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Performance of China's Macroeconomic Indicators in a Regression Model-Based Sales Forecasting

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Abstract: The impact of macroeconomic indicators on sales forecasts is a topic worthy of corporate consideration in China. However, previous research on this topic is rarely based on the Chinese context and lacks discussion of specific industry scenarios. In this study, 5 macroeconomic indicators that the Chinese government and people are concerned about are selected and put into the regression model and the AIC model selection criterion to study their performance in sales forecasts of 4 industries in China. It is concluded that under China's national conditions, Disposable Income per Capita and National Fixed Asset Investment are two macroeconomic indicators that deserve attention and perform better than other indicators in sales forecasts, and they have hardly been mentioned in previous studies. At the same time, the most appropriate model for sales forecasting in each industry contains different combinations of macroeconomic indicators. It is believed that this result is valuable for companies in various industries, and will be inspiring for subsequent research in the field of sales forecasts.

Keywords: Sales forecasting, macroeconomic indicators, multiple regression model

1. Introduction

The macroeconomic environment has an important impact on the sales performance of companies. In a complex and large economic system like China, numerous indicators serve to quantify macroeconomic performance, such as Gross Domestic Product (GDP), Consumer Price Index (CPI), and Exchange Rate (EX), etc. This paper will conduct research on the performance of China's macroeconomic indicators in sales forecasting. Specifically, these indicators will be incorporated as independent variables into a regression model to assess whether their inclusion can enhance the accuracy and significance of the model's output.

Previous research has shown that regression analysis is a commonly used sales forecasting method. As early as 1987, a survey revealed that multiple regression analysis emerged as the predominant quantitative method for sales forecasting. Among the surveyed companies, it was found that 12.7% of them regularly employ multiple regression analysis, surpassing the utilization of econometric models and Box-Jenkins as other quantitative methods for sales forecasting. There were also 6.0% of the companies using simple regression analysis as their sales forecasting method [1]. When considering forecast horizons, regression analysis stood out as one of the commonly cited methods for medium-term forecasts, and within this category, multiple regression analysis gained greater

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popularity compared to simple regression analysis [1, 2]. When considering the type of product, multiple regression was the most commonly used quantitative forecasting method in both industrial firms and consumer firms. And when considering company size, for small firms with a scale of $1 to $100M, multiple regression analysis was also the most popular quantitative forecasting method, and among large firms with a scale of more than $500 M, there was still 25% and 15% of companies choose to use multiple regression analysis and simple regression analysis as a forecasting method respectively [1]. In today's context, where computer software and data analysis technology have reached a higher level of maturity, it is reasonable to expect that regression analysis will garner increased attention among companies when conducting sales forecasting.

Meanwhile, a series of recent studies have indicated that economic indicators are considered to be of great relevance to sales forecasting. Common economic indicators including GDP, CPI, Consumer Confidence Index (CCI), Producer Price Index (PPI), and Regular Wage, etc., were tested in research about the influence of economic indicators on sales forecasting and they were divided into three categories: leading, coincident, and lagging signals according to temporal causalities [3, 4]. Other studies have already come up with the idea of using economic indicators as predictor variables in the sales forecasting model [5]. In their model, researchers used statistical methods to identify relevant economic indicators by examining the strength of their correlation with historical sales. They further utilized metrics such as Adjusted R-Squared, t-scores, correlation matrix, Variance Inflation Factor (VIF), as well as Akaike's Information Criterion (AIC) and Schwarz Criterion (BIC) to filter out the economic indicators that demonstrated the highest predictive capability. However, it is important to note that companies across various industries may be influenced by economic factors in distinct ways. As these studies did not classify companies based on industry, they cannot provide specific guidance applicable to companies in various industries.

Indeed, various studies have demonstrated that companies in different industries prioritize distinct economic indicators when formulating sales forecasts. For example, CPI and Regular Wage were considered two significant factors affecting retail sales [3]. In research focused on predicting tourism demand, GDP, CPI, and EX were recognized as the most influential economic factors [6]. In another research that studied sales forecasting in the construction industry, the Wholesale Price Index was considered to be the leading important macroeconomic indicator [7]. So far, however, the existing studies fail to give a summary of the economic indicators that companies of different categories should pay attention to when making sales forecasts. Consequently, one of the objectives of this paper is to classify different industries in order to conduct separate discussions on this matter.

Recent studies also contribute to providing frameworks that automatically select macroeconomic indicators for the tactical sales time frame [8, 9]. However, these studies failed to specify macroeconomic indicators that exert the most significant influence on sales forecasting. Consequently, companies and management lack clarity on which indicators should be consulted or prioritized when making business decisions. Few studies that focus on sales forecasting using macroeconomic indicators in the national context of China also failed to give specific examples of macroeconomic indicators that have the strongest predictive ability [10]. Therefore, in this paper, a limited set of economic indicators that epitomize utmost significance and typify prevailing conditions within the national context of China and are most concerned by companies will be carefully selected in advance.

In summary, the primary objective of this paper is to examine the applicability of common and consequential economic indicators within the national context of China in the domain of sales forecasting for companies spanning diverse categories. It is believed that understanding the performance of different China's macroeconomic indicators in sales forecasting will help companies more accurately predict sales trends, formulate reasonable market strategies, and eventually improve their business performance.

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2. Methods

2.1. Data Sources

The historical sales data from 2013 to 2022 of different industries was collected from the National Bureau of Statistics of China, and from the market research reports issued by consulting firm Bain & Company. The data on China's macroeconomic indicators from 2013 to 2022 was collected from the National Bureau of Statistics of China, with other database websites as reference, such as CEIC, iiMedia, etc.

2.2. Variable Selection

Given that macroeconomic indicators may exhibit varying sales forecasting capabilities across different industries, four of China's key industries have been chosen for research in this work: the retail industry, the catering industry, the tourism industry, and the luxury industry. The retail industry and the catering industry are closely related to the day-to-day activities of residents. However, tourism and luxury goods are not essential for most residents' daily lives, which means that these two industries may experience more pronounced declines during periods of economic downturn. Consequently, the retail and catering industries, as well as the tourism and luxury industries, have been established as the two industry control groups within this research. It is anticipated that the performance of macroeconomic indicators on sales forecasts within these two groups may differ.

Table 1: Macroeconomic indicators as independent variables.

Independent variable	Logogram	Characteristics
GDP	x_1	GDP provides insights into the overall economic activity and production capacity of a country or region and stands as a key indicator for assessing economic situation and growth. The growth of GDP is commonly regarded as a symbol of economic prosperity and advancement.
CPI	x_2	Variations in CPI reflect changes in consumer purchasing power and inflation. An increase in CPI indicates a rise in the price level, resulting in a decrease in consumer purchasing power.
Total Import and Export of Goods	x_3	Total Import and Export of Goods measures a country or region's level of activity and competitiveness in international trade. An increase in the total import and export volume can stimulate economic growth by generating more business, employment, and investment opportunities.
Disposable Income per Capita	x_4	Disposable Income per Capita serves as a reflection of individuals' economic prowess and purchasing power on average. An improvement in this value signifies residents' augmented capacity for consumption, thereby indicating market scale expansion and economic growth.

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Table 1: (continued).

National Fixed Asset Investment	x_5	Fixed asset investment stands as one of the important driving forces for economic growth and development. An increase in National Fixed Asset Investment implies heightened investments in infrastructure construction, industrial advancements, and technological innovations, all of which contribute to enhanced productivity and economic benefits.

The macroeconomic indicators selected for research in this work include GDP, CPI, Total Import and Export of Goods, Disposable Income per Capita, and National Fixed Asset Investment. GDP and CPI are two important macroeconomic indicators that many existing works of literature evaluate as having an important impact on sales forecasts [3, 6], while Total Import and Export of Goods, Disposable Income per Capita, and National Fixed Asset Investment are three macroeconomic indicators highly valued by the Chinese government.

The characteristic of each macroeconomic indicator is shown below in Table 1. Also, for the convenience of writing, logograms were used to represent the independent variables.

2.3. Research Protocol

Previous studies have confirmed that the regression model is a reliable research method in sales forecasting. Therefore, this article also used the regression model, especially the multiple regression model as the research protocol, where the macroeconomic indicators are the independent variables (X) and the sales data is the dependent variable (Y).

The Akaike Information Criterion (AIC) was employed in this study for the model selection purpose. AIC is a commonly utilized measurement that can effectively balance the complexity and fitting ability of a model. A smaller AIC indicates that the model uses fewer parameters while fitting the data. Therefore, the model with the smallest AIC value is usually chosen. In this study, given the relatively small sample size of 10, the AICc (AIC with a correction for small sample sizes) was used as the selection criterion.

2.4. Data Preprocessing

To avoid error caused by multicollinearity, the Pearson correlation coefficient between every pair of independent variables was tested in advance based on the formula:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad (1)$$

3. Results and Discussion

Table 2 shows that the Pearson correlation coefficients between the pairs (x_1,x_3), (x_1,x_4), (x_3, x_4) are larger than 0.5, which means there exists a strong linear relationship between the two independent variables in each pair. The correlation between independent variables can also be visualized through a scatter plot matrix as Figure 1 showing below. It can be clearly seen that there are very strong positive linear relationships between pairs (x_1,x_3), (x_1,x_4) and (x_3, x_4), while no obvious linear relationship exists in other pairs.

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Table 2: Pearson correlation coefficient between independent variables.

	x_1	x_2	x_3	x_4	x_5
x_1	1.000	-0.145	0.936	0.998	0.315
x_2	-0.145	1.000	-0.181	-0.137	-0.314
x_3	0.936	-0.181	1.000	0.916	0.097
x_4	0.998	-0.137	0.916	1.000	0.327
x_5	0.315	-0.314	0.097	0.327	1.000

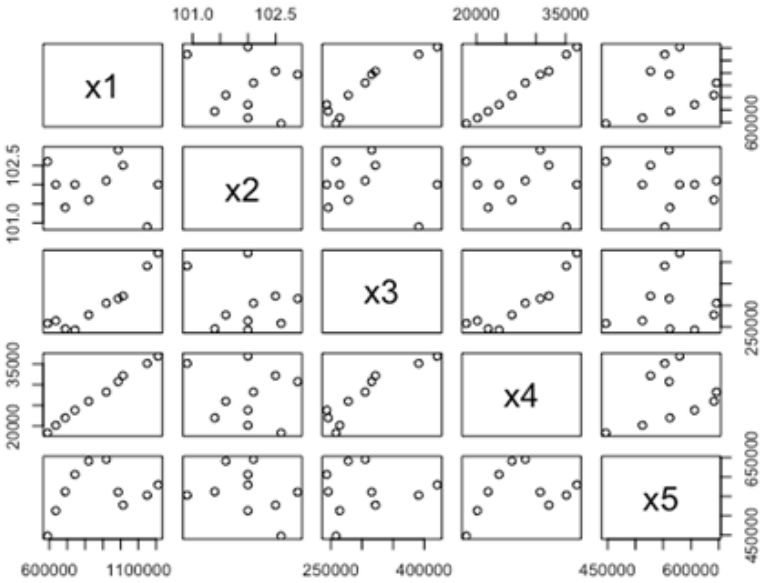

Figure 1: Scatter plot matrix for correlation between independent variables.

According to the above test result, the independent variables were combined to form multiple regression models shown in Table 3, with the guarantee that no independent variable pairs with a strong linear relationship appear in each model.

Table 3: Multiple regression models.

Model number	Variables in model	Model number	Variables in model
$model_0$	y	$model_9$	$y \sim x_2 + x_4$
$model_1$	$y \sim x_1$	$model_{10}$	$y \sim x_2 + x_5$
$model_2$	$y \sim x_2$	$model_{11}$	$y \sim x_3 + x_5$
$model_3$	$y \sim x_3$	$model_{12}$	$y \sim x_4 + x_5$
$model_4$	$y \sim x_4$	$model_{13}$	$y \sim x_1 + x_2 + x_5$
$model_5$	$y \sim x_5$	$model_{14}$	$y \sim x_2 + x_3 + x_5$
$model_6$	$y \sim x_1 + x_2$	$model_{15}$	$y \sim x_2 + x_4 + x_5$
$model_7$	$y \sim x_1 + x_5$	$model_x$	$y \sim x_1 + x_2 + x_3 + x_4 + x_5$
$model_8$	$y \sim x_2 + x_3$	-	-

*$model_0$: Blank control group without adding any independent variable.
**$model_x$: The control group with all independent variables added.

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As shown in Table 4, for the retail industry, the model with the smallest AICc is $model_{12}$, with x_4 and x_5 as the two independent variables.

Table 4: Model selection based on AICc for the retail industry.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
$model_{12}$	4	223.36	0.00	0.78	0.78	-103.68
$model_7$	4	226.76	3.40	0.14	0.92	-105.38
$model_4$	3	228.86	5.50	0.05	0.97	-109.43
$model_1$	3	230.96	7.59	0.02	0.99	-110.48
$model_{15}$	5	232.25	8.89	0.01	0.99	-103.63
$model_9$	4	234.53	11.17	0.00	1.00	-109.27
$model_{13}$	5	235.50	12.14	0.00	1.00	-105.25
$model_6$	4	236.77	13.40	0.00	1.00	-110.38
$model_{11}$	4	244.65	21.29	0.00	1.00	-114.32
$model_3$	3	246.90	23.54	0.00	1.00	-118.45
$model_{14}$	5	252.76	29.40	0.00	1.00	-113.88
$model_8$	4	252.88	29.52	0.00	1.00	-118.44
$model_0$	2	254.34	30.98	0.00	1.00	-124.31
$model_5$	3	255.81	32.45	0.00	1.00	-122.90
$model_2$	3	258.32	34.96	0.00	1.00	-124.16
$model_{10}$	4	261.80	38.44	0.00	1.00	-122.90
$model_x$	7	271.08	47.72	0.00	1.00	-100.54

*K: The number of variables in the model.
**Delta_AICc: The difference of AICc between current model and the best model.
***AICcWt: The ratio of the AICc of current model to the sum of AICc of all models.
****LL: Log-Likelihood.

Then, multiple regression analysis for $model_{12}$ was further conducted by R. The Multiple R-squared is 0.9839, and the coefficient of multiple correlation, R, equals 0.991917, indicating that there is a very strong linear relationship between the predicted sales and the combination of the two macroeconomic indicators, Disposable Income per Capita and National Fixed Asset Investment. The corresponding regression equation is:

$$y = -5.001 \times 10^4 + 9.142x_4 + 2.102 \times 10^{-1}x_5 \quad (2)$$

Table 5 shows that the best model for the catering industry is $model_4$, with x_4 as the only independent variable.

The Multiple R-squared for $model_4$ is 0.8091, and R is 0.899499, which means that the sole independent variable, Disposable Income per Capita, has a strong explanatory power for the pattern of sales. The corresponding regression equation is:

$$y = 8911.3981 + 1.0675x_4 \quad (3)$$

However, the differences in AICc between $model_4$, $model_7$, $model_{12}$, and $model_1$ are subtle. The values of AICcWt of the four models are also close to each other, which means that the predictive power of these models is equally matched. This indicates that companies in the catering industry can choose any of the four models based on the macroeconomic indicators they value to gain a reasonable sales forecasting result.

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Table 5: Model selection based on AICc for the catering industry.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
$model_4$	3	199.34	0.00	0.27	0.27	-94.67
$model_7$	4	199.58	0.25	0.23	0.50	-91.79
$model_{12}$	4	199.59	0.25	0.23	0.73	-91.80
$model_1$	3	199.68	0.35	0.22	0.96	-94.84
$model_9$	4	205.33	5.99	0.01	0.97	-94.67
$model_6$	4	205.68	6.35	0.01	0.98	-94.84
$model_{11}$	4	206.83	7.49	0.01	0.99	-95.41
$model_{13}$	5	207.89	8.56	0.00	0.99	-91.45
$model_{15}$	5	208.05	8.71	0.00	1.00	-91.53
$model_3$	3	208.37	9.03	0.00	1.00	-99.18
$model_0$	2	211.61	12.27	0.00	1.00	-102.95
$model_5$	3	212.01	12.67	0.00	1.00	-101.01
$model_8$	4	214.37	15.03	0.00	1.00	-99.18
$model_{14}$	5	214.66	15.33	0.00	1.00	-94.83
$model_2$	3	215.71	16.38	0.00	1.00	-102.86
$model_{10}$	4	217.98	18.64	0.00	1.00	-100.99
$model_x$	7	245.22	45.88	0.00	1.00	-87.61

In the case of tourism industry, however, the best model chosen by the AICc method is the empty model with no independent variable in it. The second-best option is $model_5$, with slight difference in AICc with $model_0$. The result is shown by Table 6 below.

Table 6: Model selection based on AICc for the tourism industry.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
$model_0$	2	226.88	0.00	0.30	0.30	-110.58
$model_5$	3	227.25	0.37	0.25	0.55	-108.63
$model_3$	3	229.41	2.53	0.09	0.64	-109.70
$model_{11}$	4	229.52	2.64	0.08	0.72	-106.76
$model_{12}$	4	230.52	3.64	0.05	0.77	-107.26
$model_7$	4	230.57	3.69	0.05	0.81	-107.29
$model_1$	3	230.76	3.88	0.04	0.86	-110.38
$model_4$	3	230.78	3.90	0.04	0.90	-110.39
$model_{10}$	4	230.82	3.94	0.04	0.94	-107.41
$model_2$	3	230.82	3.94	0.04	0.98	-110.41
$model_8$	4	235.25	8.37	0.00	0.99	-109.63
$model_{14}$	5	236.16	9.28	0.00	0.99	-105.58
$model_{15}$	5	236.48	9.60	0.00	0.99	-105.74
$model_6$	4	236.50	9.62	0.00	1.00	-110.25
$model_9$	4	236.52	9.64	0.00	1.00	-110.26
$model_{13}$	5	236.64	9.76	0.00	1.00	-105.82
$model_x$	7	275.40	48.52	0.00	1.00	-102.70

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In Table 7, it is clear that the model that best fits the observed data in the luxury industry is $model_{13}$. In $model_{13}$, there are three independent variables, x_1, x_2, and x_5, which are GDP, CPI, and National Fixed Asset Investment respectively.

Table 7: Model selection based on AICc for the luxury industry.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
$model_{13}$	5	151.96	0.00	0.56	0.56	-63.48
$model_{15}$	5	152.77	0.81	0.37	0.93	-63.88
$model_7$	4	158.08	6.12	0.03	0.96	-71.04
$model_3$	3	158.43	6.47	0.02	0.98	-74.21
$model_{12}$	4	159.22	7.26	0.01	0.99	-71.61
$model_{11}$	4	163.23	11.27	0.00	1.00	-73.61
$model_1$	3	163.40	11.44	0.00	1.00	-76.70
$model_8$	4	164.09	12.13	0.00	1.00	-74.04
$model_4$	3	164.23	12.28	0.00	1.00	-77.12
$model_6$	4	168.78	16.82	0.00	1.00	-76.39
$model_9$	4	169.56	17.60	0.00	1.00	-76.78
$model_{14}$	5	171.17	19.22	0.00	1.00	-73.09
$model_0$	2	178.34	26.38	0.00	1.00	-86.31
$model_2$	3	182.10	30.14	0.00	1.00	-86.05
$model_5$	3	182.63	30.67	0.00	1.00	-86.31
$model_{10}$	4	188.03	36.07	0.00	1.00	-86.01
$model_x$	7	192.88	40.92	0.00	1.00	-61.44

The multiple regression analysis result for this model shows that the Multiple R-squared is 0.9896 while R is 0.994786. Therefore, there is a really strong linear relationship between sales in the luxury industry and the value of GDP, CPI, and National Fixed Asset Investment. The corresponding regression equation is:

$$y = 5.134 \times 10^4 + 6.783 \times 10^{-3}x_1 - 4.878 \times 10^2 x_2 - 9.329 \times 10^{-3}x_5 \quad (4)$$

Based on the regression equations derived above, analysis can be made on the performance of China's macroeconomic indicators in sales forecasts in different industries:

Firstly, Disposable Income per Capita and National Fixed Asset Investment have a positive linear relationship with sales in the retail industry. An explanation for the positive correlation between Disposable Income per Capita and retail sales can be attributed to the increased financial capabilities of individuals. When the Disposable Income per Capita rises, people have more discretionary income available to spend on purchasing goods and services. Consequently, an increase in this value serves as an indicator of potential growth in retail sales. Meanwhile, the increment in National Fixed Asset Investment signifies a greater allocation of funds towards the construction and expansion of production facilities, commercial premises, and retail infrastructure. These investments enhance the production capacity and sales potential of the retail industry, thereby stimulating the growth of retail sales. By monitoring changes in these two macroeconomic indicators, retail companies can assess the industry's development momentum. It should be noted that the result of the research on the retail industry is different from the previous study. Even though Regular Wage, which was mentioned by the previous study, has similar properties to Disposable Income per Capita, the previous study also

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pointed out that CPI was a significant factor in sales forecasting in the retail industry, which is not included in the best model in this study [3].

Secondly, Disposable Income per Capita acts as the sole independent variable in the regression equation for the catering industry. A reasonable explanation for its positive linear relationship with sales in the catering industry is that as people's disposable income increases, their demand for and consumption of day-to-day activities such as going to restaurants also increases.

Next, the special situation in the tourism industry may be attributed to China's implementation of inter-city lockdowns and stringent entry and exit restrictions during the COVID-19 pandemic. In the data released by the National Bureau of Statistics, revenues in the tourism industry from 2020 to 2022 no longer includes the international tourism revenue part. As a result, there has been a significant decline in the sales revenue of China's tourism industry as shown in Figure 2. Therefore, it is not sufficient to rely solely on macroeconomic indicators for sales forecasting in this industry. Instead, it is essential to analyze the industry's performance in conjunction with China's policies and regulations. Sales forecasts for the tourism industry in the circumstance without the interference of special policies can refer to previous research results: the best-performing macroeconomic indicators are GDP, CPI, and EX [6].

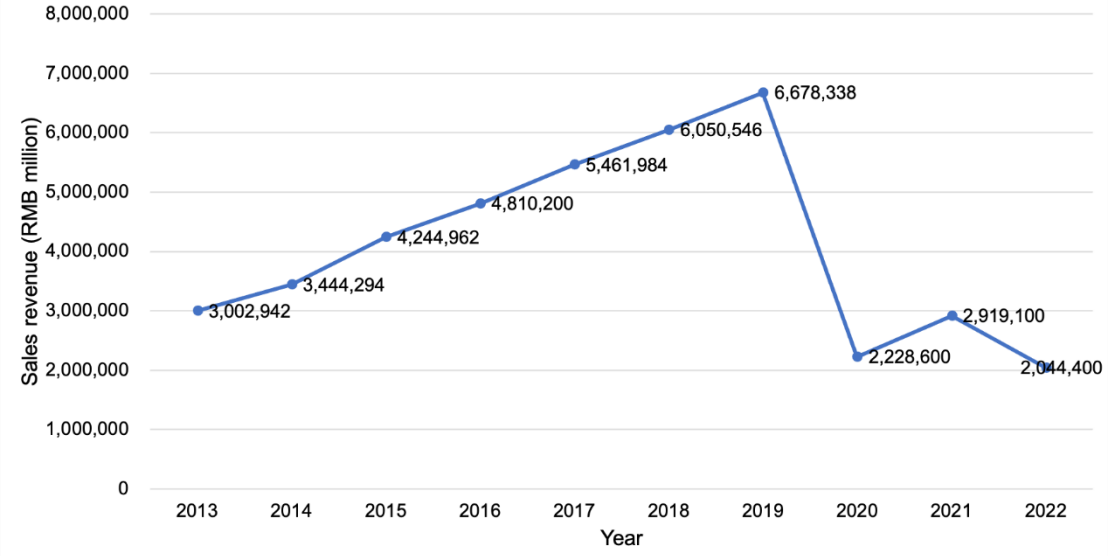

Figure 2: Sales in China's tourism industry from 2013 to 2022.

Finally, it can be seen from the last regression equation that GDP has a positive linear relationship with sales in the luxury industry, while CPI and National Fixed Asset Investment have a negative linear relationship with sales. The explanation for the positive linear relationship between GDP and sales of luxury goods can be attributed to economic growth, which increases consumers' purchasing power and leads to a higher demand for luxury goods. Conversely, when the CPI increases and the prices of consumer goods go up, individuals tend to prioritize essential daily necessities over unnecessary luxuries. Consequently, a decline in sales in the luxury industry emerges. Meanwhile, an increase in National Fixed Asset Investment often prompts the government and enterprises to allocate more funds towards industrial development and technological innovation. This shift in investment focus may result in reduced spending within the luxury industry. Additionally, consumers may choose to redirect their personal fixed-asset investments towards tangible assets such as houses and vehicles, leading to a decrease in luxury goods consumption.

When treating the retail industry and the catering industry as a group, and the tourism industry and the luxury industry as another group, more meaningful comparisons can be found:

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In both the retail industry and the catering industry, Disposable Income per Capita has a strong linear relationship with companies' sales. In the luxury industry, the most influential macroeconomic indicators include GDP and CPI, while according to the result of the previous study [6], GDP and CPI also perform well in the tourism industry's sales forecasts. This comparison can be attributed to the fact that the change in individuals' income has a more pronounced impact on people's consumption patterns concerning daily necessities and routine activities. It is only when there are shifts in the overall economic conditions and overall price levels that people tend to experience substantial changes in their consumption levels, leading to heightened or tightened expenditure on non-essential commodities or activities such as travel and luxury goods.

Moreover, National Fixed Asset Investment has a positive linear relationship with sales in the retail industry, however, the linear relationship between this indicator and sales in the luxury industry is negative. The reason for this comparison is that National Fixed Asset Investment promotes the construction of infrastructure and increases people's living standards. While stimulating people to purchase daily necessities, it skips the consumption level of luxury goods and further promotes even larger-scale consumption, such as the purchase of real estate, vehicles, and other fixed assets.

According to above comparisons and analysis, companies in other industries that not specified in this study can also decide which macroeconomic indicators should be referred to when conducting sales forecasts based on the properties of their own industries.

4. Conclusion

This study focuses on the analysis of five key macroeconomic indicators that hold significant importance for China. The objective is to examine their effectiveness in sales forecasting across four specific industries. The findings reveal that two of the indicators, Disposable Income per Capita and National Fixed Asset Investment, demonstrate superior predictive capabilities, and the performance of macroeconomic indicators varies across industries. In addition to relying solely on historical sales data, Chinese companies or companies operating within the Chinese market are advised to incorporate fluctuation trends in China's macroeconomic indicators when formulating sales forecasts, and companies in industries with different properties can focus on different macroeconomic indicators when referring to them.

The limitation of this study mainly lies in the small sample size because official disclosure data can only be found for a limited number of years. At the same time, since China has formulated a series of special policies in response to the COVID-19 outbreak from 2020 to 2022, which has caused many industries to be affected to varying degrees, abnormal situations may appear in the pattern of sales amounts in some industries from 2020 to 2022. In future research within this field, it is recommended to collect additional data and employ methodologies that can effectively mitigate the influence of China's policies. By expanding the dataset and implementing strategies to isolate the effects of special policies, researchers can attain more precise and reliable outcomes.

This study contributes to the comprehension of the influence exerted by macroeconomic indicators on sales forecasting. It furnishes companies with profound insights into the realm of sales forecasting, thereby offering scientific substantiation for informed business decision-making. By comprehending the distinct performance characteristics of various macroeconomic indicators within the Chinese context, companies owning businesses in China can enhance their ability to accurately anticipate sales trends, devise rational market strategies, and ultimately augment their overall business performance.

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