Influence of the Epidemic on the Three-Factor Model's Applicability in the Chinese Stock Market

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Abstract. The Fama-French three-factor model is regressed in this study, which examines all A-share equities for 60 consecutive months between 2017 and 2022. The portfolio is built using the average investment in the Shanghai Exchange and Shenzhen Exchange. The data for the article was downloaded from the RESSET database and contains the the market capitalization, book-to-market values, and the portfolio's return less the risk-free rate of return, weighted by market capitalization for all A-share portfolios. According to the empirical findings, there was little overall change in the coefficients of the three factors-MKT, SMB, and HML. Each portfolio's market risk indicators point to a comparable degree of market risk. The stock market can be explained and predicted well using the three-factor model. Based on the regression results, the epidemic did not have a significant impact on the overall structure of the three-factor model. This indicates that the Chinese stock market is relatively stable in the short term and more resilient to unexpected events. It also shows that A-share market can be predicted by the three-factor model.

Keywords: evaluation; three-factor model; influence.

1. Introduction

Modern financial market price theory is supported in large part by capital asset pricing models. On the basis of asset portfolio theory, William Sharpe developed the CAPM model, which is used to research the correlation between projected returns on assets and risky assets in the equity markets. The risk-free rate (r)f and the compensating risk premium for the risk taken $E_{rm} - r_f$ make up the return on a hazardous asset in the CAPM model [1,2]. The marginal cost of risk remains constant at equilibrium in the capital markets, and the risk premium's amount is solely dependent on the value of. The riskier the individual security is, the higher the reward is, and the larger the value is [3].

Stephen Ross proposed the arbitrage pricing model in 1970s; Fama and French proposed the Fama-French three-factor model in 1992 through a study of the US stock market [4], and it has been widely used in practice. The Fama-French three-factor model is an improvement on the CAPM model in that it retains the market portfolio factor and introduces the size of market factor (SMB) and the book-to-market ratio factor (HML). These two factors, SMB and HML, have a significant impact on our stock market [5]. The three-factor model was constructed as follows:

$$r_{it} - r_{ft} = \alpha_i + \beta_1(r_{mt} - r_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + \varepsilon_{it} \tag{1}$$

SMB_t represents the market capitalization factor and HML_t represents the book-to-market ratio factor. The SMB and HML factors are added to the Fama-French three-factor model, which has the advantage of keeping the market component while also accounting for most stock price changes. Additionally, it keeps the market component while also include the SMB and HML variables, which accounts for the majority of the fluctuation in stock prices [6].

However, the applicability of the three-factor model in the A-share market has been questioned for two reasons. One is that A-shares have a relatively short history, and a new accounting standard system has been implemented in China since January 2007 [7]. This new standard may result in different standards of financial data for listed companies before and after 2007, making it impossible to compare them across the board. Secondly, there is no shorting mechanism for A-shares, which may further lead to poor adaptability of the factor model.

The Chinese stock market was also hit exceptionally hard after Covid-19 completely erupted in China. Investors' assessments of the predicted future worth of a listed firm are intimately correlated with the business environment and operating conditions in which the listed company operates. Stock market prices represent investors' estimates of an enterprise's future profitability. [8]. Therefore, stock price fluctuations following public health emergencies also reflect the expectations of investors in listed companies regarding the Covid-19 outbreak. Following the outbreak of the epidemic, the Chinese stock market reacted strongly, with all sectors generally showing fewer gains and more losses in the 20 trading days before and after the Chinese New Year, with a maximum decline of nearly 15%. Under such circumstances, the applicability of the three-factor model may also be questioned as to whether the three-factor model can still correctly predict the Chinese stock market in the face of sudden and strong stock price volatility.

2. Methodology

2.1 Data Source

The data for the article was downloaded from the RESSET database and contains the the market capitalization, book-to-market values, and the portfolio's return less the risk-free rate of return, weighted by market capitalization for all A-share portfolios for the period from 31 July 2017 to 30 June 2022.

2.2 Method

Since the specific values of the three factors are directly given in the data, we would like to briefly introduce the calculation methods of these three factors. To be more specific, all stocks are categorised into three categories (Low, Mid, and High) based on the 30% and 70% quantiles of their book-to-market ratio and into two groups (S mall and Big) based on the 50% quantile of their size of market. All stocks are given two labels in this manner: one for market capitalization and the other for book-to-market ratio. Stocks with the same two labels are combined to form a portfolio, and two by three cross-indexing produces six portfolios. Up until next June, when it is rearranged to create the sequential portfolio in accordance with the aforementioned regulation, the portfolio consists of the constituent stocks. The weighted returns of the six portfolios, are then computed for each year using the indicated constituents. The following formulas are then used to compute the HML and SMB factors.

$$SMB = \frac{1}{3}(SL + SM + SH) - \frac{1}{3}(BL + BM + BH) \tag{2}$$

$$HML = \frac{SH+BH}{2} - \frac{SL+BL}{2} \tag{3}$$

Where $r_{mt} - r_{ft}$ is market return at a peried of time minus the market risk-free rate of return. As no specific stocks were selected, it was not possible to construct a specific portfolio. The solution is to construct the portfolio by investing in both exchanges as indices in the same proportion. And the full A-share is then used as the whole market. On balance, index investing is convenient and diversified. It can include a large number of stocks at the same time, which helps us to visualize the combined effect of the epidemic on the applicability of the three-factor model to the A-share market. In addition, the return on index investment is roughly the same as the market return, which fits perfectly with the objectives of the study.

Using the end of 2019 as the dividing line, the data were divided into two parts and separate time series regressions were done on both parts of the data to compare whether the occurrence of the epidemic had an impact on the the three-factor model's applicability in the Chinese stock market

3. Results and Discussion

This data is monthly data for the SSE, SZSE and all A-share stock markets, and the sample period is all from 31 July 2017 to 30 June 2022. The three factors of the sample are obtained by weighting the total market capitalization. Descriptive statistics for each factor were conducted using STATA software, as shown in Tables 1 and 2.

Table 1. Monthly descriptive statistics of the combination factor (2017.7.31-2019.12.31)

	Factor	Median	S.D.	Minimum	Maxim
ALL A share	Rmrf	-0.00238	0.04968	-0.091	0.1634
	SMB	-0.00744	0.02979	-0.059	0.0597
	HML	-0.00203	0.03139	-0.069	0.0708
SZSE	Rmrf	-0.00106	0.04588	-0.080	0.1353
	SMB	-0.01032	0.03294	-0.063	0.0673
	HML	-0.00566	0.03351	-0.068	0.0723
SSE	Rmrf	-0.00413	0.06094	-0.108	0.2108
	SMB	-0.00547	0.02549	-0.053	0.0422
	HML	0.00171	0.02765	-0.064	0.0594

Table 2. Monthly descriptive statistics of the combination factor (2019.12.31-2022.6.31)

	Factor	Median	S.D.	Minimum	Maxim
ALL A share	X1	0.00624	0.04976	-0.089	0.1289
	X2	0.00282	0.04432	-0.101	0.1058
	X3	-0.00134	0.04784	-0.087	0.0937
SZSE	X1	0.00483	0.04456	-0.074	0.1195
	X2	0.00244	0.04036	-0.088	0.1030
	X3	-0.00325	0.05213	-0.099	0.1005
SSE	X1	0.00855	0.05997	-0.115	0.1410
	X2	0.00446	0.04430	-0.101	0.0872
	X3	-0.00129	0.04264	-0.081	0.0845

Note: X1, X2, X3 represents the Rmrf factor, SMB factor and HML factor respectively

Considering the size of the sample, in order to avoid pseudo-regression problems and to exclude errors caused by small samples on data smoothness tests, the unit root test of the data was chosen for the full period of 2017.7.31-2022.6.30. Table 3 displays the outcomes of the enhanced Dickey-Fuller test (ADF) test.

Table 3. ADF Test Result

	Factor	T-test Value	1% CV	5% CV	P-value
ALL A share	X1	0.0062	0.0497	-0.0895	0.1289
	X2	0.0028	0.0443	-0.1004	0.1058
	X3	-0.0013	0.0478	-0.0865	0.0937
SZSE	X1	0.0048	0.0445	-0.0743	0.1195
	X2	0.0024	0.0403	-0.0878	0.103
	X3	-0.0032	0.0521	-0.0987	0.1005
SSE	X1	0.0085	0.0599	-0.1147	0.141
	X2	0.004	0.0443	-0.1003	0.0872
	X3	-0.0012	0.0426	-0.0808	0.0845

Note: X1, X2, X3 represents the Rmrf factor, SMB factor and HML factor respectively

The ADF test values (t-values) for all three factors at each site were extremely significant at the 0.001 level, indicating that the original hypothesis of a random wandering process with drift was rejected and all three factors were consistent with a linear trending smooth process.

The three-factor model is constructed as follows.

$$r_{it} - r_{ft} = \alpha_i + \beta_1\left(r_{mt} - r_{ft}\right) + \beta_2 SMB_t + \beta_3 HML_t + \varepsilon_{it} \tag{4}$$

The portfolio is built using the full A-share as the entire market and the underlying investments SSE and SZSE. The three factors are initially subjected to correlation analysis in order to rule out the impact of multicollinearity. According to Stata analysis, the correlation coefficient between the size of the market factor (SMB) and the book-to-market ratio factor (HML) is -0.0227, the correlation coefficient with the excess return on market factor (Rmrf) is 0.1306, and the correlation coefficient with the book-to-market ratio factor (HML) is -0.2990. As seen in table 4, there is no meaningful association between the components because of their weak linkage.

Table 4. Correlation result

	X1	X2	X3
X1	1	-	-
X2	0.1306	1	-
X3	-0.2990	0.0227	1

Note: X1, X2, X3 represents the Rmrf factor, SMB factor and HML factor respectively

This paper will use 31 December 2009 as a dividing line, which is also the time of the massive outbreak of the Covid-19 and divide the overall data into two periods of data. We will complete two time-series regression model tests to determine whether the epidemic has had an impact on the three-factor model's applicability in the Chinese stock market. The outcomes are displayed as follows:

Table 5. Period 1 time-series regression results

Variable	Coefficient	Robust S.E.	T-test	P-value	VIF
X1	1.014*	0.006	179.340	0.000	1.140
X2	0.046*	0.008	5.560	0.000	1.140
X3	-0.074*	0.009	-7.920	0.000	1.120
Intercept	0.000	0.000	0.040	0.969	
R^2=0.9993 adjusted R^2=0.9992 F(3,26)=12541.430 P=0.000					

Note: In the table, the symbols * denote statistical significance at 1%. X1, X2, X3 represents the Rmrf factor, SMB factor and HML factor respectively

The market factor's coefficient is 1.0416>0, which means that the portfolio's trend over the sample period is consistent with the general market trend. Since 1.0416 is just barely more than 1, the portfolio may be considered aggressive. According to the SMB coefficient, the portfolio may prefer to allocate to small-cap stocks, and its excess returns may be influenced by small-cap returns. which has a very high significance and is positive; the coefficient of HML is less than 0, which may suggest that the portfolio is biassed toward growth stocks (i.e. stocks with relatively low book value).

The VIF values are all less than 10 and even all less than 3, so there is no problem of multicollinearity. The coefficient of fit of the three factors to the portfolio risk premium is R^2 = 0.9993 and the adjusted coefficient of fit is 0.9992, indicating that the three factors explain 99.9% of the variance in the portfolio risk premium. In the regression model, all three factors have an extremely significant effect on the portfolio risk premium at the 0.001 level. The regression equations are shown below. In summary, the three-factor model holds.

$$r_{it} - r_{ft} = 1.014 \times (r_{mt} - r_{ft}) + 0.046 \times SMB_t - 0.074HML_t \tag{5}$$

As shown in table 6, the market factor's coefficient is 1.009>0, meaning that the portfolio moved in line with the general market trend over the sample period. Since |1.009| is so near to 1, the portfolio may be considered to be relatively cautious. Although the SMB coefficient is positive, it is much lower than it was before to the outbreak of the epidemic. The coefficient of HML is still less than 0, but it is also significantly higher than before the epidemic, indicating a decline in the tendency to allocate to growth stocks, suggesting that the epidemic has made investors less confident in stocks with good prospects. This suggests that the epidemic has reduced investor confidence in stocks with good prospects.

Table 6. Period 2 time-series regression results

Variable	Coefficient	Robust S.E.	T-test	P-value	VIF
X1	1.009*	0.004	260.060	0.000	1.160
X2	0.009*	0.003	3.570	0.001	1.130
X3	-0.027*	0.006	-4.910	0.000	1.030
Intercept	0.000	0.000	1.470	0.154	
R^2=0.9995 adjusted R^2=0.9994 F(3,26)= 17538.41 P=0.000					

Note: In the table, the symbols * denote statistical significance at 1%. X1, X2, X3 represents the Rmrf factor, SMB factor and HML factor respectively

The VIF values are all less than 10 and even all less than 3, so there is no problem of multicollinearity. The coefficient of fit of the three factors to the portfolio risk premium is R^2 = 0.9995 and the adjusted coefficient of fit is 0.9994, indicating that the three factors explain 99.9% of the variance in the portfolio risk premium. In the regression model, all three factors have an extremely significant effect on the portfolio risk premium at the 0.001 level. The regression equations are shown below. In summary, the three-factor model holds.

$$r_{it} - r_{ft} = 1.009 \times (r_{mt} - r_{ft}) + 0.009 \times SMB_t - 0.027HML_t \tag{6}$$

4. GRS-Test

Gibbons et al. invented the GRS Test to test the explanatory power and validity of the model, which is a joint test of the pricing error alpha in the factor model, with the original hypothesis that the intercept term from the regression of the factor pricing model on the return of any portfolio must be zero. A larger test statistic indicates that the regression intercept term is mostly insignificant at zero, indicating that the model does not effectively explain the portfolio returns. Therefore, the smaller the GRS test statistic, the smaller the portion of the model that cannot be explained, indicating that the model is more effective and has more explanatory power.

A|ai| is the average of the absolute values of the pricing errors. The pricing error is the value of the intercept term obtained from the regression of the factor pricing model on the returns of this portfolio in a given portfolio. The ratio is an estimate of the dispersion of the pricing error. If the smaller the pricing error in the regression results, the smaller the mean of the absolute value of the pricing error and the less the model cannot explain, indicating that the factor model has a stronger explanatory power. When the intercept term is greater than zero, it indicates that the factor pricing model overestimates the portfolio; when the intercept term is less than zero, it indicates that the factor pricing model underestimates the portfolio; either overestimation or underestimation is a mispricing of the portfolio by the factor pricing model, therefore, the absolute value of the pricing error is used to determine the explanatory power of the model.

Table 7. GRS Test

Period	GRS	A|ai|
Period 1	0.002	0.000
Period 2	2.549	0.000

As can be seen from the table above, the GRS values are small for both the first half and second half periods of the time series regressions, which do not reach the 10% significance level, indicating that the three-factor model developed in this paper is effective and has a strong explanatory power. As shown by the A|ai| values, the mean value of the absolute value of the pricing error for both the first and second half time series regressions is almost zero, indicating that the three-factor model has almost no error in the pricing of the portfolio, i.e. the model has a very strong explanatory power for the pricing of the portfolio.

5. Conclusion

This study uses time series regressions to examine whether the three-factor model can be applied to the Chinese stock market and whether its structure changed before and after the new epidemic broke out.

Based on the above empirical regressions, the epidemic did not have a significant impact on the overall structure of the three-factor model. This indicates that the Chinese stock market is relatively stable in the short term and more resilient to unexpected events. It also shows that A-share market can be predicted by the three-factor model.

Furthermore, we can see that the the portfolio's return less the risk-free rate of return factor(Rmrf) has the most significant impact on stock returns, which is consistent with the analysis of the relevant economic theories. The book-to-market ratio factor (HML) makes the second most significant contribution, suggesting that stocks with higher book-to-market ratios (HML) can be appropriately selected to increase the portfolio's return abundance. The size of firm factor (SMB) has a smaller impact, indicating that it has some influence on share prices, but less so than the portfolio's return less the risk-free rate of return. and the book-to-market ratio factor.

Therefore, when constructing the asset portfolio, you can select stocks with higher market premium, higher book-to-market ratio and relatively smaller size of firm to invest within the risk tolerance.

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