

# The impact of R&D investment and diversification on the innovation performance of enterprises

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**Abstract.** In the context of digitalization, the accumulation of R&D investment activities and enterprises with high digital technologies and diversified partners and innovation networks and knowledge can adapt to the rapidly changing market and show excellent performance, which in turn affects the innovation performance of digital transformation. By retrieving the previous literature on the impact of R&D investment activities, diversification, including strategic diversification, and partner diversification on the innovation performance of enterprises, this study collates the accumulation of R&D investment activities to help enterprises cope with sudden crises, carry out digital transformation, and in the supply chain network, the higher the degree of diversification of partners owned by enterprises, the more new knowledge of low redundancy is understood, thereby improving the innovation performance of enterprises.

**Keywords:** R&D investment; Diversified; innovation performance; Digital transformation.

## 1. Preface

At the beginning of 2020, the sudden outbreak of the novel coronavirus had an unprecedented negative impact on society and the economy. The growth rate of large-scale industrial enterprises fell sharply in March 2020 (Chen et al., 2020) [1]. Reduced orders, limited production, insufficient staffing, high fixed cost burdens, and potential credit and debt risks hit businesses hard. However, the impact of the pandemic on different types of businesses is different. Some companies have benefited from the previous high R&D (research and development) investment intensity and gradually started digital transformation innovation when emerging technologies such as big data, cloud computing, Internet of Things, blockchain, artificial intelligence emerge (Brammer et al., 2020; Huang et al., 2020) [2, 3]. As a result, when COVID-19 hits, companies that are highly digital are more resilient (Bernot et al., 2021) [4]. Digital technologies such as telecommuting, smart factories and digital workshops have become an advantage for some traditional industry companies to withstand the pandemic (Ai et al., 2022) [5]. For example, although 30% of employees of Chinese company Kenan Health were unable to return to work during the pandemic, order volumes remained unaffected due to its smart factory. In addition, Baosteel's Shanghai Baoshan base in China has also shown unique advantages in this epidemic.

Most studies explore the factors that influence firms' innovation performance in terms of technology, capabilities, management, and policy. For example, Machado et al. (2022) identified technologies that impact digital transformation innovation in enterprises, such as big and smart data, cloud computing, social media, predictive and prescriptive analytics, IoT, robotics, 3D printing, and mobile. Some scholars also consider external pressures and government policies to be environmental factors influencing the innovation process of digital transformation. However, these literature ignore the impact of R&D investment on digital transformation innovation. R&D investment activities are a source of organizational learning and enhancing technical capabilities. Thus, the organization's learning ability and technical competence promote the integration of the digital technology resources of the enterprise and equip an enterprise with the digital technology that best suits its current environment. For example, the rich R&D investment activities at Baosteel's Shanghai Baoshan site provided the company with experience in embedding digital technologies, which also helped it achieve 24-hour operations without the need for multiple employees during the pandemic. Under the background of digital transformation and innovation, the process of R&D investment activities will also be affected by many external environmental factors. Therefore, some studies have explored

which situational factors mitigate the impact of R&D investment activities on digital transformation and innovation. The transformation of enterprise R&D investment results has always been a research hotspot in the field of R&D management. Previous studies have explored the key factors affecting R&D investment and enterprise innovation performance from the aspects of complex organizational structure, functions and operational processes. For example, Kang et al. (2017) points out that the transformation of R&D investment results is influenced by the technological capabilities of enterprises, while Tebourbi et al. (2020) also considers factors that affect the relationship between R&D investment and firm innovation performance, such as manager overconfidence and government ownership. Therefore, many existing studies have explored the moderating variables affecting the relationship between R&D investment and performance, but lack attention to the moderating variables of the relationship between R&D investment and digital transformation innovation. In addition to enterprise size, diversification is also a key variable affecting the relationship between R&D investment and digital transformation innovation, and many companies benefit from their diversified knowledge resources. Statsenko and deZubielqui (2020) point out that according to the resource base theory, diversification strategies can diversify operational risks, and diversified enterprises can establish effective internal capital markets, thereby breaking through the constraints of external capital markets. However, Andreou et al. (2016) and Sakhartov (2017) have demonstrated that a diversification strategy will rationalize R&D investment by dispersing limited knowledge and resources across different business units. Many companies have eased the pressure with diversification strategies under COVID-19. When COVID-19 occurs, the premium performance of diversified companies is more pronounced than the discount performance.

## 2. Existing research

### 2.1. The impact of R&D investment on enterprise innovation performance

R&D investment refers to the investment of enterprises in research and experimental development in technology, process, instruments, equipment and other aspects. Through the production of products through "pollution-free" or "pollution-less" process technology, reduce the emission of harmful substances and save resources, so as to achieve green development, and provide a stable environmental foundation for enterprises to help the "dual carbon" policy and carry out new product research and development. The theory of sustainable development believes that today's society is an era of three combinations and three synchronizations, that is, the combination and synchronization of ecological benefits, economic benefits and social benefits, and the sustainable development of the economy must rely on a healthy and good ecological environment and resource environment. Green and innovation are the themes of our time, so this is used as a guide in the development of enterprises to achieve the effect of matching emission reduction and performance.

Existing studies have long attempted to explore the relationship between R&D investment and firms' innovation performance, but the results remain uncertain. Some studies believe that R&D investment activities can enhance competitive advantage and promote long-term development and technological progress (James et al., 2016) [6]. Scholars believe that there is a positive correlation between R&D investment and firm innovation performance (Eberhart et al., 2004) [7]. For example, Eberhart et al. (2004) argues that R&D investment activities improve long-term business performance, and this relationship is moderated by factors at the national level. However, some scholars have found that there is a negative correlation between R&D investment and enterprise innovation performance. Chan et al. (2001) [8] argued that R&D investment is detrimental to firm innovation performance, while Knecht (2013) [9] found that although current R&D investment hurts current year's innovation performance, it can improve future firm innovation performance. In line with this, Natasha and Hutagaol (2009) [10] found that R&D investment hurt current profits, but had a positive impact on profits two years later.

When a major public health emergency occurs, the market environment changes. Enterprises need to adjust their product and channel structure, as well as their marketing models, in advance to adapt

to changes in the market environment that have occurred or may occur. Existing research believes that R&D investment activities are conducive to improving organizational learning, knowledge absorption and technical capabilities (Saarikko et al., 2020) [11]. An organization's ability to learn, absorb knowledge, and use technology can improve its ability to provide comprehensive control and integration of social resources in the face of risk (Ghasemzadeh et al., 2021; Migdadi 2021) [12,13]. Only enterprises with high comprehensive control capabilities and social resource integration capabilities can quickly adapt to market changes, minimize the negative impact of emergencies, and find market opportunities from crises (Orth et al., 2021) [14]. When companies face difficulties such as liquidity control, delays in resuming work and production, and sales decline due to the COVID-19 pandemic in 2020, early R&D investment activities have advantages. The comprehensive control and social resource integration capabilities accumulated in the early R&D investment activities can provide support for emergency response.

## **2.2. The impact of diversification on enterprise innovation performance**

### **2.2.1. The impact of diversification strategy on enterprise innovation performance**

Diversification is another contextual factor that influences the translation of R&D investment into results (Baysinger et al., 1989; Banker et al., 2011) [15, 16]. Research on the impact of diversity on businesses has not reached consensus. According to the theory of market power, the fundamental reason why diversified firms operate better than centralized firms is that diversified firms are more likely to acquire corresponding market power (Matvos et al., 2018) [17]. For example, Statsenko and de Zubielqui (2020) [18] found through case studies of 156 mining equipment, technology and services companies in South Australia that service and market diversification positively moderated the relationship between customer collaboration and innovation performance. Linkov et al. (2022) [19] combine this with COVID-19 and note that COVID-19 has affected all forms of global international engagement, including long-standing and recently established research teams, and that diversity and inclusion are requirements for resilient ecosystems. However, principal-agent theory and management cost theory have a negative attitude towards diversification. Andreou et al. (2016) [20] also found that diversification reduced shareholder wealth across all companies in Compustat's sample of industrial sector from 1998 to 2008. Diversified companies require more coordination and control than centralized companies due to their broader scope of operations (Baysinger et al., 1989; Berrill et al., 2021) [16, 21]. As a result, diversified companies rely more on digital technologies and can benefit more from high R&D investment (Berrill et al., 2021) <sup>[21]</sup>. During the COVID-19 pandemic, diversification has diversified business risk to some extent. When the external environment is stable, diversified operation crowds out the R&D investment of the main business, which is not conducive to the development of the enterprise. This elasticity varies from industry to industry. For example, during the pandemic, demand increased in the pharmaceutical, detergent and food industries. Some manufacturers of cars, home appliances and mobile phones began producing masks. In the first two months of 2020, more than 3,000 companies in China began producing masks, protective clothing, disinfectants, thermometers and medical equipment. Many companies did not initially sell these medical supplies on the market, but offered them as donations. As a result, they not only gained a social and brand effect, but also expanded production to compensate for the loss of their main business.

Investing in diversified companies of different types or industries can effectively reduce unsystematic risks and obtain more heterogeneous information from other industries (Ji et al., 2020) [22]. When COVID-19 emerged, many diversified companies made timely strategic adjustments. In the current digital economy, diverse companies have multiple business units to coordinate. As a result, the need for digital technologies in diversified enterprises is even greater (Stern et al., 2004) [23]. Businesses can enhance organizational learning and accumulate technical knowledge by increasing R&D investment activities, so companies can choose the digital technology that best suits the current environment from the large number of available digital technologies. This is more beneficial for diversified businesses with more complex internal and external systems than for centralized businesses.

### 2.2.2. The impact of diversification of partner types on the innovation performance of enterprises

The more types of partners, the more heterogeneous knowledge they bring, and the company's innovation performance improves. First, the more diverse the types of partners, the more new, non-redundant knowledge can be obtained. Previous studies have shown that the more types of partners, the more differentiated and specialized knowledge and experience (Zhang et al., 2016) [24], such as suppliers have technology related to production processes (Feng et al., 2013) [25], scientific and technological knowledge held by universities and research institutes (Guo et al., 2019) [26], etc., the application of this novel and non-redundant knowledge in innovation activities can stimulate enterprises' cross-field technological innovation capabilities and promote enterprises to achieve major technological breakthroughs (Van et al., 2008) [27]. Secondly, the more diversified the types of partners, the easier it is to promote the integration of corporate knowledge. Technological inventions are seen as the result of firms establishing connections between different elements of knowledge based on their own "optimal guesses" (Fleming L, 2001) [28]. YAYAVARAM ET AL. argues that access to knowledge from new frontiers can facilitate the perception of connections that were not previously recognized and change firms' perception of existing connections between elements of knowledge (Yayavaram et al., 2015) [29]. Compared with enterprises with low diversity of partner types, enterprises with a high degree of diversity of partner types are more likely to recognize more novel knowledge in new fields (Hargadon et al., 1997) [30], and are more likely to change their "best guess" about the relationship between knowledge elements, and enterprises can use new ideas and new ideas to review the combination of existing knowledge and new knowledge, which can help them get rid of their own "technology trajectory trap" and improve their innovation performance.

However, increasing the diversity of partner types also brings challenges and costs for companies. First, in the process of realizing exploratory innovation through collaboration, the higher the diversification of partner types, the higher the growth rate of management costs of enterprises (Penney et al., 2020) [31]. LEE et al. found through meta-analysis that the above management costs include the cost of oversight due to lack of trust, the cost of search due to exposure to discontinuous information, and the cost of lack of detailed understanding (Lee et al., 2017) [32]. Because exploratory innovation involves introducing and building new technology trajectories, understanding new knowledge from different types of partners increases management costs. Second, excessive diversification of partner types will lead to knowledge overload, which will negatively affect the performance of exploratory innovation. On the one hand, the KOPUT analysis found that only a small fraction of the heterogeneous new knowledge acquired by enterprises can be taken seriously, and the problem of managers' attention allocation arises (Koput et al., 1997) [33]. With the increase of the diversity of partner types, the prominence of attention allocation is not conducive to enterprises paying attention to and integrating more new knowledge elements and innovative ideas, and hindering the improvement of enterprise exploratory innovation performance. On the other hand, from the perspective of absorptive capacity theory, heterogeneous new knowledge from external partners must be acquired and integrated at least two links before it can be applied to exploratory innovation activities. Although objectively speaking, these novel knowledge lay an important foundation for enterprises to achieve exploratory innovation, considering the difference in the knowledge base of focus enterprises and different types of partners, too high partner diversity will bring too many new knowledge that is far from the existing knowledge of the enterprise (Hagedoorn et al., 2018) [34]. Under such circumstances, the absorption of novel knowledge brought by a new type of partner will require much more absorptive capacity of focus enterprises than before. As the absorption capacity of enterprises reaches the upper limit, not only can it not be possible to transform tacit knowledge into the process of internal innovation exploration (Grimpe et al., 2010) [35], but enterprises will also be trapped in the passive acquisition of heterogeneous knowledge.

URIs (Universities and Research Institutes) play an important role in supporting businesses to possess state-of-the-art knowledge. For example, Abbott Lab, in collaboration with 11 universities, including Arizona State University, developed a 5-minute COVID-19 test. Scientific research will

ultimately improve the technological innovation performance of enterprises, because scientific knowledge can not only provide direction for enterprise technological innovation, help enterprises conduct technology searches, guide enterprises to invest innovation resources in promising and profitable technical fields, but also provide method guidance for enterprise technological innovation, provide more advanced innovation theories, methods and instruments and equipment, help enterprises understand how to carry out technological innovation, and better realize, detect and evaluate the technological innovation process (Fleming et al., 2004) [36]. However, due to the high investment, long-term, uncertainty, public nature and externality of scientific research, enterprises often prefer to engage in strategic cooperation with URIs to obtain the scientific knowledge required for technological innovation, rather than conducting scientific research in-house (Arora et al., 2017) [37]. Therefore, enterprises can obtain external scientific knowledge from various channels through scientific cooperation with external organizations such as URI to improve the performance of technological innovation.

In recent years, there has been a growing number of empirical studies on scientific collaborations between firms and external organizations and their impact on innovation performance. AndradeRojas et al. analyzed the effect of embedding of scientific cooperation network relationship on the performance of technological innovation based on two dimensions: internal and external, and believed that internal and external research activities are complementary (Andrade et al., 2018) [38]. Zucker et al. conducted pioneering research on university-enterprise scientific collaborations within the U.S. biotechnology sector (Zucker et al., 2002) [39]. Carnabuci and Operti believe that in addition to scientific cooperation between enterprises, companies can also seek to cooperate with GSI (government-sponsored institutions) (Carnabuci et al., 2013) [40]. Dtlinga et al. found that the impact of collaboration with customers and suppliers on innovation performance tends to be less pronounced. There are also many studies in this area in China (Dtlinga et al., 2009) [41].

The impact of scientific cooperation network based on thesis partnership on the technological innovation performance of enterprises is analyzed from the two dimensions of relationship breadth and relationship strength. Relationship breadth is the number of relationships between different nodes that provide information and resource access (Ricken et al., 2010) [42], reflecting resource endowments and diverse sources of knowledge. If a company has diverse partners, it will benefit more from technological innovation: First, the diversity of knowledge provided by a large number of URIs promotes "new types of connections" between participants in different roles, and pre-interaction with external information sources exposes the company to cutting-edge scientific knowledge and makes innovation more innovative. Enterprises rely on information advantages to effectively manage "market expectations", create new knowledge, new technologies and new products in a timely manner, and obtain the first-mover advantage in technological innovation activities. Second, in the case of high consumer heterogeneity, the first-mover advantage may gradually lose with the market penetration of competitors, but extensive network relationships can also bring heterogeneity, low-redundancy information, and each URI can convey non-duplicate information and knowledge. The company unites partners in various technical fields to carry out strategic layout in key positions of the industrial chain, build a product innovation system with a system concept, and improve the technological innovation performance of the enterprise. Relationship strength is the average strength of the relationship between the focus firm and the partner in the network, and is proportional to time, emotional intensity, intimacy (mutual interaction), and mutual service of the relationship (Granovetter M S, 1973) [43]. A network of strong relationships can benefit businesses in many ways. First, through strong relationships, businesses can build trust with partners, reducing conflict and solving problems together. Secondly, the scientific knowledge transmitted in the scientific cooperation network is complex and abstract tacit knowledge, and strong relationships are more conducive to the transmission of these complex information and tacit knowledge, and help to control and coordinate the behavior of partners.

### 2.2.3. The impact of diversified global innovation networks on firms' innovation performance

In the weak relationship attribute of the global innovation network, enterprises are more likely to obtain heterogeneous and diversified new knowledge and resources, maintain the freshness and breadth of knowledge, and enhance the flexibility of innovation. Foreign investment can not only help enterprises obtain foreign advanced scientific and technological resources and improve innovation efficiency, but also an important way for them to expand potential markets, respond to overseas customer needs, enhance the international competitiveness of products, and lay the foundation for them to build cooperative relations, integrate resources from all parties, and realize open innovation.

First, based on the perspective of resource-based view, enterprises can obtain knowledge from two aspects. Knowledge management absorbs, integrates, and diffuses knowledge from within, creating company-specific knowledge. In addition, the social embedding theory holds that overseas subsidiaries integrate into the social network of the host country in the form of external embedding, and thus obtain a large number of heterogeneous resources (Andersson et al., 2005) [44], and the integration and allocation of these resources further improve the innovation ability of enterprises, promote value creation, and enhance the competitive advantage of multinational companies as a whole. Finally, from the perspective of organizational learning theory, on the one hand, international experience enhances enterprises' sensitivity to external opportunities and insight into potential partners and innovation directions, thereby reducing the search cost and trial and error cost in cooperative innovation (Zheng Wei, 2020) [51], and effectively controlling innovation risks. On the other hand, enterprises implementing internationalization strategies need to face the complex overseas institutional environment and market environment, and must continuously improve their ability to transform their innovation achievements to ensure that their innovation profits are not lost (Wu et al., 2016) [45].

## 3. Summary and outlook

### 3.1. Summary

Since different types of organizations have differentiated and specialized knowledge and experience, cooperation with different types of organizations in R&D is conducive to promoting the change of the cognitive mode of enterprise knowledge integration and expanding the boundaries of technology integration. However, the high level of organizational diversity of R&D partners will lead to a sharp increase in the cost of inter-organizational relationship management, and some valuable novel knowledge cannot be recognized by enterprises, which is not conducive to improving the exploratory innovation performance of enterprises.

The digital transformation of enterprises has promoted their integration into the global innovation network, thereby improving their innovation performance; Integration into the global innovation network has a greater effect on the improvement of the innovation performance of state-owned enterprises, and the above improvement effect is greater for enterprises in areas with relatively weak innovation resources. Broad partnerships are especially important in an era of increasing industrial convergence. This could explain why, in most cases, large players in such industries are more competitive. Because large corporations have more board network resources, they are better at gathering and merging knowledge from various technical domains. The greater the breadth of relationships, the more opportunities it has as a bridge, and the greater its control over the network, the more likely it is that companies will integrate heterogeneous scientific knowledge from external organizations and conduct technology diversification activities outside of core technology areas.

Based on this, the accumulation of early R&D investment activities and enterprises with high digital technology, diversified partners and innovation networks and knowledge can adapt to a rapidly changing market and show excellent performance, which in turn affects the innovation performance of enterprise digital transformation.

### 3.2. Outlook

Since the existing research needs to be improved, follow-up research can further enrich the relationship between different key functions and different diversification of enterprises. We can try to construct a suitable mathematical model and theoretical framework for the mechanism of mediating variables, so as to provide a more in-depth investigation for the research of diversified partners and innovation networks. Future research can also comprehensively consider the internal and external factors of the enterprise, and incorporate the characteristics of the internal knowledge network and the external environment into the same analysis framework. At the same time, we can try to construct relevant indicators that reflect the integration of enterprises into domestic innovation networks, and further reveal the interaction between domestic innovation networks and international innovation networks of manufacturing enterprises under the background of digital economy and their impact on innovation capabilities. The mediating role of knowledge diversity in the relationship between scientific cooperation network and enterprise technological innovation performance is comprehensively investigated.

### References

- [1] Chen, X.G. and Yu, B. (2020), "First two months of the 2019 coronavirus disease (COVID-19) epidemic in China: real-time surveillance and evaluation with a second derivative model", *Global Health Research and Policy*, Vol. 5 No. 1.
- [2] Brammer, S., Branicki, L. and Linnenluecke, M.K. (2020), "COVID-19, societalization, and the future of business in society", *Academy of Management Perspectives*, Vol. 34 No. 4, pp. 493-507.
- [3] Huang, H., Peng, Z.C., Wu, H.T. and Xie, Q.H. (2020), "A big data analysis on the five dimensions of emergency management information in the early stage of COVID-19 in China", *Journal of Chinese Governance*, Vol. 5 No. 2, pp. 213-233.
- [4] Bernot, A., Trauth-Goik, A. and Trevaskes, S. (2021), "Handling COVID-19 with big data in China: increasing 'governance capacity' or 'function creep'", *Australian Journal of International Affairs*, Vol. 75 No. 5, pp. 480-486.
- [5] Ai, H.S., Zhong, T.L. and Zhou, Z.Q. (2022), "The real economic costs of COVID-19: insights from electricity consumption data in hunan province, China", *Energy Economics*, Vol. 105.
- [6] James, B.E. and McGuire, J.B. (2016), "Transactional-institutional fit: corporate governance of R&D investment in different institutional contexts", *Journal of Business Research*, Vol. 69 No. 9, pp. 3478-3486.
- [7] Eberhart, A.C., Maxwell, W.F. and Siddique, A.R. (2004), "An examination of long-term abnormal stock returns and operating performance following R&D increases", *Journal of Finance*, Vol. 59 No. 2, pp. 623-650.
- [8] Chan, L.K.C., Lakonishok, J. and Sougiannis, T. (2001), "The stock market valuation of research and development expenditures", *Journal of Finance*, Vol. 56 No. 6, pp. 2431-2456.
- [9] Knecht, M. (2013), *Diversification, Industry Dynamism and Economic Performance: The Impact of Dynamic-Related Diversification on the Multi-Business Firm*, Springer Gabler, and Wiesbaden.
- [10] Natasha, I.E. and Hutagaol, R.I. (2009), "The analysis of R&D on the public listed companies. Performance in Indonesia", *Journal of Applied Finance and Accounting*, Vol. 1, pp. 339-350.
- [11] Saarikko, T., Westergren, W.H. and Blomquist, T. (2020), "Digital transformation: five recommendations for the digitally conscious firm", *Business Horizons*, Vol. 63 No. 6, pp. 825-839
- [12] Ghasemzadeh, P., Sorkhabadi, S.M.R., Kebriaeezadeh, A., Nazari, J.A., Farzaneh, M. and Mehralian, G. (2021), "How does organizational learning contribute to corporate social responsibility and innovation performance? The dynamic capability view", *Journal of Knowledge Management*, Vol. 26 No. 10, pp. 2579-2601.
- [13] Migdadi, M.M. (2021), "Organizational learning capability, innovation and organizational performance", *European Journal of Innovation Management*, Vol. 24 No. 1, pp. 151-172.

- [14] Orth, D. and Schuldis, P.M. (2021), "Organizational learning and unlearning capabilities for resilience during COVID-19", *Learning Organization*, Vol. 28 No. 6, pp. 509-522.
- [15] Baysinger, B.D. and Hoskisson, R.E. (1989), "Diversification strategy and R&D intensity in multiproduct firms", *Academy of Management Journal*, Vol. 32, pp. 310-332.
- [16] Banker, R.D., Wattal, S. and Plehn-Dujowich, J.M. (2011), "R&D versus acquisitions: role of diversification in the choice of innovation strategy by information technology firms", *Journal of Management Information Systems*, Vol. 28 No. 2, pp. 109-144.
- [17] Matvos, G., Seru, A. and Silva, R.C. (2018), "Financial market frictions and diversification", *Journal of Financial Economics*, Vol. 127 No. 1, pp. 21-50
- [18] Statsenko, L. and de Zubielqui, G.C. (2020), "Customer collaboration, service firms' diversification and innovation performance", *Industrial Marketing Management*, Vol. 85, pp. 180-196.
- [19] Linkov, I., Trump, B. and Kiker, G. (2022), "Diversity and inclusiveness are necessary components of resilient international teams", *Humanities and Social Sciences Communications*, Vol. 9 No. 1.
- [20] Andreou, P.C., Louca, C. and Petrou, A.P. (2016), "Organizational learning and corporate diversification performance", *Journal of Business Research*, Vol. 69 No. 9, pp. 3270-3284.
- [21] Berrill, J., Campa, D. and O'Hagan-Luff, M. (2021), "Firm diversification and earnings management strategies: European evidence", *International Review of Financial Analysis*, Vol. 78.
- [22] Ji, S.S., Mauer, D.C. and Zhang, Y.L. (2020), "Managerial entrenchment and capital structure: the effect of diversification", *Journal of Corporate Finance*, Vol. 65.
- [23] Stern, I. and Henderson, A.D. (2004), "Within-business diversification in technology-intensive industries", *Strategic Management Journal*, Vol. 25 No. 5, pp. 487-505.
- [24] ZHANG Yan, WEI Jiang. Strategic orientation, R&D partner diversity and innovation performance. *Studies in Science of Science*, 2016, 34(3): 443-452.
- [25] FENG Taiwen, SUN Linyan. Impact of external involvement in the new product development process on firm performance. *Journal of Management Science*, 2013, 26(2): 28-39.
- [26] GUO Jianjie, XIE Fuji, WANG Haihua, et al. Research of the effect of ego-network dynamics, inter-regional collaboration network on innovation of enterprises in industry-university collaboration. *Chinese Journal of Management*, 2019, 16(7): 1026-1034.
- [27] VAN DEN BERGH JCM. Optimal diversity: increasing returns versus recombinant innovation. *Journal of Economic Behavior & Organization*, 2008, 68(3/4): 565-580.
- [28] FLEMING L. Recombinant uncertainty in technological search. *Management Science*, 2001, 47(1): 117-132.
- [29] YAYAVARAM S, CHEN W R. Changes in firm knowledge couplings and firm innovation performance: the moderating role of technological complexity. *Strategic Management Journal*, 2015, 36(3): 377-396.
- [30] HARGADON A, SUTTON R I. Technology brokering and innovation in a product development firm. *Administrative Science Quarterly*, 1997, 42(4): 716-749.
- [31] PENNEY C R, COMBS J G. A transaction cost perspective of alliance portfolio diversity. *Journal of Management Studies*, 2020, 57(6): 1073-1105.
- [32] LEE D, KIRKPATRICK-HUSK K, MADHAVAN R. Diversity in alliance portfolios and performance outcomes: a meta-analysis. *Journal of Management*, 2017, 43(5): 1472-1497.
- [33] KOPUT K W. A chaotic model of innovative search: some answers, many questions. *Organization Science*, 1997, 8(5): 528-542.
- [34] HAGEDOORN J, LOKSHIN B, ZOBEL A K. Partner type diversity in alliance portfolios: multiple dimensions, boundary conditions and firm innovation performance. *Journal of Management Studies*, 2018, 55(5): 809-836.
- [35] GRIMPE C, KAISER U. Balancing internal and external knowledge acquisition: the gains and pains from R&D outsourcing. *Journal of Management Studies*, 2010, 47(8): 1483-1509.
- [36] Fleming L, Sorenson O. Science as a map in technological search [J]. *Strategic Management Journal*, 2004, 25(8-9): 909-928.
- [37] Arora A, Belenzon S, Pataconi A. The decline of science in corporate R&D [J]. *Strategic Management Journal*, 2017, 39(1): 3-32.



- [38] Andrade Rojas M G, Solis E R R, Zhu J J. Innovation and network multiplexity: R&D and the concurrent effects of two collaboration networks in an emerging economy [J]. *Research Policy*, 2018, 47 ( 6 ) : 1111-1124.
- [39] Zucker L G, Darby M R, Armstrong J S. Commercializing knowledge: University science, knowledge capture, and firm performance in biotechnology. [J]. *Manage Science*, 2002, 48(1): 138-153.
- [40] Carnabuci G, Operti E. Where do firms' recombinant capabilities come from? Intra - organizational networks, knowledge, and firms' ability to innovate through technological recombination [J]. *Strategic Management Journal*, 2013, 34(13): 1591 - 1613.
- [41] Dtlina F T, Lehner P, Kaufmann A. Do different types of innovation rely on specific kinds of knowledge interactions? [J]. *Research Policy*, 2009, 29 (1): 59 - 71.
- [42] Ricken S T, Schuler R P, Grandhi S A, et al. TellUsWho: Guided Social Network Data Collection; Proceedings of the 2010 43rd Hawaii International Conference on System Sciences, F, 2010 [C]. IEEE.
- [43] Granovetter M S. The strength of weak ties [J]. *American Journal of Sociology*, 1973, 78(6): 1360 - 1380.
- [44] Andersson, U., I. Björkman, and M. Forsgren. Managing Subsidiary Knowledge Creation: The Effect of Control Mechanisms on Subsidiary Local Embeddedness [J]. *International Business Review*, 2005, 14(5): 521-538.
- [45] Wu, J., C. Wang, and J. Hong. Internationalization and Innovation Performance of Emerging Market Enterprises: The Role of Host-country Institutional Development [J]. *Journal of World Business*, 2016, 51(2): 251-263.