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An Evaluation of the Financing Efficiency among Smart Home Manufacturing Companies: Application of DEA-BCC and Malmquist Index

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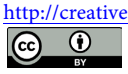

Abstract

In 2015, China proposed the "Made in China 2025" strategy to steadily grasp the upgrading of smart manufacturing enterprises, which plays a decisive role in the high-quality development of Chinese enterprises. This paper selects the financial data of 53 smart home manufacturing enterprises from 2013 to 2022, and selects the output-oriented BCC model and Malmquist index model to analyze the financing efficiency of enterprises. The results show that the overall financing efficiency of smart manufacturing enterprises in China is low, most smart home enterprises have not reached the effective state of DEA, and the financing efficiency of smart home enterprises in different regions is quite different, and the analysis shows that the main factor of the low comprehensive technical efficiency of smart home manufacturing enterprises can be attributed to the decline of pure technical efficiency. From the perspective of spatial distribution, the financing efficiency of enterprises in different regions changes greatly and shows fluctuations in different periods. Based on this, enterprises should speed up the process of digital transformation and expand economies of scale. At the same time, the government should provide financial support to alleviate the financing constraints of enterprises and improve financing efficiency.

Keywords

Financing Efficiency, DEA-BCC Model, DEA-Malmquist Index Model, Smart Home Manufacturing Enterprise

1. Introduction

According to the "14th Five-Year Plan" smart manufacturing development Plan,

the development of smart manufacturing is of key significance to stabilize China's real economy, build a modern industrial system, and achieve a new type of industrialization. In August 2022, the General Office of China and other four departments issued the "Action Plan to Promote the High-quality Development of the Household Industry" to promote cross-brand, cross-enterprise and cross-terminal connectivity of related products and data. In 2022, the support policies of the state and governments at all levels continue to be launched to stimulate the vitality of the consumer side, product iteration and update, and we have seen new changes and development trends in the technology side, product side, format and business model of the smart home industry. In the past few years, however, in the past few years, China's smart manufacturing listed companies have faced problems such as the reduction of labor costs and improvement of financial efficiency, which have brought challenges to the development of China's smart manufacturing companies, making it particularly important for smart manufacturing enterprises to upgrade and transform. Intelligent development of enterprises not only improves the degree of automation of enterprises and the accuracy of product design, but also helps enterprises to understand user needs, reduce research and development costs, and improve efficiency. Therefore, this paper takes smart home-listed companies as a specific object to use DEA model to do empirical analysis, explore enterprise financing efficiency, and then put forward countermeasures and suggestions to improve enterprise financing efficiency, in order to promote China's manufacturing industry to achieve high-quality development.

2. Literature Review

The foreign capital market is relatively mature, and the most commonly used and highly recognized financing theory is Modigliani and Miller theorem, which was jointly proposed by French scholars such as Modigliani. This theorem holds that there is no significant relationship between the distribution of corporate value and the financing structure. Zeng (1993) first put forward the concept of "financing efficiency". The following is an overview of the two main aspects of funding efficiency.

Based on the evaluation aspect, data envelopment analysis (DEA) method is widely used in the estimation of financing efficiency. Bian (2021) introduced variable returns to scale to measure the financing efficiency of enterprises. Zhang and Zhao (2015) conducted an assessment from three perspectives: financing cost, risk and return. Li (2021) built an indicator system comprehensively considering financing cost, risk and return, and studied the indirect effect of Internet finance on financing efficiency from the perspective of financing constraints. Sun et al. (2023) used DEA-Tobit two-step method to analyze the financing efficiency of cultural enterprises and its influencing factors.

In terms of influencing factors, Kumbhakar and Parmeter (2009) used a bilateral stochastic boundary model to test the impact of financing constraints and

government subsidies on financing efficiency. Jin and Huang (2018) studied the financing efficiency of small and medium-sized enterprises listed on the New Third Board and found that enterprise scale, capital concentration and financing efficiency are positively related. Zhou and An (2019) selected listed logistics enterprises as sample enterprises and found in the empirical study that sound internal control mechanism and strict asset liability management can effectively improve the financing efficiency of enterprises. Ma (2022) uses the Tobit model to explore the specific factors affecting the level of equity financing of listed companies in Hebei, and finds that there is a positive correlation between the effectiveness of equity financing, the degree of equity concentration and the financing efficiency, while a negative correlation with the operating costs of enterprises. Wu et al. (2019) applied the Tobit model to explore the factors affecting financing efficiency, and the results showed that the improvement of corporate profitability, growth ability, solvency and operation ability would improve the financing efficiency of enterprises, but the increase of asset scale would reduce the financing efficiency of non-state-owned "hidden champion" enterprises. Mu and Wang (2023) found that a good external environment can improve financing efficiency, and the company's profitability, growth ability and debt repayment ability have a significant positive impact on financing efficiency, while expanding assets and improving the ratio of assets to liabilities will reduce financing efficiency.

The development degree of smart manufacturing is directly related to the quality level of manufacturing industry in our country, and also affects the financing efficiency of manufacturing enterprises. Yu and Song (2023) used DEA method to explore the financing efficiency of artificial intelligence enterprises, calculate and evaluate the comprehensive efficiency, pure technical efficiency and scale efficiency, and evaluate the financing effectiveness and development trend of enterprises. Song and Song (2023) divided the financing process into two sub-stages by using the two-stage DEA model, and analyzed the financing efficiency of enterprises in different industries by Malmquist index. Xiao and Song (2022) used the DEA-Malmquist Tobit model to study the financing efficiency of smart manufacturing enterprises and its influencing factors.

3. Model Construction and Sample Selection

3.1. Model Construction

In 1978, A. Harnes and W. W. Cooper proposed the DEA model, the full name is data envelopment analysis method, which selects input and output data of some decision units, uses linear equations, and takes input and output as the effective frontier of constructing data enveloping curves. DEA method can best evaluate the effects of multiple inputs and outputs of complex systems, without directly analyzing the data comprehensively and without dimensionless processing. It only determines the existence of a relationship, not the relationship between the input and output of the variable. The models include CCR, BCC and DEA-Malmquist

index. The former two are basic models suitable for static measurement of financing efficiency, while the basic model suitable for dynamic measurement of financing efficiency is Malmquist index. Malmquist index is currently the most suitable DEA method for statistical analysis of production performance in various periods, and the company's investment structure has distinct phased characteristics. In this paper, each manufacturing enterprise is regarded as a decision-making unit, and BCC mode is used to conduct quantitative analysis on the efficiency of the two stages of transaction and allocation. The coupled coordination degree model is established to evaluate the overall performance of corporate investment.

The BBC model expression is:

$$\begin{cases} \min\left[\theta-\varepsilon\left(\sum_{i=1}^{m}s_i^- +\sum_{r=1}^{s}s_r^+\right)\right] \\ \text{s.t.}\sum_{j=1}^{n}x_{ij}\lambda_j+s_i^-=\theta x_{ij0}, i=1,2,\cdots,m \\ \sum_{j=1}^{n}y_{rj}\lambda_j-s_i^+=\theta y_{rj0}, r=1,2,\cdots,s \\ \sum_{j=1}^{n}\lambda_j=1,\ j=1,2,\cdots,n \\ s_i, s_r\geq 0 \end{cases} \tag{1}$$

where x_{ij} is the i input of smart home enterprise j, y_{rj} is the r output of smart home enterprise j, ε is the non-Archimedean infinitesimal, θ is the pure technical efficiency value.

The DEA-Malmquist index model is expressed as follows:

$$M\left(x^{t+1},y^{t+1},x^t,y^t\right)=\left[\frac{D^t\left(x^{t+1},y^{t+1}\right)}{D^t\left(x^t,y^t\right)}*\frac{D^{t+1}\left(x^{t+1},y^{t+1}\right)}{D^{t+1}\left(x^t,y^t\right)}\right]^{\frac{1}{2}} \tag{2}$$

$$\text{Effch}=\frac{D^t\left(x^{t+1},y^{t+1}\right)}{D^t\left(x^t,y^t\right)} \tag{3}$$

$$\text{Tech}=\left[\frac{D^t\left(x^{t+1},y^{t+1}\right)}{D^{t+1}\left(x^{t+1},y^{t+1}\right)}*\frac{D^t\left(x^t,y^t\right)}{D^{t+1}\left(x^t,y^t\right)}\right]^{\frac{1}{2}} \tag{4}$$

$$\text{Tfpch}=\text{Effch}\times\text{Tech}=\left(\text{Pech}\times\text{Sech}\right)\times\text{Tech} \tag{5}$$

where (x^t, y^t) and (x^{t+1}, y^{t+1}) respectively represent the input and output during the t and $t+1$ periods. If $M>1$, the total efficiency increases; If $M=1$, the total efficiency is unchanged; If $M<1$, the total efficiency decreases.

The model expression of coupling coordination degree is as follows:

$$C=\frac{2\sqrt{FE_1*FE_2}}{FE_1+FE_2} \tag{6}$$

$$T=\alpha_1 FE_1+\alpha_2 FE_2 \tag{7}$$

$$FE=\sqrt{C\cdot T} \tag{8}$$

where C is the degree of interconnection between the two stages; T is the com-

prehensive coordination value; $\alpha_1 = \alpha_2 = 0.5$, FE_1 and FE_2 represent transaction and allocation efficiency respectively, and FE represents the comprehensive efficiency of enterprise financing.

3.2. Index Selection and Data Source

This paper selects 10 years' financial data of 53 Chinese smart home manufacturing enterprises from 2013 to 2022 to measure their financing efficiency. The data are mainly from EastMoney.com, annual reports of enterprises and CSMAR database. This paper adopts the approach of Wei et al. (2022) and uses DEA method to measure the financing efficiency in the transaction and distribution stages. Transaction efficiency mainly considers financing cost, risk and scale, including three input indicators and one output indicator. Allocative efficiency is mainly how to allocate funds effectively and realize the return of funds, including one input index and three output indicators. The index system is shown in **Table 1**.

The evaluation measure of enterprise financing efficiency can adopt DEA method, and the index should be positive. However, since the business results of enterprises may have profit or loss, it is necessary to carry out non-dimensional processing of input-output index data. The specific treatment formula is as follows:

$$\begin{cases} Y_{ij} = 0.1 + 0.9 \times \dfrac{X_{ij} - m_j}{M_j - m_j} \\ m_j = \min\left(x_{ij}\right); M_j = \max\left(x_{ij}\right) \\ i = 1,2,3,\cdots,n; Y_{ij} \in (0,1] \end{cases} \tag{9}$$

4. Empirical Analysis

4.1. Static Analysis

DEAP 2.1 software was used to analyze the financing efficiency of the two-stage

Table 1. Input-output index system at each stage.

Primary indicators	Secondary indicators	Three-level indicators
Transaction efficiency	Input index	Financial expense
		Asset-liability ratio
		Total assets
	Output indicator	Short-term, long-term, non-current liabilities due within one year
Allocative efficiency	Input index	Short-term, long-term, non-current liabilities due within one year
	Output indicator	Return on equity
		Turnover of total assets
		Revenue growth rate

input-output of smart home manufacturing enterprises from 2013 to 2022, as shown in Table 2 and Table 3.

In the capital trading stage, the average values of comprehensive technical efficiency, pure technical efficiency and efficiency scale of smart home manufacturing enterprises from 2013 to 2022 were 0.708, 0.924 and 0.765 respectively, and in the capital allocation stage they were 0.801, 0.910 and 0.880 respectively, all higher than the comprehensive technical efficiency and scale efficiency of the transaction stage. All indicators in the transaction stage are less than 1, indicating that the selected sample enterprises are in an invalid state, and all indicators in the allocation stage are greater than 0.5, indicating that the sample enterprises have been reasonably arranged in terms of capital allocation and use. From the

Table 2. Calculation of financing efficiency in transaction stage.

Efficiency		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Mean value
Comprehensive technical efficiency	Transaction phase	0.766	0.732	0.847	0.770	0.803	0.701	0.659	0.622	0.594	0.585	0.708
	DEA effective	3	2	5	3	4	4	4	4	2	4	3.5
Pure technical efficiency	Transaction phase	0.956	0.952	0.955	0.934	0.954	0.911	0.921	0.895	0.888	0.877	0.924
	DEA effective	12	13	14	10	14	10	13	9	8	12	11.5
Scale efficiency	Transaction phase	0.801	0.769	0.887	0.825	0.841	0.769	0.714	0.699	0.672	0.672	0.765
	DEA effective	3	2	5	3	4	5	4	4	2	4	3.6

Data source: All data are calculated from the original data (the same below).

Table 3. Calculation of financing efficiency in the allocation stage.

Efficiency		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Mean value
Comprehensive technical efficiency	Configuration phase	0.842	0.820	0.805	0.760	0.828	0.779	0.809	0.802	0.786	0.779	0.801
	DEA effective	5	3	3	3	3	4	6	3	3	2	3.5
Pure technical efficiency	Configuration phase	0.901	0.884	0.873	0.867	0.926	0.911	0.917	0.939	0.941	0.939	0.910
	DEA effective	5	3	5	5	6	7	7	9	10	8	6.5
Scale efficiency	Configuration phase	0.933	0.927	0.921	0.876	0.889	0.852	0.880	0.855	0.836	0.830	0.880
	DEA effective	7	6	4	5	3	5	9	6	4	2	5.1

decomposition factor of TE, the pure technical efficiency and scale efficiency in the transaction stage jointly limit the comprehensive technical efficiency. The low comprehensive technical efficiency of enterprises in this stage is mainly caused by the decline in scale efficiency, and the pure technical efficiency plays a positive role in promoting the improvement of financing efficiency in the fund allocation stage.

In terms of years, the efficiency levels in the transaction stage increased from 2013 to 2016, but the average efficiency of each efficiency showed a downward trend from 2017 to 2021, indicating that the efficiency of smart home manufacturing enterprises in the capital transaction stage needs to be improved. During the period of 2013-2022, the efficiency change trend of the allocation stage is basically the same, indicating that the optimization progress has been made in the utilization of the funds integrated into the manufacturing enterprises in recent years. As of 2022, the transaction efficiency of 4 enterprises has reached the strong efficiency state of DEA. Meanwhile, according to TE = PTE × SE, it can be inferred that 12 enterprises have reached pure technology efficiency but failed to achieve scale efficiency in 2022, and the rest enterprises do not have the efficiency of DEA either in pure technology or scale. Two enterprises have achieved the strong efficiency of DEA, and according to TE = PTE × SE, it can be inferred that in 2022, eight enterprises have achieved pure technical efficiency but failed to achieve scale efficiency, and the rest enterprises do not have the effectiveness of DEA in either pure technology or scale.

The efficiency of transaction and allocation in DEA model is analyzed above, and the comprehensive efficiency of enterprise financing is obtained by using the coupling coordination degree model, as shown in **Table 4**. **Figure 1** shows the changing trend of the total financing efficiency of smart manufacturing enterprises. The efficiency of different stages from 2013-2014 and 201-2022 showed a downward trend. According to the analysis of the above stages, the decline of PTE and SE in the two stages together made the comprehensive technical efficiency at the lowest level. From 2016 to 2017, the comprehensive technical efficiency of the allocation stage increased more than that of the transaction stage, so the comprehensive efficiency of enterprise financing rose slowly during this period.

4.2. Dynamic Analysis

The DEA-Malmquist index model was used for dynamic analysis of input-output

Table 4. Comprehensive efficiency of static financing of enterprises.

Efficiency	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Mean value
Corporate finance efficiency	0.896	0.880	0.909	0.875	0.903	0.860	0.854	0.840	0.827	0.822	0.868

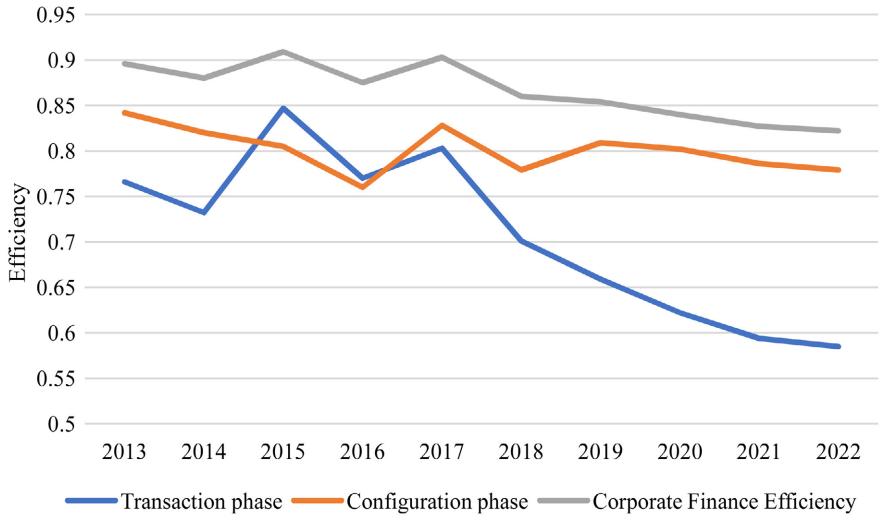

Figure 1. Change trend of mean financing efficiency in total, transaction and allocation stages of 53 sample enterprises from 2013 to 2022.

indicators, as shown in **Table 5**. During the money trading phase, the Malmquist index averaged 1.004, down 0.4% overall. Techch, on the other hand, increased by 3.6%, indicating that technological advances played a major role in the increase in Tfpch of the sample companies. Sech was 0.960 from 2013 to 2014 and 1.158 from 2014 to 2015, indicating that the improvement of scale efficiency promoted enterprises to transform into DEA efficient state. In the capital allocation stage, the average Malmquist index is 0.972, and the financing efficiency shows a downward trend, with the change of comprehensive technical efficiency decreasing by 1.6% and technological progress decreasing by 1.2%, indicating that the decline in enterprise financing efficiency is caused by the decline in technical efficiency. From the vertical point of view of the trading stage, 2022 increased by 1.2% compared with 2021, mainly because Effch increased from 0.950 in 2020-2021 to 0.985 in 2021-2022, but Techch decreased by 3.8%. In the special period of 2020, manufacturing enterprises are facing an unprecedented crisis. Although Techch has declined, the strong vitality is shown by manufacturing companies in the face of the environment. Smart home manufacturing enterprises should improve production technology on the basis of the original, constantly improve resource utilization efficiency, increase investment in technological innovation, in order to improve financing efficiency, create a more stable industrial base, and establish their own unique brand to cope with adverse changes in the external environment.

According to the DEA-Malmquist index, we analyze the transaction and allocation efficiency of enterprises, and use the coupling coordination degree model to obtain the comprehensive efficiency of enterprises' financing. For details, see **Table 6**. To sum up, from a static and dynamic perspective, financing efficiency still has significant room for improvement. Although the financing efficiency of most smart home manufacturing companies is on the rise, it has not yet reached

Table 5. Two-stage Malmquist index analysis table.

Index	Effch		Techch		Pech		Sech		Tfpch	
	Transaction phase	Configuration phase	TP	CP	TP	CP	TP	CP	TP	CP
2013-2014	0.955	0.972	1.044	1.012	0.995	0.981	0.960	0.991	0.998	0.984
2014-2015	1.161	0.983	0.852	1.028	1.002	0.987	1.158	0.997	0.989	1.011
2015-2016	0.907	0.928	1.155	1.031	0.977	0.992	0.928	0.936	1.048	0.957
2016-2017	1.046	1.076	0.941	0.884	1.024	1.071	1.021	1.005	0.984	0.951
2017-2018	0.866	0.928	1.167	1.035	0.953	0.983	0.909	0.944	1.011	0.961
2018-2019	0.931	1.037	1.070	0.948	1.010	1.006	0.922	1.030	0.995	0.983
2019-2020	0.949	0.988	1.034	0.979	0.968	1.023	0.981	0.966	0.982	0.968
2020-2021	0.950	0.973	1.069	0.986	0.992	1.002	0.958	0.971	1.016	0.960
2021-2022	0.985	0.977	1.031	0.996	0.986	0.997	0.999	0.980	1.015	0.972
Mean value	0.969	0.984	1.036	0.988	0.990	1.004	0.979	0.979	1.004	0.972

Note: TP means transaction phase; CP means configuration phase (because of the size of the page, the abbreviation is written here).

Table 6. Comprehensive efficiency of dynamic financing of enterprises.

Efficiency	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	Mean value
Corporate finance efficiency	0.996	1	1	0.984	0.993	0.995	0.987	0.994	0.997	0.994

the ideal state, so the key to improving financing efficiency is to promote technical efficiency, and to achieve it by optimizing capital allocation, improving utilization efficiency, and determining the optimal level of scale.

4.3. Regional Dynamic Analysis

As can be seen from Table 7: In the transaction stage, from 2013 to 2022, the enterprise productivity index of 7 provinces, including Guangdong, Zhejiang and Fujian, is greater than 1, and the rest are less than 1, indicating that the financing efficiency of smart home enterprises in most regions of China is low in the transaction stage, and enterprises are faced with larger financing risks, higher financing costs and smaller financing scale. However, with the increase of technological progress and state support, the financing efficiency of China's home furnishing enterprises will continue to improve. From the perspective of growth drivers, the improvement of Tfpch in Guangdong, Zhejiang and Beijing is due to technological progress, and the Tfpch in Shandong, Fujian and Jiangxi regions is promoted by technical efficiency and technological progress. The technical efficiency index of Henan, Hunan, Anhui and other regions has improved, but the total factor productivity index of smart home enterprises is affected by the technological progress index.

Table 7. Malmquist index and decomposition of two-stage financing efficiency of enterprises in each province.

Province	Effch		Techch		Pech		Sech		Tfpch		Overall efficiency
	TP	CP	TP	CP	TP	CP	TP	CP	TP	CP	
Guangdong	0.956	0.985	1.060	0.987	0.992	1.005	0.964	0.979	1.013	0.972	0.996
Shandong	1.002	0.959	1.007	1.003	0.994	0.998	1.007	0.961	1.009	0.962	0.993
Zhejiang	0.998	0.999	1.010	0.959	1.000	1.000	0.998	0.999	1.008	0.958	0.991
Shanghai	1.000	0.997	0.982	0.989	1.000	1.000	1.000	0.997	0.982	0.987	0.992
Jiangsu	0.998	1.005	0.992	0.967	1.000	1.000	0.998	1.005	0.990	0.972	0.990
Fujian	1.000	0.992	1.010	0.993	1.000	0.998	1.000	0.993	1.010	0.984	0.998
Beijing	0.997	1.012	1.025	0.940	1.000	1.000	0.997	1.012	1.022	0.951	0.993
Anhui	1.000	1.000	0.999	1.012	1.000	1.000	1.000	1.000	0.999	1.012	1.003
Guizhou	1.000	1.000	1.042	0.919	1.000	1.000	1.000	1.000	1.042	0.919	0.989
Sichuan	1.000	1.000	0.969	0.948	1.000	1.000	1.000	1.000	0.969	0.948	0.979
Jiangxi	1.000	1.000	1.009	1.009	1.000	1.000	1.000	1.000	1.009	1.009	1.004
Henan	1.000	1.000	0.977	0.999	1.000	1.000	1.000	1.000	0.977	0.999	0.994
Hunan	1.000	1.000	0.982	0.973	1.000	1.000	1.000	1.000	0.982	0.973	0.989
Mean value	0.996	0.996	1.005	0.977	0.999	1.000	0.997	0.996	1.001	0.973	0.993

Note: TP means transaction phase; CP means configuration phase.

In the allocation stage, from 2013 to 2022, only Anhui and Jiangxi provinces have enterprise productivity index greater than 1, and the rest are less than 1, indicating that the financing efficiency of smart home enterprises in most areas of China is low in the allocation stage, and enterprises do not make full use of the invested resources reasonably, unable to efficiently allocate funds, achieve financing returns, and improve financing efficiency. In terms of growth drivers from 2013 to 2022, changes in technical efficiency and technological change in Anhui and Jiangxi provinces are positively synchronized. The changes of technical efficiency and technological change in Hunan, Sichuan, Guizhou, Beijing, Jiangsu and Zhejiang provinces are negatively synchronized. The total factor productivity of the remaining five provinces is affected by the technological progress index, indicating that smart home manufacturing enterprises should digitize the process of transformation, and deeply integrate emerging digital technologies such as artificial intelligence and big data with the production and development of enterprises, which can effectively improve the financing efficiency of enterprises and alleviate financing constraints.

According to the DEA-Malmquist index, the total factor productivity of smart home enterprises in the transaction and allocation stage in each province is obtained. Through the coupled coordination model, the comprehensive financing efficiency of enterprises in each province is obtained. From 2013 to 2022, only Jiangxi and Anhui have comprehensive financing efficiency greater than 1. The

comprehensive financing efficiency of smart home manufacturing enterprises in the remaining 11 provinces is less than 1, indicating that the financing efficiency of smart home enterprises in most parts of China is not high. Taking Guangdong Province as an example, the financing efficiency is high in the transaction stage, and enterprises in the region face less financing risk, lower cost and larger scale, but the financing efficiency is low in the allocation stage. Enterprises do not reasonably make full use of the invested resources, and cannot efficiently allocate funds, achieve financing returns, and improve financing efficiency. Henan is located in the Central region, and the scale of enterprises is not as large as that in the coastal areas of Guangdong. Although the allocation efficiency is high, the comprehensive financing efficiency of enterprises is reduced due to the low transaction efficiency.

As shown in Table 8, in the transaction stage, the average TFP index of smart home manufacturing enterprises in Eastern, Central and Western regions is 1.005, 0.992 and 1.001 respectively, and the comprehensive ranking is East > West > Central, and the financing efficiency of enterprises in each region shows an upward trend. The financing efficiency of enterprises in Eastern China has improved rapidly, mainly due to the rapid progress of technology. The Central region needs to strengthen technological progress, and enterprises need to accelerate the process of digital transformation, integrate emerging technologies with the real economy, and accelerate the growth of technological progress. In the configuration stage, the average total factor productivity index of smart home manufacturing enterprises in the east, Central and Western regions was: 0.969, 0.998 and 0.934, respectively, and the comprehensive ranking was: Central > Eastern > Western. The technological progress of the Central region needs to be improved, and the growth of the technological progress index should be accelerated by strengthening the introduction of high-end technical talents and machinery and equipment. The growth of scale efficiency in the Eastern region is slow, which leads to a declining trend of technical efficiency, indicating that technical efficiency inhibits the financing efficiency of enterprises, and it is necessary to accelerate the improvement of technical level. The technological progress of enterprises in Western region shows a declining trend, and enterprises in this region should vigorously develop digital economy to enhance technological progress.

Table 8. Malmquist index and decomposition of two-stage financing efficiency of enterprises in different regions.

District	Effch		Techch		Pech		Sech		Tfpch		Overall efficiency
	TP	CP	TP	CP	TP	CP	TP	CP	TP	CP	
The Eastern	0.993	0.993	1.012	0.977	0.998	1.000	0.995	0.992	1.005	0.969	0.993
The Central	1.000	1.000	0.992	0.998	1.000	1.000	1.000	1.000	0.992	0.998	0.998
The Western	1.000	1.000	1.006	0.934	1.000	1.000	1.000	1.000	1.001	0.934	0.984

Note: TP means transaction phase; CP means configuration phase.

5. Conclusion and Suggestions

5.1. Conclusion

This paper selects the financial data of 53 smart home enterprises from 2013 to 2022, analyzes the financing process by DEA-BCC model and Malmquist index, and draws the following conclusions: 1) Static result analysis: The overall financing efficiency of smart manufacturing enterprises in China is not high, whether it is the transaction stage or the capital allocation stage, most smart home enterprises have not reached the effective state of DEA, and the number of enterprises in the capital transaction stage to reach the effective state of DEA is more than the number of enterprises in the configuration stage. This shows that in the capital transaction and configuration stage, smart home enterprises still have a lot of room for improvement. From 2013 to 2022, the average comprehensive efficiency of enterprise financing reached 0.868, indicating that the financing efficiency of enterprises in different regions varies greatly, and it is necessary to further improve the operation capacity and management level, and expand investment to achieve the best scale. 2) Analysis of dynamic results: The total factor productivity index of smart home enterprises is generally maintained at a level of about 1.0, and shows a trend of fluctuation. Low capital allocation efficiency is the main reason for the low financing efficiency of smart home enterprises, and the main reason for the low Malmquist index in the capital allocation stage is the low technological progress change index. 3) Spatial distribution: The financing efficiency of enterprises in different regions changes greatly and shows fluctuations in different periods. This shows that enterprises in different regions need to take effective measures against constraints and improve financing efficiency.

5.2. Suggestions

First, by improving the economies of scale and pure technical efficiency of smart home enterprises, so as to improve their comprehensive technical efficiency. No matter in the transaction or allocation stage, the scale efficiency of enterprises ranges from 0.714 to 0.887, which does not reach the optimal state of DEA, and the scale efficiency shows a downward trend in recent years. At present, although the smart home industry has a huge market capacity, the industry concentration is still low, the strength is scattered, and the financial support of smart home enterprises is mainly securities financing, by exploring the diversity of financial support, increasing cash flow, reducing debt and other ways to expand the scale economy of smart home enterprises, so as to improve the financing efficiency of enterprises. Specifically, while expanding their own scale, enterprises should pay attention to attracting technical talents and improving the technical level, but also continue to innovate and research and development, the main business is more detailed and precise, the birth of personalized, scenario-based home experience, design more advanced hardware products to meet user needs, improve sales and market share.

Second, accelerate the digital transformation process of smart home manufacturing enterprises. Manufacturing enterprises are faced with a series of problems such as insufficient innovation ability and increased labor costs, which makes the upgrading and transformation of manufacturing enterprises imminent. With the rise of emerging Internet technologies such as 5G, Internet of Things and artificial intelligence, "digitalization" has an increasingly significant enabling effect on smart home enterprises. Enterprises should start to launch a complete set of solutions corresponding to the field based on digitalization. Accelerate the transformation of home furnishing enterprises and improve the financing efficiency of enterprises, so digital transformation has become the only way for high-quality development of enterprises. For unlisted manufacturing enterprises, it is necessary to seize the current opportunity period of strategic change, actively implement digital transformation, reshape all aspects of the enterprise through the transformation of digital technology, enhance information disclosure, alleviate information asymmetry, and reduce corporate financing costs. At the same time, attract high-tech talents to join, and through incentive measures, make talents better serve the development of enterprises. In the current era of digital economy, enterprises should pay more attention to the integration of upstream and downstream resources, with the idea of "product + platform + service", integrate the supply chain of manufacturers, suppliers, distributors and users, and achieve refined operations.

Third, governments, financial institutions and businesses work together. Smart home attracts consumers with its convenient, efficient and comfortable characteristics, and the state should introduce relevant policies to regulate the market and product quality, create a good market environment, and protect the rights and interests of consumers and personal information security. Local governments should further optimize the transmission mechanism of national policies to manufacturing enterprises, and should also allow more private enterprises to fully benefit from various national policy preferences, and constantly optimize the external governance environment of enterprises. Commercial banks and other financial institutions should carry out targeted financial services, in order to identify risks, expand financing channels, innovate the financing convenience of different types of companies, effectively cope with the financing difficulties faced by some enterprises in the production process and price financing, manufacturing enterprises actively interact with banks and other financial institutions to maintain information symmetry. Enterprises should constantly improve their governance, keep up with the pace of The Times, accelerate the process of digital transformation, actively seek their own development and growth, and establish the internal capital market of enterprises.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Bian, Y. C. (2021). *Research on the Impact of Science and Technology Finance on Corporate Financing Efficiency*. Master's Thesis, Donghua University. (In Chinese)

Jin, H., & Huang, J. (2018). Analysis on Influencing Factors of Financing Efficiency of Chinese New Third Board Enterprises. *Journal of Hangzhou Dianzi University (Social Science Edition), 14,* 24-29. (In Chinese)

Kumbhakar, S. C., & Parmeter, C. F. (2009). The Effects of Match Uncertainty and Bargaining on Labor Market Outcomes: Evidence from Firm and Worker Specific Estimates. *Journal of Productivity Analysis, 31,* 1-14. https://doi.org/10.1007/s11123-008-0117-3

Li, S. L. (2021). *Research on the Impact of Internet Finance on the Financing Efficiency of Small and Micro Enterprises*. Master's Thesis, Hubei University of Technology. (In Chinese)

Ma, Z. Y. (2022). Research on Equity Financing Efficiency of Listed Companies in Hebei Province Based on DEA Method. Master's Thesis, Hebei University of Geosciences. (In Chinese)

Mu, L. J., & Wang, X. Y. (2023). Analysis on Financing Efficiency of Agricultural Listed Companies and Its Influencing Factors. *Times Economic & Trade, 20,* 52-56. (In Chinese)

Song, R., & Song, L. R. (2023). Research on Financing Efficiency of Intelligent Manufacturing Enterprises Based on Two-Stage DEA. *Operation and Management, 7,* 6-12. (In Chinese)

Sun, L. J., Meng, X. W., & Li, X. T. (2023). Research on Financing Efficiency and Influencing Factors of Cultural Enterprises under the Background of Industrial Upgrading. *Economic and Management Review, 39,* 134-145. (In Chinese)

Wei, J. G., Wei, Y. J., & Si, X. H. (2022). Digital Transformation of Commercial Banks and Small and Medium-Sized Enterprise Financing Efficiency. *Journal of Beijing University of Posts and Telecommunications (Social Sciences Edition), 24,* 1-11. (In Chinese)

Wu, T. R., Zhan, M. Z., & Liu, J. (2019). Evaluation and Influencing Factors of Financing Efficiency of "Invisible Champion" Enterprises in China's High-Tech Industry. *Contemporary Economy, 40,* 85-92. (In Chinese)

Xiao, Y. P., & Song, L. R. (2022). Research on Financing Efficiency of Intelligent Manufacturing Enterprises Based on DEA-Malmquist-Tobit Model. *Science & Technology and Economy, 35,* 56-60. (In Chinese)

Yu, Q., & Song, L. R. (2023). Analysis of Financing Efficiency Based on Artificial Intelligence Industry: Perspective of DEA Model. *Business and Management, 464,* 29-35. (In Chinese)

Zeng, K. L. (1993). How to View Direct Financing and Indirect Financing. *Financial Research, 11,* 7-11. (In Chinese)

Zhang, Y. X., & Zhao, L. L. (2015). Government Support and Financial Development, Social Capital and Financing Efficiency of Scientific and Technological Innovation Enterprises. *Science Research Management, 36,* 55-63. (In Chinese)

Zhou, L., & An, Y. (2019). Research on the Financing Efficiency of China's Modern Logistics Industry under the Background of the Transformation of New and Old Kinetic Energy. *Economic Issues, 11,* 53-60. (In Chinese)