The Influence of Macroeconomic State on Stock Market Return——Based on the application of macro multi-factor pricing model

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Abstract. In order to characterize the time-varying of asset pricing factors with macroeconomic conditions, on the basis of the CAPM model, this paper takes the new variable constructed based on the Treasury bond yield as the variable to characterize the market premium, and pricing model for the stock returns of CSI 300 index and Zhong Zheng 1000 index to explore the explanatory effect of macroeconomic status on the return of China's stock market. The data analysis results of this paper show that macro factors can become variables that affect stock returns, and the impact of PPI on stock returns is the most significant among the selected factors.

Keywords: CAPM Model, Macroeconomic Indicators, Macro Multi-factor Pricing Model.

1 Introduction

With the continuous development and improvement of social economy and regulatory system, which variables will affect the price of risky assets is a hot and essential research issue in the field of financial economics. Many predecessors have carried out a lot of research on this. The capital asset pricing model (CAPM) proposed by sharpe [1] and lintner [2] is one of the representatives. As the pillar of modern financial market pricing theory, this theory mainly studies the relationship between the expected return of assets and risk assets in the securities market, and how the equilibrium price in the market is formed. In addition, there are arbitrage asset pricing models (APT) proposed by ross [3] under the assumption of no arbitrage, etc. These financial models connect the expected return of assets with investors' exposure to single or multiple systemic risks, and emphasize that there is a linear relationship between the two, that is, when the risk factor is the excess return of market portfolio, the systemic risk of financial assets will be determined by its excess return on market portfolio β decision. However, with more and more empirical research on CAPM model by researchers, the disadvantages of the strict assumptions of this model are also reflected. The traditional CAPM model does not make a reasonable risk pricing for China's A-share market. Some assets of similar nature in China's A-share market also have the characteristics of

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common volatility. For example, stocks in the same sector or industry have the characteristics of rising and falling at the same time in some periods. Theoretically, these stocks should be jointly affected by potential exogenous factors, but figuring out which macroeconomic variables can affect the asset pricing of A-share market is the purpose of this paper. This paper will screen out macroeconomic indicators that can significantly affect the change of asset price from many domestic macroeconomic variables, and establish an empirical model based on the classic multi-factor asset pricing model to test its explanatory ability. The answers of the following questions will be focused on in this paper: can macroeconomic indicators become the pricing factor reflecting the systematic risk of China's A-share market, and which macroeconomic indicators can become the explanatory variables to explain the cross-sectional changes of stock market return. This paper aims to analyze the role of macroeconomic factors on stock prices through the construction and application of multi factor pricing model, thereby providing reference for the healthy development of the stock market.

2 Literature Reviewed

The international research on CAPM model starts relatively early. Since the 1960s, sharpe [1], lintner [2] and mossin [4] have independently proposed capital asset pricing models, which also directly marks the formation of modern asset pricing models, one of the three cornerstones of modern financial theory. Its core is still the mean variance model proposed by markovitz [5] in portfolio selection. The mean variance model discusses the optimal selection of portfolio under uncertainty from the relationship between the return rate of risk assets and risk. The capital asset pricing model was born because of the market, and its empirical results have been constantly tested by the market. However, the test results show that the model still has certain limitations. First, the empirical results have caused more controversy. Miller and scholes [6] conducted an empirical test with the 10-year (1954-1963) data of 631 stocks listed on the New York Stock Exchange, and the results show that coefficient β does not explain the return on assets well. However, Sharpe and cooper [7] also used the stock data of the New York Stock Exchange (1931-1967) to conduct an empirical analysis on CAPM, and through cross-sectional test, it is found that the coefficient β shows a strong linear relationship with the return rate of the portfolio, that is, the coefficient has a high explanatory ability. This controversy has led to subsequent discussions on alternative indicators of market portfolios and doubts about the availability of CAPM. Black, Jensen and Scholes [8] used the excess return rate to conduct an empirical test, and the results showed that β factor seems to be an important determinant of securities returns. Fama and Macbeth [9] tested the relationship between the average return and risk of common stocks in the New York Stock Exchange, put forward the idea of cross-sectional regression, and made an empirical analysis of CAPM from the perspective of portfolio. The results showed that CAPM was effective. These research methods and ideas also expand the scope of empirical application of CAPM. In theory, according to efficient market theory and rational expected asset pricing theory, asset prices depend on their risk load in describing the state variables of the economy, so the macro variables describing the state changes can have a systematic impact on asset pricing. In the empirical aspect, many studies show that stock returns are related to macro fundamental data. These macro variables include consumption growth rate, investment growth rate, inflation, market dividend rate, term spread, credit spread, industrial production growth rate, etc. The multi-factor model starts from Ross's arbitrage asset pricing model (APT) in theory [3]. The study of the impact of macro variables on the return on stock assets began with Chen et al. [10]. They tested a series of macroeconomic state variables and found that factors such as the industrial production value, changes in risk premium, and changes in interest rate curve can explain the expected return of stocks. Besides, the stock portfolio can be correctly priced through the risk load of macroeconomic factors.

3 Theoretical Elaboration

Capital asset pricing model is a basic theoretical and mathematical model in the field of finance. It is used to reflect the relationship between the systemic risk and securities investment return. At the same time, camp model is also based on a series of assumptions, which mainly include:

1). Investors are risk averse, and they maximize their wealth in risk and reward. 2). In the capital market, all assets can be completely split without transaction costs or income taxes. 3). There are risk-free assets in the market, and accordingly, such assets have a risk-free rate of return. 4). Investors can borrow without restrictions, and the interest rate of borrowing is the same.

The final mathematical basic formula of CAPM model can be expressed as:

$$K = R_f + \beta(K_m - R_f) \tag{1}$$

where K is the return rate of the securities portfolio; R_f is the return rate of risk-free investment, usually expressed by the interest rate of treasury bills; β is a coefficient reflecting the size of non-dispersible risk. It is generally calculated by the regression analysis; K_m is the average return rate of all stocks in the stocks market.

4 Variable Selection

In order to measure the macroeconomic status, this paper selects 121 monthly macroeconomic indicators from September 2011 to September 2022, including one-year treasury bond yield, 10-year Treasury bond yield, consumer price index, product price index for industrial products (PPI), industrial added value (IAV) on a year-on-year basis, total retail sales of consumer goods (TRSCG), and real estate index (EI) (data are from the official website of the National Bureau of Statistics). Next, the above basic data will be used to construct new indicators. Consumer price index is a representative index to measure general commodity prices in the overall macro-economy. It reflects the changes in consumer spending and the quantity and ability to pay for the prices of goods and services that the public are willing to buy. Inflation can reflect the change of consumer price index. Therefore, this paper will construct the unexpected inflation rate and the expected inflation rate, and take them as the risk factors to explain the stock return.

The unexpected inflation rate is recorded as UI, which is defined as follows. $\mathrm{I(t)}$ is the first-order difference of the consumer price index.

$$\mathrm{UI(t) = I(t) - E[I(t)|t-1]} \tag{2}$$

Expected inflation rate is expressed as DEI and define as follows.

$$\mathrm{DEI(t) = E[I(t+1)|t] - E[I(t)|t-1]} \tag{3}$$

For the characterization of market risk premium, this paper uses term spread (UTS) to define the difference between the yield of 1-year treasury bonds and the yield of 10-year treasury bonds. LGB represents the yield of 10-year treasury bonds and TB represents the yield of 1-year treasury bonds.

$$\mathrm{UTS(t) = LGB(t) - TB(t-1)} \tag{4}$$

Table 1 and 2 respectively show the descriptive statistics of each macroeconomic factor and their correlation coefficient matrix. Among them, except for the high correlation coefficient between the unexpected inflation rate and expected inflation rate, the correlation coefficient between other factors is within an acceptable range, which is related to the construction mode between the two inflation rate factors.

Table 1. Descriptive Statistics.

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
UI	120	0	.507	-1.445	1.655	-1.245	1.345	.399	4.033
DEI	119	.004	.743	-2.3	1.82	-2.2	1.8	-.143	4.409
UTS	121	.629	.295	.1	1.862	.112	1.631	1.275	6.243
IAV	104	.075	.027	-.011	.213	.031	.141	1.415	9.167
PPI	121	100.203	4.01	94.06	110.7	94.08	109.5	.676	2.57
TRSCG	101	27235.36	6887.331	15603.1	40566	15650.2	39514	-.069	1.859
EI	118	4494.307	1219.752	2731.2	7944.26	2794.82	7883.74	.639	2.712

Table 2. Pairwise Correlations..

Variables	(UI)	(DEI)	(UTS)	(IAV)	(PPI)	(TRSCG)	(EI)
UI	1.000						
DEI	0.733*	1.000					
UTS	0.103	0.077	1.000				
IAV	-0.042	-0.074	-0.013	1.000			
PPI	0.022	-0.020	-0.319*	0.023	1.000		
TRSCG	-0.134	-0.005	-0.210	-0.583*	0.393*	1.000	
EI	-0.119	-0.014	-0.044	-0.421*	-0.043	0.200	1.000

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

5 Empirical Analysis

This paper first selects the monthly rate of return (R_1) of the CSI 300 index as the explanatory variable (the time span is September 2011 to September 2021, a total of 121 monthly data). Then, a multiple linear regression model is established based on the explanatory variables including UI, DEI, UTS, IAV, TRSCG, and EI. The linear regression model is established as follows:

$$\hat{R}_i = \beta_0 + \beta_1 UI + \beta_2 DEI + \beta_3 UTS + \beta_4 IAV + \beta_5 PPI + \beta_6 TRSCG + \beta_7 EI + \mu_i \quad (5)$$

Table 3. Empirical Results of Macroeconomic Multi Index Model.

Factors	(1) model	(2) model	(3) model	(4) model	(5) model	(6) model	(7) model
UI	.005	-.007	-.014	-.015	-.021	-.023	.001
	(.022)	(.02)	(.019)	(.02)	(.017)	(.018)	(.012)
DEI	.016	.023*	.023*	.025**	.022*	.022*	
	(.013)	(.013)	(.012)	(.013)	(.012)	(.012)	
UTS	-.069***	-.068***	-.069***	-.049**	-.044**		
	(.022)	(.022)	(.021)	(.02)	(.02)		
IAV	.447	.068	.003	-.048			
	(.429)	(.364)	(.231)	(.237)			
PPI	-.005**	-.005***	-.004**				
	(.002)	(.002)	(.002)				
TRSCG	0	0					
	(0)	(0)					
EI	0*						
	(0)						
_cons	.442**	.535***	.496***	.041*	.034**	.007	.007
	(.197)	(.184)	(.179)	(.023)	(.014)	(.006)	(.006)
Observations	96	99	102	102	119	119	120
R-squared	.186	.171	.152	.094	.067	.029	0

Standard errors are in parentheses
**** $p<.01$, ** $p<.05$, * $p<.1$*

In Table 3, the model (1) is a multiple regression model of all macroeconomic indicators and the monthly return of CSI 300 index. In order to find a more concise factor structure, the number of factors in model (2) to model (7) is gradually reduced. From the data in Table 3, with the reduction of the number of factors, the statistics of R-squared are becoming less and less. In model (1), it is found that the coefficient β of EI and TRSGC are not significant. By comparing model (1) with model (2), and comparing model (2) with model (3), it is found that TRSCG and EI have little impact on the whole model after being eliminated respectively. However, by comparing model (3) and model (4), it can be that after PPI is eliminated, the R-squared statistics of the model have been significantly reduced. It proves that this macro factor has a relatively obvious impact on the return rate of the top 300 stocks with good liquidity listed on the Shanghai and Shenzhen stock exchanges.

In order to compare the impact of these macroeconomic factors on stock returns in a more accurate way, the monthly return (R_2) of Zhong Zheng 1000 index is selected as the explanatory variable (the time span is September 2011 to September 2021, a total of 121 monthly data). Using the 7 macro indicators selected in this paper, a multiple regression model is established as follows:

Table 4. Empirical Results of Macroeconomic Multi Index Model 2

Factors	(1) model	(2) model	(3) model	(4) model	(5) model	(6) model	(7) model
UI	-.019	-.03	-.033	-.034	-.032	-.032	-.011
	(.029)	(.026)	(.025)	(.026)	(.023)	(.023)	(.016)
DEI	.016	.023	.024	.026	.02	.02	
	(.018)	(.017)	(.016)	(.017)	(.016)	(.016)	
UTS	-.044	-.042	-.041	-.015	-.006		
	(.029)	(.029)	(.028)	(.027)	(.027)		
IAV	.327	-.037	.154	.087			
	(.568)	(.479)	(.304)	(.311)			
PPI	-.006**	-.006**	-.006**				
	(.003)	(.003)	(.002)				
TRSCG	0	0					
	(0)	(0)					
EI	0						
	(0)						
_cons	.541**	.618**	.603**	.01	.011	.007	.008
	(.26)	(.242)	(.235)	(.03)	(.019)	(.008)	(.008)
Observations	96	99	102	102	119	119	120
R-squared	.105	.095	.091	.029	.018	.018	.004

Standard errors are in parentheses
**** $p<.01$, ** $p<.05$, * $p<.1$*

From model (2) to model (3), the author still finds a more concise factor structure by constantly eliminating factors. By comparing the empirical results of two macroeconomic multi index models, it is found that the interpretation of the seven macroeconomic indicators constructed in this paper is weaker than that of the Zhong Zheng 1000 index. This means that through the empirical results of these seven macroeconomic indicators, the model constructed in this paper has a better explanation effect on the stock return of A-shares with good liquidity and high ranking. While for the return of the stock with poor liquidity and lower ranking, the explanation effect is relatively poor.

6 Conclusion

This paper studies whether China's major macroeconomic indicators can be used as pricing factors to determine the expected return on stock assets. Using the monthly return of the CSI 300 index and the Zhong Zheng 1000 index as explanatory variables, the author constructs a macro multi-factor pricing model and takes the seven macroeconomic indicators, namely the unexpected inflation rate (UI), expected inflation rate (DEI), term spread (UTS), year-on-year industrial added value (IAV), producer price index for industrial products (PPI), total retail sales of consumer goods (TRSCG), and real estate index (EI) as risk factors. The results show that these seven macro factors have a strong explanatory power on the monthly return of the CSI 300 index, especially the producer price index for industrial products (PPI) has a greater influence on the model than other factors. The total retail sales of consumer goods (TRSCG) and the real estate industry index (EI) have no significant impact on the monthly return of the CSI 300 index and the Zhong Zheng 1000 index.

To sum up, the macroeconomic indicators can become a pricing factor that reflects the systematic risk of the top ranked stocks with good liquidity in China's A-share market. Besides, represented by the producer price index for industrial products (PPI), the unexpected inflation rate (UI), expected inflation rate (DEI), term spread (UTS), and year-on-year industrial added value (IAV), a total of five factors can become explanatory variables to explain the cross-sectional changes of stock market returns. If the returns of each stock in the market can be formed into a data set instead of using the stock index as the explanatory variable to establish the model, the results of empirical analysis will be more specific and persuasive. Future research can even classify and combine the stocks of different industries, so as to see the impact of macroeconomic factors on specific industries.

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