Research on Financing Efficiency of Manufacturing Enterprise Supply Chain——Empirical Analysis Based on the DEA Model

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Abstract. In recent years, the global economy is sluggish. China's manufacturing technology is restricted by foreign countries, and the advantage of low cost and multi-labor force is gradually disappearing. The overall benefits of the manufacturing industry are not optimistic. Financing, providing basic power for enterprise technological innovation and transformation, is crucial to the manufacturing industry's future development. In this paper, the data envelopment method (DEA) is used to select 356 enterprises in the manufacturing industry to conduct empirical research on financing efficiency. According to the research results, relevant conclusions are drawn and relevant suggestions are proposed.

Keywords: Manufacturing industry, Financing efficiency, DEA model, empirical research.

1. Introduction

After reforming and opening, China has built a relatively complete creative industry system using foreign capital. Relying on the low advantages of a large population and low labor costs, China quickly overtook most other countries to become a manufacturing power. In recent years, these advantages have gradually failed to meet the driving force demand of China's economic growth and affected by the epidemic, the foreign trade income is low [1]. Based on the above, the creative industry urgently needs to find new development impetus. New Third Board is playing an important role in China's capital market. Since "Made in China 2025" was proposed, the New Third Board has widened financing channels for the manufacturing sector, improved the efficiency of capital allocation, and promoted the transformation of the manufacturing sector. Among the New Third Board, chi next has a low entry threshold and strict operation, which is especially conducive to providing financing opportunities for small and medium-sized enterprises. By studying the financing efficiency of manufacturing enterprises in GEM, we can comprehensively observe the growth space of the manufacturing industry.

2. Literature review

In the early stage of reform and opening up, Lan Gengyun (1990) pointed out that the essence of financing efficiency was to improve the turnover and value-added of credit financing from the inside and the balance ability of credit financing to the economic structure from the outside [2]. As for the financing efficiency of enterprises, Liu Haihong (2000) points out that under the conditions of the modern market economy, the financing efficiency of enterprises is relatively independent of the efficiency of economic development. It is determined by the size of the financing ability of enterprises, that is, enterprises are required to obtain funds at low cost and use limited resources to achieve maximum output [3]. Ren Yuxiang and Yang Shuzhi (2002) believe that the financing efficiency of enterprises can be divided into transaction efficiency and allocative efficiency, namely, obtaining financial resources at the lowest cost and optimizing the production of obtained resources [4]. Hu Huijuan and Li Gang (2008) proposed that the financing efficiency of small and medium-sized enterprises can be analyzed from the perspectives of financing cost, financing structure, financing benefits, and risks [5]. Cui Jie, Hu Haiqing, and Zhang Daohong (2014) focused on exploring financing efficiency from the perspective of the cost of enterprise financing methods [6]. Gu Haifeng

and Bian Yuchen (2020) coupled science and technology with finance and studied its influence mechanism on enterprise financing efficiency [7]. Xie Pan, Wang Yilin, and Huo Yuanyuan (2021) introduced financial structure variables to better measure the impact of changes in the financial governance level on corporate financing efficiency [8]. Wei Jiahui and Geng Chengxuan (2022) pointed out that the financing efficiency of enterprises is affected by many factors, such as enterprise management structure, business model, market environment, and government support [9].

Based on the above, domestic scholars' research on financing efficiency under the market economy of China has gradually reached maturity but is more inclined to high-tech, new energy, and other new industries. Most of the research methods are empirical studies. Data Envelopment Analysis (DEA) has become one of the mainstream models of efficiency research because it is easy to expand and free of parameters [10-11]. Although the country is vigorously supporting the high-tech industry, the traditional manufacturing industry still occupies the majority, which is characterized by insufficient innovation ability and difficulty to break through the technological blockade. It is the main body of the financing dilemma. Based on the above, this paper selects 356 manufacturing enterprises in GEM as the research object and analyzes the financing efficiency of enterprises with the DEA model, to have a more comprehensive understanding of the financing status of the manufacturing industry and put forward targeted suggestions for the formulation of relevant policies.

3. Study design

3.1. Sample selection and data sources

In this paper, 356 manufacturing enterprises on GEM are selected as sample enterprises. Considering the timeliness of data, it is inappropriate to use earlier data, and the latest data may not be perfect. Therefore, the financial reports of enterprises from 2016 to 2021 are used as indicators for analysis. The data source is the National Taian Database.

3.2. Model Selection

The DEA model jointly developed by American scholars Charnes, Cooper, and Rhodes was originally used to measure the production efficiency of enterprises. The basic principle is that, for multiple targets to be decided, m input indicators and n output indicators are assigned to each target, and the input-output ratio is calculated through specific formulas to measure the financing efficiency. After continuous innovation by scholars, DEA has developed into a new field of operations research, which can make decisions and judgments based on the economic information of enterprises, and is widely used to evaluate the financing efficiency of enterprises. This model includes the early CCR model and the improved BCC model. The former sets constant return to scale while the latter applies to variable return to scale. In reality, the latter can measure financing efficiency in any situation, which is more in line with the actual situation. Therefore, this paper chooses the BCC model. In addition, the BCC model decomposes the comprehensive technical efficiency (TE) into pure technical efficiency (PTE) and scale efficiency (SE), which provides a more detailed measurement of financing efficiency and can reflect the financing efficiency of enterprises from the perspective of their daily operating conditions.

BCC model efficiency value: comprehensive technical efficiency (TE)= pure technical efficiency (PTE)* Scale efficiency (SE).

3.3. Index Selection

In the evaluation system of financing efficiency, the selection of indicators is very important, which should not only satisfy the comprehensiveness of evaluation as much as possible but also take into account the feasibility of information acquisition [12]. Based on the existing literature, the input and output indexes in the DEA model meet 3-4 items each. In this paper, three input indicators and four output indicators are selected as follows.

3.3.1 Input indicators

(1) Total assets: Total assets can intuitively measure the size of an enterprise, which has a certain positive correlation with the solvency and operational ability of an enterprise. After financing, the total assets of enterprises will increase, but the increase in the absolute amount of total assets does not necessarily mean the improvement of the financing efficiency of enterprises. The total assets should be appropriately matched according to the specific developmental stage of enterprises, and the waste of resources should be reduced as far as possible on the premise of satisfying the development of enterprises.

(2) Asset-liability ratio: Currently the main financing method of Chinese-listed manufacturing enterprises is creditor's rights financing and equity financing. The asset-liability ratio can effectively measure the financing situation of creditors' rights of enterprises. If the asset-liability ratio is low, it indicates that the enterprise is in a more conservative operation mode, the financing source is more equity financing, and the enterprise operation risk is relatively low. The high asset-liability ratio indicates that the enterprise is in a more aggressive development mode, and the enterprise operation risk is relatively higher. In the normal operation of enterprises, we should pay attention to the balance of debt to realize the maximization of enterprise income.

(3) Cost of main business: The high cost of the main business may be due to good sales of the enterprise's products, or excessive inventory due to poor sales due to more production. The cost of the main business reflects the capital invested in the daily operation of enterprises and affects the financing demand to a certain extent.

3.3.2 Output indicators

(1) Net profit: The net profit of an enterprise can directly reflect its profitability.

(2) Return on equity: Return on equity reflects an enterprise's ability to create value by using existing assets, and a higher return on equity corresponds to a higher level of fund application.

(3) Total assets turnover rate: The total assets turnover rate reflects whether the internal and external capital circulation of the enterprise is good. The higher total assets turnover rate corresponds to the faster capital flow speed, indicating that the application of enterprise funds is better.

(4) Growth rate of main business income: The growth rate of main business income reflects the operation status and growth effect of the enterprise, which can help judge the current development stage of the enterprise. The larger the value, the larger the growth space and development potential of the enterprise, and the enterprise is in the growth stage.

3.4. Data processing

The obtained data are processed dimensionless, and the function formula is $x'=(x\text{-MIN})/(\text{MAX-MIN})$, where MIN and MAX are respectively the minima and maximum values in the index data. After processing, the values of data all fall within [0, 1], which meets the requirement of data non-negativity of the DEA model.

4. Empirical analysis of financing efficiency

DEAP2.1 was used to conduct static measurement analysis on 356 sample enterprises, and the comprehensive technical efficiency, pure technical efficiency, scale technical efficiency and return to scale from 2016 to 2021 were obtained.

4.1. Comprehensive technical efficiency

Comprehensive technical efficiency (TE) reflects the ratio between the output and input of financing activities of enterprises, and its value is positively correlated with financing efficiency. The closer TE is to 1, the higher the financing efficiency of enterprises is. As can be seen from Table 1, most of the sample enterprises are in [0, 0.5], the comprehensive technical efficiency is low, and the overall financing efficiency of the industry is low. In the past six years, very few sample enterprises

have achieved financing effectiveness (h=1), and most of the sample enterprises are in a non-financing effective state. Among them, the number of sample enterprises that reached DEA effectiveness was the largest in 2017. In that year, 14 sample enterprises reached the optimization of financing efficiency, which achieved no excess input, no little surplus output, and both the optimal pure technical efficiency and the optimal scale efficiency.

Table 1. Distribution of comprehensive technical efficiency

Year	Efficiency level	0≤h<0.5	0.5≤h<0.8	0.8≤h<1	h=1
2016	quantity	296	36	11	13
	proportion	0.831461	0.101124	0.030899	0.036517
2017	quantity	305	28	9	14
	proportion	0.856742	0.078652	0.025281	0.039326
2018	quantity	327	16	3	10
	proportion	0.918539	0.044944	0.008427	0.02809
2019	quantity	323	20	3	10
	proportion	0.907303	0.05618	0.008427	0.02809
2020	quantity	328	18	1	9
	proportion	0.921348	0.050562	0.002809	0.025281
2021	quantity	326	18	2	10
	proportion	0.91573	0.050562	0.005618	0.02809

4.2. Pure technical efficiency

Table 2. Distribution of pure technical efficiency

Year	Efficiency level	0≤h<0.5	0.5≤h<0.8	0.8≤h<1	h=1
2016	quantity	269	50	11	26
	proportion	0.755618	0.140449	0.030899	0.073034
2017	quantity	253	49	18	36
	proportion	0.710674	0.13764	0.050562	0.101124
2018	quantity	278	46	7	25
	proportion	0.780899	0.129213	0.019663	0.070225
2019	quantity	290	34	7	25
	proportion	0.814607	0.095506	0.019663	0.070225
2020	quantity	296	32	6	22
	proportion	0.831461	0.089888	0.016854	0.061798
2021	quantity	296	33	7	20
	proportion	0.831461	0.092697	0.019663	0.05618

Pure technical efficiency (PTE) reflects the daily operation status of the enterprise. The closer PTE is to 1, the better the enterprise's capital utilization and the higher the enterprise's management efficiency. It can be seen from Table 2 that most sample enterprises in the six years were in the low-efficiency interval [0, 0.5], which was characterized by less in the middle and more on both sides. The number of sample enterprises that achieved pure technical efficiency and effectiveness (h=1) increased first and then decreased, and the number was maximized in 2017.

4.3. Scale technical efficiency

Technical efficiency to scale (SE) reflects the minimum input ratio between constant return to scale and variable return to scale at a certain output level, which is used to measure whether an enterprise's current input and output reach the optimal balance. The closer SE is to 1, it indicates that the enterprise currently wastes fewer resources, and there is no shortage of production input, which can meet the normal production demand and has high output capacity. According to the output results of DEAP2.1, most sample enterprises are in the high-efficiency range of [0.8, 1], indicating that the

overall scale efficiency of the industry is relatively high. The number of enterprises achieving optimal scale efficiency (h=1) reached the maximum in 2017, indicating that 28 sample enterprises (7.86%) were in the optimal state of input and output, with no resource waste and no input shortage.

Table 3. Distribution of scale technical efficiency

Year	Efficiency level	0≤h<0.5	0.5≤h<0.8	0.8≤h<1	h=1
2016	quantity	31	74	232	19
	proportion	0.087079	0.207865	0.651685	0.053371
2017	quantity	71	94	163	28
	proportion	0.199438	0.264045	0.457865	0.078652
2018	quantity	74	147	123	12
	proportion	0.207865	0.412921	0.345506	0.033708
2019	quantity	39	88	214	15
	proportion	0.109551	0.247191	0.601124	0.042135
2020	quantity	47	86	212	11
	proportion	0.132022	0.241573	0.595506	0.030899
2020	quantity	46	102	195	13
	proportion	0.129213	0.286517	0.547753	0.036517

4.4. Return to scale

Table 4. Returns to scale

Year	Scale	Increasing returns to scale (IRS)	Constant returns to scale (-)	Diminishing returns to scale (DRS)
2016	quantity	91	30	235
	proportion	0.255618	0.08427	0.660112
2017	quantity	36	58	262
	proportion	0.101124	0.162921	0.735955
2018	quantity	29	36	291
	proportion	0.081461	0.101124	0.817416
2019	quantity	45	56	255
	proportion	0.126404	0.157303	0.716292
2020	quantity	71	29	256
	proportion	0.199438	0.081461	0.719101
2021	quantity	110	30	216
	proportion	0.308989	0.08427	0.606742

The BCC model also gives the state of return to scale. If it is in the state of increasing returns to scale (IRS), it indicates that the increasing proportion of output will be greater than the increasing proportion of input, and production has a scale effect. At this time, increasing output is beneficial to production. If the enterprise is in the state of diminishing returns to scale (DRS), it indicates that the increasing proportion of output is less than the increasing proportion of input, and the scale effect no longer exists, so it should not continue to increase production input. If the return to scale is unchanged, the increased proportion of output is equal to the increased proportion of output. In this case, whether production input can be increased or not has no effect on output.

According to the output results, most sample enterprises are in a state of decreasing returns to scale, and their distribution increases first and then decreases. The number of sample enterprises in the state of increasing returns to scale decreased first and then increased, indicating that manufacturing enterprises still have some room for adjustment in the past two years. A small number of enterprises can get more output by increasing production input, and their financing efficiency can be further improved.

4.5. Analysis of slack variables

For the enterprises that did not reach the DEA effective level from 2016 to 2021, the slack variables were analyzed, and the input and output indicators were adjusted, to clarify the direction of improvement. In this paper, the average value of a slack variable of 356 sample enterprises in six years was counted.

Table 5. Changes in average slack variables of sample enterprises

Year	Investment redundancy -- Slack variable (S-)			Insufficient output -- slack variable (S+)			
	Total assets	Asset liability ratio	Main business cost	Net profit	Return on equity	Total asset turnover	Main business revenue growth rate
2016	-0.002	-0.007	-0.003	0.007	0.183	0.02	0.001
2017	-0.002	-0.006	-0.002	0.003	0.045	0.016	0
2018	-0.001	-0.005	-0.003	0.015	0.006	0.023	0
2019	0	-0.002	-0.002	0.013	0.006	0.021	0
2020	0	-0.005	-0.001	0.013	0.028	0.021	0
2021	-0.001	-0.003	0	0.007	0.018	0.009	0

For the target to be decided that does not reach the effective DEA, the DEA model will give the suggested adjustment index of a slack variable. The slack variable S- and the slack variable S+ respectively represent that reducing the index input and increasing the index input can make the target to be decided to achieve DEA effectively. The larger the index value is, the greater the adjustment required for the index is, and the lower the enterprise financing efficiency itself is, that is, there is a negative correlation between the enterprise financing efficiency and the absolute value of the slack variable. According to Table 5, from 2016 to 2021, output indicators of sample enterprises need to be adjusted more than input indicators. Among the output indicators, the absolute value of the slack variable of return on equity is the largest, which proves that the average profit of manufacturing enterprises is too low compared with the scale of their output, the profitability is poor, and the efficiency of using existing inputs to obtain profits is not high. It is speculated that there are unreasonable capital allocation phenomena in the daily operation of enterprises, and the maximum output is not obtained. Subsequent manufacturing enterprises should pay attention to improving the efficiency of daily capital use, creating more value for enterprises, and increasing the output of enterprises. The input indicators as a whole need to make fewer adjustments, indicating that the average input of the manufacturing sector is in good shape based on current output. It is worth mentioning that the slack variable in the growth rate of the main business is 0 for five consecutive years, indicating that the average growth ability of manufacturing enterprises is good at this stage, and the industry as a whole is in a period of rising development. Based on the above, in the subsequent operation, manufacturing enterprises should try their best to improve the utilization and transformation ability of the existing input and reduce the redundancy of input. On the other hand, companies should also strive to improve their profitability.

5. Empirical summary

According to the empirical analysis, from the perspective of static efficiency, the overall financing efficiency of manufacturing enterprises is not high, and most enterprises are in a situation of low or relatively ineffective financing efficiency, and there is a large room for improving the financing efficiency of enterprises. From the perspective of disassembly, the scale efficiency of enterprises is higher while the pure technical efficiency is lower, and the pure technical efficiency plays a more important role, which is reflected in the overall low comprehensive technical efficiency. Comparatively speaking, the overall scale efficiency of manufacturing enterprises is higher, and the enterprise growth ability is good, which belongs to the rising stage of development.

From the perspective of returns to scale and slack variables, most enterprises are in a decreasing return to scale, but the decreasing scale decreases year by year. In contrast, enterprises with increasing scale are constantly increasing, indicating that more and more enterprises can achieve economies of scale by expanding financing scale and increasing investment. On the other hand, more output deficiencies in the analysis table of slack variables indicate that the overall profitability of current manufacturing enterprises is low, and the utilization rate and conversion rate of existing resources input are not high.

6. Conclusion

The DEA model is used to measure the financing efficiency of 356 manufacturing enterprises listed on GEM from 2016 to 2021, and research suggestions are given from the perspectives of the government and enterprises.

6.1. Enterprise Perspective

(1) Improve the daily operation and management level of enterprises, and improve the operation level of enterprises' capital.

The results of static financing efficiency show that the main reason for the breakdown of low financing level into the BCC model is the influence of low pure technical efficiency, that is, the current failure of enterprises to achieve financing efficiency is caused by improper internal management and low utilization rate of funds [13]. Therefore, in the subsequent sustainable operation, enterprises should pay attention to the improvement of management level and improve the efficiency of capital allocation. The specific suggestions are as follows:

1) Establish the assessment and incentive mechanism of centralized management of funds. Enterprises can formulate specific assessment methods before, during, and after the event, so that the use of funds can be implemented for individuals so that the interests of enterprises are directly related to the interests of employees. At the same time, the enterprise can also use the efficient use of funds of the department or individual model evaluation, encouraging others to take the initiative to learn. Enterprises can consider establishing a perfect supervision system, including audit departments, discipline inspection departments, etc., to regularly understand and record the use of funds of various departments and use them as evaluation indicators for performance appraisal and other work.

2) Build a safe and efficient fund management information exchange platform. Information exchange is not smooth and easily causes the internal flow of funds in the enterprise to be not transparent, and not timely. Enterprises can strictly track the source and destination of each fund based on big data development technology to provide convenience and a basis for accounting and save a lot of human resources.

3) Implement comprehensive budget management and improve the existing capital operation ability. Enterprises should strictly implement the capital budget in their daily operations, centralize the income and expenditure of the enterprise capital into the budget management system, conduct a comprehensive budget for the use of funds, timely fill the fund gap, optimize the fund structure, and control liquidity risks.

(2) Rational expansion and optimization of enterprise financing structure. According to the return to scale, enterprises with decreasing scale are decreasing year by year, and the industry as a whole has a certain space for development. Some enterprises can conduct appropriate financing expansion to expand their scale.

(3) Improve the profitability of enterprises and improve the utilization rate of existing resources. According to the results of slack variables, the output gap of enterprises is large, profit income and resource input are not suitable, but the growth space is large, enterprises should seize the industry opportunities, through expanding financing, optimizing management, product upgrading, and other ways to improve the profitability of enterprises.

6.2. Government Perspective

(1) Broaden financing channels for manufacturing enterprises. The government may consider increasing government financial support for manufacturing enterprises and providing more special funds for enterprises with development potential. At the same time, the government can encourage banks and the IMF to relax financing support for small and medium-sized creative enterprises if they meet basic assessment requirements.

(2) Create a favorable policy environment for the development of the manufacturing industry. Based on "Made in China 2025", the government can formulate relevant policy plans to send good industry signals to the manufacturing market and guide more capital inflows. At the same time, the government also needs to make a good industrial plan for future development and transformation of the manufacturing industry, so that the manufacturing industry will assume the important task of leading China's economic development.

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