# Input-output benefit analysis of automobile industry based on grey correlation method

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**Abstract.** The automotive industry is an important pillar and strategic industry of the national economy, as well as an important area for stabilizing growth, promoting consumption, and ensuring employment. This article selects 11 listed vehicle companies as samples, and based on input-output theory, constructs a financial indicator system for input-output using the financial statement correlation data of the companies. The grey correlation method is used for systematic analysis, and based on the analysis results, countermeasures and suggestions for the sustainable development of China's vehicle companies are proposed.

**Keywords:** whole vehicle enterprises; Grey correlation method; Input-output efficiency; financial data

## 1 Introduction

With the rapid development of the global economy, the automotive industry has become increasingly significant in the national economy. As a key industrial field, the input-output benefit analysis of vehicle enterprises is of great significance for understanding the development trend of the automotive industry, optimising resource allocation and formulating relevant policies. Grey correlation analysis is an analytical method that examines the degree of correlation between multiple factors and is suitable for small samples and incomplete information[1].In this paper, the grey correlation method is used to analyse the input-output benefits of the automotive industry, aiming to reveal the degree of influence of each factor on the economic benefits of the automotive industry, and to provide reference for the sustainable development of the automotive industry.

## 2 Data sources

Based on the "Market Capitalisation of Major Domestic Traditional Vehicle and Dealership Listed Companies in September 2023" released publicly by the Automotive Market Capitalisation Research Group of China Automotive News in September 2023, we have selected the top 15 companies in the order of BYD, Great Wall Motor,


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SAIC, Changan Automobile, Guangzhou Automobile Group, Geely Automobile, Sailis, Zhongsheng Holdings, FAW Jiefang, BAIC Blue Valley, Yutong Bus, JAC, Foton Motor, Brilliance China, Beijing Automobile. On this basis, due to the difference in the statistical calibre of the relevant financial statements of Hong Kong stocks and A-shares, part of the data is not easy to obtain, so "Geely Automobile", "Brilliance China" and "Beijing Automobile" are excluded. Because "Zhongsheng Holdings" is a dealer group, it is excluded. This article is based on the financial statements of 11 automotive companies from 2020 to 2022 (data from "https://www.10jqka.com.cn/").

## 3 Grey correlation analysis

Grey correlation analysis as an important method used to analyse the closeness of the relationship between the resultant factors and the influencing factors in a system, the basic idea is to judge whether the connection is close or not based on the similarity of the data series, firstly, by calculating the relative correlation and absolute correlation matrices of the system characteristics and the factor series, and then calculating the comprehensive grey correlation.

Input-output analysis is a method of economic analysis based on both inputs and outputs that provides a comprehensive picture of the interrelationships between industries in an economic system[2]. T. A. Alageel et al. used a cost-benefit analysis model to evaluate the input-output benefits of introducing smart grid technology into infrastructure[3].Shakila et al. used a two-stage data envelopment analysis method to evaluate the efficiency of 21 solar mini grids in Bangladesh for the first time, including land cost, number of service users, unit user consumption, power generation, distribution network, and annual electricity consumption[4].The input indicators selected in this paper are "operating revenues"; "total profits", and the output indicators selected are "cash paid for purchasing goods and services", "selling expenses", "management expenses", "research and development expenses", "Cash paid for acquisition of fixed assets, intangible assets and other long-term assets", "Cash paid for goods and services", "Cash paid to and for employees".

**Table 1.** List of data relating to the financial statements

| OEMs | Year | $Y_1$ | $Y_2$ | $X_1$ | $X_2$ | $X_3$ | X4 | $X_5$ | $X_6$ |
|---|---|---|---|---|---|---|---|---|---|
| BYD | 2022 | 42406064 | 2107973 | 1506068 | 1000737 | 1865445 | 9745686 | 22084250 | 5351973 |
| | 2021 | 21614240 | 451800 | 608168 | 571019 | 799097 | 3734361 | 10439912 | 2875975 |
| | 2020 | 15659769 | 688259 | 505561 | 432149 | 746486 | 1177409 | 6926012 | 2252147 |
| Great Wall Motors | 2022 | 13733999 | 880655 | 587616 | 489345 | 644516 | 1630082 | 12067457 | 1255252 |
| | 2021 | 13640466 | 748210 | 519218 | 404307 | 448957 | 1309104 | 10608666 | 989289 |
| | 2020 | 10330761 | 622729 | 410339 | 255267 | 306748 | 806159 | 9057052 | 729520 |
| SAIC Motor | 2022 | 74406288 | 2807108 | 3017540 | 2564138 | 1803092 | 2293472 | 45588373 | 3701625 |
| | 2021 | 77984579 | 4155766 | 2950510 | 2410353 | 1966850 | 1874270 | 52649655 | 3902710 |

| OEMs | Year | $Y_1$ | $Y_2$ | $X_1$ | $X_2$ | $X_3$ | X4 | $X_5$ | $X_6$ |
|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 74213245 | 3589162 | 2555133 | 2181841 | 1339504 | 1513782 | 53239795 | 3672758 |
| Changan Automobile | 2022 | 12125286 | 770826 | 513827 | 353246 | 431544 | 140500 | 9736998 | 918824 |
| | 2021 | 10514188 | 382061 | 464565 | 349965 | 351503 | 200977 | 9021468 | 760005 |
| | 2020 | 8456554 | 259659 | 340591 | 417177 | 288887 | 296005 | 6346893 | 604864 |
| Guangzhou Automobile Group | 2022 | 11000644 | 746251 | 422846 | 416780 | 170679 | 801351 | 11452796 | 841418 |
| | 2021 | 7567577 | 723688 | 433976 | 393391 | 98870 | 624294 | 7551899 | 721582 |
| | 2020 | 6315699 | 569508 | 364148 | 335611 | 97638 | 658556 | 6321690 | 635825 |
| Sailis | 2022 | 3410500 | -493041 | 481962 | 177534 | 131366 | 74976 | 2269869 | 226889 |
| | 2021 | 1671792 | -260986 | 127996 | 108875 | 94799 | 105610 | 1419500 | 173441 |
| | 2020 | 1430248 | -218718 | 72853 | 89253 | 83698 | 47749 | 1188282 | 132444 |
| FAW Jiefang | 2022 | 3833175 | 18257 | 125588 | 204034 | 289566 | 282878 | 4267201 | 476723 |
| | 2021 | 9875124 | 410918 | 175434 | 245360 | 332895 | 249185 | 6161271 | 535253 |
| | 2020 | 11368109 | 348837 | 265403 | 271647 | 283647 | 190614 | 8687841 | 519131 |
| BAIC Blue Valley | 2022 | 951427 | -542458 | 199185 | 76867 | 124897 | 206086 | 1014878 | 64282 |
| | 2021 | 869683 | -517987 | 167171 | 79768 | 120816 | 226203 | 785476 | 80128 |
| | 2020 | 527247 | -656141 | 100807 | 74842 | 97319 | 107287 | 1413552 | 106351 |
| Yutong Bus | 2022 | 2179896 | 70776 | 163900 | 84625 | 169431 | 97566 | 1701203 | 269497 |
| | 2021 | 2323346 | 54346 | 169474 | 89359 | 156077 | 69180 | 2124144 | 295705 |
| | 2020 | 2170505 | 34771 | 155333 | 83509 | 155201 | 95700 | 1991435 | 283390 |
| JAC | 2022 | 3657736 | -138968 | 145813 | 159529 | 153697 | 24023 | 2354028 | 273787 |
| | 2021 | 4031052 | 19208 | 143727 | 175014 | 137411 | 16840 | 1646011 | 184680 |
| | 2020 | 4290597 | 13491 | 153783 | 179131 | 167669 | 10135 | 625223 | 93656 |
| Foton Motor | 2022 | 4644674 | 13614 | 178833 | 148582 | 159240 | 158642 | 2721800 | 348825 |
| | 2021 | 5497387 | -494922 | 221247 | 187538 | 171509 | 201403 | 2862954 | 392860 |
| | 2020 | 5776540 | 9189 | 254727 | 177229 | 183434 | 176131 | 2446578 | 380230 |

### 3.1 Relevance calculation

The analysis of an abstract system or phenomenon requires, first of all, the selection of data series that characterise the behaviour of the system, i.e., the mapping quantities of the system behaviour[5]. The mapping quantity is used to indirectly characterise the system behaviour. In the output efficiency system of vehicle enterprises analyzed in this paper, the operating revenues and total profits of China's head vehicle enterprises from 2020 to 2022 are selected to characterize the system, after which the characteristic mapping quantities and sequences of effective factors are processed into dimensionless data, and finally the system can be analyzed using the grey correlation axiom.

As illustrated in Table 1,The operating revenue of the automobile enterprise, which characterises the system behaviour, is marked as Y1, and the total profit of the automobile enterprise is marked as Y2, and the factors affecting the automobile enterprise, are marked as X1~X6.

Based on the above data, the grey correlation between Y1 and X1-X6 is firstly found, and then the grey correlation between Y2 and X1-X6 is found, in order to get the correlation factors affecting the sustainable development of vehicle enterprises.

Firstly, the correlation calculation between Y1 and X1-X6 is carried out to calculate the correlation coefficient of the data, and the coefficient matrix is as in Table 2:

**Table 2.** Table of correlation coefficients between $Y_1$ and $X_1$-$X_6$

| | | | | | |
|---|---|---|---|---|---|
| 0.9308 | 0.8323 | 0.7567 | 0.3335 | 0.8520 | 0.6468 |
| 0.9023 | 0.9350 | 0.9284 | 0.5982 | 0.9015 | 0.7612 |
| 0.9528 | 0.9612 | 0.8686 | 0.9464 | 0.9129 | 0.7888 |
| 0.9808 | 0.9772 | 0.8874 | 0.8212 | 0.9350 | 0.9421 |
| 0.9919 | 0.9804 | 0.9833 | 0.8857 | 0.9674 | 0.9999 |
| 0.9994 | 0.9592 | 0.9947 | 0.9565 | 0.9508 | 0.9953 |
| 0.9667 | 0.9246 | 0.7855 | 0.6037 | 0.8856 | 0.7090 |
| 0.9461 | 0.9406 | 0.8049 | 0.5444 | 0.9899 | 0.7019 |
| 0.8575 | 0.8924 | 0.6518 | 0.5341 | 0.9345 | 0.7072 |
| 0.9852 | 0.9794 | 0.9676 | 0.8531 | 0.9636 | 0.9915 |
| 0.9791 | 0.9956 | 0.9842 | 0.8873 | 0.9546 | 0.9994 |
| 0.9975 | 0.9287 | 0.9839 | 0.9396 | 0.9854 | 0.9981 |
| 0.9953 | 0.9690 | 0.9135 | 0.9686 | 0.9078 | 0.9905 |
| 0.9439 | 0.9264 | 0.9297 | 0.9590 | 0.9422 | 0.9608 |
| 0.9520 | 0.9344 | 0.9484 | 0.9309 | 0.9509 | 0.9596 |
| 0.8670 | 0.9655 | 0.9854 | 0.9633 | 0.9991 | 0.9954 |
| 0.9737 | 0.9718 | 0.9762 | 1.0000 | 0.9932 | 0.9881 |
| 0.9932 | 0.9778 | 0.9782 | 0.9890 | 0.9949 | 0.9936 |
| 0.9891 | 0.9591 | 0.9110 | 0.9881 | 0.9595 | 0.9549 |
| 0.9136 | 0.9616 | 0.9836 | 0.9072 | 0.9863 | 0.9583 |
| 0.9252 | 0.9507 | 0.9646 | 0.8735 | 0.9765 | 0.9315 |
| 0.9336 | 0.9762 | 0.9486 | 0.9607 | 0.9911 | 0.9993 |
| 0.9448 | 0.9733 | 0.9494 | 0.9542 | 0.9955 | 0.9964 |
| 0.9662 | 0.9702 | 0.9562 | 0.9799 | 0.9740 | 0.9843 |
| 0.9671 | 0.9930 | 0.9451 | 0.9899 | 0.9949 | 0.9744 |
| 0.9671 | 0.9929 | 0.9543 | 0.9797 | 0.9867 | 0.9708 |
| 0.9705 | 0.9934 | 0.9523 | 0.9895 | 0.9874 | 0.9711 |
| 0.9999 | 0.9788 | 0.9773 | 0.9463 | 0.9970 | 0.9985 |
| 0.9936 | 0.9771 | 0.9927 | 0.9387 | 0.9730 | 0.9750 |
| 0.9935 | 0.9793 | 0.9803 | 0.9330 | 0.9447 | 0.9505 |
| 0.9984 | 0.9994 | 0.9910 | 0.9651 | 0.9893 | 0.9978 |
| 0.9986 | 0.9954 | 0.9988 | 0.9624 | 0.9784 | 0.9988 |
| 0.9888 | 0.9951 | 0.9969 | 0.9514 | 0.9637 | 0.9910 |

Based on the correlation coefficient, the correlation between Y1 and X1-X6 is found to be 0.9626, 0.9620, 0.9343, 0.8798, 0.9612, 0.9328, which shows that in this sequence, X1＞X2＞X5＞X3＞X6＞X4。

On the other hand, correlation calculations between Y2 and X1-X6 were carried out to calculate the correlation coefficients of the data with the following coefficient matrix in Table 3:

**Table 3.** Table of correlation coefficients between $Y_2$ and $X_1$-$X_6$

| | | | | | |
|---|---|---|---|---|---|
| 0.7195 | 0.6509 | 0.9382 | 0.3336 | 0.6648 | 0.7550 |
| 0.9423 | 0.9042 | 0.7837 | 0.5100 | 0.9433 | 0.6458 |
| 0.8931 | 0.9017 | 0.8998 | 0.9977 | 0.8528 | 0.8029 |
| 0.8448 | 0.8480 | 0.9433 | 0.9586 | 0.8880 | 0.8807 |

| | | | | | |
|---|---|---|---|---|---|
| 0.8728 | 0.8625 | 0.8963 | 0.9881 | 0.9120 | 0.8800 |
| 0.8831 | 0.8453 | 0.8770 | 0.9255 | 0.9316 | 0.8776 |
| 0.9972 | 0.9523 | 0.7363 | 0.5556 | 0.8387 | 0.6595 |
| 0.5622 | 0.5600 | 0.5020 | 0.3735 | 0.5798 | 0.4541 |
| 0.5992 | 0.6187 | 0.4778 | 0.4028 | 0.7165 | 0.5117 |
| 0.8614 | 0.8309 | 0.8775 | 0.7259 | 0.8813 | 0.8559 |
| 0.9743 | 0.9932 | 0.9802 | 0.8739 | 0.9465 | 1.0000 |
| 0.9705 | 0.8961 | 0.9557 | 0.9559 | 0.9573 | 0.9763 |
| 0.8376 | 0.8692 | 0.7707 | 0.8695 | 0.9342 | 0.8501 |
| 0.8505 | 0.8676 | 0.7506 | 0.8368 | 0.8521 | 0.8353 |
| 0.8876 | 0.9060 | 0.8011 | 0.9098 | 0.8887 | 0.8802 |
| 0.6594 | 0.7242 | 0.7371 | 0.7724 | 0.7476 | 0.7500 |
| 0.8277 | 0.8261 | 0.8298 | 0.8496 | 0.8440 | 0.8397 |
| 0.8645 | 0.8510 | 0.8514 | 0.8810 | 0.8660 | 0.8648 |
| 0.9493 | 0.8959 | 0.8478 | 0.9251 | 0.8963 | 0.8917 |
| 0.8805 | 0.9322 | 0.9935 | 0.8737 | 0.9590 | 0.9287 |
| 0.9473 | 0.9783 | 0.9953 | 0.8854 | 0.9391 | 0.9550 |
| 0.7147 | 0.7433 | 0.7248 | 0.7329 | 0.7532 | 0.7602 |
| 0.7302 | 0.7498 | 0.7334 | 0.7367 | 0.7649 | 0.7655 |
| 0.7084 | 0.7109 | 0.7022 | 0.7169 | 0.7133 | 0.7196 |
| 0.9578 | 0.9872 | 0.9331 | 0.9934 | 0.9893 | 0.9661 |
| 0.9470 | 0.9756 | 0.9329 | 0.9933 | 0.9687 | 0.9511 |
| 0.9439 | 0.9689 | 0.9241 | 0.9889 | 0.9623 | 0.9445 |
| 0.8694 | 0.8511 | 0.8498 | 0.9229 | 0.8730 | 0.8683 |
| 0.9415 | 0.9111 | 0.9267 | 0.9956 | 0.9638 | 0.9616 |
| 0.9342 | 0.9064 | 0.9074 | 0.9966 | 0.9897 | 0.9824 |
| 0.9233 | 0.9223 | 0.9120 | 0.9586 | 0.9324 | 0.9186 |
| 0.7223 | 0.7204 | 0.7225 | 0.7481 | 0.7373 | 0.7244 |
| 0.8895 | 0.9054 | 0.8970 | 0.9512 | 0.9374 | 0.9093 |

Based on the correlation coefficient, the correlation between Y1 and X1-X6 is found to be 0.8517, 0.8505, 0.8367, 0.8224, 0.8674, 0.8353, which shows that in this sequence,X5>X1>X2 >X3>X6 >X4.

### 3.2 Analysis of results

Through the grey correlation measurement results can be seen, the various types of factors selected for operating income, total profit have a high degree of correlation, based on the results of the two sorting of various types of influencing factors, can be divided into four categories of influencing factors, namely, "cash paid for purchasing goods and services", "selling expenses" and "management expenses", for the largest impact. The second important influencing factor is "research and development expenses", the third factor is "cash paid to and for employees", for the impact of the payment of cash paid to and for the employees, the smallest impact is "cash paid for acquisition of fixed assets, intangible assets and other long-term assets".

## 4 Conclusions

Based on the analysis results of the grey correlation degree method, this paper puts forward the following suggestions for the sustainable development of OEMs: Firstly, the automotive industry is a highly competitive and policy-influenced industry, and OEMs should pay close attention to the market dynamics to understand the consumer demand, competitors' strategies, and changes in policies and regulations in order to adjust their strategies and business models in a timely manner. Secondly, as consumers' demands for automotive performance, safety and intelligence continue to rise, OEMs need to continuously strengthen their technological research and development to enhance product competitiveness. At the same time, through technological innovation, production costs can be reduced and the profitability of enterprises can be improved[6]. R&D investment is an important input for enterprises to carry out technological innovation and product research and development, which is of great significance for improving the core competitiveness of enterprises and gaining market share[7].Thirdly, talent is the key to enterprise development, OEMs should pay attention to talent cultivation and introduction, establish a perfect talent incentive mechanism, and stimulate the innovation spirit and work enthusiasm of employees. In addition, OEMs can also reduce risks by diversifying their development, such as expanding into new energy, intelligent driving and other fields.

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