

Influencing Macroeconomic Indicators of Private Enterprises Stock Index Based on Bayesian Model Averaging (BMA)

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Abstract. Considering model uncertainty, this paper discerns macroeconomic indicators affecting the stock index yield of private enterprises 200 based on Bayesian Model Averaging method as well as the monthly data of private enterprises 200 and macroeconomic indicators from 2009 to 2018. The research finds, Currency in Circulation Supply (M0) and Government Revenue are the main factors affecting the stock index yield of private enterprises 200. Volume of Freight Handled in Main Coastal Ports has a certain impact on the yield, but not as significant as the first two variables. Finally, according to the empirical results, this paper puts forward suggestions for promoting the development of private enterprises.

Introduction

China's economic system is one with public ownership serving as its main body but allowing for the development of all types of ownership. The private economy is an important part of China's economic society. November 1, 2018, General Secretary Xi Jinping's speech at the private enterprise symposium pointed out, in the past 40 years of reform and opening up, the private economy has contributed more than 50% of tax revenue, more than 60% of GDP, more than 70% of technological innovations, more than 80% of urban labor employment, and more than 90% of enterprises. The private economy has become an indispensable force for the development of our country [1]. It is very meaningful to explore the macroeconomic factors that would affect the development of private enterprises and provide a good market environment for the healthy development of private enterprises. The stock price can reflect the business situation of the enterprise well. Therefore, this paper analyzes the stock return rate of the private enterprise stock index, and uses the stock return rate as the representative indicator of the development status of the private enterprise.

Yang Yating [2] analyzed the relationship between stock price and macro-economy in China through linear and nonlinear Granger causal test. The results show that there is a dynamic causal relationship between them. The stock market is the barometer of the macro-economy. At the same time, the macroeconomic fluctuations will also affect the fluctuations of the stock market to a certain extent. Xu Qianya [3], Yan Chen [4] and Liu Liwen [5] established multiple regression models to explore the macroeconomic factors affecting the stock price index. The current literatures research the impact of macroeconomic indicators on the overall stock market, whereas few literatures analyze the impact of macroeconomic indicators on private enterprise stocks. Because private enterprises and state-owned enterprises have large differences in business practices and distribution systems, this paper carries out separately analysis of private enterprise stocks to find factors affecting private enterprise stocks.

The conventional approach, using a single model to analyze the relationship between macroeconomic indicators and the stock market, has several shortcomings. First, there is no clear

consensus in the literature on which variables are super factors either from empirics or theory. Selecting a set of macroeconomic indicators as explanatory variables, which may lead to the omission of true explanatory variables. Second, lack of knowledge of the true model can lead to lower accuracy, because ignoring model uncertainty leads to overconfidence in factors from models that may not be correct. Raftery et al.[6] and Fernandez et al.[7] proved that the Bayesian Model Averaging Method (BMA) can solve the model uncertainty problem well. Moreover, the BMA method can involve as many explanatory variables as possible to improve the accuracy of the analysis results. Zhang Chao[8] using BMA approach discerned and analyzed the dominant factors of the producer services in China. He also proved that the BMA method is superior to single model in dealing with model uncertainty. Lu Erpo [9] identified and checked the determinants of real estate prices in China through BMA method. At present, there is no literature to analyze the relationship between domestic macroeconomic indicators and private enterprise stock indexes by using BMA method. This paper hopes to find out the factors that affect the development of private enterprises by studying the impact of macroeconomic indicators on private enterprise stock indexes, and then propose effectively. The purpose would be to create a healthy market environment for the development of private enterprises.

Model Sampling and Data

Model.

This paper uses the linear regression model as the single model.

$$\mathbf{y}=\boldsymbol{\alpha}+\boldsymbol{\beta}\mathbf{X}+\boldsymbol{\varepsilon} \quad (1)$$

Where \mathbf{y} is the stock index yield, $\boldsymbol{\alpha}$ is the intercept term, $\boldsymbol{\beta}$ is the explanatory variable coefficient, \mathbf{X} is the explanatory variable and $\boldsymbol{\varepsilon}$ is the error term.

BMA method integrates single models to improve the accuracy. By making full use of prior information, the posterior probability of a single model is calculated in the Bayesian framework, and then the posterior probability of each explanatory variable can be obtained by weighted average method.

Assuming $M=\{M_1,M_2,\dots,M_N\}$ represents model space generated by all potential variables arbitrarily combining. If there are K explanatory variables, then $N=2^K$, that is, the model space contains 2^K single models. And the general form of each single model is equation (1).

Let M_i denote the i model in the model space, and let $P(M_i)$ denote the prior probability of the model M_i . Bayesian model averaging can obtain the posterior probability of the model M_i calculated as

$$P(M_i|y)=\frac{P(M_iy)}{P(y)}=\frac{P(y|M_i)P(M_i)}{P(y)}=\frac{P(y|M_i)P(M_i)}{\sum_{i=1}^{2^K}P(y|M_i)P(M_i)} \quad (2)$$

$P(y|M_i)$ is given by the integral

$$P(y|M_i)=\int P(y|\boldsymbol{\beta}_i,M_i)P(\boldsymbol{\beta}_i|M_i)d\boldsymbol{\beta}_i \quad (3)$$

where $\boldsymbol{\beta}_i$ is the parameter vector of the model M_i , $P(\boldsymbol{\beta}_i|M_i)$ is the prior distribution of $\boldsymbol{\beta}_i$, and $P(y|\boldsymbol{\beta}_i,M_i)$ is the likelihood of the data given the model M_i and the parameters $\boldsymbol{\beta}_i$.

After $P(M_i|y)$ is obtained, the posterior inclusion probability, posterior mean and posterior variance of each explanatory variable can be calculated:

$$P(\beta_i|y) = \sum_{i=1}^{2^K} P(\beta_i|M_i,y)P(M_i|y) \quad (4)$$

$$E(\beta_i|y) = \sum_{i=1}^{2^K} E(\beta_i|M_i,y)P(M_i|y) \quad (5)$$

$$\text{Var}(\beta_i|y) = \sum_{i=1}^{2^K} \text{Var}(\beta_i|M_i,y)P(M_i|y) \quad (6)$$

Where $P(\beta_i|M_i,y)$ is the posterior probability of β_i given the model M_i and data. Similarly, $E(\beta_i|M_i,y)$ is the posterior probability expectation and $\text{Var}(\beta_i|M_i,y)$ is the posterior probability variance.

Parameter and Model Priors.

To implement Bayesian model averaging, I now define the parameter and model priors. George et al.[10] verified that the diffusion unit information prior distribution (DUIP) as a benchmark prior probability distribution is safe and robust. Since there is no prior information, this paper uses DUIP as the prior probability of the parameter. In the absence of any valid information, this paper considers that all models in the model space have a consistent position and adopts uniform distribution as the model prior distribution. That means all variables have a same prior inclusion probability of 0.5.

Sampling.

In the BMA method, to improve the accuracy of the results, it is necessary to use as many explanatory variables as possible. Unfortunately, that means more iterations and more complicated operations. Madigan et al.[11] proposed the Markov Chain Monte Carlo Model Composition (MC³) sampling approach and proved that, when the sampling reaches a certain number, the MC³ sampling result converges to the iterative result. Therefore this paper selects the MC³ sampling method.

Data.

This paper adopts the private enterprises 200 (000939) stock index as the representative of the private enterprise stocks. The samples of private enterprises 200 are the top 200 stocks of the China Securities Index private enterprise comprehensive index samples according to average daily transaction amount. The stock data come from the Flush software.

The response variable uses the logarithmic rate of return of the private enterprises 200 stock index:

$$r_t = \ln \frac{P_t}{P_{t-1}} = \ln P_t - \ln P_{t-1} \quad (7)$$

where P_t denotes the closing price on the t day, P_{t-1} denotes the closing price on the $t-1$ day, and r_t denotes the yield on the t day.

In this paper, 28 explanatory variables are selected in the National Bureau of Statistics of China and Sina Finance Network database. Firstly, through the correlation analysis, 10 variables with correlation more than 0.8 are excluded, and the remaining 18 variables are Consumer Price Index (CPI), Consumer Confidence Index (CCI), Producer Price Index for Industrial Products (PPI), Value-added of Industry, Growth Rate%(VA), Total Value of Exports, Growth Rate%(TVE), Total Value of Imports, Growth Rate%(TVI), Number of Projects for Contracted Foreign Direct Investment, Accumulated Growth Rate%(NPF), Freight Traffic, Growth

Rate%(FT),Passenger Traffic, Growth Rate%(PT),Volume of Freight Handled in Main Coastal Ports, Growth Rate%(VFMP),Manufacturing Purchasing Managers' Index%(MPMI),Government Revenue, Accumulated Growth Rate%(GR),Government Expenditure, Accumulated Growth Rate%(GE),Currency in Circulation Supply, Growth Rate%(M0),Money Supply, Growth Rate%(M1),Money and Quasi-Money Supply, Growth Rate%(M2), Exchange Rate—one dollar equivalent to RMB (ER),and Deposit Reserve Ratio%(DRR).

Empirical Analysis

The 18 explanatory variables generate $2^{18}=262144$ candidate models under the linear regression model. Because to numerous candidate models, this paper uses the MC³ sampling method to draw 102000 models. The first 2000 times are extracted as preheating experiments and the remaining 100,000 models are used to model BMA.

Results.

This paper uses the statistical software R and calls the BMS package to analyze the data. The analysis results are shown in Table 1.

Table 1 Private Enterprises 200 Model-Averaged Estimates

Variable	PIP	Post Mean	Post SD
M0	0.96003	0.00979	0.00359
GR	0.92131	-0.00446	0.00211
VFMP	0.63547	-0.00366	0.00349
PPI	0.26089	0.00182	0.00439
M2	0.24922	0.00164	0.00395
CCI	0.20784	0.00046	0.00124
DRR	0.20236	0.00180	0.00530
ER	0.18907	-0.01143	0.03517
MPMI	0.16808	0.00124	0.00423
CPI	0.16104	-0.00141	0.00548
GE	0.15545	-0.00021	0.00074
TVI	0.13230	-0.00007	0.00039
VA	0.12848	0.00027	0.00184
M1	0.12709	0.00005	0.00072
PT	0.12161	0.00019	0.00112
TVE	0.11720	-0.00001	0.00028
FT	0.11451	-0.00012	0.00118
NPF	0.10895	0.00001	0.00013

Table 1 reports the variable posterior inclusion probabilities (PIP), posterior mean and posterior

standard deviations. Table 1 shows the only variables with a high PIP over 0.9 are M0 and GR, which illustrates M0 and GR are robust factors in affecting stock yield of private enterprises 200. The PIP of VFMP is between 0.5 and 0.9, which is 0.63547, indicating that this variable has a certain impact on the stock return rate, however, the explanatory power is lower than the first two variables. Other variables are below 0.5 and we believe that these variables are not significant.

The value of M0's posterior mean is 0.00979, which means that the M0 supply increased by 1% year-on-year, and the stock yield increased by 0.00979. The two are positively correlated. If the supplies of M0 increase, and the cash flow in the market will increase. The investors will have more idle funds to invest in the stock market. The stock market would be active and could increase the yield of stocks. The posterior mean of GR is -0.00446, indicates that as GR increased by 1%, the stock yield would drop by 0.00446. The two are negatively correlated. The main sources of national fiscal revenue are tax revenue and national bonds. Raising the taxes paid by enterprises and laborers will reduce enterprise income as well as the funds available to investors. The number of national bonds increases result in more funds flow to the bond market, which turn out to affect the stock returns of private enterprises. The posterior mean of VFMP is -0.00366, i.e. when VFMP increases by 1%, the stock yield would decrease by 0.00366. Theoretically, an increase in port cargo throughput indicates frequent transactions and active market, which is conducive to the development of private enterprises. The stock index yield should have enhanced, nevertheless, the empirical results show that the stock index yield is inversely related to the port cargo throughput. After checking the data, the author found that nearly half of the port cargo throughput is foreign trade cargo throughput, so it is speculated that foreign products are imported leads to the development of domestic enterprises has been suppressed. The products of foreign enterprises have met some market demands, which might affect the sales market of private enterprises. In the stock market, the yield has declined.

Effectiveness Test.

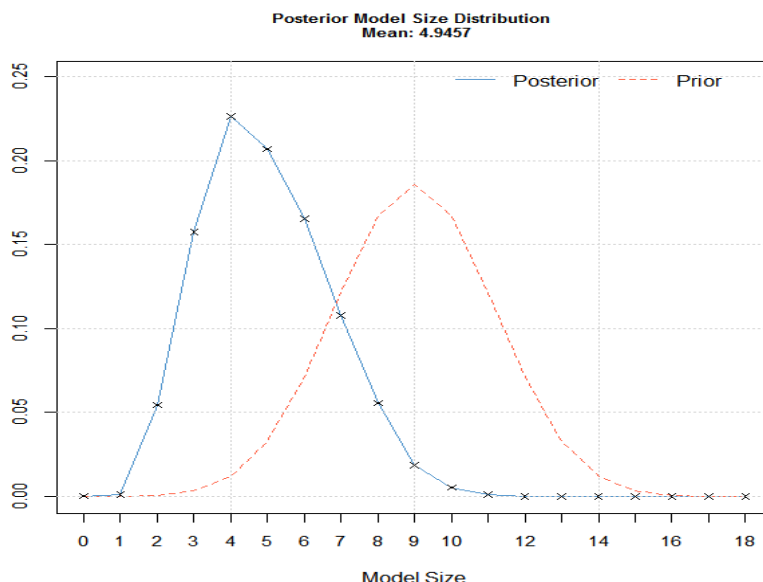


Figure. 1 Posterior Model Size Distribution Mean of the Stock Index Yield

Fig. 1 is the posterior model size distribution mean plot of the stock index yield of private enterprises 200. The dotted line in the figure denotes the prior distribution of the model scale, which is a normal distribution with mean 9 and conforms to the model priori assumption at the beginning. The solid line represents the posterior distribution of the model scale. The distribution curve reaches the highest point at 4.9457 on the horizontal axis. Therefore, the mean value of the posterior model

size is 4.9457, that is, for these 2^{18} models, each single model has an average of 5 explanatory variables.

The results of the BMA method, the single optimal model, and the five-variable model are compared in table 2. The BMA results are from table 1, and the single optimal model is the model with the highest model posterior probability. Referring to the conclusion of Fig. 1, the top five variables with the highest PIP in the BMA analysis results are selected to form the five-variable model.

Table 2 Comparisons Of BMA Method And Single Model Regression Results

Variable	BMA		Single Optimal Model		Five-variable Model	
	Post Mean	Post SD	Post Mean	Post SD	Post Mean	Post SD
M0	0.00979	0.00359	0.01173***	0.00250	0.01007**	0.00296
GR	-0.00446	0.00211	-0.00420***	0.00107	-0.00547***	0.00142
VFMP	-0.00366	0.00349	-0.00461*	0.00209	-0.00634**	0.00228
PPI	0.00182	0.00439			0.00462.	0.00271
M2	0.00164	0.00395			0.00460	0.00287
CCI	0.00046	0.00124				
DRR	0.00180	0.00530				
ER	-0.01143	0.03517				
MPMI	0.00124	0.00423				
CPI	-0.00141	0.00548				
GE	-0.00021	0.00074				
TVI	-0.00007	0.00039				
VA	0.00027	0.00184				
M1	0.00005	0.00072				
PT	0.00019	0.00112				
TVE	-0.00001	0.00028				
FT	-0.00012	0.00118				
NPF	0.00001	0.00013				
Significance	0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Table 2 shows that the posterior mean of the single optimal model as well as the five-variable model are both larger than the BMA, at the same time, the posterior standard deviations are smaller than the BMA results. The data indicate that the single model will overstate the strength of explanatory variables on response variables in the case of ignoring model uncertainty. Therefore, the BMA approach can more accurately measure the impact of macroeconomic indicators on the yield of private enterprises 200 than a single model.

Conclusion

This paper develops a Bayesian model-averaging approach for studying the impact of 18 macroeconomic indicators on the stock index yield of private enterprises 200, in the purpose of exploring convictive macroeconomic indicators influencing the development of private enterprises. The research find, Currency in Circulation Supply (M0) and Government Revenue are the main factors affecting the stock index yield of private enterprises 200. Volume of Freight Handled in Main Coastal Ports has a certain impact on the yield, but not as significant as the first two variables. M0 has a positive impact on the stock index yield, whereas the other two variables have a negative impact.

Referring to the conclusions of this paper, the author suggests that in order to promote the development of private enterprises, the state can improve measures from three perspectives of finance, fiscal policy and imports & exports. Within a reasonable range, first, increasing the supply of M0 and implementing looser monetary policy. Second, by reducing taxes, the government not only can relieve pressure on enterprises and citizens, but also can increase the available funds of investors. Thereby improving business turnover and enhancing corporate vitality. Third, moderately imposing tariffs on certain imported goods and raising standards for foreign products entering the China market. We could protect the development of local private enterprises by reducing the proportion of imported products in the domestic market.

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