Analysis of US Agriculture Market with a New Fama-French Three-Factor Model

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Abstract. In this article, we propose a new Index for Agriculture Output (AOI) in US. Sample period is from 1960 to 2004. Data is analyzed by a new model, which includes 3 factors in Fama and French (1993), the EGARCH-type volatilities in Nelson(1991) and non-Normal errors in Zhu and Zinde-Walsh(2009). This new agriculture index (AOI) is compared with that constructed by Professor Kenneth R. French. LR, KS and AIC are used for testing parameter restrictions, residual check and model comparison, respectively. MLE is used to estimate parameters via Matlab. Empirical results show the Fama-French 3 factors are still alive! The new model can capture the skewness, fat-tailness and the asymmetric kurtosis in returns, which has better in-sample fit.

1. Introduction

Treynor(1961), Sharp(1964) and Lintner(1965) propose Capital Asset Pricing Model(CAPM), which is one of the key stones in modern finance. Fama and French(1993) add two more factors such as Size and Book-to-market factors into the CAPM model and create a 3-factor model, which is capable to explain the stock returns better than the CAPM.

After that, a lot of researches about Fama-French 3-factor model have been done. And these researches can be divided into two groups. One group applies this model to different countries and show that this model has powerful explanations. For example, this model can explain the stock markets well for US and other 17 countries in Arshaapalli, Coggin and Doukas(1998), Bangladesh in Baten and Ashraf-UL-Alam(2006), and Korean in Chan(2007).

Others extend this model by finding other factors or changing error assumptions. Carhart(1997) finds the Momentum factor has great effect on stock returns. The Default factor is found by Gharghori, Chan and Faff(2007) and a State Switch variable is added into the model by He(2008). Wang(2012) adds the PE factor. Xiao, Faff and Gharghori(2012) introduce a Sustainability factor. Yin(2011) uses non-Normal error term to propose a new 3-factor model. Yang(2013) adds EGARCH-type volatilities of Nelson (1991) to suggest a new 3-factor model and shows it works better than that of Fama-French(1993).

In the literature of agricultural insurance, different factors that may influence insurance scheme have been studied. Following Rothschild and Stiglitz(1976), in this article, we propose a new index for agriculture output. Then, with this new index, the effect of Fama-French three factors on agriculture market is studied, which is new in the literature. Based on a new 3-factor model in Yang(2013), we try to test following hypotheses:

1. With EGARCH-type volatilities in Nelson(1991) and non-Normal errors of SSAEPD in Zhu and Zinde-Walsh(2009), are the three factors in Fama and French (1993) still alive in US agriculture market?

2. Can this new 3-factor model beat that of Fama and French(1993).

To answer these questions, the new 3-factor model is estimated by Maximum Likelihood Estimation (MLE). Likelihood Ratio test (LR) is used for parameter restrictions. Kolmogorov-Smirnov test (KS) is used for residual check. And AIC is for model comparison.

Empirical results show with EGARCH-type volatilities and non-Normal errors, the Fama-French 3 factors are still alive in US! EGARCH-type volatility enables the model to respond asymmetrically to positive and negative shocks. The new Fama-French 3-factor model has better in-sample fit than that of Fama-French(1993).

The organization of this article is as follows. The model and methodology are discussed in section . 3. Empirical results and the model comparisons will be presented in section 3. Section 4 is the conclusions and future extensions.

2. Model and Methodology

2.1 FF-SSAEPD-EGARCH Model

Considering the EGARCH-type volatility in Nelson (1991) and non-Normal error of SSAEPD in Zhu and Zinde-Walsh(2009), a new 3-factor model is used to analyze agriculture data (denoted as FF-SSAEPD-EGARCH).

$$R_t - R_{ft} = \beta_0 + \beta_1(R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + u_t,\ t = 1, 2, ..., T, \tag{1}$$

$$u_t = \sigma_t z_t,\ z_t \sim SSAEPD(\alpha, p_1, p_2), \tag{2}$$

$$ln(\sigma_t^2) = a + \sum_{i=1}^{s} g(z_{t-i}) + \sum_{j=1}^{m} b_j ln(\sigma_{t-j}^2), \tag{3}$$

$$\begin{aligned} g(z_{t-i}) &= c_i z_{t-i} + d_i \left[\mid z_{t-i} \mid - E(\mid z_{t-i} \mid) \right], \\ &= \begin{cases} (c_i + d_i) z_{t-i} - d_i E(\mid z_{t-i} \mid), & if\, z_{t-i} \geq 0, \\ (c_i - d_i) z_{t-i} - d_i E(\mid z_{t-i} \mid), & else. \end{cases} \end{aligned} \tag{4}$$

Where $\theta = (\beta_0, \beta_1, \beta_2, \beta_3, \alpha, p_1, p_2, a, \{b_j\}_{j=1}^{m}, \{c_i\}_{i=1}^{s}, \{d_i\}_{i=1}^{s})$ are parameters to be estimated. R_t is the rate of return for U.S index of agricultural output(AOI) at time t. R_{ft} is the rate of return for the risk-free asset at time t. R_{mt} is the rate of return for the market at time t. SMB_t stands for small market capitalization minus big market capitalization. HML_t stands for high book-to-market ratio minus low book-to-market ratio. T is the sample size. σ_t is the conditional standard deviation, i.e., volatility. The error term z_t is distributed as the Standardized Standard Asymmetric Exponential Power Distribution(SSAEPD) proposed in Zhu and Zinde-Walsh(2009).

3. Empirical Analysis

3.1 Data

In this article, the relationship between US agriculture index and stock returns are analyzed. Yearly data are downloaded from US Department of Agriculture. After calculating the proportion of

livestock, crop and other outputs, the new Index of Agriculture, AOI(Y), is created by following formula which is analogous to Industrial Production Index.

Where Qi is the quantity of livestock, crops and others at time i and W0 is the weight at time 0. Sample period is from 1960 to 2004.

For comparison, we also download a US monthly agriculture index proposed by Professor Kenneth R. French from its Data Library. For simplicity, we denote it as AOI_French. Sample period is from 1927:01 to 2011:12.

3.2 Estimation Results

For AOI(Y), we find out all coefficients are statistically significant. That means, GARCH terms should be added into 3 factor model and AOI(Y) can earn Alpha returns. Similar results are documented for AOI_French(Y) and AOI_French(M). Hence, we conclude that 3 factors are still alive. For comparison, we also estimate other models. These results show the coefficients in the mean equation are all statistically significant. The values of β1 for the new AOI data estimated by this Fama-French 3-factor model are smaller than 1, which indicates that these agriculture data in U.S. are less sensitive to market.

3.3 Fama-French 3-factor Still Alive

Likelihood Ratio test (LR) is used to test the joint and individual significance of coefficients in these models. We find out terms are joint statistically significant, which means all data can earn the Alpha returns. Non-Normality is confirmed. ARCH and GARCH terms should be added into Fama-French 3-factor model since they are all statistically significant.

4. Conclusions and Future Extensions

In this article, we design a new index for US agriculture output, denoted as AOI(Y). The relationships between US agriculture and stock market are analyzed based on Yang(2013)'s new model. This new model is an extension for Fama and French(1993)'s 3-factor model by introducing a non-Normal error of SSAEPD in Zhu and Zinde-Walsh (2009) and EGARCH-type volatilities in Nelson(1991). For comparison, French's index for US agriculture output (AOI_French(Y) and AOI_French(M)) is analyzed. Likelihood Ratio test (LR) is used for parameter restrictions, Kolmogorov-Smirnov test (KS) for residual check and AIC for model comparison. Maximum Likelihood Estimation method (MLE) is used to estimate models via Matlab.

Empirical results show with EGARCH-type volatilities and non-normal errors, the Fama-French 3 factors are still alive in US! EGARCH-type volatility enables the model to respond asymmetrically to positive and negative shocks. The FF-SSAEPD-EGARCH model fits the data well and has better in-sample fit than others for new AOI data. The Beta coefficients for the AOI β1 are all smaller than 1, which indicates that agriculture market is less sensitive than US stock market.

Future extension will include but not limited to follows. First, other type of volatility such as TGARCH-type volatility or Stochastic Volatility (SV) can be added into the model. Second, different data can be used to check the adequacy of our FF-SSAEPD-EGARCH model. Lastly, we can compare our results with those from other models such as ARIMA and GARCH models.

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