723	0.705	0.613	0.779	0.691	0.765	0.598	0.849	0.898	--		
TK	0.880	0.777	0.825	0.697	0.661	0.830	0.868	0.626	0.636	0.778	0.768	–	
TM	0.857	0.640	0.693	0.642	0.524	0.674	0.804	0.498	0.643	0.682	0.733	0.872	--

connectivity, compatibility, and modularity of BDA infrastructure should be enhanced to strengthen the flexibility of BDA infrastructure wholly. Regular staff training that focuses on knowledge and skills are required: 1) fundamental internal knowledge or skills related to BDA and how to operate and manage BDA software and hardware and 2) external knowledge related to clear organization plans, functions, existing business trends, and know-how for implementing

TABLE 9. Test of mediating role.

Path	Direct Effect	95% confidence interval	t value	Sig. (p<0.05)	Indirect Effect	95% confidence interval	t value	Sig. (p<0.05)
BDAP ->SI	0.228	(0.021,0.429)	1.845	0.033	0.162	(0.056, 0.287)	2.292	0.011
BDAT ->SI	0.199	(0.042,0.351)	2.127	0.017	0.094	(0.028, 0.189)	1.860	0.031

cross-department collaboration. Firms should utilize BDAT and BDAP to develop service innovation comprehensively.

Third, managers should focus on the BDAC's value delivery mechanism and take targeted strategies to adapt to environmental changes. Our results indicate the mediating role of dynamic capabilities during the value delivery process and highlights how BDAT, BDAP, and digital platform capabilities can be leveraged as a source of service innovation. Managers should consider dynamic capabilities building by investing in antecedents because doing so will significantly contribute to service innovation improvement if the environment is in a proper situation (the literature shows that the result of dynamic capabilities should be in a proper range). Meanwhile, the monitoring of current industrial and business environments becomes particularly crucial for firms. At a high level of the dynamic environment, the innovation risk increases, and managers should adopt the conservative developing plan and moderately decrease blind or bold investment or projects related to innovation. In a low-dynamism environment, key decision-makers should put more attention to the fist-mover advantages and increase investment in human resources and infrastructure related to BDA and digital platforms.

VII. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study has the following limitations: First, the size of this investigation sample is relatively small, and the sample range is relatively narrow. Future research should be increased for enhanced statistical power and resulting generality by expanding the effective quantity and range, such as by gathering more than 250 samples from different countries. Second, the survey is not based on a pairwise design. Future studies can design a paired questionnaire survey wherein BDAT, BDAP, and digital platform capabilities are assessed by IS or IT managers and dynamic capabilities, service innovation, and environmental dynamism are evaluated by CEOs to solve the problem of social desirability. Third, the measurement in the questionnaire belongs to cross-sectional data that cannot solve the temporal lag problem with causality. The dynamic process research model, combined with financial and operational data, can be developed in future research design.

Future research directions are as follows: First, researchers should focus on the moderating roles of other factors, such as organization technical orientation. Firms with high-level technical orientation require a high quantity and quality of BDA resources and investment for developing dynamic capabilities. Therefore, the fit between BDAT/BDAP and technical orientation should be examined. Second, additional intermediate variables, such as organization improvising competence, customer agility, and knowledge management capabilities, can be investigated. Firms in different industries require various aspects of capabilities to enable service innovation. For instance, manufacturers can rely on improvising competence to produce different types of products. Knowledge-intensive industries may rely on knowledge management capabilities to integrate an organization's existing knowledge and skills into service delivery. The entertainment industry may rely on customer agility to create innovative service in the market. Third, future research should focus on the relationship between several specific capabilities relevant to BDA (e.g., BDA decision capabilities) or artificial intelligence (e.g., AI capabilities) and examine their relationship with dynamic capabilities, service innovation, and value creation. These studies may enrich the literature in the digital innovation area and deliver novel perspectives to leverage big data resources. Correspondingly, these topics are also significant and proactive strategic issues for organization development and business competition in the future. Finally, digital innovation or digital service innovation should be regarded as the outcome of BDAC because they may support organizations in extracting additional value from BDA resources; moreover, related literature in the private sector is scared [80], [81].

VIII. CONCLUSION

This study draws on the dynamic capabilities view to conduct an integrated analysis of BDAP, BDAT, digital platform capabilities, and service innovation. Specifically, digital platform capabilities are observed as an antecedent of dynamic capabilities and a quasi-moderator of the BDAT–digital platform capabilities and BDAP–digital platform capabilities relationships. These findings respond to the call for research on the interaction of dynamic capabilities' antecedents. Moreover, digital platform capabilities positively moderate the relationship between BDAT and dynamic capabilities, thereby emphasizing the fit and coordination of BDA infrastructure and digital platform. By contrast, digital platform capabilities negatively moderate the relationship between BDAP and dynamic capabilities; this result reminds managers to note the personnel overdependence on digital platform functions, eliminate stagnation, and upgrade knowledge and skills. Moreover, this study investigates the negative moderating

TABLE 10. The constructs and measurement.

Construct	Items	Resource
Service Innovation	SI1: Our company has developed new services.	[1]
	SI2: Our company has improved and promoted existing services.	
	SI3: Our company has repackaged and promoted existing services.	
	SI4: Our company has extended and promoted existing service lines.	
	SI5: Our company has introduced new services that competitors do not offer in the market.	
Environmental Dynamism	ED1: The modes of production/service change often and in a major way.	[48]
	ED2: The environmental demands on us are constantly changing.	
	ED3: Marketing practices in our industry are constantly changing.	
	ED4: Environmental changes in our industry are unpredictable.	
	ED5: our environment, new business models evolve frequently	
Digital Platform Capabilities	Platforms to Connect to Businesses	[44], [45]
	DPC1: We have built databases that contain information about consumers and their behaviors that businesses can use to reach a target group.	
	DPC2: We have developed digital platforms to launch direct digital marketing programs for businesses.	
	DPC3: We have developed digital platforms that make it easier or more affordable for businesses to reach their prospects.	
	Platforms to Connect to Consumers	
	DPC4: We have built databases that contain extensive local information that consumers need for everyday- life decisions.	
	DPC5: We have developed digital platforms for consumers to share prior experiences, knowledge, and expertise.	
	DPC6: We have developed digital platforms for consumers to share news and information and engage in community dialogue and conversation.	
Dynamic Capabilities	Strategic Sensing capacity	[50], [53]
	SSC1: We often have meetings to discuss the market demand	
	SSC2: We have a perfect information management system	
	SSC3: We have good observation and judgment ability.	
	Timely decision-making capacity	
	TDC1: We can quickly deal with conflicts in the strategic decision-making process	
	TDC2: Under many circumstances, we can make timely decisions to deal with strategic problems	
	TDC3: We can reconfigure resources in time to address environmental change.	
	Change implementation capacity	
	CIC1: Our strategic changes can be efficiently carried out	
	CIC2: Good cooperation exists among different functions	
	CIC3: We help each other with strategic change implementation	
Big Data Analytics Technology Capabilities	Connectivity	[14], [20]
	CN1: Compared to rivals within our industry, our organization has the foremost available analytics systems	
	CN2: All remote, branch, and mobile offices are connected to the central office for analytics.	
	CN3: Our organization utilizes open systems network mechanisms to boost analytics connectivity.	
	Compatibility	
	CM1: Software applications can be easily transported and on across multiple analytics platforms.	
	CM2: Our user interfaces provide transparent access to all platforms and applications	
	CM3: Analytics-driven information is shared seamlessly across our organization, regardless of the location.	
	Modularity	
	MD1: Reusable software modules are widely used in new analytics model development.	
	MD2: End-users utilize object-oriented tools to create their own analytics applications.	
	MD3: Object-oriented technologies are utilized to minimize the development time for new analytics applications.	
	MD4: Applications can be adapted to meet a variety of needs during analytics tasks.	
Big Data Analytics Personnel Capabilities	Technical Knowledge	[14], [20]
	TK1: Our analytics personnel are very capable in terms of programming skills	
	TK2: Our analytics personnel are very capable in terms of managing project lifecycles.	
	TK3: Our analytics personnel are very capable in the areas of data and network management and maintenance.	
	TK4: Our analytics personnel create very capable decision support systems driven by analytics.	
	Technology Management Knowledge	
	TM1: Our analytics personnel show a superior understanding of technological trends.	
	TM2: Our analytics personnel show superior ability to learn new technologies.	
	TM3: Our analytics personnel are very knowledgeable about the role of big data analytics as a means, not an end.	
	Business Knowledge	
	BK1: Our analytics personnel understand our organization's policies and plans at a very high level.	
	BK2: Our analytics personnel are very knowledgeable about business functions.	
	BK3: Our analytics personnel are very knowledgeable about the business environment.	
	Relational Knowledge	
	RK1: Our analytics personnel are very capable in terms of planning and executing work in a collective environment.	
	RK2: Our analytics personnel are very capable in terms of teaching others.	
	RK3: Our analytics personnel work closely with customers and maintain productive user/client relationships.	
Key Question	Does your firm outsource the data analytics business?" with the options of "Yes", "No, _____ (Please indicate the outsource percentage)"	

role of environmental dynamism between dynamic capabilities and service innovation. The findings remind firms of the risk of performing service innovation in uncertain environments. Our results also show that dynamic capabilities partially mediate the effects of BDAT (BDAP) on service innovation. These findings advance and enrich the literature on the BDA value chain, dynamic capabilities linkage, digital platform construction, and service innovation enablers.

APPENDIXES

APPENDIX A

See the Table 5.

APPENDIX B

See the Table 6.

APPENDIX C

See the Table 7.

APPENDIX D

See the Table 8.

APPENDIX E

See the Table 9.

APPENDIX F

See the Table 10.

REFERENCES

[1] K.-H. Chen, C.-H. Wang, S.-Z. Huang, and G. C. Shen, "Service innovation and new product performance: The influence of market-linking capabilities and market turbulence," *Int. J. Prod. Econ.*, vol. 172, pp. 54–64, Feb. 2016.

[2] H. S. Ryu and J. N. Lee, "Understanding the role of technology in service innovation: Comparison of three theoretical perspectives," *Inf. Manag.*, vol. 55, no. 3, pp. 294–307, Apr. 2018.

[3] F. Svahn, L. Mathiassen, and R. Lindgren, "Embracing digital innovation in incumbent firms: How Volvo cars managed competing concerns," *MIS Quart. Manage. Inf. Syst.*, vol. 41, no. 1, pp. 239–253, Jan. 2017.

[4] I. D. Constantiou and J. Kallinikos, "New games, new rules: Big data and the changing context of strategy," *J. Inf. Technol.*, vol. 30, no. 1, pp. 44–57, Mar. 2015.

[5] R. Van der Meulen and V. Woods, "Gartner survey shows more than 75 percent of companies are investing or planning to invest in big data in the next two years," *Gartner*, vol. 5, pp. 1–2, Sep. 2015.

[6] C. Lehrer, A. Wieneke, J. vom Brocke, R. Jung, and S. Seidel, "How big data analytics enables service innovation: Materiality, affordance, and the individualization of service," *J. Manage. Inf. Syst.*, vol. 35, no. 2, pp. 424–460, Apr. 2018.

[7] W. J. Orlikowski and S. V. Scott, "The algorithm and the crowd: Considering the materiality of service innovation," *MIS Quart. Manage. Inf. Syst.*, vol. 39, no. 1, pp. 201–216, Jan. 2015.

[8] R. F. Lusch and S. Nambisan, "Service innovation: A service-dominant logic perspective," *MIS Quart. Manage. Inf. Syst.*, vol. 39, no. 1, pp. 155–175, Jan. 2015.

[9] P. Mikalef, M. Boura, G. Lekakos, and J. Krogstie, "Big data analytics and firm performance: Findings from a mixed-method approach," *J. Bus. Res.*, vol. 98, pp. 261–276, May 2019.

[10] D. Kindström, C. Kowalkowski, and E. Sandberg, "Enabling service innovation: A dynamic capabilities approach," *J. Bus. Res.*, vol. 66, no. 8, pp. 1063–1073, Aug. 2013.

[11] M. Barrett, E. Davidson, J. Prabhu, and S. L. Vargo, "Service innovation in the digital age: Key contributions and future directions," *MIS Quart. Manage. Inf. Syst.*, vol. 39, no. 1, pp. 135–154, Jan. 2015.

[12] T. P. Raptis, A. Passarella, and M. Conti, "Data management in industry 4.0: State of the art and open challenges," *IEEE Access*, vol. 7, pp. 97052–97093, Jul. 2019.

[13] M. De Reuver, C. Sørensen, and R. C. Basole, "The digital platform: A research agenda," *J. Inf. Technol.*, vol. 33, no. 2, pp. 124–135, Jun. 2018.

[14] S. Akter, S. F. Wamba, A. Gunasekaran, R. Dubey, and S. J. Childe, "How to improve firm performance using big data analytics capability and business strategy alignment?" *Int. J. Prod. Econ.*, vol. 182, pp. 113–131, Dec. 2016.

[15] V. Grover, R. H. L. Chiang, T.-P. Liang, and D. Zhang, "Creating strategic business value from big data analytics: A research framework," *J. Manage. Inf. Syst.*, vol. 35, no. 2, pp. 388–423, Apr. 2018.

[16] M. Gupta and J. F. George, "Toward the development of a big data analytics capability," *Inf. Manag.*, vol. 53, no. 8, pp. 1049–1064, Dec. 2016.

[17] O. Schilke, S. Hu, and C. E. Helfat, "Quo vadis, dynamic capabilities? A content-analytic review of the current state of knowledge and recommendations for future research," *Acad. Manage. Ann.*, vol. 12, no. 1, pp. 390–439, Jan. 2018.

[18] M. Fay and N. Kazantsev, "When smart gets smarter: How big data analytics creates business value in smart manufacturing," in *Proc. ICIS*, San Francisco, CA, USA, 2018, pp. 1–9.

[19] M. Marjani, F. Nasaruddin, A. Gani, A. Karim, I. A. T. Hashe, A. Siddiqa, and I. Yaqoob, "Big IoT data analytics: Architecture, opportunities, and open research challenges," *IEEE Access*, vol. 5, pp. 5247–5261, 2017.

[20] S. F. Wamba, A. Gunasekaran, S. Akter, S. J. Ren, R. Dubey, and S. J. Childe, "Big data analytics and firm performance: Effects of dynamic capabilities," *J. Bus. Res.*, vol. 70, no. 2, pp. 356–365, Jan. 2017.

[21] D. Trabucchi, L. Talenti, and T. Buganza, "How do big bang disruptors look like? A business model perspective," *Technol. Forecast. Soc. Change*, vol. 141, pp. 330–340, Apr. 2019.

[22] N. Côrte-Real, T. Oliveira, and P. Ruivo, "Assessing business value of big data analytics in European firms," *J. Bus. Res.*, vol. 70, pp. 379–390, Jan. 2017.

[23] P. Mikalef, M. Boura, G. Lekakos, and J. Krogstie, "Big data analytics capabilities and innovation: The mediating role of dynamic capabilities and moderating effect of the environment," *Brit. J. Manage.*, vol. 30, no. 2, pp. 272–298, Apr. 2019.

[24] E. K. Chew, "iSIM: An integrated design method for commercializing service innovation," *Inf. Syst. Frontiers*, vol. 18, no. 3, pp. 457–478, Jun. 2016.

[25] S. C. Srivastava and G. Shainesh, "Bridging the service divide through digitally enabled service innovations: Evidence from Indian healthcare service providers," *MIS Quart. Manage. Inf. Syst.*, vol. 39, no. 1, pp. 245–267, Jan. 2015.

[26] C.-H. Lee, "Building a generic platform for big sensor data application," in *Proc. IEEE Int. Conf. Big Data*, Silicon Valley, CA, USA, Oct. 2013, pp. 94–102.

[27] Y. Chen, Y. Wang, S. Nevo, J. Jin, L. Wang, and W. S. Chow, "IT capability and organizational performance: The roles of business process agility and environmental factors," *Eur. J. Inf. Syst.*, vol. 23, no. 3, pp. 326–342, Mar. 2014.

[28] V. Barrales-Molina, F. Bustinza, and L. J. Gutiérrez-Gutiérrez, "Explaining the causes and effects of dynamic capabilities generation: A multiple-indicator multiple-cause modelling approach," *Brit. J. Manag.*, vol. 24, no. 4, pp. 571–591, Dec. 2013.

[29] P. Skålen, J. Gummerus, C. von Koskull, and P. R. Magnusson, "Exploring value propositions and service innovation: A service-dominant logic study," *J. Acad. Marketing Sci.*, vol. 43, no. 2, pp. 137–158, Mar. 2015.

[30] S. Solaimani, H. Bouwman, and T. Itälä, "Networked enterprise business model alignment: A case study on smart living," *Inf. Syst. Frontiers*, vol. 17, no. 4, pp. 871–887, Nov. 2015.

[31] N. Roberts, D. E. Campbell, and L. R. Vijayasarathy, "Using information systems to sense opportunities for innovation: Integrating postadoptive use behaviors with the dynamic managerial capability perspective," *J. Manage. Inf. Syst.*, vol. 33, no. 1, pp. 45–69, Jan. 2016.

[32] K. Trantopoulos, G. Von Krogh, M. W. Wallin, and M. Woerter, "External knowledge and information technology: Implications for process innovation performance," *MIS Quart. Manage. Inf. Syst.*, vol. 41, no. 1, pp. 287–300, Mar. 2017.

[33] R. Sharma, S. Mithas, and A. Kankanhalli, "Transforming decision-making processes: A research agenda for understanding the impact of business analytics on organisations," *Eur. J. Inf. Syst.*, vol. 23, no. 4, pp. 433–441, Jul. 2014.

[34] N. Melville, K. Kraemer, and V. Gurbaxani, "Review: Information technology and organizational performance: An integrative model of it business value," *MIS Quart. Manage. Inf. Syst.*, vol. 28, no. 2, pp. 283–322, Jun. 2004.

[35] D. J. Teece, "The foundations of enterprise performance: Dynamic and ordinary capabilities in an (economic) theory of firms," *Acad. Manage. Perspect.*, vol. 28, no. 4, pp. 328–352, Nov. 2014.

[36] A. Rizk, B. Bergvall-Kåreborn, and A. Elragal, "Digital service innovation enabled by big data analytics—A review and the way forward," in *Proc. ICSS*, Hilton Waikoloa Village, HI, USA, 2017, pp. 1247–1256.

[37] A. Popović, R. Hackney, R. Tassabehji, and M. Castelli, "The impact of big data analytics on firms' high value business performance," *Inf. Syst. Frontiers*, vol. 20, no. 2, pp. 209–222, Oct. 2018.

[38] D. Q. Chen, D. S. Preston, and M. Swink, "How the use of big data analytics affects value creation in supply chain management," *J. Manage. Inf. Syst.*, vol. 32, no. 4, pp. 4–39, Oct. 2015.

[39] S. Mandal,"Exploring the influence of big data analytics management capabilities on sustainable tourism supply chain performance: The moderating role of technology orientation," *J. Travel Tourism Marketing*, vol. 35, no. 8, pp. 1104–1118, Oct. 2018.

[40] P. Mikalef, J. Krogstie, I. O. Pappas, and P. Pavlou, "Exploring the relationship between big data analytics capability and competitive performance: The mediating roles of dynamic and operational capabilities," *Inf. Manag.*, to be published, doi: 10.1016/j.im.2019.05.004.

[41] D. J. Teece, G. Pisano, and A. Shuen, "Dynamic capabilities and strategic management," *Manage. J.*, vol. 18, no. 7, pp. 509–533, Aug. 1997.

[42] C. E. Helfat and S. G. Winter, "Untangling dynamic and operational capabilities: Strategy for the (N)ever-changing world," *Strategic Manage. J.*, vol. 32, no. 11, pp. 1243–1250, Nov. 2011.

[43] M. L. Sheng, "Foreign tacit knowledge and a capabilities perspective on MNE product innovativeness: Examining source-recipient knowledge absorption platforms," *Int. J. Inf. Manage.*, vol. 44, pp. 154–163, Feb. 2019.

[44] J. Karimi and Z. Walter, "The role of dynamic capabilities in responding to digital disruption: A factor-based study of the newspaper industry," *J. Manage. Inf. Syst.*, vol. 32, no. 1, pp. 39–81, Jan. 2015.

[45] D. Sedera, S. Lokuge, V. Grover, S. Sarker, and S. Sarker, "Innovating with enterprise systems and digital platforms: A contingent resource-based theory view," *Inf. Manag.*, vol. 53, no. 3, pp. 366–379, Apr. 2016.

[46] D. Nylén and J. Holmström, "Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation," *Bus. Horizons*, vol. 58, no. 1, pp. 57–67, Jan. 2015.

[47] G. Vial, "Understanding digital transformation: A review and a research agenda," *J. Strategic Inf. Syst.*, vol. 28, no. 2, pp. 118–144, Jun. 2019.

[48] O. Schilke, "On the contingent value of dynamic capabilities for competitive advantage: The nonlinear moderating effect of environmental dynamism," *Strategic Manage. J.*, vol. 35, no. 2, pp. 179–203, Feb. 2014.

[49] R. Wilden, T. M. Devinney, and G. R. Dowling, "The architecture of dynamic capability research identifying the building blocks of a configurational approach," *Acad. Manage. Ann.*, vol. 10, no. 1, pp. 997–1076, Jan. 2016.

[50] D.-Y. Li and J. Liu, "Dynamic capabilities, environmental dynamism, and competitive advantage: Evidence from China," *J. Bus. Res.*, vol. 67, no. 1, pp. 2793–2799, Jan. 2014.

[51] A. Protogerou, Y. Caloghirou, and S. Lioukas, "Dynamic capabilities and their indirect impact on firm performance," *Ind. Corporate Change*, vol. 21, no. 3, pp. 615–647, Jun. 2012.

[52] H. Jiao, I. Alon, C. K. Koo, and Y. Cui, "When should organizational change be implemented? The moderating effect of environmental dynamism between dynamic capabilities and new venture performance," *J. Eng. Technol. Manage.*, vol. 30, no. 2, pp. 188–205, Apr. 2013.

[53] V. Wohlgemuth and M. Wenzel, "Dynamic capabilities and routinization," *J. Bus. Res.*, vol. 69, no. 5, pp. 1944–1948, 2016.

[54] S. Zheng, W. Zhang, and J. Du, "Knowledge-based dynamic capabilities and innovation in networked environments," *J. Knowl. Manag.*, vol. 15, no. 6, pp. 1035–1051, Oct. 2011.

[55] D. A. Battleson, B. C. West, J. Kim, B. Ramesh, and P. S. Robinson, "Achieving dynamic capabilities with cloud computing: An empirical investigation," *Eur. J. Inf. Syst.*, vol. 25, no. 3, pp. 209–230, Nov. 2016.

[56] A. Chakravarty, R. Grewal, and V. Sambamurthy, "Information technology competencies, organizational agility, and firm performance: Enabling and facilitating roles," *Inf. Syst. Res.*, vol. 24, no. 4, pp. 976–997, Oct. 2013.

[57] V. Ramaswamy and K. Ozcan, "Offerings as digitalized interactive platforms: A conceptual framework and implications," *J. Marketing*, vol. 82, no. 4, pp. 19–31, Jul. 2018.

[58] Y. K. Dwivedi, "Research on information systems failures and successes: Status update and future directions," *Inf. Syst. Frontiers*, vol. 17, no. 1, pp. 143–157, Feb. 2014.

[59] J. K. Nwankpa and P. Datta, "Balancing exploration and exploitation of IT resources: The influence of digital business intensity on perceived organizational performance," *Eur. J. Inf. Syst.*, vol. 26, no. 5, pp. 469–488, May 2017.

[60] A. Frederiksen, "Competing on analytics: The new science of winning," *Total Qual. Manage. Bus. Excellence*, vol. 20, no. 5, p. 583, Jun. 2009.

[61] N. Kumar, L. Qiu, and S. Kumar, "Exit, voice, and response on digital platforms: An empirical investigation of online management response strategies," *Inf. Syst. Res.*, vol. 29, no. 4, pp. 849–870, Dec. 2018.

[62] C. Camisón and V. M. Monfort-Mir, "Measuring innovation in tourism from the Schumpeterian and the dynamic-capabilities perspectives," *Tourism Manage.*, vol. 33, no. 4, pp. 776–789, Aug. 2012.

[63] D. J. Teece, "Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance," *Strategic Manage. J.*, vol. 28, no. 13, pp. 1319–1350, Dec. 2007.

[64] M. J. Janssen, C. Castaldi, and A. Alexiev, "Dynamic capabilities for service innovation: Conceptualization and measurement," *R&D Manage*, vol. 46, no. 4, pp. 797–811, Sep. 2016.

[65] M. Kim, J. Song, and J. Triche, "Toward an integrated framework for innovation in service: A resource-based view and dynamic capabilities approach," *Inf. Syst. Frontiers*, vol. 17, no. 3, pp. 533–546, Jun. 2015.

[66] S. M. S. Khaksar, F. S. Shahmehr, R. Khosla, and M. T. Chu, "Dynamic capabilities in aged care service innovation: The role of social assistive technologies and consumer-directed care strategy," *J. Services Marketing*, vol. 31, no. 7, pp. 745–759, Oct. 2017.

[67] H. Liu, S. Wei, W. Ke, K. K. Wei, and Z. Hua, "The configuration between supply chain integration and information technology competency: A resource orchestration perspective," *J. Oper. Manage.*, vol. 44, no. 1, pp. 13–29, May 2016.

[68] O. K. Lee, V. Sambamurthy, K. H. Lim, and K. K. Wei, "How does IT ambidexterity impact organizational agility?" *Inf. Syst. Res.*, vol. 26, no. 2, pp. 398–417, Jun. 2015.

[69] J. Ferreira, A. Coelho, and L. Moutinho, "Dynamic capabilities, creativity and innovation capability and their impact on competitive advantage and firm performance: The moderating role of entrepreneurial orientation," *Technovation*, to be published, doi: 10.1016/j.technovation.2018.11.004.

[70] T. Fischer, H. Gebauer, M. Gregory, G. Ren, and E. Fleisch, "Exploitation or exploration in service business development?: Insights from a dynamic capabilities perspective," *J. Service Manage.*, vol. 21, no. 5, pp. 591–624, Oct. 2010.

[71] S. Shamim, J. Zeng, S. M. Shariq, and Z. Khan, "Role of big data management in enhancing big data decision-making capability and quality among Chinese firms: A dynamic capabilities view," *Inf. Manag.*, vol. 56, no. 6, pp. 103–135, Sep. 2019.

[72] J. Zeng and K. W. Glaister, "Value creation from big data: Looking inside the black box," *Strategic Org.*, vol. 16, no. 2, pp. 105–140, May 2018.

[73] P. M. Podsakoff, S. B. MacKenzie, J.-Y. Lee, and N. P. Podsakoff, "Common method biases in behavioral research: A critical review of the literature and recommended remedies.," *J. Appl. Psychol.*, vol. 88, no. 5, pp. 879–903, Oct. 2003.

[74] H. Liang, N. Saraf, Q. Hu, and Y. Xue, "Assimilation of enterprise systems: The effect of institutional pressures and the mediating role of top management," *MIS Quart. Manage. Inf. Syst.*, vol. 31, no. 1, pp. 59–87, Mar. 2007.

[75] J. F. Hair, C. M. Ringle, and M. Sarstedt, "PLS-SEM: Indeed a silver bullet," *J. Marketing Theory Pract.*, vol. 19, no. 2, pp. 139–152, Dec. 2011.

[76] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *J. Marketing Res.*, vol. 18, no. 1, pp. 39–50, Feb. 1981.

[77] M. Ghasemaghaei, K. Hassanein, and O. Turel, "Increasing firm agility through the use of data analytics: The role of fit," *Decis. Support Syst.*, vol. 101, pp. 95–105, Sep. 2017.

[78] H. Mao, S. Liu, J. Zhang, and Z. Deng, "Information technology resource, knowledge management capability, and competitive advantage: The moderating role of resource commitment," *Int. J. Inf. Manage.*, vol. 36, no. 6, pp. 1062–1074, Jul. 2016.

[79] D. Gefen and D. Straub, "A practical guide to factorial validity using PLS-graph: Tutorial and annotated example," *Commun. Assoc. Inf. Syst.*, vol. 16, p. 5, Oct. 2005.
[80] M. Tate, I. Bongiovanni, M. Kowalkiewicz, and P. Townson, "Managing the 'Fuzzy front end' of open digital service innovation in the public sector: A methodology," *Int. J. Inf. Manage.*, vol. 39, pp. 186–198, Jul. 2018.
[81] S. Lokuge, D. Sedera, V. Grover, and X. Dongming, "Organizational readiness for digital innovation: Development and empirical calibration of a construct," *Inf. Manag.*, vol. 56, no. 3, pp. 445–461, Apr. 2019.

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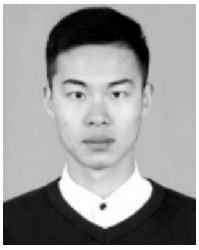

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