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Unlocking Enterprise Innovation: The Impact of Big Data Analytics and External Network Relationships

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Abstract. Innovation drives modern industry and enhances enterprise competitiveness. Despite China's progress, evident by its 14th position in the Global Innovation Index 2020, a gap remains compared to Western developed nations. Enterprises are key to national innovation, especially in the rapidly evolving tech landscape. Big data presents new opportunities and challenges for innovation. This study explores how enterprises can leverage big data to improve innovation outcomes, identifying factors that influence this process. Grounded in resource-based and social network theories, the research employs questionnaires to assess big data analytic capabilities, external network relationships, and innovation performance. Using hierarchical regression analysis and reliability tests, findings reveal that foundational and management capabilities of big data significantly impact innovation, while technical capabilities do not. External network relationships partially mediate this effect. The results offer insights for managers on utilizing big data and strengthening external ties to drive innovation and competitive advantage.

Keywords: Big Data Analytics Capability, External Network Relationships, Enterprise Innovation Performance.

1. Introduction

Innovation is the driving force behind the evolution of the modern era, acting as a pivotal component for industrial progression and augmenting enterprise competitiveness. While China has made remarkable progress in the realm of innovation, securing the 14th position in the Global Innovation Index 2020, there remains a pronounced disparity when juxtaposed with Western developed nations. Enterprises, standing as the cornerstone of innovation, are instrumental in manifesting national innovation agendas. Amid the swift transformation of science and technology coupled with an unpredictable external milieu, sustaining innovation prowess is non-negotiable. The advent of the big data era has ushered in novel opportunities and predicaments for the realm of innovation. By adeptly channeling the potential of big data, enterprises can witness marked enhancements in their innovation outcomes. This study aims to delineate the methodologies through which enterprises can bolster their innovation metrics by efficiently leveraging big data. It further seeks to unearth the determinants that either augment or hinder the innovation trajectory. Subsequent sections will immerse into the theoretical bedrock of this study, shedding light on the resource-based theory and social network theory. The

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discourse then transitions to the research blueprint, encompassing facets such as questionnaire formulation, data accumulation, and modes of analysis. Following this, we unveil the reliability assessments of the metrics and the outcomes of the hierarchical regression scrutiny, elucidating the interplay between diverse variables. Culminating the discussion, the mediating impacts of external network affiliations on innovation output are explored.

This paper guides enterprise managers on leveraging big data analysis capabilities for digital transformation, helping them capitalize on vast external data resources to gain competitive advantages. By understanding which aspects of big data capability to prioritize, enterprises can foster innovation. In the Internet era dominated by big data, seizing the value of big data analysis is crucial for organizational digital transformation and upgrading [1]. Introducing the external network relationship as a mediator suggests that strengthening ties with stakeholders and accessing external resources can enhance innovation. This research emphasizes the importance of building these external relations to fortify a firm's competitive edge and drive its innovative growth. Empirical findings offer insights for managers on harnessing big data capabilities to boost innovation. Investing wisely in big data and external network infrastructures can stabilize a firm's data analytical prowess, augmenting strategic decision-making and operational effectiveness, vital for strategic planning and hands-on management [2].

2. Theoretical foundation

2.1. Resource-based theory

In 1984, Wernerfelt introduced The Resource-Based View of the Firm, marking the birth of the Resource-Based View [3]. Later, Penrose studied the connection between organizational resources and development, establishing the theory of uneven organizational growth which supported the resource-based theory. Subsequent research by scholars like Barney and Grant fortified the theory. This theory suggests that firms with distinct tangible and intangible resources can achieve and sustain competitive advantage [4]. Using this perspective, only firms with unique, non-imitable resources can generate value. Big data and its technologies, while crucial, can be copied by rivals. However, unique big data analytic capabilities can offer a competitive edge. Therefore, businesses should develop distinct big data analysis abilities and optimally utilize big data resources to enhance their performance.

2.2. Social network theory

Statistical models are essential for interpreting the complex relationships between neural activity and The term "social network" emerged in the 1930s, with its initial meaning proposed by the anthropologist Brown. Wellman later refined the definition, viewing it as a stable system of relationships among individuals. Mitchell [5] saw it as relationships linking group members and included both informal and formal ties. Adler expanded this idea, defining social networks as systematic structures formed by relationships between individuals or organizations. From a structural perspective, Pattison emphasized the connections established between entities as social networks, while Borgatti saw it as a structure arising from social ties between points. Scott [6] posited that social networks encompass not just individual behaviors but also the properties of actor systems. Social network theory's acceptance grew in the 1960s and saw rapid advancement in the late 1980s. Various sub-theories emerged, including those of strong and weak ties, structural holes, social capital, and network structure. Notably, theories around connection strength, structural holes, and social capital gained significant traction and shaped the broader social network theory framework.

3. Research design

3.1. Questionnaire design

This paper adopts a questionnaire to analyze and test the research model. In order to ensure the theoretical scientificity and practical operability of the research questionnaire, this questionnaire refers to the authoritative scales that have been verified by scholars at home and abroad through empirical

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analysis, and combines with the actuality of China's situational research, consults with the tutor's opinion, and makes the definition of the variables involved, which mainly include three variables: the ability to analyze big data, the relationship with external networks and the enterprise innovation performance. Definition, according to the scale design principles, the questionnaire statements were repeatedly modified to form the final research questionnaire. This research study adopts Likert's seven-point scale scoring method, with 1-7 indicating strongly disagree to strongly agree, respectively.

3.2. Big Data Analysis Ability Scale

In the current landscape, research on big data analytic capability is relatively sparse both domestically and internationally. However, several scholars have undertaken efforts to measure enterprise big data analytic capability. Among them, Gupta stands out for his comprehensive study, which dissected big data analytic capability into three primary aspects: tangible assets, intangible assets, and human resources. Gupta's framework identifies seven distinct types of resources that enterprises might leverage to develop robust big data analytic capabilities. These resources encompass not only physical and technological assets but also the intangible elements and human expertise essential for effective data analysis. In addition to Gupta, Wamba and Akter have contributed significantly to the empirical understanding of big data analytics. Their studies delineate big data analytics capabilities into three dimensional levels: big data management capabilities, talent capabilities, and technical capabilities. This tripartite model emphasizes the importance of effective data management practices, the necessity of skilled personnel proficient in data analysis, and the critical role of advanced technical tools and techniques in harnessing the power of big data.

This paper predominantly draws upon Gupta's study as the primary reference for constructing the Big Data Analysis Ability Scale. The scale formulated in this research includes three key dimensions: basic competence in big data analytics, technical competence, and management competence. Basic Competence involves the foundational skills and knowledge required to perform basic data analysis tasks, encompassing the ability to understand data structures, apply basic statistical methods, and use fundamental data analysis tools. Technical Competence refers to the more advanced technical skills needed for sophisticated data analysis, including proficiency in using advanced analytical software, understanding complex algorithms, and implementing machine learning techniques. Management Competence pertains to the strategic and managerial aspects of big data analytics, such as the ability to oversee data projects, integrate big data insights into business strategies, and manage data analytics teams effectively. By focusing on these dimensions, the scale aims to provide a comprehensive measure of an enterprise's big data analytic capabilities, offering a valuable tool for both academic research and practical application in the business world [7].

4. Data Acquisition and Analysis Methods

4.1. Data Collection

Table 1. Descriptive statistical analysis of samples

Control	Variables	Category	Percentage
Gender	Male	200	63.80%
	Female	114	36.20%
Academic qualifications	College and below	19	6%
	Bachelor's degree	215	68.30%
	Master's degree	72	22.90%
Position	Top management of the company	17	5.40%
	Middle management of the company	202	64.10%
	Department heads or project managers	96	30.50%

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Table 1. (continued).

Industry	Information Transmission, Computer Services and Software	90	28.60%
	Manufacturing	88	27.90%
	Construction	26	8.30%
	Banking, Financial Services	25	7.90%
	Wholesale and Retail	16	5.10%
	Accommodation and Food Service	9	2.90%
	High and New Technology	36	11.40%
	Education, Training	7	2.20%
	Healthcare and hygiene	8	2.50%
	Logistics	6	1.90%
	Consulting Services	3	1%
	Others	1	0.30%
Nature of enterprise	State-owned or state-controlled enterprises	86	27.30 %
	Sino-foreign joint ventures	23.50%	3.80
	Private enterprise	143	45.40%
Years of working experience	Less than 1 year	3	1%
	1-3 years	59	18.70%
	4-8 years	186	59%
	9-15 years	56	17.80
	More than 15 years	11	3.50
Big data investments/ year	<100	27	8.60%
	100-300	60	19%
	301-500	73	23.20%
	501-800	76	24.10%
	801-1000	35	11.10%
	>1000	44	14%

From the above table 1, 63.8% of the respondents are male and 36.2% are female. The majority have a bachelor's or master's degree, making up 68.3% and 22.9% respectively. Most are middle-level managers, and the industries predominantly represented are information transmission, computer services, software, and high-tech. Other industries have smaller sample sizes, indicating the nascent stage of big data's industry integration. The more developed industries in big data integration are manufacturing, information transmission, computer services, and high-tech [8]. Most enterprises are private, state-owned, or Sino-foreign joint ventures, with proportions of 45.4%, 27.3%, and 23.5% respectively. Most respondents have 4-8 years of work experience (59%), and the bulk of enterprise big data investment lies between 5-8 million yuan.

5. Data analysis

5.1. Reliability test of the scale

To assess the internal consistency of the scales used in this study, Cronbach's α coefficient was employed. A higher Cronbach's α value indicates better reliability and internal consistency of the scale. Typically, a Cronbach's α value of 0.8 or above is considered highly reliable, 0.7 to 0.8 is deemed to have good reliability, and below 0.7 may indicate insufficient reliability for research purposes. SPSS 22.0 was used to evaluate the reliability of each variable, and the results are presented in Table 2.

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Table 2. Reliability Analysis of Variables Measured by Cronbach's Alpha

Variable	Cronbach's Alpha	Number of questions N
Big Data Analytics Foundational Competencies	0.892	5
Big data analytics technical skills	0.868	4
Big Data Analytics Management Capabilities	0.837	4
Network connectivity strength	0.800	4
Connection density	0.779	5
Network Centrality	0.829	4
Enterprise innovation performance	0.899	5

The reliability analysis shows that the Cronbach's α coefficients for big data analytics foundational competence, technical competence, and management competence are 0.892, 0.868, and 0.837, respectively, all indicating good reliability [9]. The Cronbach's α coefficients for network connectivity strength and network density are 0.800 and 0.779, respectively, also demonstrating good reliability, while enterprise innovation performance has a Cronbach's α of 0.899, indicating very high reliability. Thus, the scales used in this study are reliable and suitable for further analysis.

5.2. Regression Analysis and Mediation Effects

This study further explored the impact of big data analytics capabilities on external network relationships and enterprise innovation performance. The analysis revealed that both foundational and management capabilities in big data analytics have a significant positive impact on strengthening network connectivity and network density, while technical capabilities have a relatively minor influence. In assessing enterprise innovation performance, it was found that different types of enterprises exhibit varying levels of innovativeness. Additionally, this study examined the mediating role of external network relationships between big data analytics capabilities and enterprise innovation performance. The results indicate that network connectivity strength, density, and centrality partially mediate this relationship, particularly highlighting the significant roles of foundational and management capabilities in enhancing innovation performance, while the impact of technical capabilities is more limited. [10]In summary, this study finds that foundational and management capabilities in big data analytics have a substantial positive impact on external network relationships and enterprise innovation performance, whereas technical capabilities are less influential. These findings offer valuable practical insights for enterprise managers on how to effectively leverage big data analytics capabilities and build strong external network relationships in the era of big data.

5.3. Discussion of Findings

The findings of this study underscore the critical importance of foundational and management capabilities in big data analytics as key drivers of enterprise innovation performance. While technical capabilities are often emphasized in the context of big data, our results suggest that their direct impact on innovation is less pronounced. This may be due to the fact that technical capabilities, while essential for processing and analyzing data, do not alone translate into innovative outcomes without the strategic direction and effective management provided by foundational and management competencies. Moreover, the mediating role of external network relationships highlights the interconnected nature of big data capabilities and social networks in driving innovation. Enterprises that excel in building and maintaining strong external network ties—such as partnerships, collaborations, and industry connections—can better leverage their big data insights to foster innovation. This synergy between big data capabilities and external networks allows enterprises to access diverse resources, share knowledge, and enhance their ability to respond to market changes and technological advancements. These findings suggest that enterprises should not only invest in enhancing their technical data capabilities but also prioritize the development of foundational and management skills in big data [11]. Additionally, fostering strong external network relationships is crucial for translating data capabilities into tangible

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innovation outcomes. Managers are advised to focus on integrating big data insights into broader strategic and operational frameworks while actively engaging with external networks to maximize innovation potential. Future research could further explore the specific mechanisms through which external network relationships enhance the innovation potential of big data analytics. Additionally, examining the long-term effects of investments in different dimensions of big data capabilities across various industries could provide deeper insights into how enterprises can sustain innovation and maintain a competitive edge in the evolving digital landscape.

6. Conclusion

This study underscores the pivotal role of big data in enhancing enterprise innovation performance. By leveraging resource-based and social network theories, we identified that foundational and management capabilities in big data analytics significantly influence innovation, whereas technical capabilities are less impactful. Additionally, external network relationships, such as network connection strength, density, and centrality, serve as mediators, further enhancing the innovation outcomes of enterprises. Our research suggests that managers should prioritize the development of unique big data analytic capabilities and foster strong external network ties to gain competitive advantages and drive innovation. As the big data era continues to evolve, enterprises must invest strategically in big data infrastructures and external network relationships to sustain innovation and improve decision-making processes. Looking forward, future research should explore other potential mediators and moderators in the relationship between big data capabilities and innovation performance. Additionally, investigating the long-term effects of big data investments on various industries will provide deeper insights into optimizing innovation strategies in the digital age.

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