Empirical study on the relationship between big data application ability and Enterprise Innovation performance

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Abstracts

From the perspective of service supply chain integration, from the theory of resource base theory and IT ability, to verify the mediation effect of service supply chain integration and on the basis of strategic flexible adjustment effect, explore the ability of big data application mechanism of enterprise innovation performance, in order to enrich the related theory and guide the practice of enterprise management.

Keywords: Big Data Application Ability; Enterprise Innovation Performance; Empirical Research

Introduction

With the further development of economy, the more and more mature applications such as big data and other information technologies has a far-reaching impact on economic development. Enterprises need not only labor production capacity, but also the ability to apply big data to operate complex and changeable related systems (Niederman et al. 2006). The application of big data technology has still become an important tool for enterprises to deeply demand market positioning, mine information resources, optimize resource allocation, promote the integration of supply chain, and further promote enterprise innovation.

If enterprises want to win more consumers in a dominant position in the middle of the competition, they need to innovate and seize the market faster. However, the influence of big data on enterprise innovation performance is controversial, and the mechanism needs to be further discussed. At the same time, the dominant idea of service supply chain management is to serve consumers as the core, enterprises want to know more about consumers, need huge amounts of data accurate positioning consumers, enterprises began to attach importance to the application of big data technology, in order to quickly meet customer needs, enterprises need faster and better coordinated service resources, integration of supply chain, reduce the redundant process collaborative integration to improve the innovation of the enterprise.

Therefore, it is necessary to explore the process mechanism of big data application ability, and to explore the impact of big data application ability on enterprise innovation performance and the role of service supply chain integration in it.

Literature Review

Big data application ability is an important means of supply chain integration, which makes the communication, coordination and negotiation between enterprises and manufacturers, customers and other partners become more convenient and efficient, which is conducive to the good interaction of the supply chain network. Lusch and Nambisan (2015) big data application capabilities serve not only as an object resource but also as an operational system, which can not only promote the establishment of the entire value network, but also promote the sharing and integration of information, knowledge and other resources in the network. The most competitive enterprises in today's society are those enterprises that can apply big data technology to closely integrate customers and suppliers together. They are very good at using big data technology to understand and meet the preferences or demands of customers and resource owners, and successfully integrate them. In short, an efficient service supply chain integration needs accurate and real-time information sharing, and the good application of big data just improves the good support for the realization of service supply chain integration.

In the face of the complex and changeable global economic situation, the competition between enterprises has gradually transformed into the competition between supply chain management. Therefore, strengthening the supply chain management is becoming an important way for enterprises to obtain the core competitiveness, among which promoting the integration of the supply chain is the core and the key of the successful supply chain management. In recent years, supply chain consolidation has attracted the attention of many entrepreneurs and related scholars (Flynn et al., 2010; Zhao et al., 2013; Srinivasan and Swink, 2015; Huang Jien et al., 2021; Dou Chao et al., 2020). At the same time, academic research shows that enterprises can increase their market competitiveness and improve their performance through supply chain integration. In particular, the external integration of service supply chain will have a direct impact on the performance of service supply chain. In which customer integration can be enterprises timely obtain customer feedback information and quickly adjust the service content and its provision methods, thus improving the customer service level (Wongetal.2001; Fan Jun and Gao Meng, 2016). Customer integration can also build a better relationship between customers and enterprises, enable customers to better experience and understand the service, and reduce the market risk of service products (Jaakkolaetal.2017）。Chavez et al. (2015) believe that customer integration can reduce enterprise costs and promote the identification and solution of service problems, thus improve service quality and further improve supply chain performance. The rise of the platform economy makes the external integration of the service supply chain have an increasing impact on the operation performance of the entire supply chain. The integration of external organizations is conducive to the process optimization and resource integration among various parts of the enterprise (Wu Jiaxi and Wu Guisheng, 2009). Liu Huaming and Wang Yong (2017) showed that both supplier integration and customer integration will have a significant positive impact on performance. Ataseven and Niar (2017) show that long-term partnerships can effectively integrate suppliers and customers to improve operational processes to improve operational and financial performance.

In short, thorough analysis of the above scholars research results mainly include: first, academic research on big data application ability or primary stage, main research areas around the front end of big data application analysis and big data application and specific operation and related business decisions between the theory and empirical research, although some scholars began to study big data application ability on the mechanism of enterprise innovation,

but still lack of systematic theoretical deduction and related empirical support. Second, the mainstream research in the field of big data application capability is not very clear. The mainstream research focuses on the perspective from function to structure to elements (HAO S B; ZHANG H L and SONG M, 2019), the research only regards capability as a resource, but has not paid attention to the habit of resource system, resource acquisition and dependence, ignoring the application capability of human resource management and big data for big data related project management. Third, in the study of the impact on enterprise innovation performance, the academic community still did not study the impact of strategic flexibility and large data capability on innovation performance. Many literature mainly studies the direct relationship between service supply chain integration and performance or innovation performance. A small part of the literature research is the influence of big data application ability on enterprise innovation performance, but it rarely explores the relevant mechanism of service supply chain integration, and also the possible influence of strategic flexibility and other factors is ignored.

Theoretical models and assumptions

1. Relationship between big data application ability and enterprise innovation performance

The ability to use big data provides a new perspective and way for enterprises to accurately segment customers, tap potential needs and make personalized innovation, and has become an important driving force for enterprise technological innovation, product upgrading and iteration, and process optimization. Enterprise big data application ability, means that enterprises can use a new generation of data management technology and system facilities to cross-regional, cross-department long-scale semi-structured and unstructured data, make data acquisition, transfer, analysis and application more combined with enterprise operations, rich decision information source, reduce decision uncertainty and complexity, to improve enterprise insight and action (Osuszek, Stanek and Twardowski, 2016). At the same time, enterprises with big data professionals can give full play to their professional technology, management skills, business ability and collaboration spirit to provide knowledge and skills guarantee for enterprises to import big data management and drive innovation decisions (Opresnik and Taisch 2015). Finally, enterprises with strong big data application ability have reliable big data project planning and cross-organization coordination experience, and can realize more effective communication and cooperation between organizations with the help of big data technology, continuously improve business processes, jointly predict potential market demand, design competitive innovative products and quickly push them to new markets. Therefore, the following assumptions are made here:

H1: Big data application ability has a significant positive impact on enterprise innovation performance.

2. Relationship between service supply chain integration and enterprise innovation performance

Enterprise service innovation requires continuous and large-scale resource input. Resource integration across organizations, especially for suppliers, can help service integrators acquire key and complementary resources. Lusch and Nambisan (2015) emphasize that service innovation occurs in the collaborative process of the actor and actor network, and that the integration of resources involving different players is the fundamental way to achieve innovation. Vargo et al. (2015) emphasized that innovation is the combinatorial evolution of useful knowledge in the service ecosystem. It can be said that resource integration is the basic

approach to innovation. Therefore, service innovation is a collaborative process involving the resource integration of network system participants (LuschandNambisan, 2015: Barileetal, 2017). More studies have confirmed the positive role of supply chain integration on enterprise performance (Rahinan, 2013), Feng Changli et al. (2016) believe that supply chain integration directly promotes enterprise non-financial performance: Li Gang et al. (2017) research shows that enterprises using network ability to obtain external key knowledge can improve their financial performance and non-financial performance of service innovation. In addition, Ssatan et al (2015) also pointed out that service innovation needs to be determined through resource integration and determines service innovation in specific situations: Aal et al (2016) emphasized that resource integration across service system boundaries helps to achieve service innovation. Participants in the service ecosystem integrate their resources through service exchange to promote service innovation (LuschandNambisan, 2015; Aaletal, 2016). In the service supply chain system, the center integrator is closely related to the resource integration and performance of the service suppliers. Thus, the following assumptions are made:

H2: Service supply chain integration can positively affect enterprise innovation performance

H2-1: Service supply chain, internal integration can positively affect enterprise innovation performance

H2-2: Supplier integration of the service supply chain can positively affect the enterprise innovation performance

H2-3: Customer integration of the service supply chain can positively affect the enterprise innovation performance

3. Integration of big data application capabilities and service supply chain

Enterprises can rely on its big data application ability to promote supply chain integration, reflected in three aspects: first, promote information sharing, such as the use of Internet technology can quickly obtain sales, inventory, production and distribution data and sharing between each node enterprises, eliminate cooperation information asymmetry, so as to help the maintenance of long-term collaboration (Choi and Shen, 2016). Second guarantee joint decision-making, enterprises can use the huge data resources, through big data analysis technology insight into market demand and user changes, and other partners on the supply chain products and business process innovation, and suppliers and manufacturers according to the fluctuation of supply chain demand to achieve joint inventory and manufacturing on time, to improve the overall operation efficiency of supply chain (Wang Juying and Zhao Quanchao, 2014). Finally, build incentive alliances. The application of big data resources breaks the sharing barriers among the supply chain enterprises, closely combines the vertical alliance with the supply chain as the link, and effectively promotes the establishment of the alliance organizations with benefit sharing, risk sharing and coordinated development through the dynamic contract system and the reasonable benefit distribution mechanism. Considering the above analysis, big data application capabilities may have a positive impact on service supply chain integration. Therefore, this paper makes the following assumptions:

H3: Big data application capabilities can positively affect the service supply chain integration

H3-1: Big data application capabilities can positively affect the internal integration

H3-2: Big data application capabilities can positively affect supplier integration

H3-3: Big data application capabilities can positively affect customer integration

4. Intermediation effect of service supply chain integration

With the continuous accumulation of enterprise data resources and big data technology gradually mature, data-driven collaborative mode gradually become the main operation mode of supply chain ecosystem (etc. Feng Zhiyan, 2013), and the integration of data resources depends on good synergy between members, only by improving the quality of the relationship between members, enterprises can in business coordination and communication, identify evaluation innovation opportunities, absorb innovation knowledge, integration and complementary resources, eventually improve innovation performance (Xu Ke, He Zhen and Wang Rui, 2015). The evaluation of enterprise innovation opportunities requires a lot of data resources to provide decision support. Big data applications not only provide infrastructure for acquiring, storing and sharing massive data among partners in the supply chain, but also insight market demand and customer changes in real time to provide rich reference information for joint decision making between enterprises, thus promoting product and service innovation, operation process innovation, management system innovation and business model innovation (Schoenherr and Speier-Pero, 2015; Gunasekaran et al., 2017). Based on the above analysis, this paper believes that the application capability of big data will further improve the innovation performance of enterprises by improving the supply chain integration. Therefore, the following assumptions are made here:

H4-1: Big data application capabilities can affect innovation performance through internal integration

H4-2: Big data application capabilities can influence innovation performance through supplier integration

H4-3: Big data application capabilities can affect innovation performance through customer business integration

5. Regulation effect of strategic flexibility

Strategic flexibility is the ability of enterprises to reset and restructure organizational resources, processes and strategies to respond to environmental changes (Sanchez R, 1995,), composed of two factors: resource flexibility and coordinated flexibility, Resource flexibility reflects the potential use of the resources, Such as resource use fan guo, resource conversion time and cost; Coordination flexibility reflects the ability of an organization to use resources effectively, Emphasizing enterprise defining, building, and configuring existing resources, The ability to synthesize and reorganize routines to support enterprise strategy (Matthyssens P, & Pauwels P, 2005), Strategic flexibility adjusts the relationship between big data application ability and enterprise innovation performance. First of all, the strategic flexibility strengthened the big data positive influence, with the increase of strategic flexibility, enterprise potential application of internal knowledge scope to expand, enterprises can quickly and low cost conversion knowledge resources, enhance resource positioning, identification and deployment, improve the efficiency of resource allocation, speed up the adaptive response, solve solving more flexibility and creativity, strategic flexibility enables enterprises can better absorb and use new knowledge, improve the development of exploratory innovation and ability evolution reconstruction potential absorption ability (Yang Zhuo,.2016) Based on this, the following assumptions are proposed.

H5 strategic flexibility plays a positive role in regulating the application ability of big data on enterprise innovation performance

Empirical Analysis

Our research through a wide range of questionnaire distribution and collection, using scientific and rigorous empirical analysis method, complete all recycling questionnaire data processing and analysis, discusses the big data application ability, service supply chain, innovation performance and strategic flexibility, to verify the research model and research hypothesis analysis, this research object is mainly the logistics industry practitioners.

1. Correlation analysis

Table 1 Table of the correlation analysis of the variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Big data capability	0.742					
Internal integration	0.605***	0.751				
Supplier integration	0.566***	0.546***	0.734			
Customer integration	0.605***	0.480***	0.559***	0.768		
Strategic flexibility	0.515***	0.454***	0.468***	0.579***	0.748	
Innovative performance	0.833***	0.445***	0.437***	0.474***	0.508***	0.660

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: collated according to the correlation analysis results

Table 1 above is the correlation matrix between the variables, where the diagonal is the AVE value of the variables (dimension). As can be seen from the table, the correlation coefficients of big data capability, internal integration, supplier integration, customer integration, strategic flexibility, and innovation performance are all significantly and positively correlated. After determining the correlation between the variables, the differential validity and convergence validity between the variables also need to be analyzed. Differential validity refers to a certain trait, concept, with different methods to measure, will have the same effect. Fornell and Larcker (1981) suggest that the MS of variable AVE should be greater than the correlation coefficient of this variable and other variables. From the diagonal data in Table 1, the variables in this paper have good discriminative validity.

2. Proposition verification

After completing the relevant analysis, the regression analysis is then carried out to conduct hypothesis testing. The independent variables in the regression model are big data capability and intermediary variable: service supply chain integration (internal integration, supplier integration, customer integration); adjustment variable: strategic flexibility; and outcome variable: innovation performance.

1. Direct effect test of big data ability on innovation performance

$CXJX_i = \alpha + \beta DSJ_i + \sum \lambda_i CTRL + \varepsilon_i$ This study by constructing (M1) regression model, observe the impact of big data ability on enterprise innovation performance, DSJ represents big data ability, CXJX represents the innovation performance, CTRL represents a series of control variables (the study of the establishment of the enterprise, the nature of the enterprise, all properties, enterprise staff size, etc.) in order to eliminate possible heteroscedasticity, this study for robust standard error estimation through robust. The parameter estimation results are as follows, mainly observing the coefficient of DSJ, whose coefficient is 0.987, which is significant at the 5% significance level. It can be considered that big data

capability can indeed improve the innovation performance of an enterprise. Every additional unit of big data capability, the innovation performance of the enterprise increases by 0.987 units. Hypothesis 1 is validated.

Table 2 Analysis of the impact of big data application ability on innovation performance

Innovative performance	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]
Big data capability	0.987***	0.032	30.59	0.000	0.923	1.050
Central enterprises (including state holding)	-0.837***	0.115	-7.26	0.000	-1.064	-0.611
Local SOes (including state holding)	-0.550***	0.100	-5.50	0.000	-0.746	-0.353
Private enterprises (including private holding companies)	-0.716***	0.082	-8.76	0.000	-0.877	-0.555
Sololly owned and holding enterprises (including wholly owned and holding enterprises of Hong Kong, Macao and Taiwan)	-0.642***	0.119	-5.40	0.000	-0.876	-0.408
Transportation, storage, and postal services	-0.016	0.062	-0.25	0.802	-0.138	0.107
Information transmission, software, and technology services industries	-0.160**	0.069	-2.32	0.021	-0.295	-0.025
100 And below	-0.114	0.081	-1.41	0.159	-0.273	0.045
300 And below	0.117	0.084	1.38	0.167	-0.049	0.282
From 3,000 to 1,000 people	-0.033	0.100	-0.33	0.742	-0.231	0.164
Between about 1,000 and about ~ 2,000 people	-0.025	0.068	-0.37	0.711	-0.159	0.109
1~5 Years	0.032	0.080	0.40	0.689	-0.125	0.189
5~10 Years	-0.049	0.078	-0.62	0.534	-0.203	0.105
10~15 Years	0.195***	0.074	2.64	0.009	0.050	0.341
15~25 Years	-0.021	0.100	-0.21	0.836	-0.216	0.175
Constant	1.168***	0.146	8.02	0.000	0.881	1.454
Mean dependent var	3.296		SD dependent var		1.009	
R-squared	0.716		Number of obs		424.000	
F-test	.		Prob > F		.	
Akaike crit.(AIC)	706.605		Bayesian crit.(BIC)		767.351	

*** p<0.01, ** p<0.05, * p<0.1

Source: Summary of regression analysis results of innovation performance based on big data application capabilities

2. Test of the intermediary effect of the service supply chain integration

In this study, the mediation effect of the service supply chain integration in big data capability on enterprise innovation performance was verified by constructing the following regression model.

$$CXJX_i = \alpha + \beta_0 DSJ_i + \beta_1 GYL\_NBZH_i + \sum \lambda_i CTRL + \varepsilon_i \quad (\text{M4.1})$$

$$CXJX_i = \alpha + \beta_0 DSJ_i + \beta2 GYL\_GYSZH_i + \sum \lambda_i CTRL + \varepsilon_i \quad (\text{M4.2})$$

$$CXJX_i = \alpha + \beta_0 DSJ_i + \beta_3 GYL\_KH_i + \sum \lambda_i CTRL + \varepsilon_i \quad (\text{M4.3})$$

The symbol explanation in the formula is the same as above, and it can be found that M4 adds the explanatory variable of service supply chain integration to the model M1. According to Baron & Kenny (1986), the specific steps are as follows: a. Test whether the total effect coefficient in M1 is significant, namely whether there is a significant relationship between big data power and innovation performance (this is validated in M1). Subsequent analysis was continued if significant, and if nonsignificant mediation analysis was terminated.b. Check whether the big data capability in M3 acts on the integration effect of the service supply chain is significant (this is verified in M3); if significant, the subsequent test is continued, otherwise the analysis is terminated and the mediation effect does not exist; c. To test whether the mediation variable service supply chain integration in M4 acts on the innovation performance effect is significant; if significant, the subsequent test is continued, otherwise the analysis is terminated, and the mediation effect does not exist.d. To test whether the big data power coefficients in M4 were significant. If not significant (Judd & Kenny, 1981), otherwise a partial mediation effect (Baron & Kenny, 1986).

To eliminate possible heteroscedasticity, this study performed robust standard error estimation by robust. The parameter estimation results are as follows. After the internal integration is controlled, the impact of big data capability on innovation performance is still significantly positive (coefficient is 1.043). According to the test procedure of mediation role, it can be concluded that there is a mediation role between big data capability and innovation performance, and hypothesis 4-1 is verified.

When the supplier integration is controlled, the regression coefficient of the big data capability is significant at the 0.01 level, and the coefficient is 0.976; the supplier integration coefficient is not significant. According to the inspection procedure of the mediation role, it can be concluded that the mediation role of the supplier integration between the big data innovation and the innovation performance is not significant. Hypotheses 4 – 2 were not tested.

When the customer integration is controlled, the regression coefficient of the big data capability is significant at the 0.01 level, and the coefficient is 0.977; but the customer integration coefficient is not significant. According to the inspection procedure of intermediation role, it can be concluded that the intermediation effect of customer integration between big data innovation and innovation performance is not significant. Hypotheses 4 – 3 were not tested.

Table 3: An Analysis of the Mediation Role of the Service Supply Chain

	(1)	(2)	(3)
	Innovative performance	Innovative performance	Innovative performance
Big data capability	1.043***	1.020***	1.014***
	(0.039)	(0.040)	(0.041)
Internal integration	-0.079**		
	(0.032)		
Supplier integration		-0.052	
		(0.034)	

Customer integration			-0.038
			(0.034)
constant term	1.111***	1.172***	1.147***
	(0.147)	(0.145)	(0.147)
Enterprise nature control	YES	YES	YES
Industry type control	YES	YES	YES
Enterprise age control	YES	YES	YES
Employee size control	YES	YES	YES
Obs.	424	424	424
R-squared	0.720	0.717	0.716
Standard errors are in parenthesis			
*** p<0.01, ** p<0.05, * p<0.1			

Source: Summary of regression analysis results based on the impact of big data application capability on innovation performance on supply chain integration

3. Adjustment effect test of strategic flexibility

In this study, the strategic flexibility verifies the regulatory effect of big data capability on enterprise innovation performance by constructing the following regression model.

$$CXJX_i = \alpha + \beta_1 DSJ_i + \beta_2 ZLRX_i + \beta_3 DSJ*ZLRX_i + \sum \lambda_i CTRL + \varepsilon_i \quad (M5)$$

It can be found that M5 is an interaction term of adding strategic flexibility and big data capability and strategic flexibility on the basis of M1. The main observation is that the interaction term coefficient is significant, and if significant, the regulatory effect is present. To facilitate the analysis, in the present study, the M1 results are also included in the following table. It can be known that the main effect of the big data without adding the adjustment term is significantly positive on the innovation performance (0.987), and after adding the adjustment term (i. e., M5), the interaction term coefficient is significantly negative. This shows that the weakening of the adjustment variable strategic flexibility or suppresses the influence of big data ability on enterprise innovation performance, that is, it can be expressed as the effect of the variable strategic flexibility between big data ability and technological innovation has a significant weakened and inhibitory effect, and has a significant negative adjustment effect. It is not difficult to understand that strategic flexibility emphasizes changes due to time and situation, and the innovation performance of enterprises largely needs to be consistent sustainability, which leads to the impact of big data capability on innovation performance will be regulated by strategic flexibility.

Table 4 Analysis of the regulatory role of strategic flexibility in big data application ability and innovation performance

	(1)	(2)
	Innovative performance	Innovative performance
Big data capability	0.987***	1.761***
	(0.032)	(0.195)
Strategic flexibility		0.610***
		(0.112)
Big data * strategic flexibility		-0.219***
		(0.048)
_cons	1.168***	-0.869**
	(0.146)	(0.411)
Enterprise nature control	YES	YES
Industry type control	YES	YES
Enterprise age control	YES	YES
Employee size control	YES	YES
Obs.	424	424
R-squared	0.716	0.740

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Source: Strategic flexibility in the big data application ability and innovation performance of the regression analysis results summary

According to the above analysis, the following regulatory effect map can be obtained. When the enterprise has a high strategic flexibility, the impact of big data ability on innovation performance is weakened.
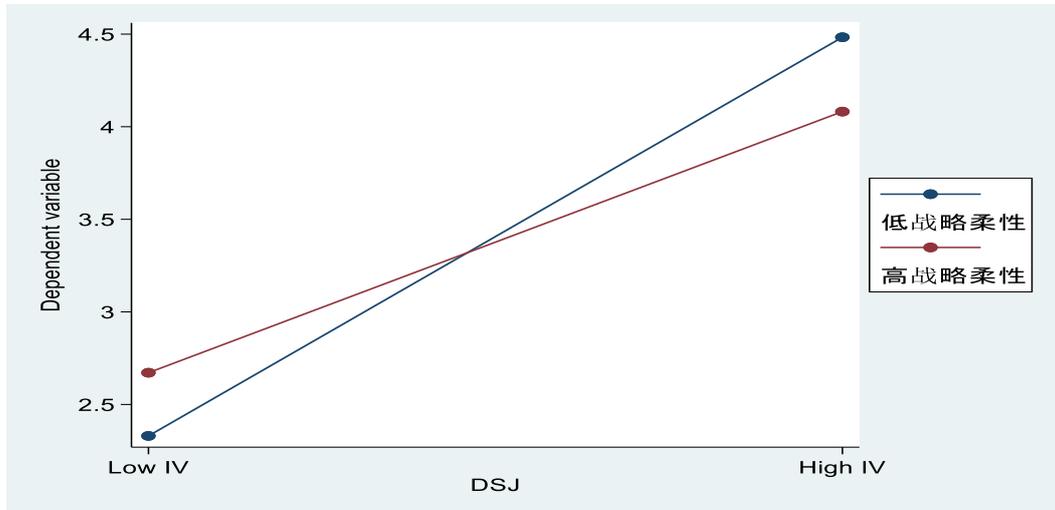
**Figure 1: Adjustment diagram of strategic flexibility on big data
application ability and innovation performance**

Conclusions

This study through the questionnaire survey, through the design of big data application can power scale, service supply chain scale, strategic flexible scale and innovation performance scale and other four scales, access to primary data, to study the strategic flexible adjustment of big data application ability of the direct effect of innovation performance and the service supply chain as the intermediary variable intermediary effect. The method of SEM and regression empirical test was used to verify a series of assumptions, mainly studying the following conclusions:

（1）Variables of big data capability, service supply chain, strategic flexibility and innovation performance have good reliability and validity. In this study, we designed four variables to measure big data ability, service supply chain integration ability, strategic flexibility and innovation performance through dynamic effect theory, root theory and other studies. Credit validity analysis was conducted through exploratory factor analysis and confirmatory factor analysis. The results found that these four variables have good reliability validity. Specifically, the KMO values of large data capability, service supply chain, strategic flexibility and innovation performance are 0.927,0.851,0.838, and 0.793, and the degree coefficient is 0.96,0.869,0.845, and 0.798, respectively. The KMO value and reliability coefficient are greater than the novel critical values, and AVE values of large data capability, service supply chain, strategic flexibility and innovation performance are also consistent with the critical values.

（2）Big data application ability has significant direct effects and indirect effects on innovation performance. The direct effect of big data power on innovation performance is 1.043, and the indirect effect is-0.079*0.709=-0.056, and this indirect effect is brought about by the internal integration in the service supply chain. The total effect was 1.043-0.056=0.987. The higher the internal integration, the contrary hinders innovation performance, while big data capability indirectly weakens innovation performance by enhancing internal integration. On the one hand, the high horizontal flow of information brings the rapid effect of the information communication and feedback mechanism, on the other hand, it also brings the generation of

massive junk information, which has a negative effect on the innovation performance.

（3）The impact of big data application ability on innovation performance will also be affected by strategic flexibility. Strategic flexibility significantly weakens the influence relationship between big data ability and technological innovation, and has a significant negative adjustment effect.

In short, our research results have basically reached our presupposition, and we have further clarified the relationship between big data application ability and innovation performance. However, due to the number of samples and the time series, our results need further testing, and we expect to remedy the above deficiencies in future studies to perfect our study.

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