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Business models and the performance of Chinese high-tech service firms: the role of the technological innovation mode and technological regimes

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ABSTRACT

Given China's rapidly developing landscape, improving innovation performance has become a critical objective for high-tech service firms. This study examined the relationship between business models and the performance of Chinese high-tech service firms. The theoretical model is based on contingency theory and incorporates concepts from business model innovation, and technological innovation. A multilevel regression analysis was conducted using data from 489 high-tech service firms in China. The results indicate significant positive correlations between innovation performance and various factors such as efficiency- and novelty-oriented business models, technology development, and technology acquisition. Second, technological innovation mode mediates the relationship between the business model and innovation performance. Third, technological regimes have different moderating effects on the relationships between the type of business model and innovation performance and that between the type of technological innovation and innovation performance. From a practical perspective, firms operating under different technological regimes should adjust their business strategies to achieve optimal innovation performance. Furthermore, the results have several theoretical contributions and practical implications. The findings offer a valuable reference for business growth in developing regions and identifies viable ways to improve the innovation performance of China's high-tech service enterprises.

1. Introduction

As China's national economy experiences accelerated growth, high-tech service companies expanded rapidly. In 2020, investment in the high-tech service industry increased 10% relative to the previous year [1]. Despite this rapid expansion, the challenge lies in maintaining sustainable growth. Compared to leading enterprises in developed regions, Chinese high-tech service companies have a relative deficiency in enterprise scale and innovation performance [2,3]. Suboptimal innovation performance constrains the progress of Chinese high-tech service enterprises [3]. Consequently, there is an urgent need to discover ways to enhance innovation performance in the context of a rapidly evolving external environment, necessitating an expeditious solution.

The role of technological innovation in fostering innovation performance growth is unequivocally evident [4]. Knowledge-creation capacity has a positive impact on the performance of high-tech enterprises [5]. Appropriate business models can promote innovation in

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Chinese enterprises [6].

Given the extant research, this study constructs a theoretical framework of innovation performance based on which it empirically analyzes the relationship between the business model, technological innovation mode, and innovation performance, as well as the moderating effect of technological regimes. Therefore, this study demonstrates the integration of technological innovation modes into business models to enhance firm performance, and explores how companies thrive in external environments characterized by diverse technological regimes.

Different countries employ various criteria to define high-tech enterprises based on their unique levels of technological development. In the United States, high-tech enterprises are characterized by the proportion of research and development (R&D) intensity in the total output and the share of R&D personnel within the overall labor force [7]. Japan defines high-tech enterprises by considering factors such as resource and energy consumption, anticipated product market size, influence on related industries, technology intensity, and the pace of technological innovation [8]. The Organization for Economic Cooperation (OECD) primarily relies on R&D input intensity as a defining criterion [9]. In 2008, China's Ministry of Science and Technology, Ministry of Finance, and State Administration of Taxation jointly issued the Administrative Measures for the Recognition of High-tech Enterprises, which clarified the criteria for defining high-tech enterprises.

This study characterizes high-tech enterprises as those that continuously engage in scientific research and successfully commercialize technological innovation achievements within their respective business domains, thereby establishing independent intellectual property rights and core competitiveness. Furthermore, this study defines the high-tech service industry as an emerging service sector that combines high technology and services and delivers high value-added services to society.

2. Literature review and hypotheses

2.1. Relevant research

Innovation is an endless source for firms' survival and growth, and is crucial for adapting to a dynamic external environment [10]. Innovation performance is a vital metric reflecting the efficiency and effectiveness of technological innovation processes [11]. Innovation performance is a pivotal focal point for research and innovation activities in both the theoretical and practical domains.

Innovation performance encompasses the entire progression from the generation of creative ideas to their implementation and realization as innovation outcomes. However, some contend that innovation performance represents an aggregate of positive outputs derived from innovation activities [11]. Innovation performance refers to the diverse positive outcomes achieved by enterprises as a result of engaging in fruitful innovation activities [12] and it measures the innovation effect of an enterprise.

A novelty-centered business model significantly affects the innovation performance of startups [13]. A reasonable choice for enterprises in uncertain environments is to adopt either an efficiency-or novelty-centered business model [13]. Novelty-centered business models foster the development of new trading methods and partnerships for enterprises, thereby stimulating innovation activities. By contrast, efficiency-centered business models help enterprises reduce transaction costs and enhance transactional efficiency [14,15].

Technological innovation helps enterprises develop new products and securing competitive advantage in the market, consequently enhancing their operational benefits [16]. Moreover, the sources of new technologies affect innovation performance [17]. The technological innovation mode covers two categories based on the source of the new technology: developed internally or purchased externally [12]. To develop technology, enterprises invest in independent R&D, which encompasses both wholly self-owned technological innovation and collaborative R&D with other entities. Conversely, when buying technology, firms acquire new technologies by purchasing patents and production equipment, licensing technology, and recruiting core technological personnel from other enterprises.

Contingency theory underscores the premise that the external environment profoundly affects the internal operational mechanisms within a corporate structure [18]. All organizations operate within and are influenced by a particular environment. The process of improving innovation performance by optimizing business model design and technological innovation is thus an internal operational and management matter under the influence of external conditions. High-tech businesses are technology intensive and hence significantly affected by the external technological environment [19]. The technological regime denotes the technological environment in which companies operate [11]. Innovation approaches vary substantially across industries, and technological regimes play a crucial role in shaping an industry's access to technological advancements and competitive advantages [20]. Technological regimes are technological environments in which enterprises conduct business, innovation, learning, and other activities [21]. They consist of key factors such as technological opportunities, technological monopolies, technological cumulativeness, and knowledge bases [22–24]. This study explores the relationship between technological monopoly, technological cumulativeness, technological opportunities, and knowledge base with enterprise innovation activities.

2.2. Research hypotheses

2.2.1. Relationship between innovation performance and the business model

Efficiency-centered business models reduce the uncertainty of transaction information, thus reducing the risks of transactions and simplifying them to lower enterprise transaction costs [25]. In other words, such models streamline the enterprise transaction process and increase stickiness between trading partners [13]. By enhancing trader adherence through an efficiency-focused business model, an enterprise can leverage the late-mover advantage in the technology spillover effect, thereby fostering knowledge creation within the enterprise [26]. Furthermore, an efficiency-centered business model improves the communication efficiency of the transaction process and promotes better uptake of knowledge from the external environment by companies [13]. This type of model reduces costs and improves efficiency to enhance innovation performance [9]. Therefore, H1 is proposed as follows:

H1. Innovation performance positively affects the efficiency-centered business model.

A business model realizes the commercialization of new technologies in enterprises, thereby delivering new value to customers [15]. Novelty-centered business models favor enterprises that continuously explore new partners and trading methods [14]. Such models may enable the firm to jointly obtain more value from their original partners through new transaction methods or develop new markets and jointly obtain new value from new partners [15]. In other words, novelty-centered business models promote technological innovation by exploring new partners and trading mechanisms, thus improving innovation performance [9]. Business models not only improve the input-to-output ratio of technological R&D but also absorb external knowledge, thus improving innovation performance [6]. Therefore, H2 is proposed as follows:

H2. Innovation performance positively affects the novelty-centered business model.

2.2.2. Correlation between the business model and the technological innovation mode

An efficiency-centered business model encourages enterprises to reduce transaction costs [13]. Creating technology for innovation requires a large amount of funds [12]. Although the costs involved in these scenarios differ, they conflict with the firm's operations [27]. Developing technology requires enterprises to continuously expand into new markets, obtain new customers, and invest in the R&D of new technologies [13]. An efficiency-focused business model requires enterprises to minimize redundant information and transaction costs to enhance transaction efficiency. The coexistence of technology and an efficiency-focused business model in an enterprise will inevitably result in mutual constraints [9]. Therefore, based on this analysis, H3 is proposed:

H3. The efficiency-centered business model negatively affects the making technology.

An enterprise that adopts a technology prioritizes time reduction and financial investment in technological innovation [12]. Thus, an enterprise that emphasizes minimizing operating expenses is more proficient in cost reduction than other enterprises [14] and thereby has greater efficiency when acquiring technology. An efficiency-centered business model minimizes the uncertainty and risk associated with technology procurement, thereby enhancing an enterprise's ability to adapt to technological advancements [28]. This business approach can reinforce the interconnectivity between enterprises and partners, which is beneficial for leveraging the information spillover effect and taking advantage of technological advancements. Consequently, an efficiency-focused business model favors the acquisition of external technology and enhances enterprises' technological innovation capabilities [9]. Therefore, H4 is proposed as follows:

H4. The efficiency-centered business model positively affects the buying technology.

A novelty-centered business model encourages enterprises to constantly explore new trading channels, develop fresh trading partners, and create emerging trading mechanisms [13]. These characteristics provide access a greater amount of external information, which helps them learn and master new external knowledge more quickly. In other words, this business model reduces the risks associated with experimentation in the technology adoption process, and creates a culture of ongoing innovation [9]. An innovative atmosphere favors technological development. Novelty-centered business models and technology focus on innovation, which helps strengthen their mutual effects [29]. Therefore, H5 is proposed.

H5. The novelty-centered business model positively affects the making technology.

Growing the number of trading partners in a novelty-focused business model enables enterprises to access new sources of technological knowledge and gather more information from the external environment [13]. Diversified technological knowledge sources afford a wider range of options when procuring technology [30], conferring a relatively high informational resource advantage. By comparing new technologies from various sources, enterprises can reduce the costs and risks associated with technological procurement. Consequently, a novelty-focused business model increases the probability of successful technology implementation [9]. Therefore, H6 is proposed as follows:

H6. The novelty-centered business model positively affects the buying technology.

2.2.3. The correlation between technological innovation mode and innovation performance

The strategy of conducting technological innovation by creating technology positively affects innovation performance [31]. Technology development improves a company's ability to master existing technological knowledge and reduces the risk of failure in the R&D of new technologies [32]. That is, developing technology increases the success rate of new-product R&D and plays a positive role in innovation performance [33]. Making technology focuses more on the company's own efforts and emphasizes the improvement of its capabilities [33]. Enterprises have stronger autonomy in terms of technological innovation, more effectively reducing the adverse impact of the external environment on technological development [33] and more easily fostering enterprises to master core technologies and quickly keep up with new technological changes compared with buying technology [34]. Therefore, H7 is proposed as follows:

H7. Innovation performance positively affects making technology.

H7a is proposed based on H1, H3, and H7:

H7a. Making technology mediates the relationship between innovation performance and an efficiency-centered business model.

H7b is proposed based on H2, H5, and H7.

H7b. Making technology mediates the relationship between innovation performance and novelty-centered business models.

Undertaking technological innovation by buying technology significantly and positively affects innovation performance [35]. Many enterprises in developing regions cannot afford the high costs associated with the technology. In such cases, acquiring new technologies from external sources is essential to technological innovation [12]. Buying technology stresses the acquisition of external technological knowledge, which enables enterprises to reduce the time and economic cost of technological innovation [13,33]. Buying technology enables companies to develop multiple technological directions and increase their organizational flexibility [36], thus helping them adapt quickly to changes in the technological environment. Therefore, enterprises may quickly introduce new technologies by buying technology, thereby improving their technological level and innovation capabilities [37,38]. Based on this analysis, H8 is proposed.

H8. Innovation performance positively affects buying technology.

H8a is proposed based on H1, H4, and H8:

H8a. Buying technology mediates the relationship between innovation performance and the efficiency-centered business model.

H8b is proposed based on H2, H6, and H8:

H8b. Buying technology mediates the relationship between innovation performance and the novelty-centered business model.

2.2.4. Moderating effect of technological regimes

Contingency theory postulates that enterprises sculpt diverse organizational structures to adapt to different environments. Technological regimes, which carry pivotal influence on the technological environment, significantly impact technological innovation. These regimes provide a crucial theoretical framework for elucidating the variations in innovation processes across diverse industries [39].

Technological opportunities represent the likelihood that enterprises will yield innovative outcomes following a specific level of R&D investment. They also mirror the potential to achieve favorable results in executing technological innovation [24]. Varying technological opportunities across different technological domains result in varying levels of innovation difficulties and R&D expenditures [40]. Enterprises are more likely to obtain advanced technologies in environments with high technological opportunities, thus providing a strong driving force for innovation activities [41]. Enterprises with technological innovation activities prefer to apply innovation results to enterprise operation [42]. Therefore, an environment with many technological opportunities is conducive to enterprises' technological development, thereby improving their innovation performance [11].

Buying technology means that enterprises introduce technological innovation achievements from other enterprises by purchasing technology [43], whereas enterprises in a robust technological opportunity environment can more easily obtain advanced technologies [24]. Therefore, the adoption of technology by enterprises in environments with numerous technological opportunities is conducive to technological innovation. Based on this analysis, H9a and H9b are proposed.

H9a. Technological opportunities positively moderate innovation performance and technology.

H9b. When innovation performance and technology purchase are related, technological opportunities have a positive moderating effect.

When operating in a dynamic technological opportunity environment, enterprises adopting a novelty-focused business model can more effectively develop new partners or establish new trading methods [44,45]. Consequently, enterprises are better positioned to leverage novelty-focused business models and enhance innovation performance. Therefore, in a dynamic technology-opportunity environment, enterprises can improve their innovation performance by adopting novel business models. On the other hand, enterprises that adopt an efficiency-focused business model in a dynamic technological opportunity environment can more easily acquire new technologies from external sources, thereby improving transaction efficiency and enhancing their innovation performance [11]. Hence, H9c and H9d are proposed.

H9c. When innovation performance and novelty-centered business models are related, technological opportunities have a positive moderating effect.

H9d. When innovation performance and efficiency-centered business models are related, technological opportunities produce a positive moderating effect.

Technological monopoly refers to enterprises that utilize technical means to prevent the imitation of their innovation outputs and prevent other enterprises from benefiting from such imitation.

On the one hand, technological monopolies incentivize enterprises to innovate by safeguarding their technological innovation outputs; on the other hand, they hinder enterprises without technological innovation from gaining advantages through imitation [11]. Consequently, enterprises operating in an environment with a strong technological monopoly are more likely to maintain their technological innovation output internally, making it challenging to transfer such output between enterprises. These enterprises conduct technological innovation activities independently, and their innovation outputs are well protected. Hence, enterprises in environments with high technological monopolies are more active in technology creation [46].

In such an environment, firms prevent the dissemination of new technologies to protect their innovations [47]. Hence, enterprises that rely on technology procurement to drive technological innovation face difficulties in obtaining advanced technology from external sources [47]. Therefore.

H10a. A technological monopoly has a positive moderating effect when innovation performance and technology are related.

H10b. When innovation performance and buying technology are related, technological monopoly has a negative moderating effect.

A high degree of technological monopoly is not conducive to other firms acquiring new technologies by forging links with trading partners. Therefore, the efficiency of enterprises that adopt novelty-centered business models declines [11]. An efficiency-centered business model emphasizes reducing transaction costs by improving the effectiveness of existing transaction activities, thereby creating more value [44,45]. Such a business model increases stickiness between partners, reducing the protectionist impact of a technological monopoly. Based on this analysis, H10c and H10d are proposed:

H10c. When innovation performance and novelty-centered business models are related, a technological monopoly produces a negative moderating effect.

H10d. When innovation performance and an efficiency-centered business model are related, a technological monopoly produces a positive moderating effect.

Enterprises in an environment with high technological cumulativeness require long-term technology accumulation to better carry out technological innovation [48]. Technological innovation output has a lasting impact on firms' future innovation efforts. Future technological innovation builds upon the accumulation of current technologies, and the technological innovation process is characterized by significant accumulative growth. Technological innovation in an environment with a high degree of technological cumulativeness indicates the need for sustained continuous innovation to benefit from high growth [49]. Innovation is highly dependent on existing technologies. Hence, technology imitators face challenges in achieving high profits, especially those without significant accumulation of prior technology. Enterprises without a long history of technological innovation struggle to reap the significant benefits of technological innovation.

Making technology is a process by which enterprises independently carry out technological innovation and apply the innovation results to their production processes. Making technology is a process of continuous technology accumulation and innovation. Developing technology helps enterprises master existing technologies. The external environment has little impact on enterprises with independent R&D capability [50]. Technology creation with a high degree of technological cumulativeness enables enterprises to accurately understand the direction of technological advancement and enhances the technological reserves of the enterprise [48]. Therefore, the enterprises with a high level of technological cumulativeness are favorable for enhancing the benefits to enterprises from making technology.

The introduction of technological innovation outputs from external sources through technology procurement leaves gaps in the firm's internal technology accumulation, hindering their ability to innovate based on existing technology. Thus, in an environment with a high degree of technological cumulativeness, enterprises face challenges in improving innovation performance through technology procurement [39]. Thus, H11a and H11b are proposed.

H11a. Technological cumulativeness positively moderates innovation performance and technology.

H11b. When innovation performance and technology purchase are related, technological cumulativeness has a negative moderating effect.

In environments characterized by high levels of technological cumulativeness, enterprises' innovation efforts hinge on existing technological outputs. Consequently, these entities face challenges regarding the swift acquisition of new technologies from external sources [48]. Enterprises with high technological cumulativeness tend to adopt novelty-focused business models that cannot technologically advance through the establishment of new trading partnerships.

However, enterprises that adopt an efficiency-focused business model can improve transaction efficiency and increase interconnectivity between trading partners [44,45]. Enhancing the interconnectivity between trading partners can facilitate information exchange and technology learning. In an environment with high technological cumulativeness, enterprises must enhance information exchange to achieve mutual technological learning. Hence, H11c and H11d are put forward.

H11c. When innovation performance and novelty-centered business models are related, technological cumulativeness has a negative moderating effect.

H11d. When innovation performance and efficiency-centered business models are related, technological cumulativeness produces a positive moderating effect.

A knowledge base refers to the knowledge required by an enterprise to conduct innovation activities [2]. An environment with a strong knowledge base requires continuous technological knowledge and R&D from enterprises. Technology-creating enterprises primarily conduct technological innovation activities independently and apply their outputs to business operations, possessing strong technological R&D and absorption capabilities.

Enterprises operating with strong knowledge bases continue to invest in technological R&D, which positively affects the role of technology creation in technological innovation. Technology procurement involves introducing technological innovations by other companies through technology acquisition [43]. In a robust knowledge-based environment, enterprises require strong technical knowledge to engage in innovation activities [51]. Hence, it is difficult for enterprises to purchase technology to achieve technological progress. Buying technology reduces a firm's ability to generate new knowledge. Therefore, H12a and H12b are proposed.

H12a. When innovation performance and technology are related, the knowledge base has a positive moderating effect.

H12b. When innovation performance and technology purchases are related, the knowledge base has a negative moderating effect.

A company with a strong knowledge base has strong capabilities to absorb and generate knowledge [52] and create a growing number of trading methods, and open up new trading partners as it adopts a novelty-driven business model. Therefore, such enterprises can better acquire new knowledge from the external environment, thus promoting innovation activities [39]. The efficiency-centered business model helps enterprises create more value by improving the effectiveness of transaction methods and reducing transaction costs [44,45]. Enterprises value controlling operating costs, improving the effectiveness of trading activities and reducing investments in technological R&D. An environment with a strong knowledge base requires enterprises to continue conducting R&D, thereby improving their technological innovation capability [53]. Therefore, an environment with a strong knowledge base hampers enterprises from adopting an efficiency-centered business model. Based on this analysis, H12c and H12d are put forward.

H12c. When innovation performance and novelty-centered business models are related, the knowledge base produces a positive moderating effect.

H12d. When innovation performance and efficiency-centered business models are related, the knowledge base produces a negative moderating effect.

Fig. 1 presents the theoretical framework of the study.

3. Methods

3.1. Sample and data collection

The sample includes high-tech service enterprises in Mainland China, excluding those in Hong Kong, Macao, and Taiwan, as the business environments in these three areas differ from those in Mainland China [54]. Because the population is large, simple random sampling was used to obtain the sample [55]. A total of 600 sample enterprises were selected from a database of China's high-tech service enterprises using a random number table. The survey participants were mainly management personnel in the sample enterprises as they had a comprehensive understanding of the enterprise's technological innovation mode and business model design. The sample enterprises are located in various cities and provinces of Mainland China. Onsite visits were arranged for enterprises that were willing to participate, whereas for those that declined, questionnaires were sent via email. The survey was conducted anonymously to maintain confidentiality.

A panel of 20 business students from various universities was assembled to administer the survey. Before conducting the research, the investigative team underwent meticulous training to enhance their survey administration skills. The questionnaire survey was conducted from July 1, 2021, to July 30, 2021, with 600 questionnaires distributed and 516 returned.

To ensure the validity of the samples, a T-test was performed to compare the age and size of the sample enterprises between the returned and non-returned questionnaires. The results revealed no significant disparities between the two sample groups, suggesting that the non-returned questionnaires did not compromise the validity of the sample. Among the returned questionnaires, 27 were deemed invalid because of the preponderance of missing values. After meticulous review and verification, 489 valid questionnaires were completed. Table 1 summarizes the initial outcomes.

The descriptive statistical analysis of the 489 questionnaires reveal that more than 70.00% of the enterprises were established for 6–15 years, 68.71% of the respondents have worked in the current company for 6–15 years, and the number of employees in the sample companies was mainly 101–300 and 501–1000 people. Companies with 101–300 employees account for 29.86% of the sample, whereas those with 501–1000 employees account for 28.63%. In terms of the job positions held by respondents, managerial positions accounted for the largest proportion, reaching 40.49%. The second largest proportion was that of respondents who held the position of

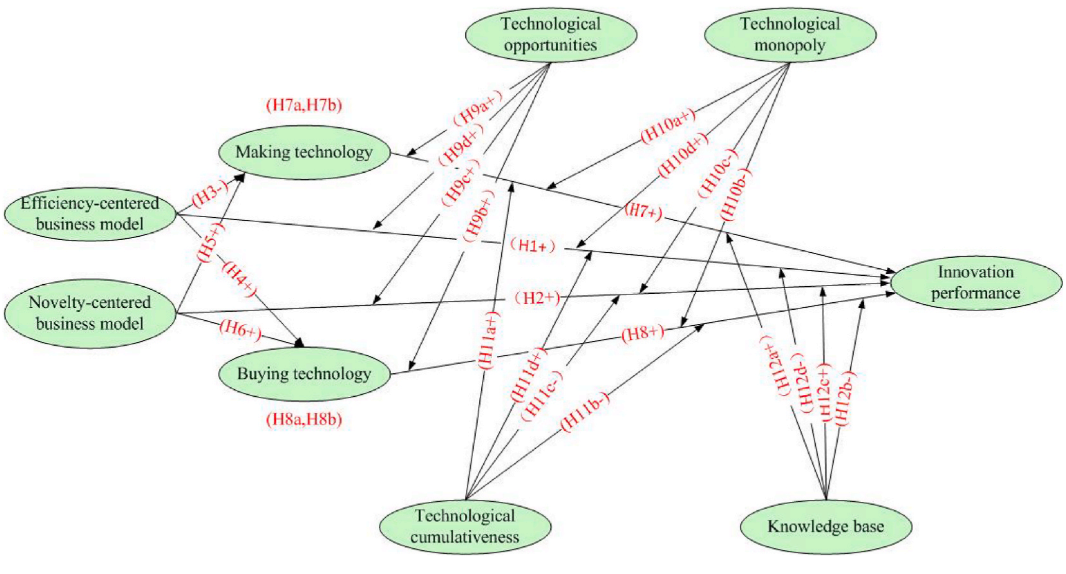

Fig. 1. Research model.

Table 1
Questionnaire recovery.

Category	Questionnaire distribution method	Quantity issued	Number recycled	Effective quantity	Recovery rate	Efficiency
Large sample survey	Site investigation visit	435	426	406	97.93%	93.33%
	Email	165	90	83	54.54%	50.30%
	Total	600	516	489	86.00%	81.50%

director, accounting for 26.58%. The respondents' characteristics met the requirements for data collection [56]. The details of the basic sample are provided in Appendix 1.

3.2. Variable measurements

3.2.1. Measurement scale

Based on the literature, we selected a mature scale for variable measurements. The questionnaire used a 7-point Likert scale (1 = strongly disagree-7 = strongly agree) [57]. Novelty- and efficiency-centered business models use the scale developed by Zott and Amit [13]. The scale of the business model is developed through empirical research on e-commerce enterprise business models. The scale for technological innovation mode was adopted from Guo et al.'s [58] research on the evaluation of the technological innovation mode of Chinese enterprises. The scale for technological regimes was adopted from research conducted by Breschi et al. [29] on 437 companies from Italy, Germany, and the United Kingdom. The scale for innovation performance was adopted from the research conducted by Story and Kelly [59], which included industries such as banking, insurance, transportation, telecommunications, and media. The survey questionnaire is presented in Appendix 2.

3.2.2. Control variables

The size and age of a company affect innovation performance [60]. Therefore, these items are included as control variables [61,62]. Firm size is the number of formal employees of the company as of July 1, 2021 [63]. Age is the number of years between the firm's establishment and July 1, 2021. Table 2 presents the assignments of the control variables.

4. Results

4.1. Common method bias detection

This study conducted an exploratory factor analysis (EFA) of all items and assessed the impact of common method deviation using the Harman single-factor test [64]. The results indicate that the highest factor variance without rotation had an interpretation rate of 17.56%, which was below the benchmark of 40.00%. Table 3 shows that the eigenvalues of the factors were greater than 1. These results suggest that no single factor can explain a significant portion of the variation in the sample data, indicating that the study was not affected by a common method bias.

4.2. Multicollinearity test

Since this study set up multiple independent, mediating, and moderating variables, the variables may suffer from multiple collinearities. Hence, a multiple collinearity test is carried out using innovation performance as a dependent variable and the other variables as independent variables. The multicollinearity VIF test for each independent, mediating, and moderating variable indicates that the VIF values of all variables are below the general standard of 5. Table 4 underscores the assertion that the variables chosen by the model were devoid of multicollinearity, thereby substantiating the reliability of the measurement of the variables.

4.3. Reliability and validity tests

This study uses AMOS 21.0 to conduct confirmatory factor analysis (CFA) of each measurement index and thereby test the convergent validity of the scale. The convergent validity test primarily adopts the model-fitting value and standardized factor load value [65]. Cronbach's coefficient was used for the reliability test [66]. We conducted reliability and validity tests for the variables involved.

Table 2
Control variables.

Assignment	Age (A1)	Size (A3)
1	5 years and below	Less than or equal to 100 employees
2	6–10 years	101–300 employees
3	11–15 years	301–500 employees
4	16–20 years	501–1000 employees
5	21 years and above	Greater than or equal to 1001 employees

Table 3
Common method bias tests.

Composition	Initial eigenvalues			Extracted square sum load		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	10.36	17.56	17.56	10.36	17.56	17.56
2	6.60	11.20	28.75	6.60	11.19	28.75
3	5.07	8.59	37.34	5.07	8.59	37.34
4	4.04	6.84	44.18	4.04	6.84	44.18
5	3.40	5.77	49.95	3.40	5.77	49.95
6	3.08	5.21	55.16	3.08	5.21	55.16
7	2.32	3.94	59.10	2.32	3.94	59.10
8	2.07	3.52	62.61	2.07	3.52	62.61
9	1.96	3.33	65.94	1.96	3.33	65.94
10	1.06	1.79	67.73	1.06	1.79	67.73
11	1.01	1.71	69.43	1.01	1.71	69.43

Table 4
Multicollinearity test results.

Variable	Tolerance	VIF
Technological opportunities	0.96	1.04
Technological monopoly	0.88	1.14
Technological cumulativeness	0.89	1.13
Knowledge base	0.92	1.09
Efficiency-centered business model	0.82	1.22
Novelty-centered business model	0.87	1.15
Making technology	0.93	1.07
Buying technology	0.84	1.19

4.3.1. Independent variables

Fig. 2 illustrates the CFA model for independent variables (efficiency-centered business model and novelty-centered business model). The fitness test of the model shows that $X^2/df = 3.86$ (<5). RMSEA = 0.07 (<0.08), and thus the model adaptability is ideal. GFI = 0.87, NFI = 0.90, and RFI = 0.87 (>0.80). IFI = 0.93, TLI = 0.91, and CFI = 0.93 (>0.90). Hence, the model established by this study fits the survey data well.

Convergent validity analysis of the independent variables showed that the standardized load of each test item was greater than 0.50, and the standard error value of the standard error was also less than 0.50. The CR of the efficiency- and novelty-centered business models is over 0.70, AVE > 0.50. Hence, all items of the independent variable explain the corresponding variables well. The Cronbach's αof the independent variable exceeds the ideal standard of 0.90. Table 5 indicates that the independent variable scales were stable and reliable.

4.3.2. Mediating variables

Fig. 3 shows the CFA model of the mediating variables (making and buying technologies). The fitness test of the model shows that $X^2/df = 2.70$ (<3). RMSEA = 0.06 (<0.08). GFI = 0.96, NFI = 0.93, RFI = 0.94 (>0.80). IFI = 0.97, TLI = 0.96, and CFI = 0.97, (>0.90). Hence, the mediating variable model exhibited good fitting properties.

A CFA was performed on the mediating variables, and the standardized load of all items was greater than 0.50, while the value of the standard error was less than 0.50. The CR and AVE of the making and buying technology variables exceed the standards of 0.70 and 0.50, respectively. Hence, all the items of the mediating variables met the standards. The Cronbach's α of the mediation variables exceeded 0.80. Table 6 shows that the scales of the mediating variables were stable and reliable.

4.3.3. Moderating variables

Fig. 4 presents the CFA model for the moderating variables. $X^2/df = 2.09$ (<5). RMSEA = 0.05 (<0.08). GFI = 0.94, NFI = 0.95, RFI = 0.94 (>0.80). IFI = 0.97, TLI = 0.97, and CFI = 0.97 (>0.90). Hence, the moderating variable model fit the survey data well.

The results of the convergent validity analysis of the moderating variable demonstrate that all items possess a standardized loading greater than 0.50, accompanied by a standard error value less than 0.50. In addition, the composite reliability (CR) of all moderating variables exceeded 0.70, and the average extracted variance (AVE) surpasses 0.50. As shown in Table 7, the convergent validity of the moderating variable is appropriate, and the Cronbach's α of the moderating variables surpasses 0.80. Consequently, the scales of the moderating variables can be considered stable and reliable.

4.3.4. Dependent variable

Fig. 5 depicts the CFA model for dependent variables. The fitness test of the dependent variable model shows that $X^2/df = 0.58$ (<5). RMSEA = 0.00 (<0.08). GFI = 0.99, NFI = 0.99, RFI = 0.99 (<0.08). IFI = 1.00, TLI = 1.00, and CFI = 1.00 (<0.09). Therefore, the dependent variable model has an ideal fitness.

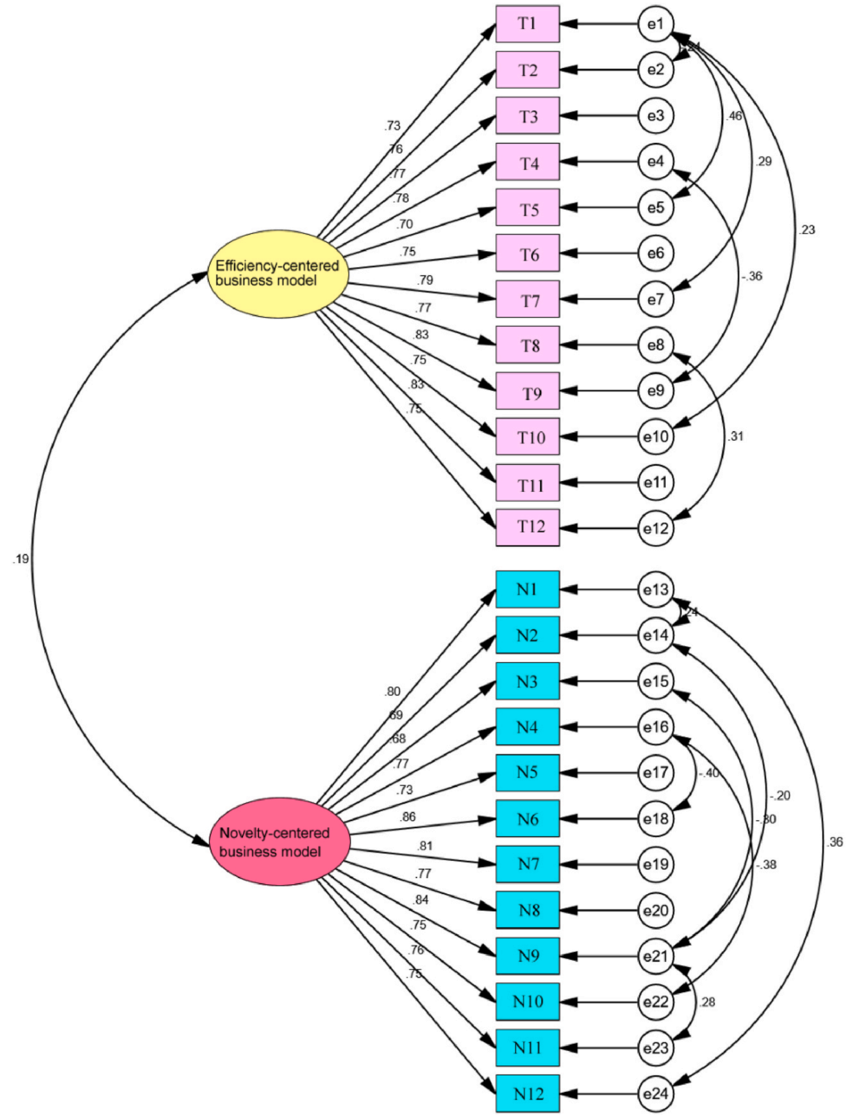

Fig. 2. Confirmatory factor analysis model of the independent variable.

The convergent validity analysis of the dependent variable claims that the standardized load of all items is greater than 0.50, and the standard error value is less than 0.50. Thus, each test item could explain its dimensions. The CR and AVE of the dependent variable reached the standards of 0.70 and 0.50, respectively. Table 8 shows that the dependent variable has ideal convergent validity. The Cronbach's α of dependent variables exceeds the ideal standard of 0.90. Table 8 indicates that the scales of the dependent variables were stable and reliable.

4.4. Discriminant validity test

The square root of the AVE value and the Pearson correlation coefficient were used to test discriminant validity. When the square root of the AVE of the equivalent table was greater than Pearson's correlation coefficient, it has good discriminant validity. Table 9 presents the results of discriminant validity tests. The square root of the AVE of all variables is greater than 0.50, and the square root of the AVE is greater than the corresponding Pearson correlation coefficient. Therefore, the scale used in this study had good discriminant validity.

4.5. Descriptive statistics and normal distribution test

Appendix 4 provides the mean, standard deviation, skewness, and kurtosis of all the items to analyze the centralized trend, dispersion, and distribution pattern. Klein proposed that an absolute skewness of less than 5 and an absolute kurtosis of less than 10 are

Table 5
Validity and reliability test of the independent variables.

Variable	Item	Factor loadings	Standard error	P	CR	AVE	Cronbach's α
Efficiency-centered business model	T1	0.73			0.95	0.59	0.95
	T2	0.76	0.07	***			
	T3	0.77	0.07	***			
	T4	0.78	0.06	***			
	T5	0.70	0.05	***			
	T6	0.75	0.06	***			
	T7	0.79	0.05	***			
	T8	0.77	0.07	***			
	T9	0.84	0.06	***			
	T10	0.75	0.05	***			
	T11	0.83	0.06	***			
	T12	0.75	0.06	***			
Novelty-centered business model	N1	0.80			0.95	0.59	0.94
	N2	0.69	0.05	***			
	N3	0.68	0.05	***			
	N4	0.77	0.06	***			
	N5	0.73	0.06	***			
	N6	0.86	0.05	***			
	N7	0.81	0.06	***			
	N8	0.77	0.06	***			
	N9	0.84	0.06	***			
	N10	0.75	0.06	***			
	N11	0.76	0.06	***			
	N12	0.75	0.04	***			

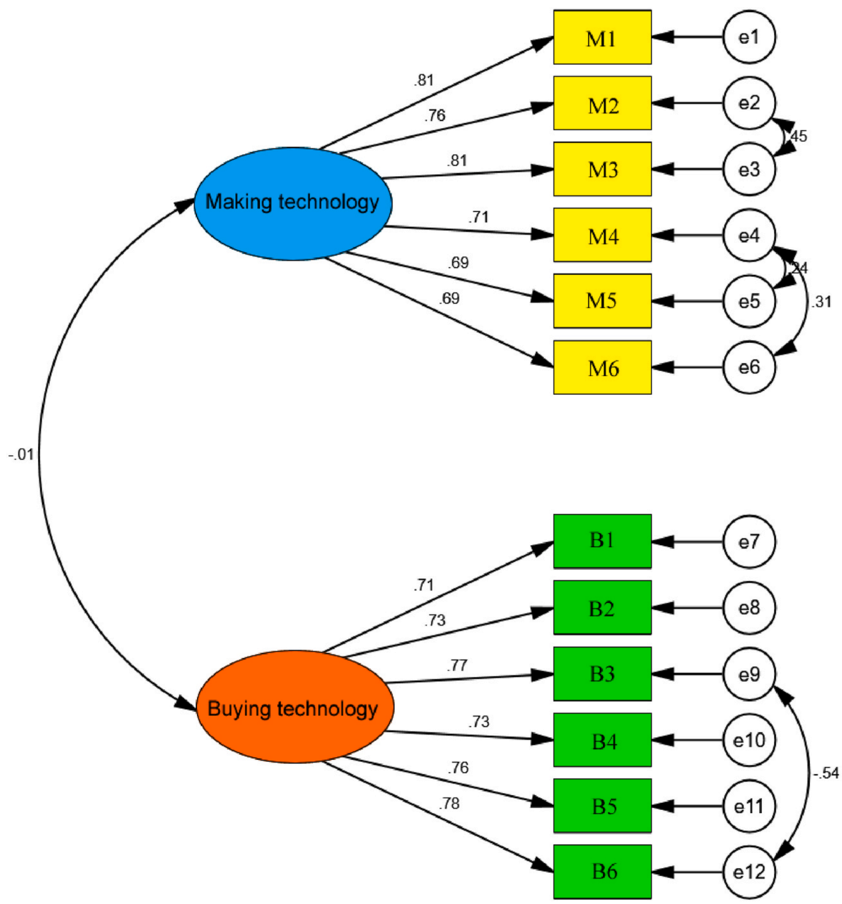

Fig. 3. Confirmatory factor analysis model of the mediating variables.

Table 6
Convergent validity and reliability test results of the mediating variables.

Variable	Item	Factor loadings	Standard error	P	CR	AVE	Cronbach's α
Making technology	M1	0.81			0.88	0.56	0.89
	M2	0.76	0.06	***			
	M3	0.81	0.05	***			
	M4	0.72	0.06	***			
	M5	0.69	0.05	***			
	M6	0.69	0.06	***			
Buying technology	B1	0.71			0.88	0.56	0.88
	B2	0.73	0.07	***			
	B3	0.77	0.07	***			
	B4	0.73	0.07	***			
	B5	0.76	0.07	***			
	B6	0.78	0.06	***			

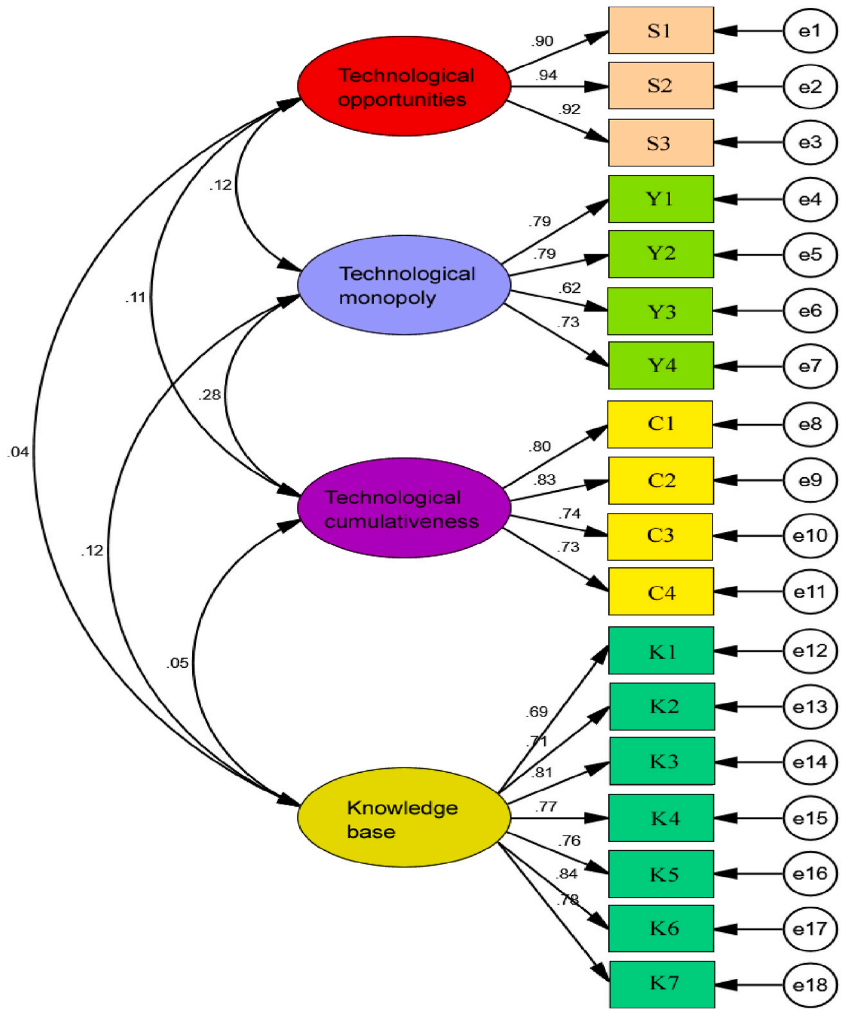

Fig. 4. Confirmatory factor analysis model of the moderating variables.

the criteria for data to meet a normal distribution. In Appendix 4, the absolute skewness and kurtosis of the sample data satisfy these conditions. The standard deviation of each data point was within 2, indicating that the degree of dispersion was small and the respondents' answers were relatively uniform and reliable. These data were used for further analyses.

Table 7
Convergent validity and reliability test results of moderating variables.

Variable	Item	Factor loadings	Standard error	P	CR	AVE	Cronbach's α
Technological opportunities	S1	0.90			0.94	0.85	0.94
	S2	0.94	0.03	***			
	S3	0.92	0.03	***			
Technological monopoly	Y1	0.79			0.82	0.54	0.82
	Y2	0.79	0.06	***			
	Y3	0.62	0.06	***			
	Y4	0.73	0.06	***			
Technological cumulativeness	C1	0.80			0.86	0.60	0.86
	C2	0.83	0.06	***			
	C3	0.74	0.06	***			
	C4	0.73	0.06	***			
Knowledge base	K1	0.69			0.91	0.59	0.91
	K2	0.71	0.07	***			
	K3	0.81	0.07	***			
	K4	0.77	0.07	***			
	K5	0.76	0.07	***			
	K6	0.84	0.07	***			
	K7	0.78	0.07	***			

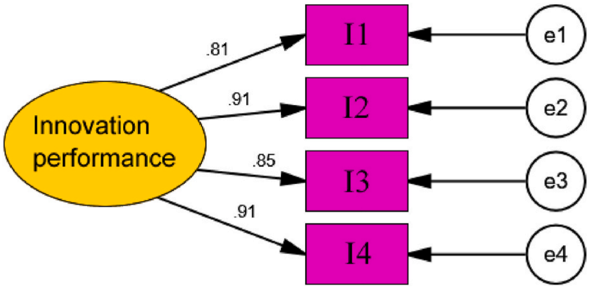

Fig. 5. Confirmatory factor analysis model of the dependent variable.

Table 8
Convergent validity and reliability of the dependent variables.

Variable	Item	Factor loadings	Standard error	P	CR	AVE	Cronbach's α
Innovation performance	I1	0.81			0.93	0.76	0.92
	I2	0.91	0.04	***			
	I3	0.85	0.05	***			
	I4	0.91	0.04	***			

Table 9
Discriminant validity analysis.

	1	2	3	4	5	6	7	8	9
Technological opportunities	**0.92**								
Technological monopoly	0.12	**0.74**							
Technological cumulativeness	0.10	0.24	**0.78**						
Knowledge base	0.05	0.12	0.05	**0.77**					
Efficiency-centered business model	−0.01	0.16	0.18	0.11	**0.77**				
Novelty-centered business model	0.09	0.02	−0.07	0.21	0.17	**0.77**			
Making technology	0.08	0.11	0.11	0.08	0.17	0.18	**0.75**		
Buying technology	0.06	−0.16	−0.11	−0.11	0.25	0.17	−0.01	**0.75**	
Innovation performance	0.24	0.10	0.03	0.05	0.20	0.20	0.16	0.21	**0.87**
AVE	0.85	0.54	0.60	0.59	0.59	0.59	0.56	0.56	0.76

Note: The value on the diagonal is the square root of the AVE, and the value below the diagonal is the Pearson correlation coefficient between variables.

4.6. Correlation analysis

Correlation reflects the degree of correlation between model variables [67]. Pearson's correlation coefficient was used to analyze the degree of correlation between variables. Table 10 summarizes the analysis results. The correlation coefficient between innovation performance and technological opportunities is significantly positive ($r = 0.24$, $P < 0.01$). The correlation coefficient between innovation performance and technological monopoly is significantly positive ($r = 0.10$, $P < 0.05$). The correlation coefficient between innovation performance and technological cumulativeness is positive but not significant ($r = 0.03$, $P > 0.05$). The correlation coefficient between innovation performance and knowledge base is positive but not significant ($r = 0.05$, $P > 0.05$).

The correlation coefficient between innovation performance and the efficiency-centered business model is significantly positive ($r = 0.20$, $P < 0.01$). The correlation coefficient between innovation performance and the novelty-centered business model is significantly positive ($r = 0.20$, $P < 0.01$). The correlation coefficient between innovation performance and technology is significantly positive ($r = 0.16$, $P < 0.01$). The correlation coefficient between innovation performance and buying technology is significantly positive ($r = 0.21$, $P < 0.01$).

4.7. Main effect test

The results of the hierarchical regression analysis reflect the structural and measurement relationships between the variables. The central processing of the original data allows for further analysis and testing of various hypotheses using the hierarchical regression analysis method [68]; therefore, standardized path coefficient values are used to reflect the regression relationship. A correlation was observed between two variables when the regression coefficient was significant. There was no correlation between two variables [68, 69].

4.7.1. Direct effect test

Fig. 6 shows the main effect structural equation model (SEM). Before using SEM for hypothesis testing, the model was tested for fitness. In the model, $X^2/df = 2.65$ (<5). RMSEA = 0.06 (<0.08). GFI = 0.84, NFI = 0.87, RFI = 0.86 (<0.80). IFI = 0.91, TLI = 0.91, and CFI = 0.91 (<0.90). Therefore, the degree of adaptation between the model and survey data is ideal.

Table 11 presents the regression analysis effect and standardized path coefficient results. The path coefficient in H1 is 0.12, $t = 2.49$, and $p = 0.01$. There is a significant positive correlation between an efficiency-centered business model and innovation performance; thus, H1 is supported. With respect to H2, the path coefficient = 0.13, $t = 2.74$, $p = 0.006 < 0.01$. Hence, a novelty-centered business model positively correlates with innovation performance; thus, H2 is supported. For H3, the path coefficient = 0.17, $t = 3.37$, $P = 0.000 < 0.001$. Hence, a significant positive correlation exists between efficiency-centered business models and technology. Hence, H3 is rejected. For H4, the path coefficient = 0.25, $t = 5.07$, $P = 0.000 < 0.001$. Hence, there is a significant positive correlation between an efficiency-centered business model and buying technology comes out, so H4 is supported. In path H5, the coefficient = 0.14, $t = 2.89$, $P = 0.004 < 0.01$. The results indicate a significant positive correlation between novelty-centered business models and the development of technology; hence, H5 is supported. For H6, the path coefficient = 0.11, $t = 2.38$, $P = 0.017 < 0.05$. Clearly, there is a significant positive correlation between the novelty-centered business model and the adoption of buying technology; thus, H6 is supported. In the path of H7, the coefficient = 0.135, $t = 2.73$, $P = 0.006 < 0.01$, indicating a significant positive correlation between developing technology and innovation performance, supporting H7. Regarding the path of H8, the coefficient is 0.17, $t = 3.52$, $P = 0.000 < 0.001$. There is a significant positive correlation between buying technology and innovation performance, so H8 is supported.

4.7.2. Mediating effect test

This study used the bootstrap method to conduct the mediating effect test through 2000 iterative calculations [70]. Table 12 shows that the effect value of H7a was 0.02, $P = 0.004 < 0.01$, and both the upper and lower intervals were positive. Developing technology has a significant mediating effect on efficiency-centered business models and innovation performance. Therefore, H7a is supported. Because H3 is assumed to be true in the opposite direction, which is inconsistent with the proposed hypothesis, it cannot be tested here. First, when H7b is set to 0.02, $P = 0.006$ (<0.01), both the upper and lower intervals were positive. Developing technology thus has a significant mediating effect on novelty-centered business models and innovation performance. Therefore, H7b was supported. Second,

Table 10
Correlation analysis.

	1	2	3	4	5	6	7	8	9
Technological opportunities	1								
Technological monopoly	0.12*	1							
Technological cumulativeness	0.10*	0.24**	1						
Knowledge base	0.05	0.12**	0.05	1					
Efficiency-centered business model	−0.01	0.16**	0.18**	0.11*	1				
Novelty-centered business model	0.09*	0.02	−0.07	0.21**	0.17**	1			
Making technology	0.08	0.11*	0.11*	0.08	0.17**	0.18**	1		
Buying technology	0.06	−0.16**	−0.11*	−0.11*	0.25**	0.17**	−0.01	1	
Innovation performance	0.24**	0.10*	0.03	0.05	0.20**	0.20**	0.16**	0.21**	1

Note: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

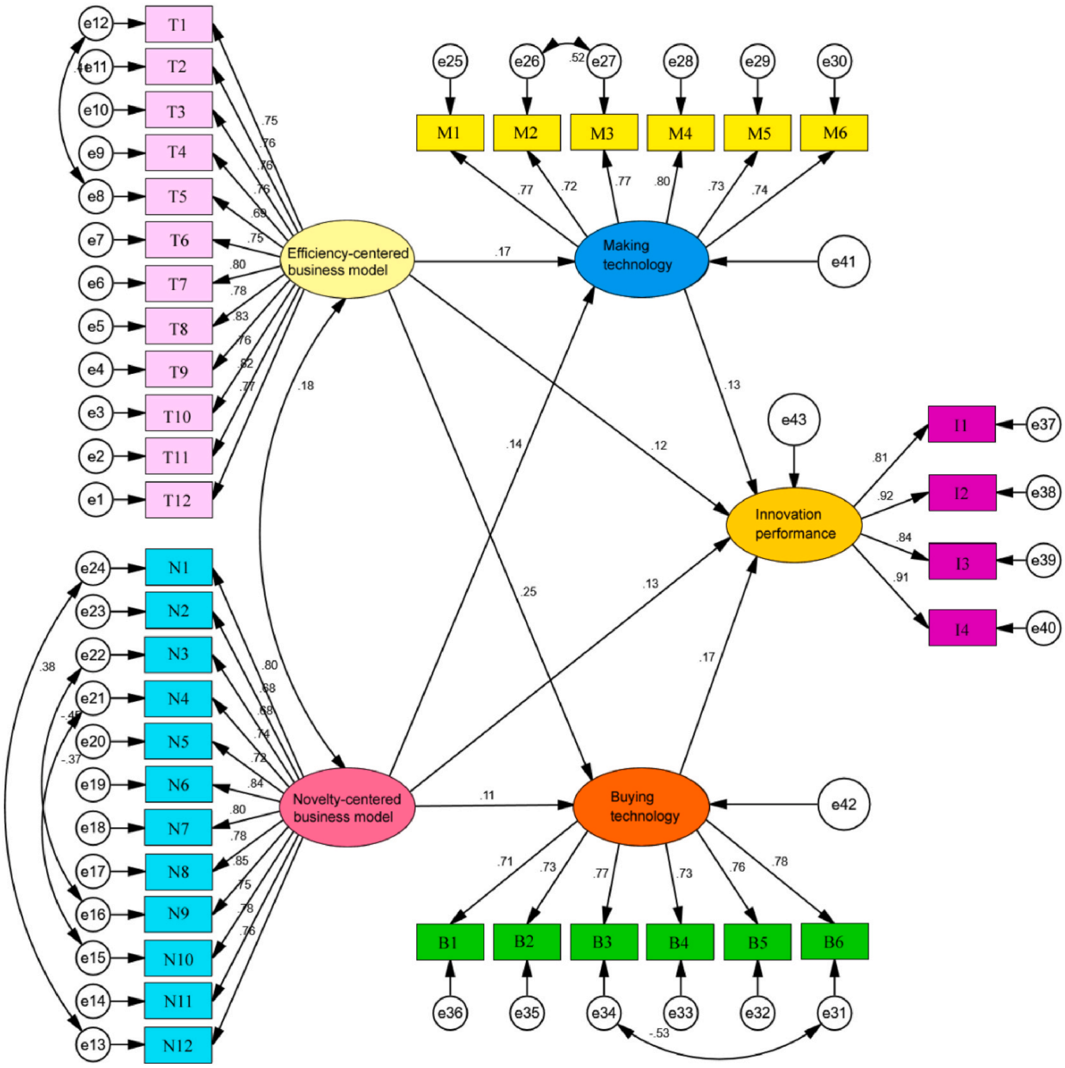

Fig. 6. Main effect structural equation model.

Table 11
Standardized path analysis results.

Hypothesis	Hypothesized entry	Standardized path coefficient	T	P
H1	Efficiency-centered business model →innovation performance	0.12	2.49	0.013*
H2	Novelty-centered business model →innovation performance	0.13	2.74	0.006**
H3	Efficiency-centered business model →making technology	0.17	3.37	***
H4	Efficiency-centered business model →buying technology	0.25	5.07	***
H5	Novelty-centered business model →making technology	0.14	2.89	0.004**
H6	Novelty-centered business model →buying technology	0.11	2.38	0.017*
H7	Making technology →innovation performance	0.14	2.73	0.006**
H8	Buying technology →innovation performance	0.17	3.52	***

Note: ***P < 0.001, **P < 0.01, *P < 0.05.

Table 12
Mediating effect test results.

Hypothesis	Hypothetical path	Effect size	95% confidence interval		P
			Lower limit	Upper limit	
H7a	Efficiency-centered business model→making technology→innovation performance	0.02	0.01	0.05	0.004
H7b	Novelty-centered business model→making technology→innovation performance	0.02	0.01	0.05	0.006
H8a	Efficiency-centered business model→buying technology→innovation performance	0.04	0.02	0.08	0.001
H8b	Novelty-centered business model→buying technology→innovation performance	0.02	0.01	0.04	0.008

the correlation of the path of H8a is set to 0.04. In this case, $P = 0.001$ (<0.01) and both the upper and lower intervals were positive. Thus, buying technology has a significant mediating effect between an efficiency-centered business model and innovation performance. Therefore, H8a was supported. The correlation of the path of H8b = 0.02, $P = 0.008$ (<0.01), and both the upper and lower intervals are positive, indicating that buying technology has a significant mediating effect on the novelty-centered business model and innovation performance. Therefore, H8b was supported.

4.8. Moderating effect test

The moderating effect test is conducted mainly through multivariate hierarchical regression analysis [71]. Model 1 included the control, moderating, and dependent variables. To prevent the occurrence of pseudo-regression, the control variables are introduced as the regulation effect is sensitive. Model 2 involves the control, explanatory, moderating, and dependent variables, and primarily analyzes the relationship between the explanatory and moderating variables to assess the explanatory power of the model. Model 3 introduces the control variables, explanatory variables, moderating variables, dependent variables, and the interaction term between the explanatory and moderating variables.

A positive and significant coefficient of the interaction term indicates a positive moderating effect of technological regimes. A negative and significant coefficient for the interaction term indicates a negative moderating effect of technological regime. If the coefficient of the interaction term is not significant, the moderating effect of technological regime is not valid. The regression equations for the three models were as follows:

Model 1: $y = a + bv + cm + e$

Model 2: $y = a + bv + cm + dx + e$

Model 3: $y = a + bv + cm + dx + fmx + e$

where y is the dependent variable; v is the control variable; x is the explanatory variable; m is the moderating variable; mx is the interaction term between the moderating variable and the explanatory variable; and a, b, c, d, and f are coefficients; and e is the residual term.

4.8.1. Moderating effect test: technological opportunities

Table 13 shows the moderating effects of technological opportunities. Sequences (1), (2), and (3) are the test results for H9a. The regression coefficient of the interaction item (making technology * technological opportunities) is 0.14, and $P < 0.01$. Thus, technological opportunities have a significant and positive moderating effect on technological development and innovation performance. Therefore, H9a was supported.

We performed the test for H9b and obtained sequences (1), (4), and (5). The results of sequence (5) show that the regression coefficient of the interactive item (buying technology × technological opportunities) is 0.06, $P > 0.05$. In this case, there is no close relationship between innovation performance and the interactive items (buying technology and technological opportunities). Thus, technological opportunities do not have a moderating effect on technology purchase or innovation performance. Therefore, H9b was supported.

Sequences (1), (6), and (7) were obtained from the tests of H9c. From sequence (7), the regression coefficient of the interaction term (novelty-centered business model × technological opportunities) is 0.13, with a significance level of $P < 0.01$. Therefore, technological opportunities have a significantly positive moderating effect on novelty-centered business models and innovation performance. Therefore, H9c was supported.

The test of H9d yielded the results for sequences (1), (8), and (9). The analysis of sequence (9) indicates that the regression coefficient of the interaction item (efficiency-centered business model × technological opportunities) is 0.15, $P < 0.01$. Hence, there is a significant positive correlation between efficiency-centered business models and innovation performance, and technological opportunities play a significant positive moderating role in this relationship. Therefore, H9d is supported.

To elucidate the moderating effect of technological opportunities with greater clarity, this study employs Model 1 from the SPSS macro program Process, developed by Hayes, to analyze the data presented in Fig. 7. The interaction items of H9a were coeff = 0.10, $t = 3.02$, and $P = 0.0027 < 0.01$. In testing H9b, the interaction items were coeff = −0.04, $t = 1.29$, $P = 0.1968 > 0.05$, further verifying that H9b was not valid. The interaction items for H9c were coeff = 0.09, $t = 2.90$, and $P = 0.0040 < 0.01$. For H9d, the interaction items were coeff = 0.12, $t = 3.49$, and $P = 0.0005 < 0.001$.

Table 13
Moderating effect of technological opportunities.

Variable		Dependent variable: Innovation performance								
		(1) β (t)	(2) β (t)	(3) β (t)	(4) β (t)	(5) β (t)	(6) β (t)	(7) β (t)	(8) β (t)	(9) β (t)
Independent variable	Making technology		0.14** (3.22)	0.13** (2.96)						
Interactive term	Making technology *Technological opportunities			0.14** (3.02)						
Independent variable	Buying technology				0.20*** (4.60)	0.20*** (4.45)				
Interaction term	Buying technology *Technological opportunities					0.06 (1.30)				
Independent variable	Novelty-centered business model						0.18*** (4.11)	0.18*** (4.06)		
Interaction term	Novelty-centered business model *Technological opportunities							0.13** (2.89)		
Independent variable	Efficiency-centered business model								0.20*** (4.63)	0.19*** (4.46)
Interaction term	Efficiency-centered business model *Technological opportunities									0.15** (3.49)
Moderator	Technological opportunities		0.23*** (5.25)	0.20*** (4.51)	0.23*** (5.29)	0.23*** (5.34)	0.23*** (5.17)	0.21*** (4.86)	0.24*** (5.61)	0.21*** (4.71)
Control variable	Company age	−0.04 (−0.76)	−0.02 (−0.34)	−0.02 (−0.34)	−0.03 (−0.57)	−0.03 (−0.63)	−0.00 (−0.08)	−0.01 (−0.15)	−0.00 (−0.09)	0.00 (0.07)
	Company size	0.01 (0.13)	−0.00 (−0.02)	−0.01 (−0.15)	0.03 (0.73)	0.03 (0.70)	0.01 (0.16)	0.00 (0.10)	0.01 (0.20)	0.01 (0.33)
Model fit	R^2	0.00	0.08	0.10	0.10	0.10	0.09	0.10	0.10	0.12
	Adj. R^2	−0.00	0.07	0.09	0.09	0.09	0.08	0.10	0.09	0.11
	$\triangle R^2$	0.00	0.08	0.017	0.10	0.00	0.09	0.02	0.10	0.02
	F	0.29	10.34***	10.23***	13.21***	10.92***	12.07***	11.47***	13.29***	13.32***

Note: ***P < 0.001, **P < 0.01, and *P < 0.05.

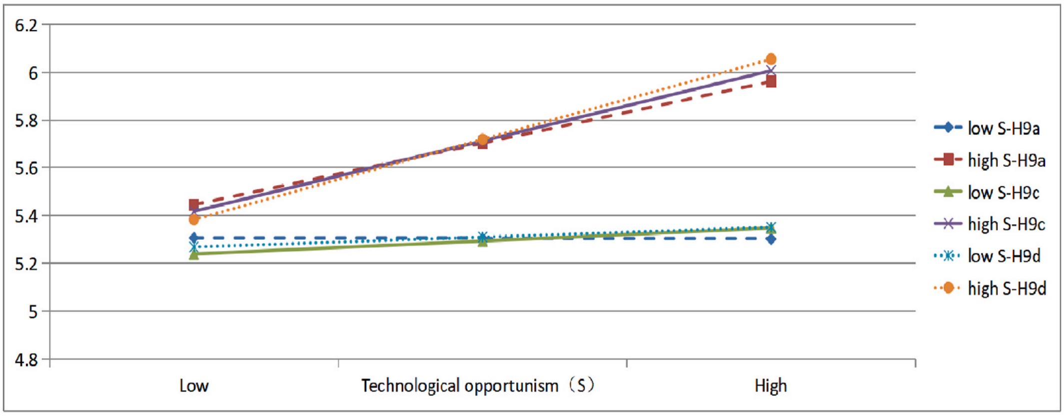

Fig. 7. Slope diagram of technological opportunities.

4.8.2. Moderating effect test: technological monopoly

Table 14 shows the moderating effect test results of technological monopoly. Sequences (1), (2), and (3) are the results of H10a. In sequence (3), the regression coefficient of the interactive term (making technology * technological monopoly) is 0.20, $P < 0.001$. The results demonstrate that technological monopolies have a significant positive moderating effect on the relationship between technological development and innovation performance. Hence, it can be concluded that H10a is supported.

Sequences (1), (4), and (5) show results for H10b. In sequence (5), the regression coefficient of the interactive item (buying technology * technological monopoly) is −0.17, $P < 0.001$. The results demonstrate that the technological monopoly level has a

Table 14
Moderating effect test of technological monopoly.

Variable		Dependent variable: Innovation performance								
		(1) β (t)	(2) β (t)	(3) β (t)	(4) β (t)	(5) β (t)	(6) β (t)	(7) β (t)	(8) β (t)	(9) β (t)
Independent variable	Making technology		0.15** (3.32)	0.14** (3.13)						
Interaction term	Making technology *Technological monopoly			0.20*** (4.58)						
Independent variable	Buying technology				0.24*** (5.26)	0.24*** (5.38)				
Interaction term	Buying technology *Technological monopoly					−0.17*** (−3.90)				
Independent variable	Novelty-centered business model						0.20*** (4.44)	0.20*** (4.46)		
Interaction term	Novelty-centered business model *Technological monopoly							−0.02 (−0.40)		
Independent variable	Efficiency-centered business model								0.19*** (4.15)	0.18*** (4.06)
Interaction term	Efficiency-centered business model *Technological monopoly									0.10* (2.31)
Moderator	Technological monopoly		0.09 (1.89)	0.10* (2.20)	0.14** (3.12)	0.14** (3.19)	0.10* (2.23)	0.10* (2.23)	0.07 (1.61)	0.07 (1.52)
Control Variable	Company age	−0.04 (−0.76)	−0.02 (−0.50)	−0.02 (−0.50)	−0.03 (−0.65)	−0.04 (−0.85)	−0.01 (−0.19)	−0.01 (−0.17)	-0.02 (-0.33)	-0.02 (-0.43)
	Company size	0.01 (0.13)	−0.01 (−0.11)	−0.02 (−0.37)	0.03 (0.69)	0.03 (0.62)	0.00 (0.07)	0.00 (0.03)	0.01 (0.13)	0.01 (0.25)
Model fit	R^2	0.00	0.03	0.07	0.07	0.09	0.05	0.05	0.05	0.06
	Adj. R^2	−0.00	0.03	0.06	0.06	0.08	0.04	0.04	0.04	0.05
	$\triangle R^2$	0.00	0.03	0.04	0.06	0.03	0.05	0.00	0.04	0.01
	F	0.29	4.19**	7.68***	8.41**	9.97***	6.40***	5.14***	5.76***	5.72***

Note: ***P < 0.001, **P < 0.01, and *P < 0.05.

significant negative moderating effect on the relationship between purchasing technology and innovation performance. Thus, H10b is supported.

Testing H10c yielded sequences (1), (6), and (7). The results of sequence (7) show that the regression coefficient of the interactive term (novelty-centered business model * technological monopoly) is −0.02, P > 0.05. The test results indicate no significant correlation between the two variables. These results show that technological monopoly does not have a significant moderating impact on the relationship between a novelty-centered business model and innovation performance. Thus, H10c was rejected.

The analysis results of sequence (9) show that the regression coefficient of the interaction term (efficiency-centered business model × technological monopoly) is 0.10, P < 0.05. Thus, the presence of a technological monopoly has a significant positive impact on the relationship between an efficiency-centered business model and innovation performance. Thus, H10d was supported.

This study analyzes the moderating role of technological monopolies, resulting in the slope graph depicted in Fig. 8. The interaction term of H10a was coeff = 0.17, t = 4.57, and P = 0.000 < 0.001. For H10b, the interaction items were coeff = −0.15, t = −3.88, P = 0.0001 < 0.001. The detection of H10c indicated that the interaction term was coeff = −0.02, t = −0.41, P = 0.68322 > 0.05, further verifying that H10c was not valid. For H10d, the interaction items were coeff = 0.10, t = 2.29, and P = 0.0224 < 0.05.

4.8.3. *Moderating effect test: technological cumulativeness*

Table 15 presents the results of the moderating effect tests for technological cumulativeness. Sequences (1), (2) and (3) are the results of H11a. The regression coefficient of the interaction term (making technology × technological cumulativeness) in sequence (3) was 0.15, P < 0.01. Thus, technological cumulativeness has a significant moderating effect on technological development and innovation. Therefore, H11a was supported.

Sequences (1), (4), and (5) show the results for H11b. In sequence (5), the regression coefficient of the interactive item (buying technology × technological cumulativeness) is −0.16, P < 0.001. Hence, technological cumulativeness between buying technology and innovation performance has a significant negative moderating effect. Therefore, H11b was supported.

Sequences (1), (6), and (7) test the support for H11c. The results of sequence (7) indicate that the regression coefficient of the interactive item (novelty-centered business model × technological cumulativeness) is 0.05, P > 0.05. Technological cumulativeness has no significant regulatory effect on novelty-centered business models and innovation performance. Therefore, H11c was rejected.

The results of the hypothesis test for H11d demonstrate a significant positive correlation among the interaction of the efficiency-centered business model, technological cumulativeness, and innovation performance. The analysis of sequence (9) reveals that the regression coefficient of the interaction term (efficiency-centered business model × technological cumulativeness) is 0.15, with a p-value of <0.01. These findings indicate that technological cumulativeness has a significant positive moderating effect on the relationship between an efficiency-centered business model and innovation performance. Thus, H11d is supported.

Further data analysis of the moderating role of technological cumulativeness was conducted, as represented by the slope graph in Fig. 9. For H11a, the interaction items were coeff = 0.12, t = 3.43, and P = 0.0007 < 0.001. For H11b, the interaction items were coeff = −0.13, t = −3.52, P = 0.0005 < 0.001. The detection of H11c revealed that the interaction items were coeff = 0.04, t = 1.08, P = 0.28 > 0.05, further verification of H11c was not valid. The results for H11d revealed that the interaction items were coeff = 0.13, t = 3.10, and P = 0.0020 (<0.01).

4.8.4. *Moderating effect test: knowledge base*

Table 16 presents the moderating effect test results of the knowledge base. Sequences (1), (2) and (3) are the results of H12a. In sequence (3), the regression coefficient of the interactive term (making technology * knowledge base) is 0.21, P < 0.001. Hence, knowledge base has a significant positive moderating effect between technology and innovation performance. Therefore, H12a was rejected.

The results for H12 are shown in sequences (1), (4), and (5). The regression coefficient of the interaction term (buying technology

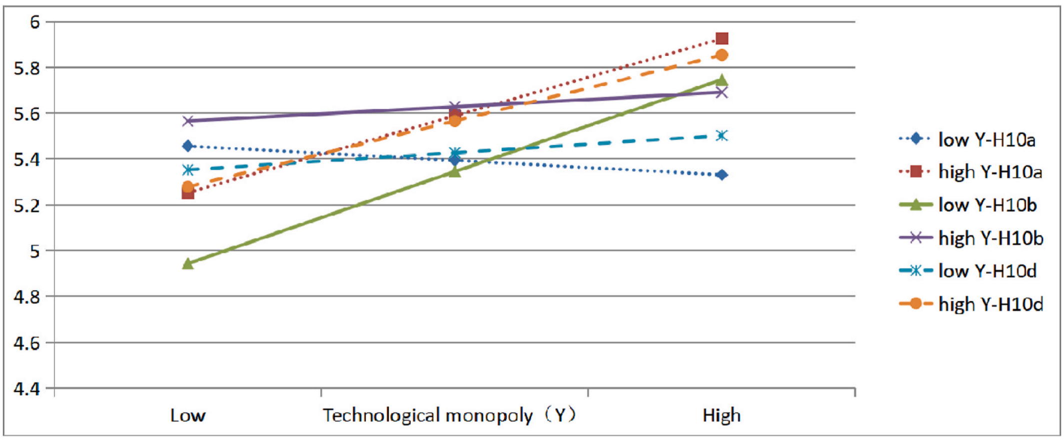

Fig. 8. Slope diagram for technological monopoly.

Table 15
Moderating effect test of technological cumulativeness.

Variable		Dependent variable: Innovation performance								
		(1) β (t)	(2) β (t)	(3) β (t)	(4) β (t)	(5) β (t)	(6) β (t)	(7) β (t)	(8) β (t)	(9) β (t)
Independent variable	Making technology		0.16** (3.49)	0.15** (3.39)						
Interaction term	Making technology *Technological cumulativeness			0.15** (3.40)						
Independent variable	Buying technology				0.22*** (4.88)	0.23*** (5.08)				
Interaction term	Buying technology *Technological cumulativeness					−0.16*** (−3.52)				
Independent variable	Novelty-centered business model						0.20*** (4.52)	0.20*** (4.42)		
Interaction term	Novelty-centered business model *Technological cumulativeness							0.05 (1.08)		
Independent variable	Efficiency-centered business model								0.20*** (4.40)	0.19*** (4.16)
Interaction term	Efficiency-centered business model *Technological cumulativeness									0.14** (3.08)
Moderator	Technological cumulativeness		0.01 (0.27)	0.02 (0.46)	0.05 (1.16)	0.06 (1.40)	0.04 (0.99)	0.04 (0.86)	−0.01 (−0.16)	−0.01 (−0.30)
Control variable	Company age	−0.04 (−0.76)	−0.03 (−0.65)	−0.02 (−0.51)	−0.04 (−0.90)	−0.04 (−0.87)	−0.02 (−0.36)	−0.02 (−0.35)	−0.02 (−0.43)	−0.02 (−0.33)
	Company size	0.01 (0.13)	−0.00 (−0.06)	−0.01 (−0.13)	0.03 (0.69)	0.04 (0.80)	0.00 (0.10)	0.01 (0.142)	0.01 (0.20)	−0.00 (−0.02)
Model fit	R^2	0.00	0.03	0.05	0.05	0.07	0.04	0.05	0.04	0.06
	Adj. R^2	−0.00	0.02	0.04	0.04	0.06	0.03	0.04	0.03	0.05
	$\triangle R^2$	0.00	0.03	0.02	0.05	0.02	0.04	0.00	0.04	0.02
	F	0.29	3.29 **	5.01 ***	6.22 ***	7.58 ***	5.36 ***	4.52 ***	5.09 **	6.05 ***

Note: ***P < 0.001, **P < 0.01, and *P < 0.05.

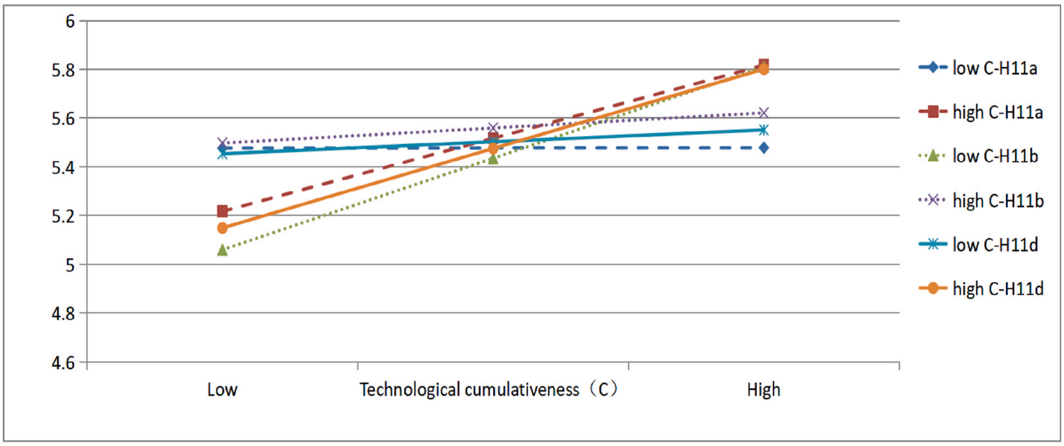

Fig. 9. Slope diagram for technological cumulativeness.

Table 16
Moderating effect test of the knowledge base.

Variable		Dependent variable: Innovation performance								
		(1) β (t)	(2) β (t)	(3) β (t)	(4) β (t)	(5) β (t)	(6) β (t)	(7) β (t)	(8) β (t)	(9) β (t)
Independent variable	Making technology		0.16** (3.47)	0.15** (3.32)						
Interaction term	Making technology *Knowledge base			0.21 *** (4.85)						
Independent variable	Buying technology				0.22*** (4.94)	0.22*** (4.87)				
Interaction term	Buying technology *Knowledge base					−0.09* (−2.10)				
Independent variable	Novelty-centered business model						0.20*** (4.34)	0.19*** (4.10)		
Interaction term	Novelty-centered business model *Knowledge base							0.13** (2.86)		
Independent variable	Efficiency-centered business model								0.20*** (4.37)	0.20*** (4.33)
Interaction term	Efficiency-centered business model *Knowledge base									0.02 (0.47)
Moderator	Knowledge base		0.03 (0.68)	0.04 (0.91)	0.07 (1.56)	0.07 (1.65)	0.00 (0.05)	0.00 (−0.00)	0.02 (0.52)	0.02 (0.44)
Control variable	Company age	−0.04 (−0.76)	−0.03 (−0.60)	−0.02 (−0.38)	−0.04 (−0.79)	−0.03 (−0.72)	−0.02 (−0.36)	−0.02 (−0.44)	−0.02 (−0.41)	−0.02 (−0.38)
	Company size	0.01 (0.13)	0.00 (0.00)	0.00 (0.06)	0.04 (0.87)	0.04 (0.836)	0.01 (0.154)	0.02 (0.33)	0.01 (0.22)	0.01 (0.25)
Model fit	R^2	0.00	0.03	0.07	0.05	0.06	0.04	0.06	0.04	0.04
	Adj. R^2	−0.00	0.02	0.06	0.04	0.05	0.03	0.05	0.03	0.03
	$\triangle R^2$	0.00	0.03	0.05	0.05	0.01	0.04	0.02	0.04	0.00
	F	0.29	3.39**	7.54***	6.50***	6.12***	5.10***	5.78***	5.16**	4.16**

Note: ***P < 0.001, **P < 0.01, and *P < 0.05.

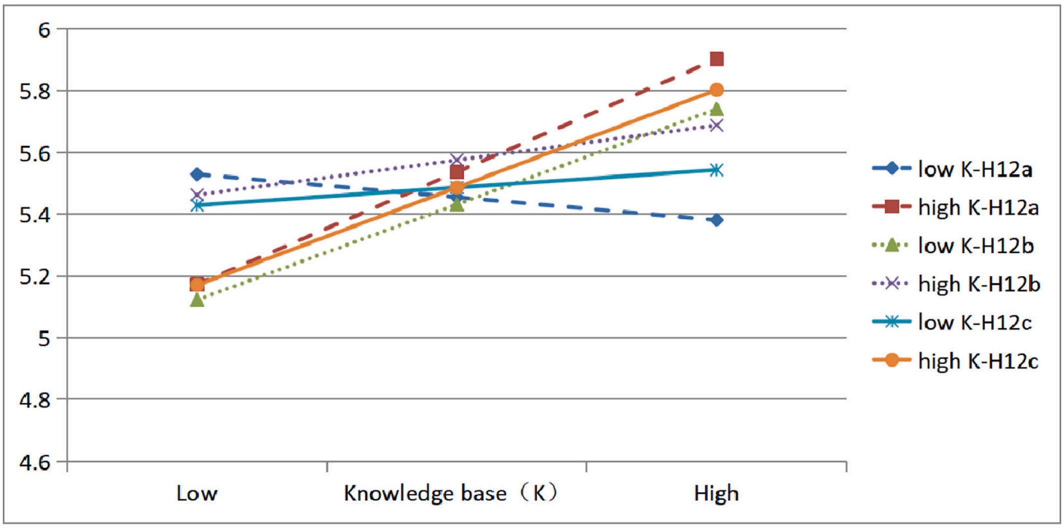

Fig. 10. Slope diagram for the knowledge base.

× knowledge base) in sequence (5) is −0.09, with a significance level of less than 0.05. The findings reveal that knowledge base has a significant negative moderating effect on the relationship between buying technology and innovation performance. Therefore, H12b was supported.

The results of testing H12c are reflected in sequences (1), (6), and (7). In sequence (7), the regression coefficient of the interaction term (novelty-centered business model × knowledge base) was 0.13, with a significance level below 0.01. The results suggest that the knowledge base plays a significant positive moderating role in the relationship between novelty-centered business models and innovation performance. Thus, H12c was supported.

The test of H12d indicates that the relationship between the efficiency-centered business model and innovation performance is not significantly influenced by the knowledge base. The analysis of the interaction term (efficiency-centered business model × knowledge base) shows a regression coefficient of 0.02, with a p-value greater than 0.05, indicating that the knowledge base does not play a significant moderating role in the relationship between the efficiency-centered business model and innovation performance. Therefore, H12d was rejected.

A more comprehensive analysis was conducted on the moderating role of the knowledge base through the slope graph in Fig. 10. According to H12a, the interaction items were coeff $= 0.19$, $t = 4.88$, and $P = 0.000 < 0.001$. For H12b, the interaction items are coeff $= -0.09$, $t = -2.14$, $P = 0.0328 < 0.05$. For H12c, the interaction items are coeff $= 0.12$, $t = 2.84$, and $P = 0.0047 < 0.01$. The results for H12d show that the interaction items were coeff $= 0.02$, $t = 0.47$, $P = 0.6362 > 0.05$. Therefore, the results further verify the rejection H12d.

A robustness test was used to validate the reliability of the findings. Appendix 5 reports the regression analysis was repeated for each variable, methodically excluding the control variables. For all variables, the results are consistent with the results of the baseline regression in terms of their signs and statistical significance. Therefore, the findings of this study are robust.

5. Discussion

A significant positive correlation exists between innovation performance and efficiency-centered business models. Moreover, innovation performance is highly positively correlated with novelty-centered business models. The finding is consistent with the research conclusions of many scholars [6,9,13,26]. If companies choose an efficiency-oriented business model, they can promote innovation performance by improving transaction efficiency, while if companies choose a novelty-oriented business model, they can promote innovation performance improvement by developing new transaction methods and partners.

Developing technology is beneficial for enterprises in terms of improving their R&D capabilities and helping them master core technologies, thereby promoting innovation performance [34]. By contrast, buying technology helps enterprises quickly grasp the development trends of new technologies to improve innovation performance [37]. A significant positive correlation is observed between innovation performance and technological development. Additionally, innovation performance has a highly positive correlation with technology purchases. Corporations can enhance innovation performance by either generating or acquiring technology and leveraging an efficiency-driven business model as a strategic tool. Similarly, enterprises that adopt a novelty-centered business model can improve their innovation performance by making or buying technology [72]. These discoveries contrast with previous studies [9,27] that propose a negative correlation between an efficiency-centered business model and the process of technology creation. Prior studies focus on innovative enterprises listed on China's new Third Board stock market, which are relatively young small and medium-sized enterprises [9,27] and face the challenges of limited funding, resulting in reduced investment in independent R&D.

This study conducted empirical research on the moderating effect of technological regimes, and its findings largely agree with the conclusions of previous research [39,73]. However, a high-tech opportunity-rich environment does not have a noticeable impact on enterprises buying technology. This conclusion differs from those of Breschi et al [24] and Thite et al. [43]. The lack of intellectual property rights protection in China could be a contributing factor to this discrepancy. The cost of acquiring knowledge from external sources is reduced because of inadequate protection of intellectual property rights. Consequently, technological opportunism in the external environment does not have a significant effect on knowledge acquisition, and the moderating effect of technological opportunities is not reflected when purchasing and introducing new technologies.

6. Conclusion

6.1. Summary

This study explores how high-tech service enterprises in China can enhance their innovation performance. This study was conducted using a survey to collect data from 489 high-tech service enterprises. A thorough empirical analysis was performed, incorporating theoretical derivation, questionnaire surveys, and statistical analysis to arrive at the main research conclusions.

In this study, companies' business models were divided into efficiency-oriented and novelty-oriented to determine the relationship between these two categories and their influence on innovation performance. Empirical evidence supports the division of business models into these two categories. The research findings indicate that there is a significant positive correlation between innovation performance and the efficiency-centered business model and a strong positive association between innovation performance and the novelty-centered business model.

The technological innovation mode includes the concepts of making and buying technology. Technology mediates the relationship between novelty-centered business models and innovation performance. Buying technology mediates the relationship between an efficiency-centered business model and innovation performance. There is a positive relationship between both efficiency- and novelty-centered business models and the adoption of technology. Additionally, both types of business model positively affect the utilization of buying technologies. Furthermore, making and buying technology is positively related to innovation performance.

This study divides technological regimes into technological opportunities, technological monopolies, technological cumulativeness, and knowledge bases. The results indicate a positive relationship between both efficiency-focused and novelty-centered business models and innovation performance, as well as between both types of business models and technology and buying technology. Furthermore, technological opportunities positively moderate the relationship between innovation performance and technology as well as the relationship between innovation performance and both efficiency- and novelty-centered business models. Technological monopoly also positively moderates the relationship between innovation performance and technology and between innovation performance and the efficiency-centered business model. However, it has a negative moderating effect on the relationship between innovation performance and buying technology. Technological cumulativeness positively moderates the relationship between innovation performance and technology and between innovation performance and the efficiency-centered business model but has a negative moderating effect on the relationship between innovation performance and buying technology. The knowledge base positively moderates the relationship between innovation performance and technology, and between innovation performance and the novelty-centered business model, but there is a negative moderating effect on the relationship between innovation performance and buying technology.

6.2. Theoretical contributions

This study attempts to clarify the interrelationships among the type of business models, mode of technological innovation, technological regimes, and innovation performance, specifically within the context of China's high-tech service enterprises. These findings help advance the theory of innovation performance by constructing a comprehensive framework of the innovation performance of China's high-tech service enterprises.

This study contributes to the research on innovation performance developing regions. First, previous research on innovation performance concentrates mainly on enterprises in newly industrialized regions such as South Korea and Japan, paying less attention to those in developing regions. China's economy has grown rapidly since the beginning of its reform and opening-up. China is fundamentally different from other newly industrialized countries in terms of its business environment. Therefore, the successful development experience of Chinese enterprises has more effective reference significance for enterprises in developing regions.

Innovation performance was originally proposed after the Industrial Revolution [3]. Therefore, research on innovation performance focuses primarily on industrial technological innovation. The more developed the society, the higher the proportion of tertiary industries in the social economy. The rapid development of information technology enriched and furthered the implications of innovation performance and technological innovation.

This study empirically analyzes the relationship between innovation performance and the type of business model, the results of which verify the validity of the concept of the business model and enrich and expand the business model theory. The conclusion of this research not only confirms the logical value of business models, but also highlights an appropriate business model design that enables enterprises in developing regions to overcome the disadvantage of being a laggard and fully leverage its advantages, thereby facilitating the rapid development of such firms' innovation performance.

Second, this study builds a theoretical bridge between various types of business models and innovation performance by empirically analyzing the relationships among technological innovation modes, types of business models, technological regimes, and innovation performance. Each technological regime has different moderating effects on the relationships between business models, technological innovation modes, and innovation performance [74].

Existing research concentrated on the industrial level of society and explored how technological regimes affect industrial innovation behavior [24]. This study considers technological regimes as the technological context of an enterprise's external environment. This study divides technological regimes into technological opportunities, monopolies, cumulativeness, and knowledge bases to analyze the relationships among the technological regimes, innovation performance and business models. Therefore, enterprises must adopt appropriate business models and technological innovation modes according to the characteristics of their technological regimes to promote innovation performance.

6.3. Practical implications

Business model design is crucial for determining an enterprise's competitive edge. Choosing a business model according to the environment helps enterprises improve their innovation performance and gain a competitive market advantage. A novelty-focused business model enables enterprises to continuously explore new partnerships and methods of conducting business while also improving the integration of internal and external resources, thereby enhancing their ability to cater to customer needs. On the other hand, an efficiency-focused business model helps reduce transaction costs, increases transaction efficiency, and ultimately enhances the ability to create value.

Technological innovation is vital for enterprises to realize product and service innovations. Continuous technological innovation is a significant way for enterprises to gain competitive advantage. Enterprises must select appropriate technological innovation strategies aligned with their operational conditions. When an enterprise has robust operating capabilities, it can opt for the in-house technology development mode, thereby enhancing its R&D capabilities and staying abreast of industry technology advancements. Conversely, weaker enterprises can adopt the technology acquisition approach by purchasing technology, allowing them to keep pace with industrial development and leverage the benefits of being late adopters.

Choosing appropriate business strategies is crucial for enterprises to improve their innovation performance. Enterprises operating in environments with numerous technological opportunities benefit from adopting either an efficiency-centered or novelty-centered business model and implementing technological innovation through technology. In an environment characterized by high levels of technological monopolies, enterprises should adopt an efficiency-centered business model and conduct technological innovation through making technology. In an environment with high technological cumulativeness, enterprises are advised to adopt an efficiency-centered business model and implement technological innovation through making technology. Meanwhile, firms with a strong knowledge base should adopt a novelty-centered business model and implement technological innovation through making technology.

6.4. Research limitations and future prospects

This study used random sampling and did not consider a reasonable distribution of samples in different industries, thus hampering the classification of the sample enterprises. Although the variable scales are all well-tested, a subjective scoring method is used to collect information, which inevitably has subjective judgment bias. This study focuses on Chinese high-tech service enterprises. Compared with ordinary enterprises, such enterprises have certain particularities; therefore, the research conclusions obtained have limitations in terms of their applicability.

Innovation performance is an important research topic. Future research should aim to collect data in stages by tracking and observing the research objects to avoid bias caused by the subjective judgments of respondents. The research sample should include service enterprises of different types, sizes, and ages using stratified sampling to make the conclusions more applicable.

Declarations

Author contribution statement

Zhang Jian: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Li Hongxia: Conceived and designed the experiments.

Data availability statement

Data associated with this study has been deposited at Research data https://doi.org/10.17632/fsxwvhf6m6.1, Data URL: https://data.mendeley.com/datasets/fsxwvhf6m6/1.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix 1

Table 17
Basic Information of the Sample

Background	Category	Frequency	Percentage
Age of company	5 years and below	39	7.96%
	6–10 years	204	41.72%
	11–15 years	144	29.45%
	16–20 years	67	13.70%
	21 years and above	35	7.15%
How long have you worked for your company?	5 years and below	108	22.09%
	6–10 years	190	38.85%
	11–15 years	146	29.86%
	16–20 years	25	5.11%
	21 years and above	20	4.09%
Company size	100 people and below	58	11.86%
	101–300 people	146	29.86%
	301–500 people	64	13.09%
	501–1000 people	140	28.63%
	1001 people and above	81	16.56%
Your position	Supervisor	51	10.43%
	Senior manager	81	16.56%
	Manager	198	40.49%
	Director	130	26.58%
	Minister	22	4.50%
	President	7	1.43%

Appendix 2. English Survey Questionnaire

Rattanakosin International College of Creative Entrepreneurship of Rajamangala University of Technology, Rattanakosin

The Impact of High-tech Enterprise Business Models on Innovation Performance: Mediating Effect of Technological Innovation and Moderating Effect of Technological Regimes

You are invited to participate in a study that focuses on the mechanism of influence of business models on innovation performance. This research forms part of Doctor of Philosophy Program in Management being conducted by Zhang Jian (RMUTR student ID: 1622110381139) the candidate, and Li Hongxia, the supervisor.

The level of global economic development is uneven. Enterprises in developed regions have strong innovation capabilities and strong competitiveness in the market. Enterprises in developing regions have relatively weak innovation capabilities and are at a disadvantage in the market. How to improve the innovation performance of enterprises has become an important management dilemma faced by enterprises in developing regions. As a member of a developing region, China has many things in common with other developing countries. Over the past 40 years of reform and opening up, the tremendous achievements China has made in economic development are inseparable from the contribution of corporate innovation. The innovative performance improvement methods of

Chinese enterprises, especially high-tech enterprises, have a good reference value for the development of enterprises in other developing regions. Previous studies on corporate performance were mainly concentrated on companies in developed countries, and the conclusions reached were inconsistent with the business scenarios of companies in developing regions. Therefore, this study will provide reference for companies in developing regions with the same business background by studying the innovative performance improvement methods of Chinese high-tech companies.

Procedures to be followed

It only takes 15–20 min to complete this survey. It mainly includes questions about business models, technological innovation, technological regimes, and innovation performance. Besides, the survey also comprises some general information without personal identification.

For this investigation, we adopted two methods: on-site visit and e-mail. Our investigators will take appropriate investigation methods according to your wishes.

Participation is purely voluntary and no financial remuneration or incentive will be offered for taking part in this research. There are no travel expenses nor are there any costs associated with participation in this research. There is no cost to you apart from your time.

Possible Discomforts and Risks

There were no foreseeable risks or discomforts throughout the investigation process. If you choose to visit on site, our investigators will strictly follow the investigation specifications. If you choose email, you are free to choose when to fill out the questionnaire. You will be required to sit and concentrate on a computer screen, so if you have eyesight problems you will be required to provide your own glasses for the task.

Responsibilities of the Researcher

It is our duty to make sure that any information given by you is protected. The questions pertained in the questionnaire do not require any information that require your identification of any forms. By agreeing to complete the questionnaire, your informed consent is assumed. However, you are free to withdraw from completing the survey at any time.

Responsibilities of the Participant

If there is anything that might impact upon completing the survey such as problems with health and eyesight, you are asked not to participate. You may leave the survey questionnaire voluntarily without explanation of such factors.

Freedom of Consent

If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time. However, we would appreciate you letting us know your decision.

Inquiries

This form is yours to keep for future reference. If you have any questions, we expect you to ask us. If you have any additional questions at any time please ask:

Researcher	Supervisor
Zhang Jian Rattanakosin International College of Creative Entrepreneurship of Rajamangala University of Technology, Rattanakosin 96 M.3 Phutthamonthon Sai 5 Road, Salaya, Phutthamonthon, Nakhon Pathom, 73170, Thailand **e-mail:** 466134721@qq.com **Telephone Number:**008615918455949	**Li Hongxia** Rattanakosin International College of Creative Entrepreneurship of Rajamangala University of Technology, Rattanakosin 96 M.3 Phutthamonthon Sai 5 Road, Salaya, Phutthamonthon, Nakhon Pathom, 73170, Thailand **e-mail:** lihongxia@ctbu.edu.cn **Telephone Number**: 008615918680076

If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Program Chair:

Assistant Professor Dr. Jirawan DEEPRASERT.

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All complaints, in the first instance, should be in writing to the above address. All complaints are investigated fully and according to due process of Rajamangala University of Technology Rattanakosin. Any complaint you make will be treated in confidence and you will be informed of the outcome.

MHESI 0653.37/

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Nakhonpathom, 73170, Thailand

March 2021

Dear manager,

Subject: THE IMPACT OF BUSINESS MODELS ON CHINESEHIGH-TECH SERVICE ENTERPRISES. As the Head of Ph. D program at RICE of Rajamangala University of Technology Rattanakosin- RMUTR and also the thesis supervisor, I am writing to request for your kind assistance in reviewing the primary data collection instruments of our Ph.D. Student.

Mr. Zhang Jian (RMUTR's ID number 1622110381139), a Ph.D. candidate of Doctor of Philosophy Program in Management of RICE of RMUTR, is developing her thesis under the topic *THE IMPACT OF BUSINESS MODELS ON CHINESEHIGH-TECH SERVICE ENTERPRISES*. The subjects of this survey are managers of high-tech companies who hold or concurrently serve as directors of operations.

As you are recognized nationally and internationally for achievement at work we would like to seek for your kind assistance in verifying the content validity and appropriateness of the instruments as per the attached files.

Yours sincerely

(Asst. Prof. Dr. Jirawan Deeprasert)
Head of Ph. D. Program
Rajamangala University of Technology Rattanakosin

Qualitative Data

A1: How long has your company has been established	
A2: How long have you worked in your company	
A3: Number of employees in the company	
A4: Your job position in the company	
A5: Your education	☐A:High school,☐B:Junior college,☐C:Bachelor, ☐D:Master,☐E:Doctor,☐F:Others, please specify

Quantitative Data

The 1–7 points in the following items represent the gradual change from disagreement to agreement. Please tick √ in the corresponding box according to your actual situation (1 means strongly disagree, 4 means neutral, 7 means agree).	Disagree ⟷ agree						
	1	2	3	4	5	6	7
T1: Your company's business model design helps enterprises reduce operating costs (i.e., marketing costs, transaction processing costs, communication costs, etc.).							
T2: Your company's business model design helps the enterprise simplify the transaction procedures and makes the partners think it is easy to conduct transactions with your company.							
T3: Your company's business model design helps the enterprise simplify the transaction procedures and makes the partners think it is easy to conduct transactions with your company.							
T4: Your company's business model design helps partners reduce operating costs (i.e., marketing costs, transaction processing costs, communication costs, etc.).							
T5: The business model design of your company makes the transaction procedures between the enterprise and its partners highly extensible (for example, the enterprise can handle a large number of transactions of different scales at the same time).							
T6: Your company's business model design makes the enterprise's business decision more scientific and reasonable.							
T7: Your company's business model design makes the transaction process more transparent and makes the use and delivery of information, services and products in the transaction process easier to query.							
T8: Your company's business model is designed so that both parties in a transaction have better access to each other's information.							
T9: Your company's business model is designed to give the business access to a wide variety of goods, services, information, and other actors.							
T10: Your company's business model is designed to enable transaction participants to obtain more information on their needs.							
T11: Your company's business model is designed to support rapid transaction activity.							
T12: Your company's business model design overall improves the efficiency of corporate transactions.							
N1: Your company's business model design brings together products, information and services in new ways.							
N2: Your company's business model design has helped the company develop new business partners.							
N3: Your company's business model design provides novel incentives to transaction participants.							
N4: Your company's business model is designed to help the business reach out to different collaborators and products.							
N5: Your company's business model design enhances the richness (including the quality and depth of the connection) and novelty of the contacts between the parties to the transaction.							
N6: Your company's business model design has helped the company gain more technological innovation.							
N7: Your company's business model is based on trade secrets or patents.							
N8: Your company's business model is the industry leader.							
N9: Your company is constantly improving and innovating its business model.							
N10: Competitors' business models have the potential to outperform yours.							
N11: There is still room for improvement in your company's business model.							
N12: Overall, your company's business model is novel and innovative.							
M1: The percentage of key technologies of an enterprise originating from independent research and development (including cooperative research and development with other enterprises, universities, research institutions, etc.) is higher than that of its main competitors.							
M2: Compared with its peers, the enterprise has stronger independent R & D capability.							
M3: The percentage of R & D expenses in sales is higher than that of major competitors.							
M4: The percentage of enterprise technology introduction expenses in sales is higher than that of main competitors.							
M5: Enterprises continue to develop new technologies and open up new products.							
M6: Companies attach great importance to R&D activities.							
B1: The percentage of the key technology of the enterprise from technology introduction (including through authorization, R&D contracts, consulting companies, mergers and acquisitions, and hiring of relevant technological personnel, etc.) is higher than that of major competitors.							
B2: The enterprise has stronger technology introduction ability compared with its peers.							
B3: The percentage of enterprise technology introduction expenses as a percentage of sales is higher than that of major competitors.							
B4: Enterprises often hire scientific researchers who master core technologies from the outside.							
B5: Enterprises often obtain important technologies or technological information sources from the outside.							
B6: The new technology that the enterprise obtains from the outside becomes the core technology of the enterprise.							
S1: Enterprises in the industry have invested a lot in research and development.							
S2: In the industry, a large number of new technologies are produced every year.							
S3: Suppliers, users, R&D institutions, etc., are important sources of technological knowledge.							
Y1: Enterprises in the industry use patents and trade secrets to protect technological innovation achievements.							
Y2: Enterprises in the industry can achieve the purpose of protecting the technological innovation achievements of enterprises by adopting patents, trade secrets and other methods.							
Y3: In the industry, corporate innovation is difficult to imitate.							
Y4: In the industry, companies can obtain higher returns through technological innovation.							
C1: In the industry, frequent innovation can ensure that competitors are difficult to imitate.							
C2: In the industry, due to rapid technological change, imitators can only obtain limited profits.							
C3: In the industry, technological innovation cannot be carried out without sufficient technological reserves.							
C4: In the industry, the technological innovation of enterprises depends on the existing technology.							
K1: The enterprise has extensive knowledge of product development.							
K2: The enterprise fully understands the core technological knowledge in the industry.							
K3: The enterprise has comprehensive knowledge of operation.							
K4: The enterprise has a comprehensive knowledge of management theory and practice.							
K5: The company is at the leading level of its domestic counterparts in the field of professional technology.							

(*continued on next page*)

(*continued*)

The 1–7 points in the following items represent the gradual change from disagreement to agreement. Please tick √ in the corresponding box according to your actual situation (1 means strongly disagree, 4 means neutral, 7 means agree).	Disagree ⟷ agree						
	1	2	3	4	5	6	7
K6: The enterprise has a deep understanding of the relevant knowledge of product development.							
K7: The enterprise is proficient in using unique operational knowledge.							
I1: The new services developed by the company can always achieve the expected benefits.							
I2: The services developed by the company can always fully achieve the results expected by customers.							
I3: The company always completes the development of professional services ahead of schedule.							
I4: The company has a high success rate in developing new services.							

If you find that the attached instruments need modification or need further clarification, please inform to the students (466134721@qq.com) or the supervisor (lihongxia@ctbu.edu.cn) or telephone number 008615918680076. I would like to express my sincere gratitude for your acceptance to be the expert for the content validity of these data collection instruments.

Appendix 3. Chinese Survey Questionnaire

关于企业商业模式设计对高新技术企业影响的调查问卷

尊敬的先生/女士：

您好！本调查问卷是由泰国兰塔纳功欣皇家理工大学国际创新创业学院在读博士生开展的一项学术研究项目。调研的目的旨在探索企业商业模式设计对创新绩效的影响机制，问卷答案没有对错或优劣之分。如果某个问题的答案不能完全表达您的意见，请选择最接近您想法的答案，或给出您的理想答案。本问卷的内容不会涉及贵公司的商业机密，所收集的信息也不会用于任何商业目的，仅用于本次学术研究。本问卷的填写过程将需要 10 分钟左右，请您放心并客观填写。

您的回答对我们的研究非常重要，非常感谢您的配合！

A1.贵公司已经成立多长时间		A2.您在公司工作了多长时间	
A3.贵公司员工人数		A4.您在公司的职位	
A5.您的教育程度	☐1.高中，☐2.大专，☐3.本科，☐4.硕士，☐5.博士，☐6.若是其他，请列出_______________		

每个题项的 1-7 分值表示从不同意到同意的渐进变化，请根据自身实际情况在相应的框内打 √（1 为非常不同意，4 为中立，7 为同意）	不同意 ⟷ 同意						
	1	**2**	**3**	**4**	**5**	**6**	**7**
T1.贵公司的商业模式设计帮助企业减少了经营成本（即，营销成本，交易处理成本，通信成本等）。							
T2.贵公司的商业模式设计帮助企业简化了交易程序，使合作伙伴认为与贵公司进行交易活动简单易行。							
T3.贵公司的商业模式设计帮助企业降低了交易过程的出错率。							
T4.贵公司的商业模式设计帮助合作伙伴减少了经营成本（即，营销成本，交易处理成本，通信成本等）。							
T5.贵公司的商业模式设计使企业与合作伙伴的交易程序具有很强的扩展性（比如：企业可以同时处理大量不同规模的交易）。							
T6.贵公司的商业模式设计使企业的经营决策更为科学合理。							

T7.贵公司的商业模式设计使交易过程更为透明，使交易过程的信息、服务和产品的使用及交付更容易被查询。							
T8.贵公司的商业模式设计使交易双方能更好地获得彼此的信息。							
T9.贵公司的商业模式设计使企业获得各种各样的商品、服务、信息和其他参与者。							
T10.贵公司的商业模式设计使交易参与者能够获取更多的需求信息。							
T11.贵公司的商业模式设计支持企业快速开展交易活动。							
T12.贵公司的商业模式设计整体提高了企业交易的效率。							
N1.贵公司的商业模式设计以新的方式实现了产品、信息和服务的结合。							
N2.贵公司的商业模式设计帮助企业开拓了新的业务合作者。							
N3.贵公司的商业模式设计向交易参与者提供了新颖的激励措施。							
N4.贵公司的商业模式设计帮助企业接触到不同的合作者和产品。							
N5.贵公司的商业模式设计增强了交易双方联系方式的丰富性（包括联系的质量和深度）和新颖性。							
N6.贵公司的商业模式设计帮助企业获得了更多的技术创新。							
N7.贵公司的商业模式建立在商业机密或专利基础之上。							
N8.贵公司的商业模式是行业的领先者。							
N9.贵公司不断对商业模式进行改进和创新。							
N10.竞争对手的商业模式有可能超越贵公司的商业模式。							
N11.贵公司的商业模式还存在着改进的可能性。							
N12.整体来说贵公司的商业模式是新颖的，具有创新性。							
M1.企业关键技术来源于自主研发（包括与其他企业、大学、研究机构等的合作研发）的百分比高于主要竞争对手。							
M2. 企业与同行对手相比具有更强的自主研发能力。							

M3.企业研发费用占销售额的百分比高于主要竞争对手。							
M4.企业研发人员占总员工数的百分比高于主要竞争对手。							
M5.企业持续不断地研发新技术、开放新产品。							
M6.企业非常重视研发活动。							
B1.企业关键技术来源于技术引进（包括通过授权、研发合同、顾问公司、并购和聘用相关技术人员等）的百分比高于主要竞争对手。							
B2. 企业与同行对手相比具有更强的技术引进能力。							
B3.企业技术引进费用占销售额的百分比高于主要竞争对手。							
B4.企业经常从外部聘请掌握核心技术的科研人员。							
B5.企业经常从外部获得重要的技术或技术的信息源。							
B6.企业从外部获得的新技术成为企业的核心技术。							
S1.行业内企业在研发上都进行了大量的投入。							
S2.在行业内，每年都会有大量的新技术产生。							
S3.供应商、用户、研发机构等是技术知识的重要来源。							
Y1.行业内的企业使用专利、商业秘密等方式保护技术创新成果。							
Y2.在行业内企业使用专利、商业秘密等方式就能很好地保护技术创新成果。							
Y3.在行业内，企业的创新很难被模仿。							
Y4.在行业内，企业能够通过技术创新获得较高的回报。							
C1.在行业内，频繁的创新才能保证竞争者难以模仿。							
C2.在行业内，由于技术变革较快，模仿者只能获得有限的利润。							
C3.在行业内，没有充分的技术储备是无法进行技术创新。							

C4.在行业内，企业的技术创新要依赖于现有的技术。							
K1. 企业对产品开发的相关知识具有广泛认识。							
K2.企业全面了解行业内的核心技术知识。							
K3.企业全面掌握运营方面的知识。							
K4.企业掌握全面的管理理论与实践知识。							
K5. 企业在专业技术领域处于国内同行的领先水平。							
K6.企业对产品开发方面的相关知识具有深刻认识。							
K7.企业熟练运用独特的运营知识。							
I1. 本企业开发的新服务总能实现预期的收益。							
I2. 本企业开发的服务总能完全达到客户预期的效果。							
I3. 本企业总是提前于计划时限完成专业服务的开发。							
I4. 本企业开发新服务的成功率很高。							

非常感谢您的大力支持与配合！在填写问卷的过程中，如果有什么疑问，请电话联系张先生，15918455949。问卷回答完成后，2 天内将有人过来回收，请不要丢弃。再次感谢您的合作！

Appendix 4

Table 18
Descriptive Statistical Results

Variable	Measurement items	N	Mean value	Standard deviation	Kurtosis	Standard error of kurtosis	Skewness	Standard error of skewness
Technological opportunities (S)	S1	489	5.47	1.41	-0.55	0.22	-0.60	0.11
	S2	489	5.28	1.35	-0.48	0.22	-0.46	0.11
	S3	489	5.38	1.37	-0.59	0.22	-0.54	0.11
Technological monopoly (Y)	Y1	489	5.28	1.32	-1.34	0.22	0.05	0.11
	Y2	489	4.95	1.35	-1.01	0.22	0.10	0.11
	Y3	489	5.07	1.38	-1.34	0.22	0.20	0.11
	Y4	489	5.07	1.40	-1.16	0.22	0.02	0.11
Technological cumulativeness (C)	C1	489	5.24	1.37	-1.25	0.22	-0.01	0.11
	C2	489	5.06	1.41	-1.09	0.22	-0.01	0.11
	C3	489	5.13	1.35	-1.16	0.22	0.11	0.11
	C4	489	5.11	1.35	-0.97	0.22	-0.02	0.11
Knowledge base (K)	K1	489	4.86	1.36	-1.15	0.22	0.31	0.11
	K2	489	4.91	1.28	-0.60	0.22	0.07	0.11
	K3	489	4.85	1.28	-0.72	0.22	0.30	0.11
	K4	489	4.85	1.38	-1.13	0.22	0.30	0.11
	K5	489	4.94	1.41	-1.26	0.22	0.18	0.11
	K6	489	5.1	1.35	-1.24	0.22	0.18	0.11
	K7	489	5.25	1.40	-1.39	0.22	-0.02	0.11
Efficiency-centered business model (T)	T1	489	5.24	1.15	-1.04	0.22	0.09	0.11
	T2	489	5.02	1.14	-0.82	0.22	0.35	0.11
	T3	489	5.13	1.26	-1.18	0.22	0.32	0.11
	T4	489	5.23	1.13	-0.92	0.22	0.09	0.11
	T5	489	5.33	1.16	-1.07	0.22	-0.03	0.11
	T6	489	5.04	1.14	-0.95	0.22	0.25	0.11

(*continued on next page*)

Table 18 (*continued*)

Variable	Measurement items	N	Mean value	Standard deviation	Kurtosis	Standard error of kurtosis	Skewness	Standard error of skewness
	T7	489	5.03	1.12	-0.96	0.22	0.32	0.11
	T8	489	5.10	1.24	-1.03	0.22	0.09	0.11
	T9	489	5.08	1.19	-1.09	0.22	0.36	0.11
	T10	489	5.11	1.07	-0.80	0.22	0.16	0.11
	T11	489	5.30	1.22	-1.16	0.22	-0.02	0.11
	T12	489	5.09	1.19	-1.18	0.22	0.27	0.11
Novelty-centered business model (N)	N1	489	5.21	1.15	-1.12	0.22	0.22	0.11
	N2	489	5.22	1.23	-1.26	0.22	0.22	0.11
	N3	489	5.41	1.16	-1.17	0.22	-0.12	0.11
	N4	489	5.33	1.32	-1.18	0.22	-0.17	0.11
	N5	489	5.06	1.28	-0.85	0.22	-0.10	0.11
	N6	489	5.13	1.27	-1.17	0.22	0.15	0.11
	N7	489	5.09	1.34	-1.21	0.22	0.08	0.11
	N8	489	5.22	1.32	-1.31	0.22	-0.02	0.11
	N9	489	5.30	1.30	-1.40	0.22	0.03	0.11
	N10	489	5.11	1.32	-1.29	0.22	0.11	0.11
	N11	489	5.39	1.27	-1.27	0.22	-0.13	0.11
	N12	489	5.23	1.16	-0.91	0.22	-0.06	0.11
making technology (M)	M1	489	5.22	1.33	-1.44	0.22	0.06	0.11
	M2	489	5.22	1.35	-1.18	0.22	-0.09	0.11
	M3	489	5.28	1.21	-1.51	0.22	0.26	0.11
	M4	489	4.96	1.34	-1.19	0.22	0.28	0.11
	M5	489	5.16	1.25	-1.24	0.22	0.17	0.11
	M6	489	4.97	1.33	-1.20	0.22	0.18	0.11
buying technology (B)	B1	489	5.22	1.33	-1.36	0.22	0.06	0.11
	B2	489	5.35	1.35	-1.49	0.22	-0.05	0.11
	B3	489	5.14	1.37	-1.17	0.22	0.02	0.11
	B4	489	5.24	1.33	-1.45	0.22	0.11	0.11
	B5	489	5.27	1.34	-1.15	0.22	-0.078	0.11
	B6	489	5.07	1.17	-1.03	0.22	0.38	0.11
innovation performance (I)	I1	489	5.54	1.13	-1.39	0.22	-0.03	0.11
	I2	489	5.40	1.07	-1.24	0.22	0.08	0.11
	I3	489	5.57	1.11	-1.31	0.22	-0.14	0.11
	I4	489	5.54	1.08	-1.25	0.22	-0.15	0.11

Appendix 5

Table 19
obustness test results.

Serial number	Constant	Dependent variable	Regression coefficients	T-stat	P-value
1	Making technology	Innovation performance	0.13	2.70	0.000
2	Efficiency-centered business	Innovation performance	0.12	2.44	0.000
3	Efficiency-centered business	Making technology	0.17	3.44	0.000
4	Novelty-centered business model	Innovation performance	0.13	2.71	0.000
5	Novelty-centered business model	Making technology	0.15	2.97	0.000
6	Buying technology	Innovation performance	0.18	3.56	0.000
7	Efficiency-centered business	Buying technology	0.26	5.25	0.000
8	Novelty-centered business model	Buying technology	0.12	2.38	0.000
9	Buying technology*technological opportunities	Innovation performance	0.06	1.29	$0.197 > 0.05$
10	Making technology*technological opportunities	Innovation performance	0.13	3.02	0.003
11	Novelty-centered business model*technological opportunities	Innovation performance	0.13	2.89	0.004
12	Efficiency-centered business*technological opportunities	Innovation performance	0.15	3.49	0.001
13	Making technology*technological monopoly	Innovation performance	0.20	4.57	0.000

(*continued on next page*)

Table 19 (*continued*)

Serial number	Constant	Dependent variable	Regression coefficients	T-stat	P-value
14	Buying technology*technological monopoly	Innovation performance	-0.17	-3.88	0.000
15	Novelty-centered business model*technological monopoly	Innovation performance	-0.02	-0.41	0.683 > 0.05
16	Efficiency-centered business*technological monopoly	Innovation performance	0.10	2.29	0.022
17	Making technology*technological cumulativeness	Innovation performance	0.15	3.43	0.001
18	Buying technology*technological cumulativeness	Innovation performance	-0.15	-3.52	0.000
19	Novelty-centered business model*technological cumulativeness	Innovation performance	0.05	1.08	0.282 > 0.05
20	Efficiency-centered business*technological cumulativeness	Innovation performance	0.14	3.10	0.002
21	Making technology*knowledge base	Innovation performance	0.21	4.88	0.000
22	Buying technology*knowledge base	Innovation performance	-0.10	-2.14	0.033
23	Novelty-centered business model*knowledge base	Innovation performance	0.13	2.84	0.005
24	Efficiency-centered business*knowledge base	Innovation performance	0.02	0.47	0.636 > 0.05

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