Research on Strategic Decision Model of Contribution Rate of Intelligent Manufacturing Factor and Production Efficiency of Total Factor——Take Liaoning Equipment Manufacturing Enterprises as Example

[1st] Zimin Yin[1,a], [2nd] Jin Yin[2,b*], [3nd] Xin Geng[3,c], [4nd] Lida Song[1,d]

{ lgdyzm@163.com[a], yinjin850731@163.com[b*], 2022t0084@pwu.edu.ph[c], 3161016825@qq.com[d]}

[1]School of Management Engineering, Liaoning Institute of Science and Engineering, Jinzhou P.R.China,
[2]School of Economics and Management, Xiamen University of Technology, Xiamen P.R.China,
[3]School of Fine Arts & Designm Philippine Women's University, Manila Philippines

Abstract. In order to scientifically measure the optimal allocation effect of all input factors and the contribution rate of the intelligent manufacturing factor, based on Industry 4.0, based on the principle of C.W.Cobb- PaulH.Douglas production function it builds production efficiency of the total factor mathematical models and it reflectes overall output effect of total inputting production factors of equipment manufacturing enterprises, and it reflects the utilization efficiency of all input factors and the effect of factor optimal allocation of materialized labor factor, live labor factors and intelligent manufacturing factor of equipment manufacturing enterprises, and it realizes scientific measurement of the overall economic efficiency of materialized labor, live labor factors and intelligentized level of equipment manufacturing. Meanwhile by combining the rate of intelligent manufacturing elements with the production efficiency of the total factor two-dimensional elements this paper establishes the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor. This strategic decision model incorporates Industry 4.0 smart manufacturing ideas into the research process, it enriches and develops the concept of the Boston matrix model in some extent, and it comprehensively reflects the corresponding relationship between production efficiency of the total factor and intelligent factor contribution rate of each sample rely on the graphical approach. According to specific location of each company in this strategic decision model decision makers can clearly complete their strategic environment analysis of SWOT,and it will provide the scientific basis for every enterprise to make strategy of optimizing the allocation of intelligent manufacturing resources and implement intelligent manufacturing.

Keywords: Industry 4.0; Cobb-Douglas production function; production efficiency of the total factor; contribution rate of the intelligent manufacturing factor; strategic decision model.

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1 Introduction

Production, operation and management process of equipment manufacturing enterprises is a comprehensive action process of the materialized labor and live labor, the integration degree of these production factors will determine the overall output effect[1], enterprise production efficiency of the total factor level depends on the enterprise technical equipment and its intelligent and digital configuration,the level of enterprise digitization and intelligentization directly determines the level of enterprise technological progress, and it also determines the use efficient of intelligent manufacturing resources[2]. So, in Industry 4.0 times, the idea of intelligent production and intelligent economy is integrated into the technological progress research and strategic decision-making process of enterprises, this will be helpful to analyze and study the efficiency of intelligent manufacturing resources optimal allocation and its comprehensive application effect of equipment manufacturing enterprises based on the background of intelligent manufacturing.

In the past strategic decision-making method research process, most scholars use Boston matrix model to analyze strategic environment and strategic decision. But because the Boston matrix model establishes the strategic decision-making model rely solely on a single metric as the horizontal and vertical coordinates[3], its decision-making is based on a single basis. Therefore this research combines the contribution rate of intelligent manufacturing factors with the production efficiency of the total factor two-dimensional factors, and it creates strategic decision models of intelligent factor contribution rate strategy and production efficiency of the total factor, its horizontal coordinates is the production efficiency of the total factor, it is the ratio of enterprise total output value with all input factors in a certain period, and it reflects the total efficiency of production factors of materialized labor and live labor from the overall perspective; At the same time, the vertical coordinates of this strategic model is the contribution rate of the intelligent manufacturing factor, it is the intelligence contribution to output efficiency in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, and it reflects the resource efficiency of enterprise intelligent manufacturing from the perspective of science and technology, and the development level of enterprise digitization and intelligentization. This strategic decision model comprehensively reflects the corresponding relationship between production efficiency of the total factor and intelligent factor contribution rate of each sample rely on the graphical approach, it can accurately and effectively analyze the action degree of enterprise intelligence factors to production efficiency of the total factor. The application of this strategic model will provide method support for enterprises to optimization allocation method of intelligent manufactur and to realize digital and intelligent strategy.

2 Principle of strategic decision model of contribution rate of intelligent manufacturing factor and production efficiency of the total factor

In the strategic decision models of intelligent factor contribution rate and production efficiency of the total factor, its horizontal coordinates is the production efficiency of the total

factor, and its vertical coordinates is the contribution rate of the intelligent manufacturing factor. The strategic state of each sample in the strategic decision model can be observed by this strategic decision models, then rely on the strategic environment of each sample to make strategic decisions.

2.1 Establishment of contribution rate model of intelligent factors

The contribution rate of the intelligent manufacturing factor is the intelligence contribution to output efficiency in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, and it reflects the resource efficiency of enterprise intelligent manufacturing from the perspective of science and technology, and the development level of enterprise digitization and intelligentization, , and it is a mathematical model based on the production function Model of C.W.Cobb-PaulH.Douglas[4]. The production function model of C.W.Cobb-PaulH.Douglas reflects the quantitative relationship between total output and total input of the materialized labor and live labor, usually, after obtaining the big sample data of the total output amount and total input amount of the materialized labor and live labor a certain period, the production function model can be obtained based on big data processing, the specific models are as follows:

$$O=EAC^{\alpha}L^{\beta} \quad (1)$$

In the above model (1), O is the total output value of an enterprise in a given period of operation; EA is contribution rate of the intelligent manufacturing factor, it is the intelligence contribution to output efficiency in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, and it reflects the resource efficiency of enterprise intelligent manufacturing from the perspective of science and technology, and the development level of enterprise digitization and intelligentization; C is corresponding input value of the materialization labor of enterprises; L is the corresponding input amount of live labor input quantity of enterprises; α is an output elasticity of the materialization labor of enterprises; β is a output elasticity of live labor of enterprises.

The production function model is established according to the sample statistical data, furthermore, the contribution rate model of intelligent manufacturing factors can be established:

$$EA=O/(C^{\alpha}L^{\beta}) \quad (2)$$

In the above model (2), O, EA, C, L, α, β have the same meaning as model (1).

2.2 Principles of the enterprise production efficiency of the total factor model

The production efficiency of the total factor of enterprises is the ratio of enterprise total output value with all input factors in a certain period, and it reflects the total efficiency of production factors of materialized labor and live labor of enterprises from the overall perspective. The production efficiency of the total factor not only reflects the total using efficiency of the materialized labor and live labor of enterprises, but also reflects the input amount of enterprise asset input value and labor input quantity of enterprises, and it also reflects the enterprise integration degree of intelligent manufacturing and digitization[5]. The model of production efficiency of the total factor is as follows:

$$TFPE=O / (C+bL) \quad (3)$$

In the above model(3), TFPE is production efficiency of the total factor; O is the total output of enterprises; C is corresponding input value of the materialization labor of enterprises; L is the corresponding input amount of live labor input quantity of enterprises; b is a quantity equivalent of live labor input and the materialized labor input, and it can realize the normalization of live labor input quantity and materialized labor input value. The associated model of quantity equivalent is:

$$b=\beta C^1 / (\alpha L^1) \quad (4)$$

In the above model(4), b is a quantity equivalent of live labor input and the materialized labor input; C^1 is the average value of input value of materialized labor; L^1 is the average value of input quantity; α is an output elasticity of the materialization labor of enterprises; β is a output elasticity of live labor of enterprises.

2.3 Establishment of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor

In the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor, the horizontal coordinates is production efficiency of the total factor, and the longitudinal coordinate is the contribution rate of the intelligent manufacturing factor, the horizontal and vertical coordinates divide the plane into four areas. Based on the basic principle of matrix strategic decision model of BCG[3], this strategic decision model is divided into four strategic areas: (1)in the upper right area not only is higher of the production efficiency of the total factor, and it's also a higher of the contribution rate of the intelligent manufacturing factor. The companies located in this area are higher in the overall combination efficiency of materialized labor and live labor, and it also has advantages in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation. So these companies should choose the scale and market development strategy modal, by the integration strategic model of digital, intelligent and personalized development they become the leading equipment manufacturers on the basis of its high production efficiency of the total factor, especially its leading edge in contribution rate of the intelligent manufacturing factor. (2)in the upper left area the production efficiency of the total factor is lower, but its contribution rate of the intelligent manufacturing factor is higher. The companies located in this area have to take advantage in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, they should realize the optimized combination efficiency of materialized labor and living labor factor. So these companies should choose the centralized strategic model, they should concentrate limited intelligent manufacturing resources to develop product projects that are in short supply in the market, and to meet the needs of specific markets, so to develop the market and improve market share, and then improve their overall utilization efficiency of materialized labor and live labor; (3)in the lower left area the production efficiency of the total factor is lower, furthermore its contribution rate of the intelligent manufacturing factor is also lower. The companies located in this area are not only poor in the optimized combination efficiency of materialized labor and living labor factor, but are also weak in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements,

intelligent production of man-machine cooperation. So these companies should choose concretionary strategic model, while retaining core products and technologies they should give up products with low market share or profitability, and they should develop new product projects to look for new market development opportunities; (4)in the lower right area the production efficiency of the total factor is lower, but its contribution rate of the intelligent manufacturing factor is higher. The companies located in this area although they are not high in the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, but they should make full use of their advantages in the optimized combination efficiency of materialized labor and living labor factor. So these companies should choose a harvest-based strategic model, these enterprises rely on the optimal allocation of intelligent manufacturing resources to achieve product technological transformation or improvement, they maintain and increase their existing market share by further extending the life cycle of product projects, and to generate greater sales and profits.

3 Application Examples

3.1 Selection of evaluation samples and data

This paper takes 20 equipment manufacturing companies of Liaoning as the research object, and it uses cross-sectional data of the previous year as evaluation samples, and it takes revenues as the value of total output, it takes the average balance of fixed assets as the input value of assets, and it takes the average number of workers as the amount of labor input, and it collects and collates data from the previous year. The relevant data is shown in columns 2-4 of Table 1.

Table 1. Analysis table of contribution rate of intelligence factors and total factor production efficiency.

Sample	Ln(Y)	Ln(K)	Ln(L)	EA(%)	TFPE
1	14.473	12.221	9.239	14.392	490.139
2	14.903	13.429	8.838	13.977	367.641
3	15.154	12.069	10.205	13.746	564.345
4	15.133	13.347	10.255	13.765	323.718
5	15.552	13.446	11.078	13.394	300.275
6	14.608	11.356	9.343	14.259	743.358
7	13.512	11.688	9.565	15.416	192.418
8	16.062	13.530	10.156	12.968	769.383
9	16.167	12.849	9.958	12.884	1360.102
10	13.739	12.140	9.308	15.161	236.467
11	16.008	13.472	10.568	13.012	626.546
12	13.738	11.842	8.188	15.163	449.647
13	13.733	11.385	7.338	15.168	790.275
14	17.851	14.282	11.884	11.669	1321.268
15	14.216	13.538	8.244	14.652	180.175
16	13.691	12.729	8.778	15.214	192.829
17	12.638	11.409	8.786	16.482	145.596
18	13.745	11.569	8.323	15.155	511.754
19	13.489	11.479	8.164	15.442	446.102
20	13.671	11.553	8.078	15.237	527.903

3.2 The establishment of production function model of companies

According to Model (1) , after inputting the relevant cross-sectional data of 20 equipment manufacturing companies into the software of SPSS, the production function model of total companies is established:

$$O=AC^{\alpha}L^{\beta}=e^{2.083}C^{0.569}L^{0.583} \quad (5)$$

According to the calculation results of the software of SPSS, the complex correlation coefficient (R)of the model(5) is 0.882, it shows that the model(5) there is a strong correlation; Meanwhile, the significance test index of the model(5) is 29.794, and because significance test index of the model(5) is much larger than the threshold $F_{0.005}(2,19)= 7.09$, and since the Sig. of the model(5) is 0.000, it shows that the model (5) is highly significant.

3.3 The contribution rate analysis of companies intelligence factors

According to Model (2), the contribution rate of the intelligent manufacturing factor of 20 equipment manufacturing companies is calculated, the results are shown in column 5 of Table 1. The results of the following analysis are obtained from Table 1. (1)the company with the highest contribution rate of the intelligent manufacturing factor is company 17 (16.482%), the order are company 19, company 7, company 20, company 16, company 13, company 12, company 10, company 18，the contribution rate of the intelligent manufacturing factor of these 9 enterprises is above 15%, it shows that these enterprises are more advanced in the aspects of optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation; (2)the companies with high contribution rate of the intelligent manufacturing factor are company 15, company 1 and company 6 respectively, the contribution rate of the intelligent manufacturing factor of these three companies is between 14% and 15%, it shows that these companies need to be further improved in the aspects of in the aspects of optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation. (3)the companies with lower contribution rate of the intelligent manufacturing factor are company 2, company 4, company 3, company 5, and company 11, the contribution rate of the intelligent manufacturing factor of these five companies is between 13% and 14%, it shows that these companies urgently need to take corresponding measures to upgrade in the aspects of optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation; (4)the companies with the lowest contribution rate of the intelligent manufacturing factor are company 14 (11.669%), and companies 9 and company 8, the contribution rate of the intelligent manufacturing factor of these three companies is below 13%, it shows that these three companies have big problems in the aspects of optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation, these three companies urgently need to strengthen the digital and intelligent construction.

3.4 Analysis of production efficiency of the total factor of companies

According to Model (3) and (4), this paper is calculates the production efficiency of the total factor of 20 equipment manufacturing companies, the calculation results are shown in the last

column of Table 1. according to Table 1 this paper makes follows analysis: (1)the companies with the highest production efficiency of the total factor were company 9 (1360.102 Million dollars) and company 14(1321.268 Million dollars), the production efficiency of the total factor of these two companies were above 1000 Million dollars, it shows that these two companies are the most outstanding in the organic integration configuration of the materialized labor and live labor; (2) the companies with the higher production efficiency of the total factor were company 13, company 8 and company 6, the production efficiency of the total factor of the three companies ranged from 700 Million dollars to 1,000 Million dollars, it shows that the three companies have better effect in the organic integration configuration of the materialized labor and live labor; (3)the companies with the lower production efficiency of the total factor were company 11, company 3, company 20, company 18, company 1, company 12 and company 19, the production efficiency of the total factor of these seven samples are between 400 Million dollars and 700 Million dollars, it shows that these 7 enterprises are poor in the organic integration configuration of the materialized labor and live labor; (4)the companies with the lowest production efficiency of the total factor were company 17 (145.596 Million dollars), and company 15, company 7, company 16, company 10, company 2, company 4 and company 5, the production efficiency of the total factor of the companies were all below 400 Million dollars, it shows that the 8 companies are very poor in the organic integration configuration of the materialized labor and live labor, these 8 enterprises belong to the urgent need to take measures to reform the enterprise.

3.5Analysis of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor

Given the matrix strategic decision model of BCG divides the strategic area by the average level, therefore, the horizontal and vertical coordinates of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor divides strategic regions by median. The horizontal coordinates of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor is production efficiency of the total factor, it comprehensively reflects the integration and distribution of materialized labor and live labor. At the same time, it takes the intelligence factor contribution rate as the vertical coordinate of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor, it reveals the developing power of enterprise intelligent manufacturing from the perspective of intelligent manufacturing resource combination optimization. Based on the relevant data in Table 1, this paper makes all the companies strategic location map on the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor in Figure 1.

According to Figure 1: (1)in the right upper area not only is higher of the production efficiency of the total factor, and it's also a higher of the intelligent manufacturing factor. The companies located in this area have company 13 and company 6, these two companies should choose the scale and market development strategy modal, they should make the most of their lead in the higher production efficiency of the total factor and higher contribution rate of the intelligent manufacturing factor. So these two companies should research and develop more intelligent technology equipment based on digital technology as the core, and maintain a leading position in equipment manufacturing; (2)in the left upper area the production

efficiency of the total factor is lower, but the contribution rate of the intelligent manufacturing factor is higher. The companies located in this area have company 20, company 18, company 19, company 12, company 1, company 17, company 10, company 7, company 16 and company 15, these 10 companies should choose the centralized strategic model, they should concentrate limited intelligent manufacturing resources to develop product projects that are in short supply in the market, and to meet the needs of specific markets, so to develop the market and improve market share, and then promote the integration efficiency of materialized labor and live labor; (3)in the left lower area the production efficiency of the total factor is lower, furthermore the contribution rate of the intelligent manufacturing factor is also lower. The companies located in this area have company 5, company 4, company 11, company 2 and company 3, These five companies should choose concretionary strategic model, while retaining core products and technologies they should give up products with low market share or profitability, and they should develop new product projects to look for new market development opportunities; (4)in the right lower area the production efficiency of the total factor is lower, but the contribution rate of the intelligent manufacturing factor is higher. The companies located in this area have company 9, company 14 and company 8, these three enterprises should choose a harvest-based strategic model, these companies rely on the optimal allocation of intelligent manufacturing resources to achieve product technological transformation or improvement, they maintain and increase their existing market share by further extending the life cycle of product projects, and to generate greater sales and profits[6].

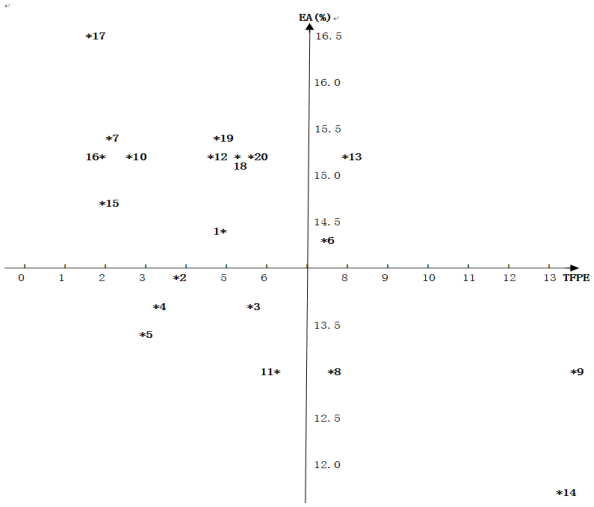

Figure 1. Strategic decision diagram of contribution rate of intelligent manufacturing factor and production efficiency of total factor

4 Conclusion

This paper draws important conclusions based on relevant research work of the strategic decision model of contribution rate of the intelligent manufacturing factor and production efficiency of the total factor: (1)this strategic decision model not only realizes the analysis of total input and total output efficiency, but also realizes the contribution degree measurement

of the optimal allocation of enterprise intelligent manufacturing resources, transformation of scientific and technological achievements, intelligent production of man-machine cooperation to output value; (2)this strategic decision model comprehensively reflects the corresponding relationship between production efficiency of the total factor and intelligent factor contribution rate of each sample rely on the graphical approach, it can accurately and effectively analyze the action degree of enterprise intelligence factors to production efficiency of the total factor; (3) this strategic decision model incorporates Industry 4.0 smart manufacturing ideas into the research process, it enriches and develops the concept of the Boston matrix model in some extent, and this will provide some reference for related scholars to continue further study and application of Boston matrix model; (4)according to specific location of each company in this strategic decision model decision makers can clearly complete their strategic environment analysis of SWOT, and it will provide the scientific basis for every enterprise to make strategy of optimizing the allocation of intelligent manufacturing resources and implement intelligent manufacturing. The application examples show that this research is practical and scientific.

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About the Author: Corresponding author: Yin Jin (1985-), Associate professor, Doctor. Work unit: School of Economics and Management, Xiamen University of Technology; E-mail address: yinjin850731@163.com.

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