Technological Forecasting & Social Change 186 (2023) 122129

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

The impact-mechanism of "Internet +" on the innovation performance of traditional enterprises: Empirical evidence from China

Renai Jiang [a], Muhammad Saeed [a,*], Shenghao Yang [a], Shahab E. Saqib [b]

[a] School of Economics and Finance, Xi'an Jiaotong University, China
[b] Directorate of Commerce Education and Management Sciences, Higher Education Archives and Libraries Department, Peshawar, Khyber Pakhtunkhwa, Pakistan

ARTICLE INFO

JEL classification:
O32 L86 L44

Keywords:
"Internet +"
Impact-mechanism
Traditional enterprises
Innovation performance
China

ABSTRACT

Most traditional industries in China have reached a mature or declining stage, and their core competitiveness has declined compared to developing industries in the recent past. The paper studied the impact-mechanism of "Internet +" and verified its impacts on enterprise innovation performance. The data of 1040 traditional Chinese enterprises from 2011 to 2019 listed on the Shanghai and Shenzhen stock exchange were obtained from their annual reports by text-mining method. The purpose of these enterprises' selection was their present transformation of traditional Chinese enterprises from resource-driven to innovation-driven development strategy. The study employed poison-regression model to investigate the relationship of independent variables with innovation performance of these firms. In addition, we employed bootstrap method for validity of indirect effect. Based on the empirical evidence, we found that the "Internet +" significantly affects the innovation performance of traditional Chinese enterprises by influencing the organization's innovation elements, corporate governance structure, and corporate culture. The results do not change when we apply alternative variables in the model, which shows strong robustness. The findings of this research will help promote the deep integration of the internet in the real economy and promote more effective implementation of the "Internet +" national strategy in traditional enterprises.

1. Introduction

Based on the life cycle theory, most traditional industries in China have entered a mature or declining stage, and their core competitiveness has weakened. Compared with the emerging industries in recent years, the growth rate of traditional industries began to decline, which is in the bottleneck period of development. China's economy is in the downward stage of the new normal, and the development of China's traditional enterprises is facing an unprecedented grim situation (Chenxi, 2020). From the perspective of China's economic development, China's economic growth has entered a new normal[1] in the process of transformation from resource-driven to innovation-driven (Wang et al., 2016). How to transform and find new economic growth points has become the main problem faced by the development of traditional industries in China.

On March 5, 2015, the concept of "Internet +" was integrated into China's national economic policy so that enterprises could explore new growth targets. Internet thinking has been ingrained in China's economic development, providing new growth opportunities for the country's economy, especially for the traditional industry. Paunov and Rollo (2016) provided evidence of a strong positive relationship between the use of internet technology by industries and firm performance in the developing world. Similarly, firms with increased ICT investment are more likely to increase productivity (Reeson and Rudd, 2016). The integration of traditional industries and the internet has gradually accelerated in China. Specifically, the medical, financial, educational, and tourism industries are closely related to consumer life. The integration of these industries has been in a relatively mature stage, and a new internet economic model, such as Online-2-Offline (O2O), has emerged.

With the vigorous development of internet technology, traditional industries in China should speed up their integration with "Internet +" to form a new momentum of economic development and speed up their transformation to innovation-driven. On the one hand, China's internet economy is booming, and by the end of December 2020, China's internet penetration rate has reached 70.4 % (Satistica, 2021). On the other

* Corresponding author.
E-mail addresses: jiangrenai@xjtu.edu.cn (R. Jiang), m.saeed.iiu@gmail.com (M. Saeed).

[1] Chinese authorities and analysts use this term to describe how yearly GDP growth has dropped from double-digit levels in recent years to between 7.0 and 7.5 %.

https://doi.org/10.1016/j.techfore.2022.122129
Received 31 March 2022; Received in revised form 25 September 2022; Accepted 19 October 2022
Available online 29 October 2022

hand, China's innovation resources investment and the number of patents show a surging trend. As a result of this reality, whether the development of "Internet +" is the reason to improve the innovation performance of Chinese enterprises has become worthy of discussion.

Considering the above discussion, the motivations for this study are mentioned below. Firstly, the concept of "Internet +" is relatively new, and the existing literature has only focused on the relationships between "Internet +" and the audit fees of listed companies (Yang Deming, 2017), business performance (Yang Deming, 2018), and corporate governance (Feng and Wen, 2008). Secondly, regarding enterprise innovation performance, most of the existing researchers focused on enterprise culture (Zhang Min, 2014), innovation factor input (Ju Xiaosheng and Yihua, 2013), institutional arrangement (Wei Xuhua and Liuqing, 2015), and government support (Li Wenjing, 2016). Thirdly, no attention has been paid to study the relationship between the development level of the "Internet +" and the innovation performance of traditional industries at the world level in general and China in particular. Lastly, the empirical evidence on how the "Internet +" affects the enterprise innovation performance of traditional industries in China is somewhat limited.

Therefore, this study aims to fill this gap by exploring the path of "Internet +" on corporate innovation performance from three aspects. First, we linked the "Internet +" with the R&D funds and technical personnel of the selected enterprises to further explore their relationship with the invention patents. Second, we consider the ratio of the top five shareholders as indicators of ownership concentration and the ratio of independent directors to find whether "Internet +" plays a vital role in the corporate governance structure. Third, we used the level of indicators represented by keywords in annual reports as the organization's corporate culture to investigate their relationship with innovation performance in the presence of "Internet +."

It is worth mentioning that this paper has a certain degree of originality in selecting indicators to measure enterprise innovation efforts. The existing literature measures enterprise innovation performance only from macro-level data. This paper enriches the current literature by providing a certain degree of innovation using micro-level data for our independent and mediating variables, extracted through the text mining method, to quantify the impact-mechanism of "Internet +" and the innovation performance of traditional enterprises.

The rest of the research contents are organized as follows. Section 2 presents the related literature review and the development of the hypothesis. Section 3 provides model construction and variables definitions. Section 4 makes the empirical tests on the constructed econometric model, conducts robust tests, and discusses the empirical results. The last section provides the research conclusion and policy recommendation.

2. Review of literature

2.1. Enterprise innovation performance and innovation elements

"Internet +" has its characteristics of openness, sharing, and connectivity, which provide a tool and platform for enterprises to realize the open innovation structure. Through internet access, enterprises can cross the physical boundaries and constraints of time and space and globally allocate innovation resources (Boutellier et al., 2013). In addition, Wang et al. (2016) conducted their study at the early stages and only theoretically examined the characteristics of "Internet +," and they concluded that innovation elements could be improved. The research and development (R&D) funds and technical personnel are two important elements of firms' innovation. According to Tong et al. (2014), enterprises can obtain the necessary (R&D) funds and technical personnel for innovation activities. However, studying the innovation of state-owned and non-state-owned firms discovered that the quality of state-owned enterprises has significantly decreased in the case of China. Díaz-Roldán and Ramos-Herrera (2021) stated that through the internet, transaction and contract costs are reduced, and the efficiency of internal capital is improved, further enhancing its innovation performance. Economists like Schultz (1961) believed that human capital is the crucial input factor. Moreover, Subramaniam and Youndt (2005) revealed that intellectual capital is the core element. Likewise, Cao et al. (2016) stated that human capital is one of the essential factors affecting enterprise innovation performance at different stages of the product life cycle. A highly knowledgeable workforce boosts the service and scope of a company's innovation, and the existence of formal and informal R&D expenditures enhances the firm innovation dramatically (Love and Mansury, 2007). However, their study cannot glean the dynamics of the innovation process because they only investigated a cross-sectional sample of a sizable business. Thus, it is obvious from the preceding discussion that firms' R&D funds and human capital play a key role in innovation performance.

Integrating internet technology based on the ubiquitous and shared features of "Internet +" helps to restructure and utilize innovation elements inside and outside the enterprises. Therefore, technical personnel in organizations influence enterprise innovation by playing their subjective initiative because technically qualified personnel and technology information increase the innovation performance (Xie et al., 2013). Internet-access enables technical personnel to obtain more innovation-related information and collaborative R&D opportunities through multiple channels. It is, therefore, hypothesized that *"Internet +" influences the innovation performance of enterprises by integrating innovation elements*.

2.2. Innovation and corporate governance structure

Corporate governance is one of the essential factors for the stable, sustainable, and healthy development of companies (Genfu and Jianshan, 2009) and innovation and technological change (Tylecote and Visintin, 2007). While for corporate governance, the large shareholders and independent board of directors are critical elements. The theory of corporate governance states that large shareholders may maximize their interests due to the differences in expected utility functions and their interests (Hill and Snell, 1989; Su et al., 2008); to prevent this kind of behavior, enterprises lead to produce agency costs. Managers and shareholders may be less likely to have conflicts of interest if large shareholders have a check on managers (Shleifer and Vishny, 1997). However, due to much influence in the management decisions, large shareholders make it difficult to cooperate with the shareholders having less shareholding ratio. Large shareholders may act in their own best interests (Shleifer and Vishny, 1986). Smaller and medium shareholders can participate in and supervise the enterprise's internal innovation decision-making, to ensure the effectiveness and timeliness of enterprise management (Asensio-López et al., 2019). Most traditional enterprises adopt the vertical governance (large shareholders) structure, which makes the efficiency of enterprise and business activities relatively low (Hsueh and Tu, 2004). Thus, large shareholders representing the corporate governance structure of the enterprises may generate corporate governance and agency costs. Furthermore, corporate governance literature has also uncovered the importance of independent directors in the corporate governance framework in relation to firms' innovation performance. Among others, Jensen and Meckling (1976), Fama (1980), and Fama and Jensen (1983) suggested that directors should be independent to ensure the board can exercise effective checks on managers. Hence, it can prevent opportunistic behavior of managers that might damage the firm's performance. According to Yong et al. (2007) and Feng and Wen (2008), independent directors play an essential role in decision-making because they have diversified and specialized knowledge and skills. For instance, McCabe and Nowak (2008) interviewed 30 independent directors in Australian public listed firms and pointed out that independent directors would lessen the dangers of "group think". However, they conducted their study in the context of public-listed firms, where the requirements for independent directors on the board are relatively different compared to private limited firms. Moreover, Li

et al. (2020) pointed out that independent directors, based on their supervisory and technical role, influence enterprise innovation primarily by encouraging firms to deepen their current field of research.

The improved communication among members of an industry facilitates learning about new technologies and governance efficiency of enterprise innovation activities (Conley and Udry, 2010). Internet use makes information dissemination more open and timelier so that enterprise stakeholders can obtain business information through various internet channels. The presence of "everyone participates in governance, and everyone supervises governance" can be formed to reduce corporate governance costs and agency costs, thus transposing the governance structure from "vertical" to "horizontal" governance structure. The discussion above leads us to our second hypothesis of this study: *"Internet +" influences corporate innovation performance by changing the corporate governance structure*.

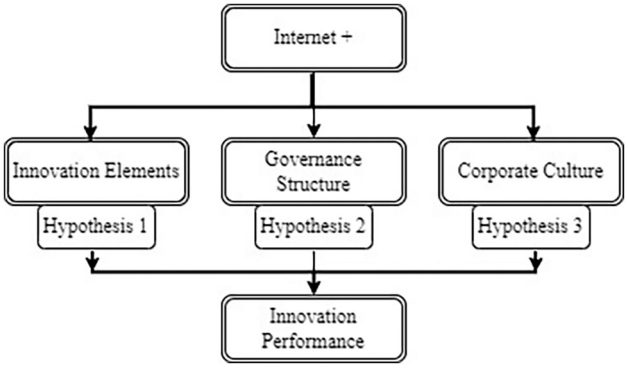

Fig. 1. Theoretical framework.

2.3. Innovation and corporate culture

Several studies found that corporate culture plays a vital role in enterprise innovation performance (Schein, 1990; Lau and Ngo, 2004; Hartmann, 2006). Corporate culture improves the firm's performance by enhancing coordination and control within the firm, improving goal alignment between the firm and its members, and increasing employees' efforts (Sørensen, 2002). Regarding workers' engagement, an open corporate culture enhances the knowledge and creative minds necessary for organizational success (De Long and Fahey, 2000). It improves employees' interaction and engagement (Jacobs et al., 2013). Consequently, information is efficiently communicated (Crémer, 1993). By strengthening employees' bonds with the company, corporate culture can help them become more committed to it (O'Reilly, 1989). The organization's open culture motivates employees to actively participate in the decision-making process and provide innovative ideas to improve organizational performance (Shahzad, 2014). A flexible and supportive environment of the organization is one of the determinants of the creativity and innovation performance of the organization (Shahzad et al., 2017). However, their empirical evidence is related to software firms that belong to the high-technology industry. Further, Dasgupta and Gupta (2019) provided evidence that the organization's culture must be properly handled to adopt internet technology successfully. The scope of their research was limited to governmental institutions, while organizational culture in small firms is different from large ones.

Internet thinking enables enterprises to establish a more open, equal, quick, and shared innovation culture. The fast and easy flow of information in the organizations reduces the cognitive differences of enterprise stakeholders on innovation value to improve the enterprise innovation performance (Subramaniam and Youndt, 2005). When studying the impact of "Internet +" on the innovation performance of listed companies in traditional industries in China, this study focuses on whether the internet has changed enterprises' business models. Therefore, we hypothesize that "*Internet +" helps enterprises become part of the open innovation culture atmosphere, thereby affecting the innovation performance of enterprises*. From the above literature review, we hypothesize that "Internet +" can influence enterprise innovation performance by influencing enterprise innovation elements, corporate governance structure, and corporate culture (Fig. 1).

3. Empirical framework

3.1. Model setting and methodology

The study has improved the model of Wang Jinjie and Longpeng (2018) after incorporating the mechanism of "Internet +" on innovation performance at the enterprise level. The innovation performance of the enterprises is measured by the number of invention patents. The model that estimates the direct effect of "Internet +" is given in Eq. (1).

$$\text{innovation}_{it} = \alpha + \beta \text{internet}_{it} + \gamma X_{it} + f_i + \varphi_{it} \quad (1)$$

where i and t represent the i^{th} enterprise and year, respectively, X_{it} represents a series of control variables based on asset-liability structure, including enterprise total operating income, asset-liability ratio, current ratio, and the ratio of net fixed to total assets, f_i denotes firm fixed effect. Due to the small sample size and normal years observations, we did not control our model for year-fixed effects, φ_{it} is the random disturbance term.

The study further verifies the channel based on the above hypothesis to confirm the path of "Internet +" affecting enterprise innovation performance. Specifically, we used a stepwise test to verify the indirect effect of "Internet +" on enterprise innovation performance. The test model is as follows:

$$Y = cX + e_1 \quad (2)$$

$$M = aX + e_2 \quad (3)$$

$$Y = \acute{c}X + bM + e_3 \quad (4)$$

In equations Eqs. (2), (3), and (4), Y, X, and M represent the dependent, independent, and intermediary variables of the model, respectively, while e_1, e_2, and e_3 are the error terms. If H_0: c = 0, H_0: a = 0 and H_0: b = 0 are rejected, the mediating effect is significant, otherwise it is insignificant. The total effect of X on Y is measured by "c," whereas "a" measures the effect of X on M. Similarly, "b" measures the effect of M on Y, accounting for the effect of X and $\acute{c}$, quantifies the indirect effect adjusted for the effect of M on Y. Regarding "Internet +" and innovation performance, this paper adopts the number of patents as a dependent variable while the level of internet development and internet dummy are the independent variables. Likewise, the R&D funds, the technical personnel, the shareholding ratio of the top five shareholders, the ratio of independent directors, the number of indicators reflecting corporate culture, and the level of corporate culture are mediating variables.

The mediating effect and the indirect effect models that capture the possible effects of "Internet +" are presented in Eqs. (5) and (6) as follows:

$$M_{it} = \partial_0 + \beta_0 \text{internet}_{it} + \gamma X_{it} + f_i + \varphi_{it} \quad (5)$$

$$Innovation_{it} = \partial_1 + \beta_1 internet_{it} + \beta_2 M_{it} + \gamma X_{it} + f_i + \varphi_{it} \quad (6)$$

Since the dependent variables of the model presented in Eq. (6) follow count data with no negative numbers, we employ the Poisson regression model suggested by Cameron and Trivedi (1998). Specifically, we have to test our first hypothesis that "Internet +" affects enterprise innovation performance by influencing innovation elements. We next have to test the second hypothesis, namely, "Internet +" affects the performance of corporate governance by affecting the corporate

governance structure. Similarly, this study further verifies our third hypothesis, namely, "Internet +" influences innovation performance through the influence of corporate culture.

3.2. Bootstrap confidence interval (CI)

After estimating the regression coefficient for the indirect effect $\widehat{a}\widehat{b}$, its significance must be tested because the sampling distribution of the indirect effects might not be normal (Craig, 1936; Aroian, 1947). Therefore, we employed the bootstrap method to measure the standard errors of estimate and test the confidence interval to overcome this problem. In small sample sizes, the distributions of $\widehat{a}\widehat{b}$, generated by bootstrap sampling are skewed and asymmetric, resulting in biased confidence intervals and low statistical power (Stone and Sobel, 1990; Fritz and MacKinnon, 2007; MacKinnon et al., 2007). Therefore, this study next has to compute bias-corrected (BC) and bias-corrected and accelerated (BCa) confidence intervals using Efron and Tibshirani (1986) and Tibshirani and Efron (1993) to verify the significance of the indirect effect. The BC and BCa intervals account for bias and skewness in the bootstrap distribution of estimates (Efron and Tibshirani, 1994; MacKinnon et al., 2004).

3.2.1. BC confidence intervals

For bias-corrected confidence intervals, we have followed methods suggested by Efron and Tibshirani (1986) and Tibshirani and Efron (1993), mentioned in Eqs. (7) & (8), to verify the significance of the indirect effect.

$$BCLC = \widehat{a}\widehat{b}^{\varnothing\left(2\widehat{Z}_{\widehat{ab}}+Z^{(\alpha)}\right)} \tag{7}$$

$$BCUC = \widehat{a}\widehat{b}^{\varnothing\left(2\widehat{Z}_{\widehat{ab}}+Z^{(1-\alpha)}\right)} \tag{8}$$

where *BCLC* represents BC lower CI, *BCUC* is for BC upper CI. Moreover, $\varnothing(.)$ shows the standard normal cumulative distribution function, $\widehat{Z}_{\widehat{ab}}$ is the measure of bias for the indirect effect, and $Z^{(\alpha)}$ is the 100αth percentile point of a standard normal distribution. If $\alpha = 0.05$, the lower and upper CIs can be calculated using $2\widehat{Z}_{\widehat{ab}} - 1.96$, and $2\widehat{Z}_{\widehat{ab}} + 1.96$, respectively.

3.2.2. BCa confidence intervals

The BCa accounts for two components, the bias correction $(\widehat{Z}_0)$ and the acceleration $(\widehat{k})$. The term acceleration is defined as the rate at which the standard deviation of $\widehat{a}\widehat{b}$, changes as a function of ab, and is shown in Eq. (9).

$$\widehat{k} = \frac{\sum_{i=1}^{n}\left(\widehat{a}\widehat{b}_{()} - \widehat{a}\widehat{b}_{(-i)}\right)^3}{6\left[\sum_{i=1}^{n}\left(\widehat{a}\widehat{b}_{()} - \widehat{a}\widehat{b}_{(-i)}\right)^2\right]^{\frac{3}{2}}} \tag{9}$$

where $\widehat{a}\widehat{b}$ $(-i)$ is the estimate of *ab* with case *i* observation deleted from the original data set, also called the ith jackknife estimate of *ab*, and $\widehat{a}\widehat{b}$ (•) is the mean of all the jackknife estimates of *ab*. The BC*a*, confidence limits can be written as shown in Eqs. (10) & (11).

$$BCaLC = \widehat{a}\widehat{b}^{\varnothing\left(\widehat{Z}_{\widehat{ab}}+\frac{\widehat{Z}_{\widehat{ab}}+Z^{(\alpha)}}{1-\widehat{k}\left(\widehat{Z}_{\widehat{ab}}+Z^{(\alpha)}\right)}\right)} \tag{10}$$

$$BCaUC = \widehat{a}\widehat{b}^{\varnothing\left(\widehat{Z}_{\widehat{ab}}+\frac{\widehat{Z}_{\widehat{ab}}+Z^{(1-\alpha)}}{1-\widehat{k}\left(\widehat{Z}_{\widehat{ab}}+Z^{(1-\alpha)}\right)}\right)} \tag{11}$$

When $\widehat{k} = 0$, the BCa reduces to the BC. For a more detailed explanation, one can consult Efron and Tibshirani (1986) and Tibshirani and Efron (1993).

3.3. Data collection and variables' definitions

The data set of 1040 traditional enterprises of China is extracted from Shanghai and Shenzhen stock exchange for a period from 2011 to 2019. We cleaned our dataset first by excluding the high-tech industry because this study intends to explain the dynamic integration effect of "Internet +" and traditional industries. Second, we dropped financial enterprise industry supervision companies since these companies do not come under the traditional industries. Third, considering the unique nature of government regulation, the public utility industry and companies with missing data are eliminated. Finally, 4299 sample observations are left after cleaning the data. The study variables are explained below.

3.3.1. Dependent variables

Innovation can create new value for enterprises, customers, and stakeholders. We measured innovation performance by the number of patents each firm invented, which is our dependent variable. The number of patents is winsorized at 5 % and treated as another dependent variable to test the robustness of the dependent variable. The fundamental source of patent data is the patent grant filings published by the China National Intellectual Property Administration (CNIPA, 2021). First, we use python software to perform text analysis of all invention patent filings. Second, the aggregation is based on the patent assignee and the year of the grant. Finally, the aggregated enterprises' patents and listed enterprises are matched yearly to construct the sample enterprises.

3.3.2. Independent variables

The "Internet +" is incorporated as an independent variable. Following the work of Yang Deming (2018), we extracted the data from the annual reports of enterprises by text mining method. We used a level of internet development (internet_dl) based on internet-related keywords that indicate the implementation of the "Internet +" policy. After the text mining, if the keywords appeared 0 times, assigned 0 value, 1–5 times = 1, 6–20 = 2 and >20 = 3. To test the robustness of the independent variable, we also used a dummy variable (internet _dm) for "Internet +" taking a value of 1 if the enterprise's annual report shows internet-related information and 0 otherwise.

3.4. Mediating variables

The study employed six mediating variables, two variables for each hypothesis to examine. These are the innovation elements represented by internal R&D funds and the number of technical personnel working in each enterprise. It is expressed by taking the natural log of internal R&D expenditure (lnRdf) and internal technical personnel (lnTI). Corporate governance is measured by the shareholding ratio of the top five shareholders (Cr5) and the ratio of the independent directors (in_ratio) in the board of directors. As measuring corporate culture is a kind of qualitative that leads to enterprises' development, its measurement is quite difficult. Therefore, we follow the work of Wang and Kan (2014) and select the cultural keywords that are conducive to the innovation and development of enterprises from three dimensions: enterprise level, employee level, and social level. At the enterprise level, this study selected words such as change, cooperation, efficiency, decentralization, system, supervision, ability, dedication, innovation, talent, diversification, implementation, and sharing. At the employee level, motivation, ability, knowledge, collaboration, optimism, passion, and boldness are selected, while at the social level, words such as green, environmental protection, gratitude, win-win, and responsibility are chosen. These variables are modeled in two different forms; the number of keywords that appeared in the reports (culture_num) and assigned values (culture_dl). For later, the data are obtained from the annual reports of each

firm and are assigned 0, 1, 2, and 3 values if keywords are in ranges 0–100, 101–200, 201–300, and >300, respectively.

3.5. Control variables

The study used enterprises' asset size and financial structure as control variables. The current ratio (Debt), the liquidity ratio (Liquidity), and the natural logarithm of the total operating income (lnGoi) of the listed companies are used to control the scale of the enterprise. In addition, we used the ratio of net fixed assets to total assets (Nta) to control the efficiency of the firms' fixed assets. The data of control variables of enterprises are extracted from the wind database (Wind Information, 2021).

4. Empirical results and analysis

4.1. Descriptive statistics

Descriptive statistics such as the number of observations (N), mean, standard deviation (SD), and minimum (Min) and maximum (Max) of the variables under study for the empirical analysis are provided in Table 1. In particular, the mean value, SD, minimum, and maximum of the patents are 18.85, 129.57, 1, and 296, respectively. The standard deviation value shows that the variation among the firm's patents is quite high. The highest SD of the number of patents shows a greater variability of the innovation performance among the selected traditional enterprises. It may be because each firm implemented the "Internet +" policy in various capacities.

Similarly, the mean and standard deviations of Cr5 are 56.2 and 16, while the same for culture_num, 171.68, and 82.73 show the highest mean and standard deviation among the mediating variables. The high standard deviation of culture_num suggests that some firms are flexible in the adoption of the "Internet+" policy while others are laggers.

4.2. Results of the baseline model

We used the number of invention patents as dependent variables to articulate the effects of "Internet +" on enterprise innovation performance. In our base model estimation, first, we estimated it without mediating and control variables and provided the results in column (1) of Table 2. The coefficient of the explanatory variable (internet_dl) is significantly positive, indicating that "Internet +" increased the number of invention patents. It shows that the integration of enterprises and the "Internet +" improved the innovation performance of enterprises.

Following prior studies (Dichev et al., 2013; Sun et al., 2016; Yang and Shi, 2018; Yang Deming, 2018), we selected the factors such as the firms' assets-liability as control variables while estimating our econometric models. We next estimated the model presented in Eq. (1) after controlling for the enterprise-specific variables. In particular, columns

Table 1
Descriptive statistics.

Variables	Notations	N	Mean	SD	Min	Max
Dependent	inve_num	4299	18.85	129.57	1	296
	inve_new	4299	7.22	10.5	1	43
Independent	internet_dl	4299	0.75	0.84	0	3
	internt_dm	4299	0.53	0.5	0	1
Innovation elements	lnTI	4220	6.06	1.27	2.57	12.2
	lnRdf	4210	18.1	1.47	11.4	23.8
Corporate governance	Cr5	4299	56.2	16	10.8	100
	in_ratio	4299	0.37	0.06	0	0.8
Corporate culture	culture_num	4299	171.68	82.73	0	891
	culture_dl	4299	1.18	0.73	0	3
Firm-specific	Debt	4299	42.3	19.5	2.24	229
	Liquidity	4296	2.28	2.38	0.1	38.3
	lnGoi	4299	21.8	1.54	17.9	28.7
	Nta	4299	0.25	0.14	0.002	0.81

Table 2
The direct impact of "Internet +" on the innovation performance.

Variables	(1)	(2)
	inve_num	inve_num
internet_dl	0.269***	0.168***
	(49.92)	(29.09)
Debt		−0.026***
		(−32.76)
Liquidity		−0.066***
		(−8.42)
lnGoi		0.713***
		(47.81)
Nta		−2.140***
		(−27.15)
Log likelihood	−20,162.31	−17,596.04
Wald chi2	2491.64	7218.88
Prob > chi2	0.0000	0.0000
Hausman Test	4.61	95.37
Prob > chi2	0.0318	0.0000
Observations	4093	4090

Note: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. The z-values are in the parenthesis.

(2) of the table quantify the effect of the "Internet +" in the presence of the control variables, and the empirical results remained unchanged.

The "Internet +" has the characteristics of connectivity and openness. It enables enterprises to break the boundaries of time and space and accelerate the speed of information (Wang et al., 2016; Tong Zehua and Xiaoting, 2019; Jingxian, 2021). Also, it helps enterprises acquire more internal and external innovation resources and form an open innovation culture. Further, in the industrial chain, the high integration of enterprises and the internet accelerates enterprises' innovation process (Zhuning, 2021). Thus, access to the "Internet +" can effectively increase enterprise innovation performance. It indicates that "Internet +" directly promotes enterprise innovation performance.

4.3. Mediating effects

4.3.1. "Internet +" and innovation elements

This study expects enterprises to use the internet to obtain and integrate more internal and external innovation resources at a low cost. Consequently, it affects their innovation performance by influencing the enterprise innovation elements. To test this hypothesis, we first selected the enterprises' R&D funds (lnRdf) and technical personnel (lnTI) and estimated them separately. We then combined the mediating variables with the internet development level in a single model. The empirical results (Table 3) provided in columns (1) and (3) are based on the estimation of Eq. (5), while columns (2), (4), and (5) are obtained by Eq. (6). The response variables are R&D funds and technical personnel, and the explanatory variable is the "Internet +". The results in column (1) show that traditional enterprises' R&D funds increase significantly after the adoption of "Internet +". The positive sign of the "Internet +" and (R&D) funds in column (2) reveal that "Internet +" significantly affects enterprises' innovation performance. These findings are in-line with Kafouros (2006). However, he reported a positive relationship between the internet and R&D efficiency using the Cobb-Douglas framework. Based on the property of openness, interoperability, and sharing of the internet, enterprises break the original physical boundaries and obtain more external innovation resources in the form of R&D funds and technical personnel. Adopting an internet policy enables businesses to increase their R&D fund and improve innovation output. These results are in-line with the study of Tong et al. (2014). They revealed that high-quality innovation elements significantly improved the innovation degree of new products and directly enhanced the innovation output of enterprises.

In our same hypothesis 1, next is to see the impact of technical personnel on innovation performance in the presence of "Internet +".

Table 3
"Internet +," innovation elements, and innovation performance.

Variables	(1)	(2)	(3)	(4)	(5)
	lnRdf	inve_num	lnTI	inve_num	inve_num
internet_dl	0.109***	0.030***	0.023**	0.027**	0.020***
	(6.90)	(2.61)	(2.08)	(2.37)	(3.06)
lnRdf		0.071***			0.249***
		(4.92)			(22.74)
lnTI				0.078***	0.393***
				(3.40)	(20.86)
Debt	−0.005***	−0.002**	0.004***	−0.002**	−0.014***
	(−4.49)	(−2.19)	(4.73)	(−2.06)	(−16.66)
Liquidity	−0.011	−0.025***	−0.004	−0.024***	−0.054***
	(−1.57)	(−3.27)	(−0.87)	(−3.07)	(−8.78)
lnGoi	0.979***	−0.065***	0.441***	−0.040*	−0.054**
	(37.51)	(−2.58)	(21.94)	(−1.68)	(−2.63)
Nta	0.243***	0.761***	0.187***	0.804***	−1.115***
	(1.62)	(13.96)	(3.80)	(15.42)	(−13.26)
Constant	−3.147**		−4.266***		
	(−5.57)		(−11.15)		
Log-likelihood		−8054.77		−8053.68	−13,069.02
Wald chi2		509.66		468.78	3243.66
Prob > chi2		0.0000		0.0000	0.0000
R-squared	0.555		0.270		
corr(u_i, Xb)	−0.3828		0.3878		
Hausman Test	113.90	366.36	75.47	187.25	154.66
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	4207	4015	4217	4016	3946

Notes: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. In columns (1) and (3), the values in the parenthesis are t-values, while these values in columns (2), (4), and (5) are z-values.

The positive and significant coefficient of the internet in column (3) shows that enterprise technical personnel increase significantly after implementing the "Internet +" policy. Column (4) further verifies the indirect impact of the "Internet +" on the innovation performance of enterprises. The coefficients indicate that the development level of the internet and the technical personnel are significantly positive. Through the open-source nature of the internet, the employees of the organizations utilize, improve their skills and knowledge and reallocate their human capital (Li et al., 2021). We further combined both innovation elements in a single model. The estimated results in column (5) confirm the previous relationships (individual models). The sustainable economic growth relies heavily on human capital. At the same time, internet access enables technical personnel to play their subjective initiative to obtain more innovation-related information and collaborative R&D opportunities through multiple channels (Xie et al., 2013) and achieve new growth targets. Thus, it enhances technological innovation ability and further improves the quality of enterprise innovation. These results are consistent with Love and Mansury (2007). They conducted a study to explore the linkages between R&D, workforce, and innovation performance in the US services industry. The search and

Table 4
"Internet +," ownership concentration, the ratio of independent directors, and innovation performance.

Variables	(1)	(2)	(3)	(4)	(5)
	Cr5	inve_num	in_ratio	inve_num	inve_num
internet_dl	−1.358***	0.081***	0.002***	0.198***	0.080***
	(−7.66)	(7.59)	(2.44)	(33.47)	(7.51)
Cr5		−0.005***			−0.004***
		(−3.77)			(−3.57)
in_ratio				2.781***	0.665***
				(25.23)	(3.79)
Debt	−0.013	−0.003***	0.000	−0.023***	−0.003***
	(−0.93)	(−2.92)	(0.93)	(−28.68)	(−2.79)
Liquidity	0.279***	−0.037***	−0.000	−0.056***	−0.037***
	(3.60)	(−4.74)	(−1.02)	(−7.39)	(−4.76)
lnGoi	−4.158***	0.154***		0.669***	0.143***
	(−14.03)	(7.75)		(44.43)	(7.17)
Nta	−1.357	−0.051	0.011	−1.973***	−0.062
	(−0.81)	(−0.45)	(1.27)	(−24.97)	(−0.53)
Constant	148.28***		0.366***		
	(23.05)		(85.30)		
Log-likelihood		−8370.02		−17,280.58	−8362.90
Wald chi2		242.91		7733.57	257.29
Prob > chi2		0.0000		0.0000	0.0000
R-squared	0.1217		0.009		
corr(u_i, Xb)	−0.5004		0.0427		
Hausman Test	269.09	88.28	19.29	68.10	93.14
Prob > chi2	0.0000	0.0000	0.0007	0.0000	0.0000
Observations	4296	4090	4296	4090	4090

Notes: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. In columns (1) and (3), the values in the parenthesis are t-values, while these values in columns (2), (4), and (5) are z-values.

communication feature of the internet improved R&D funds and technical personnel because of the reduction of transaction cost, time management and quality of funds. Our findings argue that "Internet +" not only contributes to academic knowledge but also has vital practical ramifications.

4.3.2. "Internet +" and corporate governance structure

The empirical results mentioned in columns (1) and (3) of Table 4 are based on the estimation of Eq. (5), while columns (2), (4), and (5) are obtained by Eq. (6). In particular, column (1) and (2) show the impact of "Internet +" on mediating variables while the results of the indirect impact of the "Internet +" is presented in column (2), (4), and (5). The results in column (1) show that the coefficient of internet development level is significant with a negative sign. It indicates that enterprises' access to the internet inhibits the formation of their "vertical" governance structure. It makes their governance structure more decentralized. Access to the internet dilutes ownership concentration and reduces the pressure on management decision-making. As a result, the decentralized governance structure in an organization is more conducive to its long-term development. Similarly, the results of the indirect effect of the "Internet +" in column (2) show that the development level of the internet is significant and positive. However, the ownership concentration is significantly negative. These results are contrary to the study of (Hill and Snell, 1989). They argued that there is a positive relationship between ownership concentration and productivity because large shareholders maximize their interests due to the differences in their expected utility functions and interests. However, our study measures the relationship between ownership concentration and innovation performance. Therefore, our results are different due to the nature of different variables. The negative association between ownership concentration and innovation perforce implies that the decision-making of innovation activities is more decentralized from the original state. More shareholders have the absolute decision-making power to "everyone makes decisions and everyone supervises." Thus, it is possible to achieve a "horizontal" governance structure. Moreover, a "horizontal" governance structure can: 1) reduce the cost of supervision. It avoids the unnecessary losses caused by the "vertical" regulatory process, which involves layers of approvals, 2) improves regulatory efficiency. In the process of "vertical" supervision, the distance between the supervisory and executive levels often creates serious information asymmetry. The "horizontal" supervision promoted by the "Internet +" can be dynamically adjusted according to the situation immediately during the supervision process. Thus, it helps avoid poor supervision in advance, untimely feedback, and unmatched processing afterward.

The ratio of independent directors to the board of directors is used as mediating variable. The results are presented in column (3). It indicates that the ratio of independent directors has significantly increased because of access to the internet. Interestingly, the control variables are insignificant and do not determine the ratio of independent directors. The availability of the internet makes the independent directors obtain more information about the enterprise's internal innovation activities and is helpful for enterprises, as suggested by McCabe and Nowak (2008). Column (4) shows the indirect impact of "Internet +" and the ratio of independent directors on innovation performance. The ratio of independent directors is significantly positive, indicating that the increase in independent directors can promote the development of enterprise innovation performance. The existence of an independent director can help the enterprise reconcile mistakes in decision-making due to the incompleteness of professional knowledge. Our findings are supported by Li et al. (2020), who claimed that independent directors significantly impacted innovation by encouraging companies to expand their research into new sectors (Hu and Sun, 2019).

The internet can make the independent directors obtain more information about the enterprise's internal innovation through their better supervisory role that improves the enterprise's innovation performance. The estimated results reported in column (5) are obtained by placing both the mediating variables into a single model and confirming that our results are unchanged. It implies that the internet helped transform their corporate governance from a "vertical" to a "horizontal" structure. Access to the internet discloses innovation activities more transparent, where independent directors can play their role in innovation activities. Thus, it further reduces the cost of governance and supervision in enterprise innovation activities. Our findings are in-line with Díaz-Roldán and Ramos-Herrera (2021). They discovered that the influence of ICT on the innovation performance of EU enterprises occurs through a reduction in production and transaction costs. Therefore, access to the internet reduces the degree of ownership concentration and increases the ratio of independent directors making the corporate governance structure "horizontal," hence improving the innovation performance of enterprises.

4.3.3. "Internet +" and corporate culture

The empirical results (Table 5) in columns (1) and (3) are based on the estimation of Eq. (5), while columns (2), (4), and (5) are obtained by Eq. (6). The results in column (1), show a statistically significant and positive relationship. It indicates that the internet helps enterprises form a more open corporate culture. The empirical investigation is further carried out by estimating the indirect impact of "Internet +" on innovation performance through the level of the corporate culture. The results in column (2) show that the internet development and corporate culture levels are significantly positive. This evidence is in-line with the findings Shahzad et al. (2017). The flexible organizational culture encourages employees to participate in decision-making with innovative ideas, which boosts innovation performance.

The relationship between "Internet +", corporate culture, and innovation performance is further confirmed (columns 3–4) using the corporate culture measured by the number of indicators. The empirical results in column (4) are statistically significant, and the positive signs of the coefficients indicate that open access to the internet creates open innovation culture, thus affecting enterprise innovation performance positively. These results are consistent with Dasgupta and Gupta (2019), who revealed that the acceptance and use of the internet affect an organization's culture. Next, we combined both mediating variables of corporate culture in a single model to find a more robust effect of "Internet +" on corporate culture and innovation performance. These findings confirm the results in columns (2) and (4). The results show that the "Internet +" helps promote an organizational culture, communication, and employees motivation (Jacobs et al., 2013; Shahzad, 2014), strengthening employee's bond with the organization (O'Reilly, 1989), creating minds necessary for the organization (De Long and Fahey, 2000). Consequently, corporate culture enhances the innovation performance of traditional organizations in China.

This paper considered that the path of "Internet +" affecting enterprise innovation performance is threefold. First, in the innovation process, the innovation elements of enterprises are thoroughly reorganized and utilized in the light of the characteristics of "Internet +," such as ubiquitous and sharing. Their transaction costs are reduced, and internal funds utilization has been improved. Second, the internet enabled enterprises to break the original "vertical" governance structure and establish a "horizontal" governance structure by reducing the share of large shareholders and increasing the independent directors' ratio. It implied that enterprises achieved a "horizontal" corporate governance structure, thus positively affected their innovation performance. Third, internet thinking enabled enterprises to establish a more open, equal, quick, and shared innovation culture that improved employees' communication and created the minds necessary for the organization. Therefore, the "Internet +" had a positive role in the innovation performance of traditional enterprises in China.

4.4. Testing for confidence intervals (CIs)

The validity of the indirect effect is further tested using an

Table 5
"Internet +," corporate culture and innovation performance.

Variables	(1)	(2)	(3)	(4)	(5)
	culture_dl	inve_num	culture_num	inve_num	inve_num
internet_dl	0.100***	0.125***	13.046***	0.126***	0.055***
	(6.33)	(20.59)	(8.85)	(20.55)	(8.69)
culture_dl		0.158***			0.082***
		(24.36)			(5.93)
culture_num				0.001***	0.001***
				(20.74)	(4.23)
Debt	−0.001	−0.024***	0.155	−0.024***	−0.010***
	(−0.71)	(−30.02)	(1.38)	(−29.64)	(−12.36)
Liquidity	0.011	−0.071***	2.184***	−0.068***	0.023***
	(1.57)	(−8.98)	(3.39)	(−8.65)	(3.30)
lnGoi	0.379***	0.606***	42.82***	0.634***	0.174***
	(14.33)	(39.26)	(17.37)	(41.44)	(10.44)
Nta	−0.579***	−2.561***	−34.789***	−2.510***	2.292***
	(−3.87)	(−31.67)	(−2.50)	(−31.05)	(70.39)
Constant	−7.013***		−776.370***		
	(−12.22)		(−14.51)		
Log-likelihood		−17,294		−17,375.00	−15,086.4
Wald chi2		7874.74		7735.04	11,778.43
Prob > chi2		0.0000		0.0000	0.0000
R-squared	0.099		0.146		
corr(u_i, Xb)	−0.6294		−0.6237		
Hausman Test	145.19	95.47	209.37	93.40	468.67
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	4296	4090	4296	4090	4090

Notes: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. In columns (1) and (3), the values in the parenthesis are t-values, while these values in columns (2), (4), and (5) are z-values.

increasingly popular testing method called bootstrapping. Among the many arguments in favor of using bias-corrected confidence intervals, researchers consider both the size and statistical significance of an effect. The interval's width provides a more nuanced picture of the range of possible outcomes. To test the significance of the indirect effect, we estimated our models for each mediating variable. In particular, we estimated our models with 5000 repetitions using the bootstrap method with the variance-covariance estimator (vce) option in STATA-15. The use of vce() is advantageous since it eliminates the need to explicitly provide the dataset's features and instead takes care of clustering and other model-specific factors when selecting random observations for the bootstrap.

The coefficients of the indirect effect obtained from each model are presented in Table 6. The bias-corrected CIs are obtained by utilizing Eqs. (7)–(8). While the bias-corrected and accelerated CIs are estimated using Eqs. (9)–(10). First, as one can see, zero does not lie in the confidence intervals for any of the indirect effects of all three hypotheses (Table 6). It indicates that the indirect effect is significantly different from zero. Second, signs of these coefficients justify our claim about the possible impact of "Internet +" through different mediators on the innovation performance of traditional enterprises in China. These confidence intervals provide additional proof of partial mediation.

Table 6
Bootstrap confidence intervals (95 %) for the indirect effect.

Indirect effect (a*b)	Coefficient (BSE)	z-Values	Bootstrap CIs (95 %)	
			BC	BCa
internet_dl*lnRdf	0.0099	2.19**	[0.0030,	[0.0029,
	(0.0045)		0.0213]	0.0205]
internet_dl*lnTI	0.0828	1.79*	[0.0123,	[0.0151,
	(0.0463)		0.1952]	0.2076]
internet_dl*Cr5	−0.0469	−1.79*	[−0.1014,	[−0.1193,
	(0.0262)		−0.0057]	−0.0163]
internet_dl*in_ratio	0.5505	1.87*	[0.1285,	[0.1518,
	(0.2941)		1.4450]	1.6105]
internet_dl*culture_num	0.0975	4.04***	[0.0505,	[0.0495,
	(0.0241)		0.1465]	0.1446]
internet_dl*culture_dl	0.1495	4.43***	[0.0846,	[0.0835,
	(0.0338)		0.2182]	0.2169]

Note: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. Values in the parentheses are the bootstrap standard error, while values in the square brackets are CIs.

4.5. Robustness tests

4.5.1. Robustness test for independent and dependent variables

To ensure the robustness of the empirical results Yang Deming (2018) and Wang and Qi (2021), we further adopted a dummy variable (internet_dm) for "Internet +". As the level of internet development is measured using the text mining method and may lead to the presence of subjective elements. Thus, we employed the internet dummy to clearly and intuitively observe the impact of the "Internet +" on enterprise innovation performance. Table 7 provides the models incorporating a dummy variable to measure the direct impact of "Internet +" on the innovation performance of the enterprises. In column (1), we have

Table 7
"Internet +" dummy variables and enterprises' innovation performance.

Variables	(1)	(2)	(3)	(4)
	inve_num	inve_num	inve_new	inve_new
internet_dm	0.352***	0.245***	0.221***	0.187***
	(40.41)	(26.60)	(14.34)	(11.76)
Debt		−0.027***		−0.003***
		(−33.70)		(−2.97)
Liquidity		−0.066***		−0.039***
		(−8.48)		(−5.03)
lnGoi		0.760***		0.155***
		(52.01)		(7.96)
Nta		−2.194***		−0.088
		(27.76)		(−0.77)
Log-likelihood	−20,601.96	−17,668.18	8428.79	−8340.30
Wald chi2	1632.62	7052.50	205.61	302.04
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Hausman Test	4.10	107.76	4.75	78.48
Prob > chi2	0.0428	0.0000	0.0293	0.0000
Observations	4093	4090	4093	4090

Notes: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. The z-values are shown in parenthesis.

selected the number of invention patents without control variables. In contrast, the results in column (2) are obtained in the presence of control variables. Moreover, the results provided in columns (1) and (2) are obtained by estimating Eq. (1). The empirical results show that the internet dummy is significantly positive, which is consistent with the results obtained in Table 2.

For the robustness of the dependent variable, we removed the outliers by winsorizing the number of patents at 5 % and treated it as an alternative dependent variable. We estimated Eq. (1) to find the direct impact of "Internet +" first without control variables and second with control variables. The results are provided in columns (3) and (4) of Table 7. It can be seen that the results are significant and unchanged, showing the robustness of the dependent variable.

4.5.2. Robustness test for the mediating effect of "Internet +"

To find whether the impact-mechanism of "Internet +" holds when we use the internet dummy. The study finds the relationship between our mediating variables after introducing a dummy variable to measure the impact of "Internet +." Specifically, to test the role of mediating variables, we utilized mediating effect model presented in Eq. (5), where the explanatory variable is the internet dummy. This relationship aims to confirm that the mechanism of "Internet +" is not respondent to only one type of internet variable. All the models in Table 8 have been estimated after controlling for the firm fixed effect and related control variables. Notably, in columns (1) and (2), we measured the impact of the internet dummy on R&D funds and technical personnel. The significance levels and positive signs provide evidence that incorporating the "Internet +" policy has expanded the R&D investment expenditure and increased the number of technical personnel. We next investigated the corporate governance structure represented by the shareholding ratio of the top five shareholders and the ratio of independent directors in the presence of an internet dummy. These results are shown in columns (3) and (4). The negative sign of the shareholding ratio of the top five shareholders provided in column (3) reveals a decreased ownership concentration. Unlike, the ratio of independent directors has increased. Our robust test results confirm our earlier findings of the models. Furthermore, we confirmed the robustness of our third hypothesis and provided the results in columns (5) and (6). The empirical results have not been changed even after changing our explanatory variable. This demonstrates that the "Internet +" policy does not rely on a single variable and verifies the impact-mechanism of "Internet +" to assess the organizations' innovation performance.

4.5.3. Robustness test results for the indirect effect of "Internet +"

We tested the indirect effect of the internet dummy by utilizing Eq. (6) to verify the path of "Internet +." We follow this step to confirm whether the mediating variables play a critical role in improving the innovation performance of the enterprises. Specifically, the study used two different mediating variables for each hypothesis developed. We first explored the impact of each mediating variable on the number of patents and presented the results in a separate column. Second, we explored the combined effect of these mediating variables on the number of patents. This analysis is performed to ensure that either one mediating variable has not derived the impact of "Internet +" of another mediating variable.

The results provided in columns (1) and (2) incorporate R&D funds and technical personnel, while column (3) used both of these mediating variables in a single model (Table 9). The results suggest that both R&D funds and technical personnel play a crucial role in the innovation performance of the selected enterprises. Combining these results with the results in (Table 8) suggests that the "Internet +" can effectively increase enterprise innovation performance by influencing innovation elements. The shareholding ratio of the top five shareholders and the ratio of the independent directors is tested and presented in columns (4) and (6). The ownership concentration falls while the independent directors on the board increase when the firm uses the "Internet +". If mediating variables are combined in a single model, no change in the significance level and coefficient signs are found. These findings suggest the robustness of the results and confirm the "horizontal" governance structure, which enhances innovation performance. Next, we estimated our model by considering the number and the level of the corporate culture. Columns (7) and (8) show the results of the models estimated with individual mediating variables, while column (9) provides the results of the combined model. One can observe from the table that both the mediating variables are statistically significant with a positive coefficient. It shows a positive role of corporate culture in the innovation performance of enterprises. These results suggest that the "Internet +" can affect enterprise innovation performance by influencing enterprise innovation elements, governance structure, and enterprise culture. The above empirical results further verify hypotheses 1–3 and ensure the robustness of the empirical results.

4.5.4. Robustness test for indirect effect (interaction-based regression)

Interaction-based regression is employed to further validate the robustness of the mechanisms. For this purpose, we added an interaction term in Eq. (6) to test three mechanisms. However, we kept the control variables unchanged. The estimated results are provided in Table 10.

Table 8
Robustness of mediating effect.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	lnRdf	lnTI	Cr5	in_ratio	culture_dl	culture_num
internet_dm	0.149***	0.053***	−1.744***	0.003**	0.142***	19.903***
	(6.75)	(3.60)	(−6.97)	(2.13)	(6.36)	(9.60)
Debt	−0.005***	0.004***	−0.014	0.000	−0.001	0.173
	(−4.38)	(4.47)	(−1.04)	(0.32)	(−0.60)	(1.54)
Liquidity	−0.011	−0.004	0.283***	−0.0004	0.011	2.151***
	(−1.63)	(−0.79)	(3.65)	(−1.07)	(1.54)	(3.34)
lnGoi	0.985***	0.486***	−4.280***	0.001	0.385***	43.184***
	(38.04)	27.97	(−14.54)	(0.35)	(14.66)	(17.70)
Nta	0.229	0.273**	−1.231***	0.011	−0.588***	−36.038**
	(1.53)	(2.74)	(−0.73)	(1.23)	(−3.93)	(−2.59)
Constant	−3.291***	−4.786***	150.898***	0.366***	−7.139***	−785.51***
	(−5.86)	(−12.70)	(23.61)	(85.18)	−12.53	(−14.83)
corr(u_i, Xb)	−0.3897	0.3136	−0.5084	0.0123	−0.6332	−0.6242
R-squared	0.5546	0.6425	0.1190	0.0046	0.0997	0.1501
Hausman Test	90.12	68.63	201.99	17.32	143.78	203.27
Prob>chi2	0.0000	0.0000	0.0000	0.0017	0.0000	0.0000
Observations	4207	4217	4296	4296	4296	4296

Notes: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. The t-values are shown in parenthesis.

Table 9
Robustness of indirect effect of "Internet +".

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Hypothesis-1			Hypothesis-2			Hypothesis-3		
	inve_num	inve_num	inve_num	inve_num	inve_num	inve_num	inve_num	inve_num	inve_num
internet_dm	0.085***	0.210***	0.062***	0.182***	0.264***	0.180***	0.174***	0.179***	0.017*
	(8.56)	(22.31)	(6.05)	(11.39)	(28.38)	(11.22)	(18.00)	(18.51)	(1.69)
lnRdf	0.292***		0.241***						
	(26.91)		(21.77)						
lnTI		0.717***	0.401***						
		(39.95)	(21.19)						
Cr5				−0.004***		−0.004***			
				(−3.61)		(−3.43)			
In_ratio					2.318***	0.599***			
					(21.37)	(3.40)			
culture_dl							0.164***		0.079***
							(25.25)		(5.71)
culture_num								0.001***	0.001***
								(18.51)	(5.59)
Debt	−0.010***	0.027***	−0.014***	−0.003**	−0.025***	−0.003***	−0.025***	−0.024***	−0.011***
	(−12.15)	(−32.73)	(−16.63)	(−2.84)	(−30.65)	(−2.72)	(−30.96)	(−30.33)	(−12.88)
Liquidity	−0.033***	−0.092***	−0.072***	−0.037***	−0.059***	−0.037***	−0.072***	−0.069***	0.023***
	(−4.55)	(−10.80)	(−8.78)	(−4.7)	(−7.67)	(−4.77)	(−9.11)	(−8.74)	(3.26)
lnGoi	0.252***	0.256***	−0.054***	0.147***	0.735***	0.138***	0.638***	0.664***	0.188***
	(13.01)	(14.95)	(−2.65)	(7.48)	(49.84)	(6.96)	(41.84)	(43.89)	(11.34)
Nta	−1.922***	−1.143***	−1.154***	−0.080	−2.051***	−0.090	−2.608***	−2.568***	2.327***
	(−23.47)	(−13.87)	(−13.67)	(−0.70)	(−25.88)	(−0.78)	(−32.24)	(−31.76)	(70.85)
Log-likelihood	−14,986.46	−15,254.31	−13,055.43	−8333.76	−17,441.75	−8328.01	−17,344.48	−17,414.56	−15,122.63
Wald chi2	4486	6698.76	3274.05	314.9	7416.53	32.66	7767.74	7645.92	11,711.46
Prob > chi2	0.0000	0.0000	0.0000	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
Hausman Test	144.40	136.27	150.25	91.92	84.82	97.21	95.07	96.79	111.42
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	4015	4016	3946	4090	4090	4090	4090	4090	4090

Note: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. The z-values are shown in parenthesis.

The results provided in columns (1) and (2) incorporate internet development level, internet dummy, and its interaction term with R&D funds. The coefficients of the interaction terms are significantly positive. It indicates that "Internet +" and R&D funds have a mutually reinforcing effect. In addition, enterprises with more R&D funds lead to higher innovation performance. Columns (3) and (4) show the results of the governance structure mechanism. The interaction terms are significantly negative, indicating that "Internet +" enhancement is stronger in a "horizontal" governance structure. The interaction terms for corporate culture mechanism shown in columns (5) and (6) are significantly positive. From these results, we can conclude that an open corporate culture can enhance the positive impact of "Internet+" on innovation performance. These results are consistent with the stepwise regressions, which further validate the robustness of the mechanisms and confirm the partial mediation.

4.6. Limitations of the study and future directions

The study has some limitations. First, the current study explored the relationship between "Internet+" and the enterprise innovation performance of traditional enterprises. However, the high-technology industries of China are not covered, which are expected to be more adaptive to the "Internet +" policy. Second, the data obtained through the text mining method is based on the selected keywords used in the annual reports. These results may be changed if different keywords are selected. The measurement method of "Internet +" at the enterprise level can be further explored. Third, the mechanisms used in the study are based on the internal perspectives of the enterprises. In fact, "Internet +" not only affects innovation directly from within the firm but may also have some externalities, such as facilitating knowledge spillovers among enterprises and enhancing enterprises' competition.

The study has explored some gaps in literature and areas to be covered by researchers in the future. First, innovation quality is one of the concerns in innovation performance, so the patents produced by these enterprises due to the implementation "Internet +" policy must also be tested for quality. Second, there is a need to explore traditional enterprises' financial performance in post and pre-scenarios of "Internet +".

5. Conclusion and policy implications

The concept of "Internet +" is proposed to solve the problem of traditional enterprises to transmute from resource-driven to innovation-driven development strategy. The findings of this study extend the existing literature with new content by providing a certain degree of innovation in using micro-level data, innovation performance, and impact-mechanism of "Internet +". The results show that "Internet +" significantly improves enterprise innovation performance. Based on the empirical evidence through the impact-mechanism of "Internet +," this paper draws the following conclusions.

The findings first revealed that the "Internet +" policy of the Chinese Government allowed companies to raise their R&D funds and boost their innovation performance. Technical personnel influenced enterprises' innovation by playing their initiative. Internet access enabled technical personnel to obtain more innovation-related information and collaborative R&D opportunities. Thus, it enhanced technological innovation ability and further improved enterprise innovation performance. Second, the corporate governance structure has been converted from "vertical" to "horizontal". The "horizontal" governance structure decreased the ownership concentration by reducing the largest shareholding ratio in the enterprises and by increasing the ratio of independent directors. As a result, the innovation performance of the selected enterprises is enhanced. Third, internet-enabled enterprises establish a more open and shared innovation culture. It improved communication among employees and helped enterprises to perform well in the innovation process. Therefore, the "Internet +" had a positive role in the innovation performance by employing the innovation elements, corporate governance structure, and corporate culture of traditional

Table 10
Interaction-based regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	inve_num	inve_num	inve_num	inve_num	inve_num	inve_num
internet_dl	−1.710***		0.338***		−0.029***	
	(−26.16)		(17.15)		(−2.92)	
internet_dm		−0.912***		0.916***		−0.085***
		(−9.09)		(26.07)		(−4.65)
internet_dl*lnRdf	0.085***					
	(27.53)					
internet_dm*lnRdf		0.047***				
		(9.99)				
internet_dl*Cr5			−0.003***			
			(−9.44)			
internet_dm*Cr5				−0.009***		
				(−19.40)		
internet_dl*culture_dl					0.105***	
					(20.20)	
internet_dm*culture_dl						0.181***
						(16.54)
lnRdf	0.284***	0.276***				
	(26.07)	(25.12)				
Cr5			0.018***	0.024***		
			(16.20)	(22.33)		
culture_dl					0.050***	0.061***
					(6.07)	(6.89)
Debt	−0.008***	−0.010***	−0.031***	−0.032***	−0.022***	−0.023***
	(−9.18)	(−11.39)	(−34.50)	(−35.76)	(−26.83)	(−29.03)
Liquidity	−0.041***	−0.037***	−0.111***	−0.116***	−0.068***	−0.070***
	(−5.51)	(−4.96)	(−10.76)	(−11.13)	(−8.71)	(−8.79)
lnGoi	0.163***	0.242***	0.835***	0.845***	0.545***	0.610***
	(8.20)	(12.48)	(49.89)	(51.53)	(34.82)	(39.88)
Nta	−1.699***	−1.918***	−2.295***	−2.346***	−2.304***	−2.455***
	(−20.91)	(−23.51)	(−26.59)	(−27.02)	(−28.28)	(−30.29)
Log-likelihood	−14,550.30	−14,936.63	−16,422.23	−16,255.62	−17,093.08	−17,208.24
Wald chi2	5309.07	4606.70	8400.97	8389.31	8554.38	8160.06
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
Hausman Test	505.53	100.34	80.74	126.56	82.51	77.92
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
Observations	4015	4015	3927	3927	4090	4090

Note: *, **, and *** indicate the significance at 10 %, 5 %, and 1 %. The z-values are shown in parenthesis.

enterprises in China.

The study puts forward some practical implications and insights: first, the government should increase the investment in ICT infrastructure by setting up special funds and providing technology assistance to modernize enterprises. Moreover, it should guide the internet transformation of traditional enterprises, accelerate their internet process, and promote the informatization of their production and management processes. This strategy can realize the function of the internet in enhancing enterprises' innovation performance. Second, all enterprises should incorporate "Internet +" into their development strategies and fully integrate with internet technology to expand the market scope and provide the impetus for innovation activities. Third, while implementing "Internet +", enterprises should also ensure the input of innovation elements and a reasonable ratio of different components. This can make full use of the advantages of a "horizontal" governance structure to develop innovation project management; link innovation culture with development ideals to inspire innovation in focused fields.

Funding

This study is partially funded by the National Natural Science Foundation of China under Project No. 71874138.

CRediT authorship contribution statement

Renai Jiang: Overall study supervision, conceptualization, data collection, and extraction. Muhammad **Saeed**: Data analysis, methodology, interpretation, write-up. Yang **Shenghao:** Data collection and extraction, Data Analysis, interpretation, write-up. Shahab E. **Saqib**: Refinement of the first draft of the manuscript, proof reading, write-up.

Declaration of competing interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

References

Aroian, L.A., 1947. The probability function of the product of two normally distributed variables. Ann. Math. Stat. 265–271 https://doi.org/10.1214/aoms/1177730442.
Asensio-López, D., Cabeza-García, L., González-Álvarez, N., 2019. Corporate governance and innovation: a theoretical review. Eur. J. Manag. Bus. Econ. 28 (3), 266–284. https://doi.org/10.1108/EJMBE-05-2018-0056.
Boutellier, R., Gassmann, O., Von Zedtwitz, M., 2013. Managing global innovation: Uncovering the secrets of future competitiveness. Springer, Berlin, Heidelberg.
Cameron, A.C., Trivedi, P.K., 1998. Regression Analysis of Count Data, 53. Cambridge University Press.
Cao, Y., Xiong, S.Y., Hu, H.L., 2016. A study of the relationship between intellectual capital and innovation performance based on the life cycle of enterprises. Sci. Res. Manag. (In Chinese) 37 (10), 69–78.
Chenxi, L., 2020. Research on the Internet transformation path of traditional enterprises in the "Internet +" era. Techn. Econ. Manag. Research 11 (2020), 56–60 (In Chinese).
CNIPA, 2021. Patents Data. Retrieved from: https://english.cnipa.gov.cn/col/col1324/index.html.
Conley, T.G., Udry, C.R., 2010. Learning about a new technology: pineapple in Ghana. Am. Econ. Rev. 100 (1), 35–69. https://doi.org/10.1257/aer.100.1.35.
Craig, C.C., 1936. On the frequency function of xy. Ann. Math. Stat. 7 (1), 1–15. https://doi.org/10.1214/aoms/1177732541.

Crémer, J., 1993. Corporate culture and shared knowledge. Ind. Corp. Chang. 2 (3), 351–386. https://doi.org/10.1093/icc/2.3.351.
Dasgupta, S., Gupta, B., 2019. Espoused organizational culture values as antecedents of internet technology adoption in an emerging economy. Inf. Manag. 56 (6), 103142 https://doi.org/10.1016/j.im.2019.01.004.
De Long, D.W., Fahey, L., 2000. Diagnosing cultural barriers to knowledge management. Acad. Manag. Perspect. 14 (4), 113–127. https://doi.org/10.5465/AME.2000.3979820.
Díaz-Roldán, C., Ramos-Herrera, M.d.C., 2021. Innovations and ICT: Do They Favour Economic Growth and Environmental Quality? Energies 14 (5), 1431.
Dichev, I.D., Graham, J.R., Harvey, C.R., Rajgopal, S., 2013. Earnings quality: evidence from the field. J. Account. Econ. 56 (2–3), 1–33. https://doi.org/10.1016/j.jacceco.2013.05.004.
Efron, B., Tibshirani, R., 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Stat. Sci. 1, 54–75.
Efron, B., Tibshirani, R.J., 1994. An Introduction to the Bootstrap. CRC Press.
Fama, E.F., 1980. Agency problems and the theory of the firm. J. Polit. Econ. 88 (2), 288–307. https://doi.org/10.1086/260866.
Fama, E.F., Jensen, M.C., 1983. Separation of ownership and control. J. Law Econ. 26 (2), 301–325. https://doi.org/10.1086/467037.
Feng, G., Wen, J., 2008. An empirical study on relationship between corporate governance and technical innovation of chinese listed companies. China Ind. Econ. (In Chinese) 7 (2008), 91–101.
Fritz, M.S., MacKinnon, D.P., 2007. Required sample size to detect the mediated effect. Psychol. Sci. 18 (3), 233–239. https://doi.org/10.1111/j.1467-9280.2007.01882.x.
Genfu, F., Jianshan, H., 2009 (In Chinese). In: Empirical Analysis on the Influence of Corporate Governance on the Growth Ability of Listed Companies in China Economic Management, 12, pp. 61–68 (2009).
Hartmann, A., 2006. The role of organizational culture in motivating innovative behaviour in construction firms. Constr. Innov. 6 (3), 159–172. https://doi.org/10.1108/14714170610710712.
Hill, C.W., Snell, S.A., 1989. Effects of ownership structure and control on corporate productivity. Acad. Manag. J. 32 (1), 25–46. https://doi.org/10.5465/256418.
Hsueh, L.-M., Tu, Y.-Y., 2004. Innovation and the operational performance of newly established small and medium enterprises in Taiwan. Small Bus. Econ. 23 (2), 99–113. https://doi.org/10.1023/B:SBEJ.0000027663.84972.ac.
Hu, X., Sun, X., 2019. Independent directors and Enterprise technology innovation. Am. J. Ind. Bus. Manag. 9 (10), 1915–1930. https://doi.org/10.4236/ajibm.2019.910125.
Jacobs, R., Mannion, R., Davies, H.T., Harrison, S., Konteh, F., Walshe, K., 2013. The relationship between organizational culture and performance in acute hospitals. Soc. Sci. Med. 76 (1), 115–125. https://doi.org/10.1016/j.socscimed.2012.10.014.
Jensen, M.C., Meckling, W.H., 1976. Theory of the firm: managerial behavior, agency costs and ownership structure. J. Financ. Econ. 3 (4), 305–360.
Jingxian, L., 2021. In: Research on Enterprise Economic Management Innovation Strategy Under the Background of "Internet +" Northern Economy (In Chinese), 1, pp. 131–133.
Ju Xiaosheng, L.D., Yihua, Yu., 2013. Financing constraints, working capital management and enterprise innovation sustainability. Econ. Res. (In Chinese) 48 (1), 4–16.
Kafouros, M.I., 2006. The impact of the Internet on R&D efficiency: theory and evidence. Technovation 26 (7), 827–835. https://doi.org/10.1016/j.technovation.2005.02.002.
Lau, C.M., Ngo, H.Y., 2004. The HR system, organizational culture, and product innovation. Int. Bus. Rev. 13 (6), 685–703. https://doi.org/10.1016/j.ibusrev.2004.08.001.
Li Wenjing, Z.M., 2016. Substantive innovation or strategic innovation? The impact of macro industrial policies on micro enterprise innovation. Economic research (4), 60–73 (In Chinese).
Li, Z., Li, X., Xie, A., 2020. Independent technical directors and their effect on corporate innovation in China. China J. Account. Res. 13 (2), 175–199. https://doi.org/10.1016/j.cjar.2020.06.001.
Li, X., Guo, Y., Hou, J., Liu, J., 2021. Human Capital Allocation and Enterprise Innovation Performance: An Example of China's Knowledge-Intensive Service Industry. Res. Int. Bus. Financ. 58 (12), 101429 https://doi.org/10.1016/j.ribaf.2021.101429.
Love, J.H., Mansury, M.A., 2007. External linkages, R&D and innovation performance in US business services. Ind. Innov. 14 (5), 477–496. https://doi.org/10.1080/13662710701711380.
MacKinnon, D.P., Lockwood, C.M., Williams, J., 2004. Confidence limits for the indirect effect: Distribution of the product and resampling methods. Multivar. Behav. Res. 39 (1), 99–128. https://doi.org/10.1207/s15327906mbr3901_4.
MacKinnon, D.P., Fritz, M.S., Williams, J., Lockwood, C.M., 2007. Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. Behav. Res. Methods 39 (3), 384–389. https://doi.org/10.3758/BF03193007.
McCabe, M., Nowak, M., 2008. The independent director on the board of company directors. Manag. Audit. J. 23 (6), 545–566. https://doi.org/10.1108/02686900810882101.
O'Reilly, C., 1989. Corporations, culture, and commitment: Motivation and social control in organizations. Calif. Manag. Rev. 31 (4), 9–25. https://doi.org/10.2307/41166580.
Paunov, C., Rollo, V., 2016. Has the internet fostered inclusive innovation in the developing world? World Dev. 78 (2), 587–609. https://doi.org/10.1016/j.worlddev.2015.10.029.
Reeson, A., Rudd, L., 2016. ICT activity, innovation and productivity: an analysis of data from Australian businesses. Econ. Pap. 35 (3), 245–255. https://doi.org/10.1111/1759-3441.12145.
Satistica, 2021. Penetration rate of internet users in China from December 2008 to December 2020. Retrieved from. https://www.statista.com/statistics/236963/penetration-rate-of-internet-users-in-china/ [Accessed: 20 January 2022].
Schein, E.H., 1990. Organizational culture. Am. Psychol. 45 (2), 109–119. https://doi.org/10.1037/0003-066X.45.2.109.
Schultz, T., 1961. Investment in human capital. Am. Econ. Rev. 51 (1), 1–17.
Shahzad, F., 2014. Impact of organizational culture on employees' job performance. Int. J. Commer. Manag. 24 (3), 219–227. https://doi.org/10.1108/IJCoMA-07-2012-0046.
Shahzad, F., Xiu, G., Shahbaz, M., 2017. Organizational culture and innovation performance in Pakistan's software industry. Technol. Soc. 51 (11), 66–73. https://doi.org/10.1016/j.techsoc.2017.08.002.
Shleifer, A., Vishny, R.W., 1986. Large shareholders and corporate control. J. Polit. Econ. 94 (3, Part 1), 461–488. https://doi.org/10.1086/261385.
Shleifer, A., Vishny, R.W., 1997. A survey of corporate governance. the. J. Financ. 52 (2), 737–783. https://doi.org/10.1111/j.1540-6261.1997.tb04820.x.
Sørensen, J.B., 2002. The strength of corporate culture and the reliability of firm performance. Adm. Sci. Q. 47 (1), 70–91. https://doi.org/10.2307/3094891.
Stone, C.A., Sobel, M.E., 1990. The robustness of estimates of total indirect effects in covariance structure models estimated by maximum. Psychometrika 55 (2), 337–352. https://doi.org/10.1007/BF02295291.
Su, Y., Xu, D., Phan, P.H., 2008. Principal-principal conflict in the governance of the Chinese public Corporation. Manag. Organ. Rev. 4 (1), 17–38. https://doi.org/10.1111/j.1740-8784.2007.00090.x.
Subramaniam, M., Youndt, M.A., 2005. The influence of intellectual capital on the types of innovative capabilities. Acad. Manag. J. 48 (3), 450–463. https://doi.org/10.5465/amj.2005.17407911.
Sun, J., Wang, B., Cao, F., Liu, X., 2016. Does corporate strategy affect earnings management? Management World 32 (3), 160–169. https://doi.org/10.1108/CFRI-06-2019-0083.
Tibshirani, R.J., Efron, B., 1993. An introduction to the bootstrap. Monogr. Statist. Appl. Probab. 57, 1–436.
Tong Zehua, J.Z., Xiaoting, Liu, 2019. In: The Characteristics of "Internet +" and the Impact of Enterprise Innovation Performance. Scientific and Technological Progress and Countermeasures, 21, pp. 125–133 (In Chinese).
Tong, T.W., He, W., He, Z.-L., Lu, J., 2014. Patent regime shift and firm innovation: evidence from the second amendment to China's patent law. Sci. Technol. Prog. Countermeasures 1, 14147–14177. https://doi.org/10.5465/ambpp.2014.14174abstract.
Tylecote, A., Visintin, F., 2007. Corporate Governance, Finance and the Technological Advantage of Nations. Routledge.
Wang Jinjie, G.S., Longpeng, Zhang, 2018. The impact of the internet on enterprise innovation performance and its mechanism: an explanation based on open innovation. Nankai Econ. Res. 6, 170–190 (In Chinese).
Wang, Y., Kan, S., 2014. Corporate culture and M&A performance. Management World 11, 146–163 (In Chinese).
Wang, Z., Qi, Z., 2021. Analysis of the influences of ICTs on enterprise innovation performance in China. Manag. Decis. Econ. 42 (2), 474–478. https://doi.org/10.1002/mde.3247.
Wang, Z., Chen, C., Guo, B., Yu, Z., Zhou, X., 2016. Internet plus in China. IT Prof. 18 (3), 5–8. https://doi.org/10.1109/MITP.2016.47.
Wei Xuhua, L.Y., Liuqing, Yue, 2015. The influence of power inequality of top management team on enterprise innovation intensity: moderating mediating effect. Nankai Manag. Review 3, 24–-33 (In Chinese).
Wind Information, 2021. Wind Economic Database. Retrieved from: https://www.wind.com.cn/en/edb.html.
Xie, X., Zeng, S., Peng, Y., Tam, C., 2013. What affects the innovation performance of small and medium-sized enterprises in China? Innovation 15 (3), 271–286. https://doi.org/10.5172/impp.2013.15.3.271.
Yang Deming, L.M., 2017. Will Internet business model affect audit fees of listed companies. Audit Res. 6, 84–90 (In Chinese).
Yang Deming, L.Y., 2018. In: Why Does "Internet +" Add Performance China's Industrial Economy (In Chinese), 5, pp. 80–98.
Yang, D., Shi, Y., 2018. Will the internal control affect the strategic behavior of enterprises? Research based on the internet business model. Account. Res. 2, 69–75 (In Chinese).
Yong, Y., Qingli, D., Qin, Z., 2007. An empirical study of the impact of corporate governance on investment expenditure in technological innovation. Science of Science and Management of S. & T 11, 61–65 (In Chinese).
Zhang Min, Z.Y., 2014. Research on the relationship between cultural embeddedness, contractual governance and enterprise innovation behavior: Empirical Test from Wenzhou private enterprises. Sci. Sci. Research 3, 445–463 (In Chinese).
Zhuning, G., 2021. In: Research on the Value of Big Data Technology in Enterprise Economic Innovation in the "Internet +" Era China Management Informatization (In Chinese), 1, pp. 80–82.

Renai Jiang is an Associate Professor of Economics at the School of Economics and Finance, Xi'an Jiaotong University. His research focuses on technology innovation, economic growth, and the impact of ICT on technology progress. Renai also collaborates with the Chinese Academy of Science and Technology Development, assessing the patenting and innovation contribution of China's research institutes.

Muhammad Saeed is a Ph.D. Candidate at the School of Economics and Finance, Xi'an Jiaotong University, China. His research focuses on Internet development, ICT, technological progress, firm performance, and economic growth.

Shenghao Yang is a Ph.D. candidate at the School of Economics and Finance, Xi'an Jiaotong University. His research focuses on Internet development, technological progress, and economic growth. Yang's research also extends to evaluating the patent quality in China.

Shahab E. Saqib is an Assistant Professor of Economics at the Directorate of Commerce Education and Management Sciences, Higher Education Department Khyber Pakhtunkhwa, Peshawar, Khyber Pakhtunkhwa, Pakistan. His research areas are Sustainable Entrepreneurship and Management & Innovation.