

Retraction

Retracted: Research on the Evaluation and Optimization of Innovation Ability of Private Enterprises Based on DEA Model

Security and Communication Networks

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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- [1] F. Li, "Research on the Evaluation and Optimization of Innovation Ability of Private Enterprises Based on DEA Model," *Security and Communication Networks*, vol. 2022, Article ID 1239890, 7 pages, 2022.

Research Article

Research on the Evaluation and Optimization of Innovation Ability of Private Enterprises Based on DEA Model

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As private businesses are an integral part of China's market economy, it is essential to foster their expansion in a positive manner. Even though some private enterprises have made significant strides in their ability to innovate independently, the majority of them have not yet established an effective endogenous mechanism of independent innovation, and their independent innovation capability and level are insufficient to meet the requirements of economic and social development in the new era. Therefore, it is essential to evaluate the innovation capacity of private businesses. Therefore, the first section of this paper examines the research on measuring enterprise productivity. Second, this paper employs a combination of endogenous dynamics to develop an endogenous dynamics mechanism that encourages innovation in private companies. In addition to employing the DEA model, this paper proposes an evaluation optimization mechanism for assessing the innovation capability of private enterprises in a Chinese province from 2015 to 2021. It concludes that the innovation capability of private enterprises in this province is generally low and that factors such as the number of technical employees, the R&D investment funds of private enterprises, and the number of granted patents have a significant impact.

1. Introduction

After more than four decades since the start of China's reform and opening up, the country's private economy has grown tremendously in size and strength, going from nothing to large, from being weak to strong, and from being domestic to international. Despite the fact that China's reform and opening up began over 40 years ago, this growth has occurred. As a result, it has become a significant contributor to the expansion of both the economy and society. As a result, the private sector of China's market economy currently possesses the most vitality, potential, and innovation [1–3], it serves as a strong pillar for the prosperity of urban economies. The actions of private businesses are beneficial not only to those looking for jobs but also to those in charge of collecting taxes and to overall economic expansion. Particularly as a new era begins for the economy of China, private businesses are emerging as an important engine of economic growth. More than sixty percent of the GDP and eighty percent of urban employment is

contributed by private businesses. More than seventy percent of rural migrant workers are employed by them, and ninety percent of newly created jobs are in the private sector, whereas only fifty percent of jobs are created in the public sector [4–7].

My country's economy has expanded rapidly despite the introduction of advanced science and technology as well as scientific management expertise from other nations. There are, however, a few issues that must be resolved for the economy to continue expanding at its current rate. The commercial sector of China is experiencing a phenomenon known as technology hollowing out, which is caused by a lack of either core technology or own technology. The manufacturing sector, which is positioned at the base of the global industrial and value chain, continues to rely heavily on imports [8, 9]. Due to the fierce competition on the global market, the lack of independent innovation, and the over-draft of natural resources, Chinese companies will be at a growing disadvantage in international trade in the years to come. How to transform China from a manufacturing

superpower into an innovation superpower is one of the most significant challenges facing businesses in the new era. The capacity to pursue self-directed innovation has emerged as the single most important determinant of the success or failure of the vast majority of small and medium-sized businesses [10, 11].

The primary focus of current research in this field is on analyzing and contrasting the levels of productivity achieved by businesses that are either privately or publicly owned. Some researchers claim that the overall level of technical efficiency of private businesses in China is quite low, despite the fact that this trend has been rising steadily over the past few years and is currently in the stage of increasing scale [12–14]. The DEA approach Before the year 2003, it was discovered that the production efficiency of state-owned businesses was lower than that of other businesses owned by the state [15, 16]. However, after that year, there was no discernible difference between the production efficiency of state-owned businesses and that of the economy as a whole, which was not owned by the state. According to research that was carried out using the DEA method, there is no difference between state-owned and privately listed companies in terms of technical efficiency or scale efficiency; however, when looking at data from 2002 to 2009, state-owned businesses have a higher pure technical efficiency than privately listed businesses. After 2007, state-owned industrial enterprises reportedly have a higher capital production efficiency and labor production efficiency than nonstate-owned industrial enterprises [17–19], but their overall performance is superior to that of nonstate-owned industrial enterprises. This conclusion was reached after applying the DEA method to research conducted between the years 2000 and 2013 on the effectiveness of state-owned industrial enterprises. In enterprises that are owned by the government, it has been discovered that when environmental factors and the interference of random error are taken out of the equation, the average comprehensive efficiency of privately held businesses is found to be higher than that of publicly held businesses on average [20, 21]. Using the DEA method, a number of researchers have investigated the production practices of state-owned and private companies operating in strategically important emerging industries. The empirical evidence demonstrates that state-owned companies have a slightly higher scale efficiency than private companies, while private companies have a slightly higher overall technical efficiency than state-owned companies [22]. Private companies also have a higher overall efficiency than state-owned companies [21]. When considering overall efficiency, the effect of external factors is relatively minor. Using the DEA method in three stages to examine the efficacy of technological innovation in these companies, researchers determined that the overall technological efficacy of Chinese publicly traded companies is poor. He reached this conclusion after discovering that technological innovation in these companies was inefficient. The vast majority of academics have not studied the production efficiency of privately-owned businesses in specific regions when comparing the production efficiency of state-owned and privately-owned businesses [23–26].

The purpose of this paper is to encourage innovation in the private sector through the application of endogenous power and an endogenous power mechanism. This paper proposes an evaluation and optimization mechanism for analyzing the production efficiency of private firms in a resource-rich province of China from 2015 to 2021 using the DEA model, which has been further integrated with Tobit.

2. Endogenous Dynamics

2.1. Necessity. Private industry innovation manifests itself not only through financial investments in new technologies and products, but also through new management practices, expanded business horizons, and philosophical approaches to business. Entrepreneurship is the most dynamic aspect of the economy, and private businesses play a crucial role in fostering high-quality economic expansion. They are adaptable to alterations in institutional structure and technological advancement. This capability is what drives the internal expansion of the private economy.

In order to make progress in the realm of private enterprise, independent innovation is required. It is necessary to have a private sector that operates independently of the public sector for both economic and social development. As a result of the onset of the global new crown pneumonia epidemic at the start of the year 2020, numerous innovative policies have been implemented to aid small and medium-sized enterprises (SMEs). Since the introduction of big data and artificial intelligence, there has been a significant shift in how our entire society conducts economic operations, and innovation has emerged as the driving force behind both economic and social growth.

Private enterprises, which account for the vast majority of China's businesses, play a crucial role in the country's economic development because they promote technological advancement and independent innovation while also enhancing the fundamental competitiveness of businesses. This is one of the reasons why private enterprises dominate China's business sector. Both China's current innovative capacity and its long-term ambition to become a nation renowned for innovation are of the utmost importance. Implementing an independent innovation strategy is also indispensable for the long-term success of private businesses.

Second, the ability to independently come up with new concepts is required for the expansion of private businesses, otherwise, it is impossible. The increasingly globalized and networked nature of today's economic development is contributing to an increase in the level of competition that private companies face in the market. The inability or unwillingness of private companies to innovate at sufficiently high levels is becoming an increasingly significant barrier to the competitiveness of these companies. If Chinese private companies want to thrive in today's rapidly changing technological and economic environments, they need to be more innovative and creative than their competitors. The only way for private companies to prevail in a competitive environment is for them to consistently prioritize innovation. Innovation within private businesses is an efficient

strategy for developing internationally competitive businesses. My nation’s economy currently relies heavily on private companies as its primary source of innovation, and it is imperative that this trend continues. In addition, independent innovation can assist in my nation’s overall scientific and technological innovation by hastening the expansion of private businesses in response to increased economic competition.

In today’s uncertain economy, private businesses face a number of obstacles, such as a difficult external environment, weak external demand, weak domestic growth, and a difficult to transform and modernize the industrial structure. These factors all contribute to a difficult external environment. There will be restrictions on the growth of private companies. In recent years, countries across the globe, particularly developed nations, have accelerated the rate at which they are adapting to new circumstances and transforming themselves as a result of the ongoing economic recession and other factors. If nations are able to pursue green, intelligent, and sustainable development, they will be able to emerge from the current economic crisis, revive their growth rates, and refocus their efforts on the creation of cutting-edge technologies. Competition for the highest technological and industrial development levels. As a direct result, there is no reason for privately-owned companies to pursue innovative concepts. In this new era of big data and artificial intelligence, competition places a greater emphasis on the ability to acquire and apply knowledge as opposed to the ability to acquire and apply knowledge. Due to the unpredictability and instability of the global environment, privately held businesses in my country have discovered that self-initiated innovation has become a vital survival strategy. The core competitiveness of a private economy can be enhanced by endogenous power originating from within the private sector.

The hierarchy of necessity is shown in Figure 1.

2.2. Build Path. A connotative expansion that is propelled by novel concepts is necessary for high-quality development. Create an innovation system that closely integrates science and technology, education, and industry. Expand the role that businesses play in the process of technological innovation. Make businesses a new force in the integration of innovative elements and the transformation of technological advancements. It is imperative and urgent to construct an endogenous power mechanism for the independent innovation of private enterprises in the new era. This is imperative and urgent because the innovation subject of private enterprises is an important part of China’s economic development.

The first step is to instill a culture of innovation within the organization itself while simultaneously emphasizing the significance of increasing the rate of scientific and technological advancement. When it comes to the success of a business, the owners and managers of that business need to understand the significance of technological innovation and do what they can to bring more attention to it. In order for businesses to be able to pursue independent innovation as a

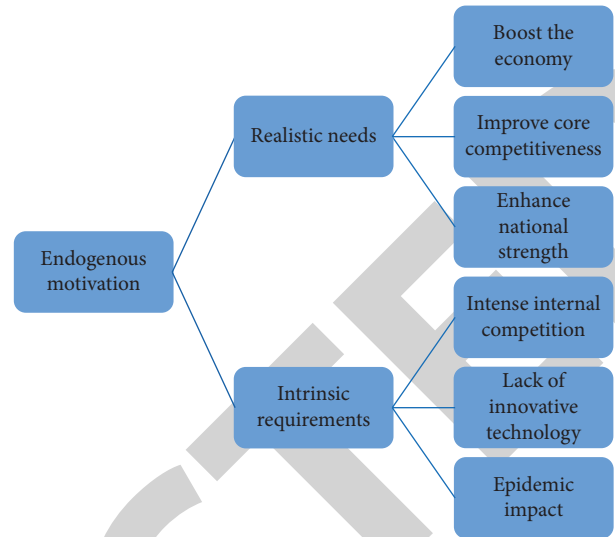


FIGURE 1: Necessity diagram for building endogenous motivation mechanism.

strategic foundation for growth, they need to have their own proprietary core technology. A scientific and technological innovation system is established that is adapted to the regional characteristics of the company, with the goal of concentrating on the most important aspects while also making an effort to overcome any technical challenges.

It is also essential to improve training for private entrepreneurs so that their businesses can become sustainable and institutionalized in the long run. The department of human resources ought to devise training and implementation guidelines for proprietors of small businesses, in addition to establishing specialized files. The training is designed to improve ‘participants’ innovative thinking as well as their capacity to manage new technologies. Some of the primary topics that will be covered in the training include enterprise management, enterprise planning, and scientific and technological development. Independent innovation forums should be held in order to make it easier for business owners to communicate and share their ideas with one another. In order for business owners to improve their innovation awareness and enrich their innovation wisdom and methods, it is possible to organize them to conduct research and surveys at well-known innovation centers, advanced businesses, and R&D institutions in the country.

The third step involves establishing a framework that offers entrepreneurs incentives, oversight, and constraints. Independent private enterprise innovation is characterized by substantial financial commitments, lengthy iterations, and a high risk profile. In order to encourage a healthy increase in the number of entrepreneurs, it is necessary to establish a new mechanism that provides incentives, competition, and oversight to encourage entrepreneurs to emerge rapidly. To encourage a healthy increase in the number of entrepreneurs, this is necessary.

On the other hand, it is imperative to enhance the current incentives available to business owners. It is impossible to overstate the importance of ‘entrepreneurs’ work in terms of the financial and social benefits they bring to the

communities in which they reside and the businesses they work for. However, it is a significant issue that the income and returns of entrepreneurs are not comparable or proportional to the labor they produce, the risks they assume, and the financial and social wealth they create for society at this time. This is an issue that requires immediate attention. As a result, the zeal and originality of entrepreneurs are dampened, which hinders the business's healthy expansion. In order to succeed in the competition for the most qualified candidates, it is necessary to develop an incentive system that provides both monetary compensation and a sense of purpose. The system of providing an annual salary is the most practical method for monetary incentives. The 'managers' tendency to engage in entrepreneurial behavior is restrained by the fact that they are constantly reminded of the importance of their own business results. In addition, it serves as a systemic guarantee for the returns associated with intellectual capital. In addition to satisfying their own spiritual needs, the provision of social honor and social status as part of an incentive system for spiritual development can help business owners feel a sense of purpose and accomplishment in the successful operation of their companies.

Entrepreneurs should have decision-making, command, and management authority in both production and operation. Alternatively, measures should be implemented to monitor and control entrepreneurs. If they lose effective oversight and constraints, they may abuse their power, deviate from the original intent of enterprise development, and even disrupt the normal and orderly operation and growth of businesses. If they lose effective oversight and restrictions, they may also disrupt the orderly operation and growth of businesses. Controlling and restricting the actions of business owners is necessary, necessitating the establishment of a system similar to those listed as follows: to begin with, the law imposes restrictions. There are numerous laws in our country that are used to restrict the behavior of managers, and managers should not deviate from the permitted range. The second issue is one that restricts the market's natural competition mechanisms. The market success of a manager's company's products is used to evaluate that manager's abilities, and that manager's position is filled through the use of the talent market, which increases the competitive pressure on the manager's employees to achieve high levels of performance. In conclusion, the corporate governance structure must be monitored and checked for errors. The board of directors and each operator's own supervisory board are responsible for appointing and monitoring the operators. Directors should closely monitor and evaluate the operator's business performance, as well as ensure that the operator's decision-making authority does not exceed the scope of authority granted to the operator by board decisions.

3. Method and Indicator Selection

Charnes et al. introduced the DEA model in 1978. Multi-input and multioutput departments can be evaluated using models such as the CCR and BCC. Input-oriented BCC is the model of choice in this paper.

The formula for BCC is expressed as follows:

$$\begin{aligned} \min & \left[\theta - \varepsilon \left(\sum_{j=1}^m I + O \right) \right], I \geq 0, O \geq 0, \\ \text{s.t.} & \sum_{j=1}^n x_j \lambda_j + I = \theta x_0, \\ & \sum_{j=1}^n t_j \lambda_j + O = y_0, \\ \text{s.t.} & \sum_{j=1}^n \lambda_j = 1, \lambda_j \geq 0, \end{aligned} \quad (1)$$

where $Y_j = (y_{1j}, \dots, y_{nj})^T$ and are input and output vectors of the j th decision-making unit (DMU), ε is an infinitesimal quantity, I is the input variable, O is the output variable, and θ is the efficiency value of the evaluation unit.

The overall efficiency (OE) is calculated as follows:

$$OE = PTE * SE, \quad (2)$$

where PTE is pure technical efficiency, SE is scale efficiency.

The efficiency value of a decision-making unit cannot accurately reflect both production efficiency and external environmental factors when using the DEA method to conduct the analysis. According to the author of this study, the two-stage DEA method measures the efficiency value's influencing factors. The DEA method is a two-step procedure for determining the factors that influence the efficiency value. Typically, the Tobit model, which is a model with a limited dependent variable, is used to evaluate efficiency values between 0 and 1. Because the results of regression could be skewed if the method of ordinary least squares is used, which is not the case here, the Tobit model for regression is used instead.

$$\begin{cases} Y = a + bX + \varepsilon, & Y > 0, \\ Y = 0, & Y \leq 0. \end{cases} \quad (3)$$

This paper incorporates the Malmquist production efficiency index into the research that investigates the dynamic changes of private enterprises in a specific province in China between the years 2015 and 2021. The goal of this research is to gain a deeper understanding of the dynamic changes that occur in the production efficiency of enterprises. The following is an expression of it:

$$M = \left(\frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)} \right)^2, \quad (4)$$

where $D_0^{t+1}(x_t, y_t)$ is the throwing distance function at time t .

M can also be decomposed as follows:

$$M = SE \times TE \times PE, \quad (5)$$

where TE stands for technical level, and PE stands for pure technical efficiency. The specific calculation method is as follows:

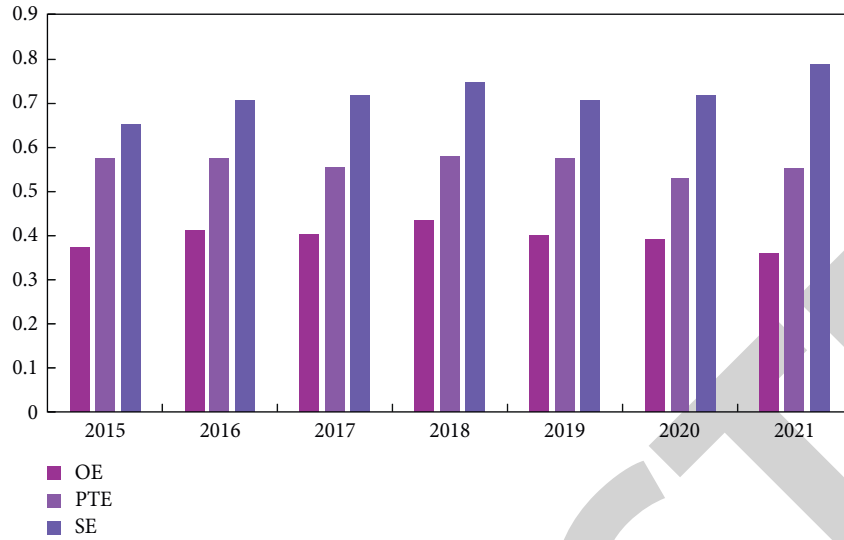


FIGURE 2: Comparison chart of static efficiency of 100 companies in different years.

$$M = \frac{s_0^t(x_t, y_t)}{s_0^t(x_{t+1}, y_{t+1})} \times \frac{D_0^t(x_t, y_t)}{D_0^t(x_t, y_t)} \times \frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \quad (6)$$

Based on the basic principles of the DEA model for the selection of input and output variable indicators, combined with the existing results of domestic and foreign research on the innovation and entrepreneurship efficiency of listed companies, and the availability of input-output indicators, this paper selects three basic input variables: technology number of employees (person), private enterprise R&D investment (10,000 Yuan), and patent authorization (10,0). 2015 to 2021 is the time period covered by the data, which pertains to 100 listed private enterprises in a specific Chinese province. Since different years have varying degrees of missing data, this paper eliminates all samples with missing data.

Figure 2 displays the static efficiency of the 100 companies selected for this study.

From 2015 to 2021, the average OE for private companies in the region is 0.40, the average PTE is 0.57, and the average SE is 0.72. The overall OE of these businesses is relatively low, and there is still considerable room for improvement in PTE and SE. OE exhibited a rising and then falling trend, PTE exhibited no discernible trend, fluctuating around 0.55, and SE exhibited a rising and then falling trend. In particular, the OE of private enterprises in the region peaked in 2018 with a value of 0.435%, followed by 2016 with a value of 0.415%. The year with the lowest OE was 2021, with a value as low as 0.363, which was closely associated with the emergence of the new crown epidemic. The PTE of private enterprises in the region reached its highest point in 2018 at 0.581%, and its lowest point in 2020 at 0.532%. From 2015 to 2019, the PTE of the region’s private businesses changed little, fluctuating around 0.57. The SE of private companies in the region will peak in 2021 and fall to its lowest point in 2015.

4. Empirical Analysis

Table 1 and Figure 3 illustrate the innovation capabilities of 100 private companies in the province from 2015 to 2021.

TABLE 1: Dynamic innovation capabilities from 2015 to 2021.

Year	CR	TE	PE	SE
2015	1.12	0.89	1.01	1.12
2016	0.99	0.96	0.96	1.04
2017	1.07	0.96	1	1.03
2018	0.83	1.06	1.02	0.93
2019	1.01	1.27	1.12	0.91
2020	1.26	1.31	1.03	1.13
2021	0.95	1.26	0.79	1.09
Mean	0.99	1.10	0.97	1.04

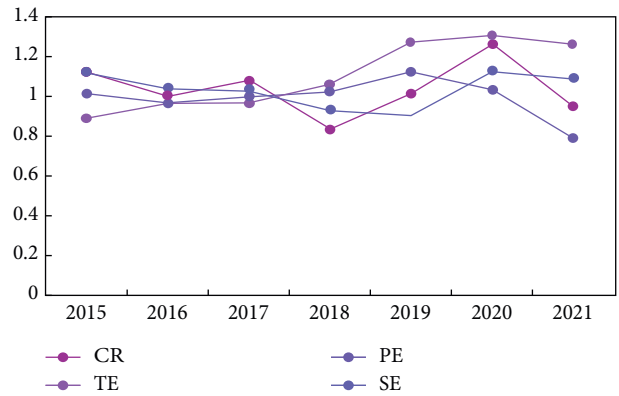


FIGURE 3: Dynamic innovation capabilities from 2015 to 2021.

Innovation capability is one of them. The average innovation capability of selected private companies from 2015 to 2021 is 0.99, exhibiting an upward trend of first increasing, then decreasing, and peaking in 2020. The innovation capability value is 1.26 at present, and CR in 2021, the current value of 0.95 is less than the seven-year average of 0.99. The TE value exhibits a gradual upward trend, increasing from 0.89 in 2015 to 1.31 in 2020, with values below 1 in 2015, 2016, and 2017. In the other four years, the TE values were all greater than 1. The difference between the average TE value from

2018 to 2021 and the average TE value from 2015 to 2017 is 0.28. The PE exhibited a fluctuating trend with no discernible rise or fall. SE exhibited a decreasing and then increasing trend. The highest value was 1.13, which was close to 1.12 in 2015, the lowest value was 0.91, and the mean value was 1.04. Among them, the SE for the three years from 2017 to 2019 was below average, while the other two were above average. Each of the four years had above-average SE.

Number of technical employees, R&D investment funds of private enterprises, number of patent authorizations.

In order to further study the influencing factors of the innovation ability of private enterprises, the innovation value obtained by the first stage DEA was used as the dependent variable, the factors affecting the efficiency were used as the independent variables, and a Tobit model was constructed to comprehensively evaluate the innovation ability of private enterprises.

Hypothesis 1. The lower the number of technical employees, the stronger the innovation ability.

The number of technical employees is used to measure the innovation ability of private enterprises. The number of technical employees reflects whether it is actually a technology-based company. Possibly survive the tough competition. The output of innovative achievements will also help enterprises to reduce production costs, enhance the value of commodities, and strengthen the company's competitiveness. Therefore, it is expected that the lower the number of technical employees, the better the innovation ability of enterprises.

Hypothesis 2. The lower the R&D investment, the stronger the innovation ability.

Whether an enterprise can produce innovative results is closely related to the investment of R&D funds. Therefore, it is expected that the higher the investment, the stronger the innovation ability.

Hypothesis 3. The less the number of patents authorized, the stronger the innovation ability of the enterprise.

The number of patents granted reflects the output of enterprises in terms of innovation, so it is expected that the less the number of patents granted, the stronger the innovation capability of the company.

In this paper, NTE represents the number of technical employees, R&D represents R&D investment, and NPA represents the number of patents granted. The regression results of the model are shown in Table 2.

The P -values are all less than 0.05, so we reject all three hypotheses. It is believed that the greater a company's NTE, R&D, and NTA, the greater its innovation capability.

In addition, we classify the locations of the 100 selected companies, which facilitates the examination of regional disparities. We divide the region into the provincial capital center and the remainder of the province. Figure 4 illustrates the comparative outcomes.

It can be observed that the TE, PTE, and SE of private enterprises in the central area are all relatively high, which correlates with the movement of people. There are a greater number of scientific and technological institutions, such as

TABLE 2: Results of regression.

Explanatory variables	Coefficient	P value
NTE	0.24	0.00023
R&D	0.05	0.00015
NPA	0.03	0.00018

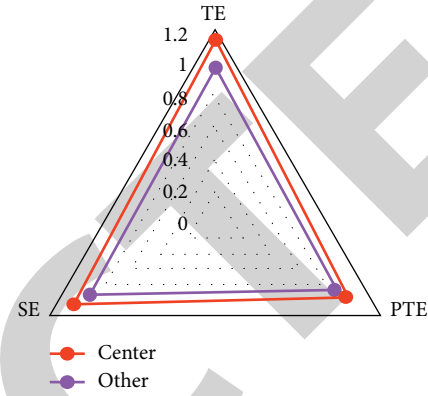


FIGURE 4: Comparison results of different regions.

patents, in the provincial capital center, where technical talent tends to work. Declaration of enterprise patents, projects, etc.

5. Conclusion

Because private companies play such a crucial role in China's market economy, it is crucial to encourage their healthy growth. Even though some private companies have made substantial strides in their ability to innovate independently, the majority of these companies have not yet developed an effective endogenous mechanism of independent innovation. Consequently, their innovation capability and level are insufficient to meet the needs of economic and social development in the new era. It is essential, therefore, to evaluate the level of innovative capacity possessed by private businesses. In the first section of this paper, we will examine the research that has been conducted on measuring business productivity. Second, this article employs a variety of endogenous dynamics to develop an endogenous dynamics mechanism that encourages private companies to be more innovative. In addition to employing the DEA model, this paper proposes an evaluation optimization mechanism for analyzing the innovation capability of private businesses located in a Chinese province between 2015 and 2021. Several factors, including the number of technical employees, the amount of R&D investment funds provided by private businesses, and the number of patents granted, have a significant impact on the innovation capability of private businesses in this province, according to the findings of this study.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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