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Evaluation of Technological Innovation Efficiency and Influencing Factors of Biomedical Enterprises in Guangdong Province-Based on DEA-Malmquist-Tobit Method

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Abstract. In the 21st century, biomedical enterprises are the core force to promote medical technology innovation and meet public health challenges. As a major economic province in China, Guangdong Province is also the leading province in the development of biomedical enterprises in China. For biomedical enterprises, technological innovation ability and efficiency are the key to obtain competitive advantage. Based on this situation, this paper takes Guangdong Province as the main research object to carry out the evaluation research on the technological innovation ability efficiency of biomedical enterprises, which can provide ideas and suggestions for the development and innovation of biomedical enterprises in China. This study takes 30 biopharmaceutical listed enterprises in Guangdong Province as the research object, and takes intangible asset financing capability as the core explanatory variable to analyze the influencing factors of technological innovation efficiency of biopharmaceutical enterprises. In this paper, DEA-BCC model is used to analyze static efficiency, Malmquist index model is used to analyze dynamic efficiency, and Tobit regression model is used to analyze influencing factors. The following findings were made in this study: DEA-BCC model analysis shows that the overall level of comprehensive technical efficiency of 30 selected enterprises is low; Malmquist index model analysis shows that the total factor productivity of 30 selected enterprises present a high level; Tobit regression model analysis shows that intangible asset financing capability, government R & D subsidies, employee quality and enterprise operation ability have positive promotion effects on innovation efficiency, and solvency fails to pass the test.

Keywords: Biomedicine, Technological innovation efficiency, DEA-BCC model, Malmquist index model, Tobit regression model.

1. Introduction

As an important component of strategic emerging industries, biomedical enterprises have developed innovative drugs and vaccines that provide key support for the precise treatment of major diseases and human health. The biomedical enterprises in Guangdong Province occupy a prominent position in China with leading industrial scale and outstanding innovation ability, and have become the benchmark province for the high-quality development of biological medicine in China.

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As a leading area and agglomeration area for the development of biomedical industry in China, Guangdong Province is in a leading position in terms of technological innovation ability, industrial chain layout and policy support. In recent years, Guangdong has significantly improved the innovation efficiency and industrialization level of biomedical enterprises by optimizing the review and approval mechanism, building major scientific and technological infrastructure and promoting the in-depth integration of production, learning and research. Data for 2024 shows. The approved number of innovative drugs and devices in Guangdong was 19 innovative drugs and 14 innovative medical devices, with significant year-on-year growth. There were 684 pharmaceutical manufacturing enterprises and 5052 medical device manufacturing enterprises, ranking first in China, forming a biomedical industry cluster with Guangzhou and Shenzhen as the core. However, compared with developed regions such as Yangtze River Delta, Guangdong still faces problems such as fewer leading enterprises, insufficient original innovation ability, and further improvement of innovative drug R & D support system. Under this background, systematically evaluating the efficiency of technological innovation ability of biomedical enterprises in Guangdong Province, analyzing its influencing factors are not only helpful to optimize regional resource allocation, enhance industrial competitiveness, but also provide replicable experience for the high-quality development of national biomedical industry.

2. Literature review

Technological innovation is the focus of business management in biomedical enterprises. Hou Pengbo and Ma Zhanxin [1] constructed an average-type efficiency measurement method to correct the traditional DEA efficiency overestimation, and measured and evaluated the innovation efficiency and convergence trend of biomedical enterprises. Dai Hongbin et al. [2] conducted targeted thinking from the perspectives of government and enterprises, and offered suggestions for the international development of biomedical enterprises in China and the export of innovative drugs. Yin Jie et al. [3] found that innovation investment positively affected knowledge spillover of biomedical enterprises through research on 345 listed companies in China, and put forward corresponding policy suggestions for promoting biomedical enterprises to increase innovation investment and enhance knowledge spillover effect from two levels of enterprises and governments.

There are few researches on efficiency evaluation of biomedical enterprises in existing literature. Now we look for research ideas from other aspects. Dong Chunyu et al [4] conducted empirical analysis through DEA, Malmquist and Tobit to analyze and study the technological innovation efficiency of listed companies related to agriculture in the Yangtze River Basin of China. Hou Xindi [5] studied the technological innovation efficiency of industrial enterprises in Anhui Province through BCC and DEA. Tian Yuexin et al. [6] proved the positive impact of R & D expenditure on enterprise science and technology innovation by constructing a multidimensional linear regression model. Zhao Shukuan et al [7] evaluated and analyzed the innovation activities of 151 high-tech enterprises in Jilin Province from four aspects: efficiency, effectiveness, scale return and projection analysis by DEA method combined with the data obtained from field investigation. The results show that scale efficiency is the main factor leading to low innovation efficiency.

Through combing and studying the above literatures, we find that the existing research on enterprise innovation efficiency mainly adopts data envelopment analysis, and the analysis of influencing factors of enterprise technology innovation efficiency mainly adopts Tobit model and multiple linear regression model for empirical test. DEA method is also combined with Malmquist index, convergence model and Tobit model to analyze innovation efficiency characteristics of enterprises more systematically. At the same time, whether government subsidies have a positive

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effect on technological innovation efficiency remains controversial. On this basis, this study focuses on listed biomedical enterprises in Guangdong Province, including intangible asset liquidity as the core explanatory variable, and makes an empirical analysis of government subsidies focusing on enterprise R & D at a deeper level.

3. Research methods and model construction

3.1. Data Envelopment Analysis (DEA)

Data Envelopment Analysis is a new field of interdisciplinary research among operations research, management science and mathematical economics. It was founded by Charnes et al [8]. in 1978. DEA is a mathematical programming evaluation model that calculates DMUS at the frontier of production efficiency (best practice or optimal resource utilization level) according to the ratio of input to output under a given Decision Making Unit (DMU), and then evaluates its relative effectiveness by the degree to which other DMUS deviates from the frontier of production efficiency.

This study use BCC model to measure the technological innovation efficiency of biomedical enterprises in Guangdong Province. The specific mathematical model is constructed as follows:

$$
\begin{gathered}
D_{BCC} = min\theta \\
\Sigma_j^n \lambda_j x_{ij} + s^- = \theta x_{i0}, i = 1,2,3,\cdots m \\
\Sigma_j^n \lambda_j y_{rj} - s^+ = y_{r0}, r = 1,2,3,\cdots k \\
\Sigma_j^n \lambda_j = 1 \\
\Lambda_j, s^-, s^+ \geq 0, j = 1,2,3,\cdots n
\end{gathered} \tag{1}
$$

In equation (1), θ is technological innovation efficiency, λ is weight coefficient, s^+ is output slack, s^- is input slack, j represents biomedical enterprises in Guangdong Province, n is the number of selected pharmaceutical enterprises, x_{i0} (i=1, 2, 3,··m) is input factor, y_{r0} (r=1, 2, 3,··k) is output factor.

3.2. Malmquist index model

Malmquist index model was put forward by Malmquist in 1953, which is mainly used to analyze the dynamic efficiency of different decision making units. Malmquist index model is widely used in combination with data envelopment analysis in existing literature to achieve the combination analysis of dynamic and static efficiency and improve the integrity of evaluation. Fare et al [9]. decomposed Malmquist index, i.e. total factor productivity change index, into the product of technical efficiency change index and technical progress change index, so that we can deeply analyze the dynamic change in the production process, and technical efficiency can be decomposed into pure technical efficiency and scale efficiency. Specific mathematical models are constructed as follows:

$$
M = [D_0^t(X_{t+1}, Y_{t+1}) \times D_0^{t+1}(X_{t+1}, Y_{t+1}) / D_0^t(X_t, Y_t) \times D_0^{t+1}(X_t, Y_t\,]^{1/2} = TFP = PTI \times SI \times TPI \tag{2}
$$

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In equation (2),(X_{t+1}, Y_{t+1}) and (X_t, Y_t) represent vectors of input and output in t+1 and t periods respectively, D^t_0 and D^{t+1} represent distance functions in t and t+1 periods. Malmquist indices of t and t+1 periods are M_0=D_t^t(X_0, Y_t)D_t^t (X_{0t}, Y_{+1}), M_{t+}=D_{1t+}(X_1^t, Y^{+1})D_{0t} (X_+, Y_{1t}), TFP is total factor productivity, PTI is pure technical efficiency, SI is scale efficiency, TPI is technical progress efficiency.

3.3. Tobit regression model

Tobit regression model was originally proposed by economist James Tobin [10] in 1958. It mainly considers the existence of truncation phenomenon in the explained variable. Truncation means that some observed values cannot be observed, that is, the values of the explained variable are limited to some interval. In Tobit regression model, dependent variables are usually assumed to be continuous variables, and truncated in a certain interval, and this study uses data envelopment analysis in the efficiency analysis, the method output efficiency results value range of 0-1, there is truncation phenomenon, and the results are continuous variables, so Tobit regression model can be more accurate for influencing factor analysis. Specific mathematical models are constructed as follows:

$$
\begin{gathered}
y_i^* = \beta x_i + \mu_i \\
\mu_i \; N(0, \sigma 2) \\
y_i = 1, y_i > 1① \\
y_i = y_i^*, 0 \le y_i \le 1② \\
y_i = 0, y_i < 0③
\end{gathered}
\tag{3}
$$

In Equation (3), y^*_i denotes the original dependent variable, y_i denotes the truncated dependent variable, x_i denotes the value of the independent variable, β denotes the regression coefficient of the independent variable, and μ_i denotes an error term that is independent and obeys a normal distribution.

4. Empirical analysis

4.1. Sample selection and index system construction

4.1.1. Selection of research samples

The data sources of this study mainly come from sina financial database, enterprise annual report and incopat database. This study takes the representativeness and data integrity of biomedical enterprises in Guangdong Province as the starting point, and some enterprises with late marketing time or missing data, such as Yirui Biology and Maipu Medicine, are excluded. In addition, this study selects the recent five years, that is, 2020-2024 as the research period. Based on this, the data of 30 A-share listed enterprises in biopharmaceutical industry in Guangdong Province from 2020 to 2024 are finally selected as the research samples of this study.

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4.1.2. Index system construction

There are few existing studies on the evaluation of innovation efficiency in the biomedical industry. Now, research indicators are sought from multiple perspectives. The specific situation is shown in Table 1:

Table 1. Sorting of technological innovation efficiency indicators

input index	research field	output index	research field
R&D expenses	biomedicine	Main business income	Biomedicine
Proportion of R&D	agriculture	Number of newly added patents	Agriculture
Number of new product development projects	industry	Number of patent applications	Industrial innovation
Fixed asset	construction enterprise patent	Patent authorization quantity	Material enterprise
Selling expenses	new energy vehicles	Net profit	artificial intelligence

According to relevant definitions of innovation efficiency and sorting out relevant literature indicators, a three-level evaluation index system for innovation efficiency of biomedical enterprises in Guangdong Province is established from two perspectives of input and output respectively. For specific index selection, see Table 2:

Table 2. Selection of input and output indicators

First level indicator	Second level indicator	Third level indicator	Unit	Data sources
input index	human resources	R&D personnel	quantity	Annual Report of the Enterprise
		Total number of employees	quantity	Annual Report of the Enterprise
	material resources	fixed assets	a hundred million	Sina Finance Database
	financial resources	Research and Development	a hundred million	Sina Finance Database
output index	tangible assets	operating revenue	a hundred million	Sina Finance Database
	intangible assets	Number of newly added patents	quantity	incopat

4.2. Static efficiency analysis of DEA-BCC model

The data of selected biomedical enterprises in Guangdong Province in 2024 were input into Deap2.1 software for static data analysis, and the analysis results are shown in Table 3:

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Table 3. Technological innovation efficiency of biomedical enterprises in Guangdong Province in 2024

Number	Enterprise	CTE	PTE	SE	RTS
1	Huarun Sanjiu	0.5408	0.5471	0.9885	increasing
2	Xinli Tai	0.5017	0.5744	0.8734	increasing
3	Shangrong Medical	0.3872	0.9984	0.3878	increasing
4	Weiguang Biology	0.6419	1.0000	0.6419	increasing
5	Hanyu Pharmaceutical	0.5262	0.7515	0.7002	increasing
6	Libang Instrument	1.0000	1.0000	1.0000	
7	Kangtai Biotechnology	0.5268	0.7169	0.7348	increasing
8	Kaili Medical	1.0000	1.0000	1.0000	
9	BGI	0.3963	0.4919	0.8056	increasing
10	New industries	0.8881	0.9472	0.9376	increasing
11	Health Yuan	0.4123	0.4302	0.9586	increasing
12	Microchip Biology	0.3873	0.6793	0.5701	increasing
13	Pumen Technology	0.3168	0.6379	0.4967	increasing
14	Daan Gene	0.8318	0.9335	0.8911	increasing
15	Zhongsheng Pharmaceutical	0.5602	0.8370	0.6693	increasing
16	Teyi Pharmaceutical	0.3741	0.8984	0.4164	increasing
17	Rundu Corporation	0.6783	0.8005	0.8474	increasing
18	Improve Medical	0.2826	1.0000	0.2826	increasing
19	Guanhao Biotechnology	0.3693	1.0000	0.3693	increasing
20	Biolight	0.8786	1.0000	0.8786	increasing
21	Yiduoli	0.3793	0.6651	0.5703	increasing
22	Boji Pharmaceutical	0.5501	1.0000	0.5501	increasing
23	Wanfu Biotechnology	0.5015	0.5787	0.8665	increasing
24	Jianfan Biology	0.4550	0.5550	0.8198	increasing
25	LeXin Medical	0.6416	1.0000	0.6416	increasing
26	poinsettia	0.4196	0.6332	0.6626	increasing
27	Kepu Biology	0.8870	1.0000	0.8870	increasing
28	White Cloud Mountain	1.0000	1.0000	1.0000	unchanged
29	Weili Medical	0.3787	0.5835	0.6489	increasing
30	Jinyu Medicine	0.9303	0.9750	0.9541	increasing
	mean	0.5897	0.8168	0.7263	
	Effective Enterprise	3	10	3	

Comprehensive technical efficiency analysis: The average innovation comprehensive technical efficiency of 30 biomedical listed companies in Guangdong Province selected in 2024 is 0.5017, indicating that the overall level of innovation efficiency of biomedical companies in Guangdong Province is low. Among them, 19 enterprises are lower than the average value of comprehensive

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technical efficiency, which is close to 64% of the total sample, reflecting that many enterprises have insufficient input-output conversion ability in innovation, and some enterprises, such as Yangpu Medical Enterprise, have extremely low efficiency value because of the influence of scale efficiency, which is related to excessive scale expansion of enterprises.

Pure technical efficiency analysis: pure technical efficiency is the maximum output that can be achieved under the premise of considering variable returns to scale. From the analysis results in Table 3, the following conclusions can be drawn: the average value of pure technical efficiency of 30 enterprises selected in 2024 is 0.8168, and the overall level is relatively good. However, there is still some room for development from the optimal innovation efficiency of enterprises, among which 10 enterprises are located at the forefront of innovation efficiency.

Scale efficiency analysis: Scale efficiency reflects whether the current scale of enterprises can efficiently utilize resources. The average scale efficiency is 0.7263, and the overall level is medium. There are 14 enterprises below the average, and the two-level differentiation is serious. Enterprises below the average should be transformed into refined innovation or focus on core technologies in innovation to improve scale efficiency.

4.3. Dynamic efficiency analysis of Malmquist index model

Malmquist index is the index of total factor productivity, which can dynamically reflect the trend of technological innovation efficiency of 30 biopharmaceutical enterprises selected in this study in Guangdong Province. In addition, the index can be decomposed into technical progress efficiency and comprehensive technical efficiency. Based on this, this study takes the 30 enterprises from 2020 to 2024 as the research object and uses Stata18.0 software to conduct dynamic research on them.The results of dynamic analysis on innovation efficiency of biomedical enterprises in Guangdong Province are shown in Table 4:

Table 4. Malmquist index and its decomposition index

	effch	pech	sech	techch	tfpch
2020-2021	1.1291	1.0071	1.1204	0.9264	1.0433
2021-2022	0.9767	1.0483	0.9258	1.0409	1.0096
2022-2023	1.0443	0.9923	1.0419	0.9836	1.0256
2023-2024	1.0427	1.0190	1.0198	0.9580	0.9954
mean	1.0482	1.0167	1.0270	0.9772	1.0185

It can be seen from the table data that the Malmquist index of biomedical enterprises in Guangdong Province in recent years is greater than 1 except for the efficiency of technological progress, which is in a relatively effective state. However, the total factor productivity, comprehensive technical efficiency and scale efficiency from 2023 to 2024 are all less than their efficiency values from 2020 to 2021, indicating that the innovation efficiency value of biomedical enterprises in Guangdong Province decreases, among which the total factor productivity decreases by nearly 0.05.

The main reason for the downward trend of total factor productivity is the decline of scale efficiency, which indicates that there is a certain blind expansion in technological innovation business of biomedical enterprises in Guangdong Province, and the resource utilization efficiency is not high, which leads to the decline of scale efficiency.

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Technological progress efficiency and pure technical efficiency have fluctuated and increased in recent years, with a significant upward trend during 2021-2022, as shown in Figure 1, which also indicates that total factor productivity can maintain an average efficiency greater than 1 in recent years after being negatively affected by scale efficiency, mainly relying on the driving effect of technological progress. Except for technological progress and pure technical efficiency, the other three indicators are in a state of fluctuation and decline, indicating that biomedical enterprises in Guangdong Province should pay attention to the problem of resource utilization efficiency, reduce the input of redundant resources when expanding other technical businesses, and focus more resources on core technology businesses to promote the improvement of innovation efficiency with core technology businesses.

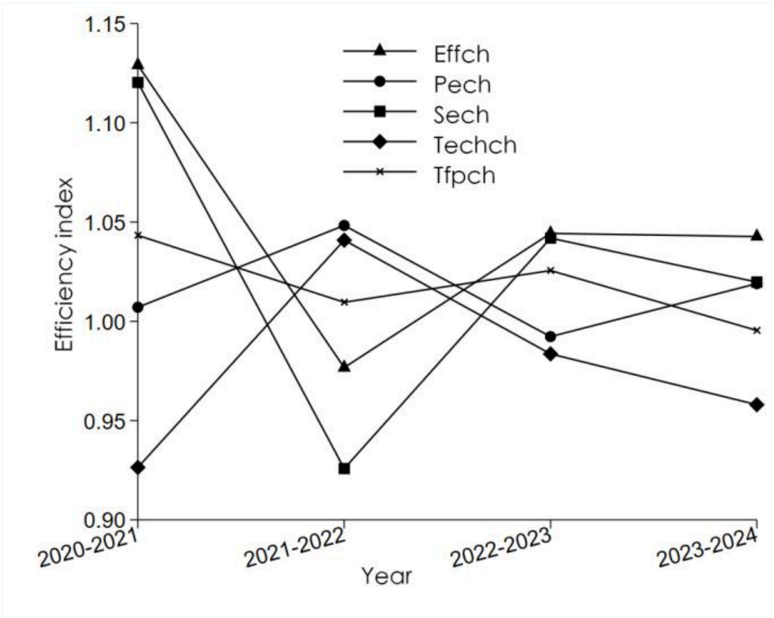

Figure 1. Malmquist index and its decomposition time series diagram

4.4. Regression analysis of Tobit model influencing factors

4.4.1. Selection and measurement of control variables

Control variables are selected mainly by referring to existing relevant studies, as well as the correlation of technological innovation capability of biomedical enterprises and the availability of data. The specific selection is shown in Table 5:

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Table 5. Selection and measurement of control variables

Variable selection	Variable name	Variable measure	Data sources
Explained variable	eff	The ratio of innovation output to input	deap2.1
Core explanatory variable	iafc	Ratio of operating income to intangible assets	Sina Finance Database
Control variable	eq	Proportion of graduate students and above	Annual Report of the Enterprise
	gs	Government subsidies for innovative businesses	Annual Report of the Enterprise
	oa	Asset turnover	Sina Finance Database
	sol	Asset liability ratio	Sina Finance Database

4.4.2. Tobit regression analysis

Tobit regression analysis was performed on the selected variable data by Stata18.0 statistical analysis software.The analysis results are shown in Table 6:

Table 6. Regression results of Tobit model

eff	Coefficient	Std.err.	t	P>|t|	95% conf.interval	
iafc	0.0027495	0.0011145	2.47	0.015	0.0005468	0.0049522
eq	0.3887673	0.1623521	2.39	0.018	0.0678849	0.7096498
gs	0.0012364	0.000542	2.28	0.024	0.0001652	0.0023076
oa	0.12992	0.0463614	2.8	0.006	0.0382886	0.2215515
sol	0.0303989	0.1274008	0.24	0.812	-0.2214037	0.2822015
_cons	0.5830296	0.06668	8.74	0.000	0.4512394	0.7148198
var(e.eff)	0.0480326	0.0061558			0.0372846	0.0618789

Note: When p <0.05, there is a significant correlation between variables; when coefficient>0, there is a positive correlation between variables.

From the table data, we can know that intangible asset financing capability, employee quality, government subsidies, operating ability and innovation efficiency are significantly positively correlated, and the solvency fails to pass the test.

This shows that the higher intangible asset financing capability, the higher the innovation efficiency of enterprises, because the higher the value of intangible assets can bring certain pledge financing ability to enterprises. Through pledge financing of intangible assets, enterprises can be helped to guard against certain unknown innovation risks and relieve the capital pressure of technological innovation of enterprises. Secondly, it is noted that the promotion coefficient is only 0.0027495. Enterprises should pay attention to their own intangible assets reserve and enhance the value of intangible assets, improve the ability of intangible assets financing to promote enterprise innovation; the higher the quality of employees, can also improve the enterprise's technological

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innovation ability, specifically, the higher the quality of employees, indicating that they have better professional knowledge reserve and skill level, can greatly promote the research and development of new products, improve the innovation efficiency of enterprises. The government's R & D subsidies can directly supplement the R & D investment gap of enterprises. The early investment in technological innovation is relatively high and the return period is relatively long. The government subsidies can directly cover part of the costs, which also provides certain economic foundation and self-confidence for enterprise innovation. At the same time, it is noted that the promotion coefficient of government subsidies is only 0.0012364. Enterprises should improve the utilization efficiency of government subsidies in technological innovation business. Avoiding moral hazard to improve the ability of government subsidies to promote innovation. In addition, enterprises with strong operation ability mean higher asset turnover rate of enterprises, which can help enterprises avoid delaying technological innovation projects due to shortage of funds. Innovation often brings certain uncertainty and risk. Enterprises with strong operation ability have strong anti-risk ability, provide certain trial and error opportunities for enterprises, and have low dependence on external financing, thus reducing financial risks.

4.4.3. Tobit regression robustness test

In order to further verify the accuracy of Tobit regression analysis evaluation, this study conducted robustness test by reducing the sample size by 20% and censoring. The results are shown in Table 7. Except for the correlation change of solvency, the core explanatory variables and other control variables have not changed substantially, which further proves the accuracy of this study.

Table 7. Regression results of Tobit model

eff	Coefficient	Std.err.	t	P>|t|	95% conf.interval	
	0.0025755	0.0012063	2.14	0.035	0.000186	0.0049649
	0.3767178	0.1878866	2.01	0.047	0.0045506	0.748885
gs	0.0014064	0.0006078	2.31	0.022	0.0002023	0.0026104
oa	0.1166642	0.0539273	2.16	0.033	0.0098446	0.2234838
	-0.0469879	0.144328	-0.33	0.745	-0.3328739	0.238898
_cons	0.6078923	0.076244	7.97	0.000	0.4568676	0.758917
var(e.eff)	0.0497815	0.0071316			0.0374827	0.0661158

Note: When $p < 0.05$, there is a significant correlation between variables; when coefficient>0, there is a positive correlation between variables.

5. Research conclusion and management enlightenment

5.1. Research conclusions

According to DEA-BCC model analysis, the average pure technical efficiency of 30 selected enterprises is 0.8168 at a high level, and 10 of them are located on the effective innovation frontier. However, due to the relatively low level of overall scale efficiency and serious polarization, the average comprehensive technical efficiency of 30 selected enterprises is only 0.5897, and there is still a large room for improvement from the effective innovation frontier.

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According to Malmquist index model, the comprehensive technical efficiency and total factor productivity of 30 selected enterprises present high level, but total factor productivity is affected by scale efficiency in recent years. Although the overall level of total factor productivity is high, it presents a downward trend. In addition, the technical progress efficiency index is less than 1, and the efficiency index level is relatively low, but it and pure technical efficiency have both fluctuated and increased in recent years.

Tobit regression analysis shows that technological innovation efficiency of biomedical enterprises in Guangdong Province is affected by multiple factors, among which intangible asset financing capability, employee quality, government R & D subsidies and enterprise operation ability pass the test and present positive correlation, enterprise solvency fails to pass the test, and enterprise operation ability has the most significant impact, followed by intangible asset financing capability, employee quality and government R & D subsidies. However, the promotion coefficient of intangible asset financing capability and government R & D subsidies is relatively low, and the positive promotion effect on technological innovation efficiency of biomedical enterprises in Guangdong Province is relatively low.

5.2. Theoretical contribution

This paper provides a brand-new perspective for the analysis of the factors affecting the innovation efficiency of biomedical enterprises in Guangdong Province. intangible asset financing capability is introduced as the core explanatory variable. In addition, there are disputes about the promotion effect of government subsidies in the analysis of previous literatures. This paper focuses on government subsidies for R & D as the control variable and finds that intangible asset financing capability and government R & D subsidies play a positive role in promoting the innovation efficiency of biomedical enterprises in Guangdong Province, thus alleviating the dispute about the role of government subsidies in enterprise innovation.

5.3. Managerial implications

In terms of government subsidies, the government should strengthen incentive and supervision mechanisms, establish scientific and transparent subsidy application and evaluation mechanisms, clarify the scope of fund use, strengthen project performance evaluation and post-audit systems to avoid moral hazard in enterprises, and ensure that financial funds are truly used for technological innovation activities. Enterprises should improve the efficiency of government subsidy funds, link subsidies with innovative achievements, and improve the efficiency of financial funds.

In the aspect of intangible assets reserve, enterprises should strengthen the protection of intellectual property rights, actively apply for patents, and truly protect the products of independent innovation. The government should improve the local intellectual property laws and regulations system, promote the establishment of rapid rights protection centers and patent administrative law enforcement linkage mechanisms, improve the efficiency of infringement cases, and create a good innovation environment. In addition, the government should guide enterprises to increase the layout of patents, trademarks and proprietary technologies, and set up special funds to support high-quality patent cultivation and international patent application. Promote the construction of regional biomedical intellectual property trading platform, promote the transformation and trading circulation of technological achievements, and provide basic support for intangible asset pledge financing.

In terms of employee quality, improving the educational level of employees is an important guarantee to enhance the innovation ability of enterprises. Enterprises should increase support for

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the introduction of high-level talents, such as housing subsidies for the introduction of doctoral and master's talents. The government should encourage enterprises, universities and scientific research institutions to build training bases and carry out targeted talent training programs. In addition, special training funds can be set up to support on-the-job personnel of enterprises to participate in professional skills training and continuing education, so as to comprehensively improve the professional quality of R & D and management teams.

In terms of improving operational capabilities, enterprises should establish and improve modern enterprise management systems and enhance strategic planning, resource allocation and risk control capabilities. The government encourages enterprises to introduce advanced digital management systems to achieve refined management and data-driven decision-making. At the same time, strengthen market research and product positioning analysis, improve the response speed of enterprises to policy changes, market demands and technological trends, and enhance core competitiveness and anti-risk ability.

References

[1] Hou Pengbo, Ma Zhanxin. Research on Innovation Efficiency Measurement and Improvement Path of China Biomedical Enterprises--Based on Improved Super-efficiency DEA and fsQCA Methods [J/OL]. Soft Science, 2025, 1 -15

[2] Dai Hongbin, Xu Honghao, Zhao Yanjiao. Motivation, Problems and Thinking of Innovative Drugs Going to Sea Development of Chinese Biomedical Enterprises [J]. Business Watch, 2025, 11 (09): 79-84.

[3] Yin Jie, Ge Rong, Li Feng. The mechanism of innovation input on knowledge spillover of biomedical enterprises [J]. Science and Technology Management Research, 2024, 44 (20): 102-110.

[4] Hou Xindi. Evaluation of Technological Innovation Efficiency of Industrial Enterprises in Anhui Province [J]. Modern Industrial Economics and Informatization, 2025, 15 (01): 7-10.DOI: 10.16525

[5] Shi Xiaoli, Xu Yingqi, Guo Ruiting, et al. Research on the Path to Enhance the Independent Innovation Ability of Biomedical Industry in Fujian Province Based on Patent Navigation [J]. Intelligence Quest, 2025, (05): 41

[6] Zhao Shukuan, Yu Haiqing, Gong Shunlong. Research on Innovation Efficiency of High-tech Enterprises in Jilin Province Based on DEA Method [J]. Scientific Research Management, 2013, 34 (02): 36-43+104.DOI: 10.19571

[7] Chen S, Feng Y, Lin C, et al. Research on the technology innovation efficiency of China's listed new energy vehicle enter prises [J].Mathematical Problems in Engineering, 2021.6613602.

[8] Charnes A, Cooper W W, Rhodes E, Measuring the efficiency of decision making units. European Journal of Operational Research, 1978, 2: 429~444

[9] Scazzier R, Fare R, Grosskopf S, et al. Production frontiers [J]. The Economic Journal, 1995, 105(430): 738.

[10] Tobin J. Estimation of relationships for limited dependent variables [J]. Econometrica, 1958, 26(1): 24.