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Analysis of the Effect of Index Futures on Stock Market with a New Fama-French 3-Factor Model

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Abstract

In this paper, the effect of Index Futures on stock market is studied. A new model, which is based on the 3-factor model in Fama and French (1993), the EGARCH-type volatility in Nelson (1991) and non-normal distribution of SSAEPD in Zhu and Zinde-Walsh (2009) is used. Fama-French 25 portfolios for US stock market (1951-2007) are analyzed. Following Pericli and Koutmos (1997), we divide data into 2 sub-samples: sample 1 (pre-SP500 Index Futures) and sample 2 (post-SP500 Index Futures). Our three main findings are as follows. Fama-French 3 factors are still alive in both samples. During the period of post-SP500 Index Futures, the coefficients in this new model become slightly lower and the volatility of stock market is bigger.

Keywords

1. Introduction

Trading of stock Index Futures was first introduced by the Kansas City Board of Trade on February 24, 1982. Then, the Chicago Mercantile Exchange began trading of SP500 Index Futures in April. After that, similar instruments were introduced in other countries, such as FTSE100 Index Futures in England, Composite Index Futures in Japan and All-Ordinaries Index Futures in Australia. The development of Index Futures has recieved

many attensions.

One group of researchers show volatility of spot market is increased after the introduction of Index Futures. For example, Kang and Yoon (2007) found that the spot market became more volatile after the introduction of five Index Futures in Asia based on GARCH, GJR-GARCH and APGARCH model [1]. However, others show the opposite. Friedman, Harrison and Salmon (1983) suggested that spot prices tended to be less volatile after futures markets operate [2]. Gulen and Mayhew (2000) concluded stock Index Futures decreased the volatility of stock market in 25 countries (except US and Japan) [3]. Similar conclusion was drawn by Bologna and Cavallo (2002) [4].

In addition to previous results, the 3rd groups of researchers show there is no statistically significance relationship between Index Futures and stock return. For example, Santoni (1987) analyzed SP500 index and found no significant change on stock index volatility [5]. Also, Xie and Huang (2014) use daily data of the China Securities Index (CSI) 300 between 2005 and 2012 and find that the launch of Index Futures does not decrease the volatility of the spot market [6]. Liu and Wang (2008) ran empirical test based on GARCH model and suggested that the introduction of Index Futures in Taiwan, Japan and South Korea did not increase the volatility in long term [7]. For other researches on Index Futures, one can refer to **Table 1**.

Following previous researches, this paper studies the influence of the Index Futures on stock market. SP500 Index Futures is analyzed. We use a new model based on the 3-factor model of Fama-French (1993), the EGARCH-type volatility of Nelson (1991) and non-Normal error of SSAEPD in Zhu and Zinde-Walsh (2009) [8]-[10]. This new model was first proposed by Yang (2013) [11]. The reason why we chose this new model was that it had better in-sample fit than that of Fama and French (1993).

In this paper, we will test following two hypotheses.

1) Are the 3 factors in Fama-French (1993) still alive if EGARCH-type volatility and non-Normal error are considered?

2) Can we find any differences before or after the introduction of SP500 Index Futures?

To answer these questions, Fama-French 25 portfolios are analyzed. Following Pericli and Koutmos (1997), we choose 1982 as the break point and divide the data into 2 sub-samples: pre-SP500 Index Futures as sample 1 (from September 1951 to March 1982) and post-SP500 Index Futures as sample 2 (from April 1982 to March 2007)[1] [15]. Likelihood Ratio test (LR) is used for parameter restriction testings. Kolmogorov-Smirnov test (KS) is used for model diagnostics.

Empirical results show Fama-French 3 factors are alive in both samples. After the introduction of SP500 Index Futures, the estimates for Fama-French three factors becomes lower and show less fluctuating. And we find the coefficients in EGARCH equaltion becomes bigger so we conclude that the volatility of the stock market becomes higher.

This paper is organized as follows. Section 2 is the model and methodology. Section 3 is the empirical results. Section 4 is the conclusion.

2. Model and Methodology

2.1. FF-SSAEPD-EGARCH Model

In this paper, we apply following new model (denoted as FF-SSAEPD-EGARCH) to study the effect of Index Futures on stock returns[2].

$$R_t - R_{ft} = \beta_0 + \beta_1 \left(R_{mt} - R_{ft} \right) + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + u_t, \quad t = 1, 2, \cdots, T \tag{1}$$

$$u_t = \sigma_t z_t, \quad z_t \sim \text{SSAEPD}\left(\alpha, p_1, p_2 \right)$$

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

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[1]We choose short sample periods because we think shorter period may reduce the noise such as the impact of other unrelated events on stock market. Also, we set the end of sample period before April 2007 because during the period of 2007 financial crisis, the volatility is too big, which is not related to oil crisis.

[2]Based on the 3-factor model in Fama and French (1993), 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 proposed by Yang (2013). Yang (2013) denotes this new model as the FF-SSAEPD-EGARCH model, whose MatLab program is revised from that of Yin (2011). And in this paper, we first exam the simulation program of Yang (2013) and then apply this model and methodology to analyze data.

Table 1. Researches about the index futures and Fama-French 3-Factor model.

Author (Year)	Research Purpose	Model	Estimation	Computer	Data		
			Method	Algorithm	Country	Variables	Frequency & Period
Panel A: Studies on Index Future Trading							
Rahman (2001) [12]	Empirical Tests	GARCH	OLS	-	USA	Stock price return	Min199704-199706
Lien *et al.* (2007) [13]	Empirical Analysis	BGARCH	OLS	-	Australia	Future price, spot price	Min199804-199806 D19800101-19991231
Hwang *et al.* (2000) [14]	Empirical Tests	self-selection model	-	-	UK	Index return/future return/call option vol.	D19840101-19960329
Pericl *et al.* (1997) [15]	Empirical Tests	EGARCH	-	-	USA	Dummy	D19530102-19440909
Zhong *et al.* (2004) [16]	Empirical Tests	EGARCH	OLS, GMM	-	Mexico	Future/underlying cash price, days to maturity	D19990415-20020724
Madarassy *et al.* (2003) [17]	Empirical Tests	GARCH	-	-	USA	Future return	D19820104-20001231
Matanovic *et al.* (2012) [18]	Empirical Tests	GARCH	QML	-	Germany	Index return, dummy	D19700101-20090501
Alexakis (2007) [19]	Empirical Tests	GJR-GARCH	-	-	Athens	Spot price, dummy	D19970923-20040607
Ülkem *et al.* (2009) [20]	Model Comparison	ECM, COC, ARIMA, VAR	-	Eviews	Turky	Future/spot price, RF, dividend yield, days to maturity	D20050204-20080509
Hong *et al.* (2014) [21]	Model Comparison	GARCH, EGARCH, IGARCH	-	-	USA	Future price	Min20080901-20090930
Panel B: Extensions for Fama-French 3-Factor Model							
Carhart (1997) [22]	Model Comparison	CAPM, FF, Carhart 4-factor	OLS	-	USA	ER, RP, SMB, HML, Momentum	M196201-199312
Gharghori *et al.* (2007) [23]	Default Risk	FF with Default factor	GMM	-	Australia	ER, RP, SMB, HML, DEF	M1996-200412
He (2008) [24]	Model Comparison	FF, FF with State Switch	OLS	-	China	ER, RP, SMB, HML, State Switch	M199506-200512
Wang (2012) [25]	Model Extension	FF with PE factor	OLS	Eviews	China	ER, RP, SMB, HML, PE Factor	M200407-201106
Yang (2013) [11]	Model Extension	FF-EGARCH-SSAEPD	MLE	MATLAB	USA	ER, RP, SMB, HML	M1926-2011

Note: "-" means information is not available in the paper. D means daily. M means monthly. Min means minite.

$$g(z_{t-i}) = c_i z_{t-i} + d_i \left[|z_{t-i}| - E(|z_{t-i}|) \right]$$
$$= \begin{cases} (c_i + d_i) z_{t-i} - d_i E(|z_{t-i}|), & \text{if } z_{t-i} \geq 0, \\ (c_i - d_i) z_{t-i} - d_i E(|z_{t-i}|), & \text{else.} \end{cases} \quad (2)$$

Here, R_t, R_{ft} and R_{mt} are the rate of return for stock portfolio, the risk-free rate and the return rate of the market at time t, respectively. SMB_t stands for small size (market capitalization) minus big size (market capitalization) and HML_t for high book-to-market ratio minus low book-to-market ratio. The conditional standard deviation is σ_t, *i.e.*, volatility. $\theta = \left(\beta_0, \beta_1, \beta_2, \beta_3, \alpha, p_1, p_2, a, \{b_j\}_{j=1}^m, \{c_i\}_{i=1}^s, \{d_i\}_{i=1}^s \right)$ are the parameters to be estimated. The error term z_t is distributed as the Standardized Standard Asymmetric Exponential Power Distribution (SSAEPD) proposed by Zhu and Zinde-Walsh (2009). The probability density function (PDF) of z_t is

$$f(z_t) = \begin{cases} \delta\left(\dfrac{\alpha}{\alpha^*}\right)K(p_1)\exp\left(-\dfrac{1}{p_1}\left|\dfrac{\omega+\delta z_t}{2\alpha^*}\right|^{p_1}\right), & \text{if } z_t \le -\dfrac{\omega}{\delta}, \\[3ex] \delta\left(\dfrac{1-\alpha}{1-\alpha^*}\right)K(p_2)\exp\left(-\dfrac{1}{p_2}\left|\dfrac{\omega+\delta z_t}{2(1-\alpha^*)}\right|^{p_2}\right), & \text{if } z_t > -\dfrac{\omega}{\delta}, \end{cases} \tag{3}$$

$$z_t = \frac{x_t - \omega}{\delta}$$

$$\omega = E(x_t) = \frac{1}{B}\left[(1-\alpha)^2 \frac{p_2\Gamma(2/p_2)}{\Gamma^2(1/p_2)} - \alpha^2 \frac{p_1\Gamma(2/p_1)}{\Gamma^2(1/p_1)}\right]$$

$$\delta^2 = \mathrm{Var}(x_t) = \frac{1}{B^2}\left[(1-\alpha)^3 \frac{p_2^2\Gamma(3/p_2)}{\Gamma^3(1/p_2)} + \alpha^3 \frac{p_1^2\Gamma(3/p_1)}{\Gamma^3(1/p_1)}\right] - \frac{1}{B^2}\left[(1-\alpha)^2 \frac{p_2\Gamma(2/p_2)}{\Gamma^2(1/p_2)} - \alpha^2 \frac{p_1\Gamma(2/p_1)}{\Gamma^2(1/p_1)}\right]^2$$

$$K(p_1) = \frac{1}{2p_1^{1/p_1}\Gamma(1+1/p_1)}$$

$$K(p_2) = \frac{1}{2p_2^{1/p_2}\Gamma(1+1/p_2)}$$

$$B = \alpha K(p_1) + (1-\alpha)K(p_2)$$

x_t is distributed as the standard AEPD (SAEPD)[3]. And $\Gamma(.)$ is the gamma function. $\alpha \in (0,1)$ is the skewness parameter. $p_1 > 0$ and $p_2 > 0$ are the left and right tail parameters, respectively. When $\alpha = 0.5$, $p_1 = p_2 = 2$, SSAEPD will be reduced to Standard Normal, *i.e.*, Normal $(0,1)$.

2.2. Method of Maximum Likelihood Estimation

The maximum likelihood function for this new model is

$$L\left(\{R_t - R_{ft}, R_{mt} - R_{ft}\}_{t=1}^T; \theta\right) = \prod_{t=1}^T f(R_t - R_{ft})$$

$$= \prod_{t=1}^T \begin{cases} \dfrac{\delta}{\sigma_t}\left(\dfrac{\alpha}{\alpha^*}\right)K(p_1)\exp\left(-\dfrac{1}{p_1}\left|\dfrac{\omega+\delta z_t}{2\alpha^*}\right|^{p_1}\right), & z_t \le -\dfrac{\omega}{\delta}, \\[3ex] \dfrac{\delta}{\sigma_t}\left(\dfrac{1-\alpha}{1-\alpha^*}\right)K(p_2)\exp\left(-\dfrac{1}{p_2}\left|\dfrac{\omega+\delta z_t}{2(1-\alpha^*)}\right|^{p_2}\right), & z_t > -\dfrac{\omega}{\delta}, \end{cases} \tag{4}$$

where

$$z_t = \frac{R_t - R_{ft} - \beta_0 - \beta_1(R_{mt} - R_{ft}) - \beta_2\mathrm{SMB}_t - \beta_3\mathrm{HML}_t}{\sigma_t} \tag{5}$$

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[3]By changing variable techniques, we obtain PDF of $\mathrm{SSAEPD}(\alpha, p_1, p_2)$ from $\mathrm{SAEPD}(\alpha, p_1, p_2)$. When X is distributed as the standard AEPD, its probability density function is

$$f(x|\beta) = \begin{cases} \left(\dfrac{\alpha}{\alpha^*}\right)K(p_1)\exp\left(-\dfrac{1}{p_1}\left|\dfrac{x}{2\alpha^*}\right|^{p_1}\right), & \text{if } x \le 0, \\[3ex] \left(\dfrac{1-\alpha}{1-\alpha^*}\right)K(p_2)\exp\left(-\dfrac{1}{p_2}\left|\dfrac{x}{2(1-\alpha^*)}\right|^{p_2}\right), & \text{if } x > 0. \end{cases}$$

$$\ln\left(\sigma_t^2\right) = a + \sum_{i=1}^{s} g\left(z_{t-i}\right) + \sum_{j=1}^{m} b_j \ln\left(\sigma_{t-j}^2\right) \tag{6}$$

3. Empirical Analysis

3.1. Data

In this paper, we study the effect of SP500 Index Futures on stock returns. The data used are the monthly return for the Fama-French 25 portfolios, which is downloaded from the French's Data Library[4]. The sample period is from September 1951 to March 2007 with 666 observations. Following Pericli and Koutmos (1997), we select April 1982 as the breakpoint and set pre-SP500 Index Futures as sample 1 (from September 1951 to March 1982, the period before the introduction of SP500 Stock Index Futures) and the post-SP500 Index Futures as sample 2 (from April 1982 to March 2007, the period after the introduction of SP500 Stock Index Futures).

The descriptive statistics of these samples are listed in **Table 2**. The P-value of Jarque-Bera test for most portfolios is smaller than 5% significance level[5]. Hence, we conclude the asset returns in both samples do not follow Normal distribution.

3.2. Empirical Results

3.2.1. Estimations

For sample 1, the estimations are listed in **Table 3**. According to the results, all estimates of β_1 are around 1 (ranging from 0.84 to 1.12) and statistically significant under 5% significance level[6]. β_2 estimates decrease from small-size to big-size quintiles and all estimates, except portfolio at (5th, 5th) quintile, are statistically significant under 5% significance level. So we conclude that the small-size effect exsists in sample 1. Estimates of β_3 increase from low to high book-to-market quintiles and 23/25 estimates are statistically significant. 19/25 estimates of β_0 are not statistically significant. Similar results can be found for sample 2 (see **Table 4**). Hence, we conclude the Fama and French three factors are still alive in both samples.

For the parameters in SSAEPD, the estimates of α range from 0.3 to 0.76 with only 3 estimates in sample 1 (4 estimates in sample 2) statistically different from 0.5. That means after considering the 3 factors and EGARCH-type volatility, most errors of the data show no obvious skewness. The p_1-values range from 1.00 to 3.14 with 6 estimates in sample 1 (5 estimates in sample 2) statistically different from 2. The p_2-values range from 0.79 to 2.35 with 7 estimates in sample 1 (7 in sample 2) statistically different from 2. So we conclude that most parameters in SSAEPD errors do follow some characteristics of Normal distribution, which may be caused by the EGARCH-type volatility.

In the EGARCH model, most estimates of a are close to zero and 14 estimates in sample 1 (5 estimates in sample 2) are statistically significant. 24/25 estimates of b in sample 1 (all in sample 2) are statistically significant. 18 estimates of c in sample 1 (22 estimates in sample 2) are not statistically significant, so we conclude that the good news and bad news do not have significant different impact on volatility. 11 estimates of *d* in sample 1 (22 estimates in sample 2) are statistically significant. Hence, we conclude that the asymmetric effect is not documented in the data.

3.2.2. Comparisions

To compare the factors before and after the introduction of SP500 index futures, we plot the estimates of β_1, β_2 and β_3 in **Figure 1**. We discover that the coefficients in these two samples present similar patterns. During the period of post-SP500 Index Futures, most of the 25 portfolios have smaller β_1, β_2 and β_3. Also the estimates of β_2 and β_3 in sample 2 are all obviously less fluctuating compared with those in sample 1.Hence, we conclude that after the introduction of index futures the estimates for Fama-French three factors becomes smaller and show less fluctuating.

To compare the volatility of stock market, we plot the estimates of *a*, *b*, *c*, *d* in the EGARCH equation (see **Figure 2**). As mentioned above, most of the *a* and *c* values are small and close to zero so the values of condition

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[5]Only the P-value of JB test of the (5,2) portfolio in sample 1 is more than 0.05.
[6]H_0 : $\beta_1 = 0$. If the P-value of LR test is smaller than 5% significance level, the null hypothesis is rejected. Otherwise, it is not rejected.

Table 2. Descriptive statistics.

Size	Book-to-market quintiles									
Quintile	Low	2	3	4	High	Low	2	3	4	High
					Sample 1: 9/1951-3/1982					
			Mean					Median		
Small	0.88	1.15	1.12	1.35	1.51	0.69	0.80	1.05	1.33	1.48
2	0.85	1.08	1.21	1.28	1.51	1.03	1.17	1.33	1.34	1.57
3	0.90	1.09	1.12	1.28	1.26	1.24	1.17	1.60	1.39	1.15
4	0.81	0.86	1.19	1.17	1.18	1.02	1.22	1.46	1.20	1.22
Big	0.72	0.77	0.94	0.94	0.98	1.01	0.87	0.87	0.88	1.10
			Maximum					Minimum		
Small	26.59	29.55	28.35	27.82	32.77	−26.79	−23.41	−21.87	−18.66	−21.37
2	22.49	25.83	26.87	27.03	30.36	−24.89	−20.14	−19.01	−15.84	−18.96
3	19.31	25.00	21.92	23.41	28.98	−22.91	−18.67	−16.35	−14.35	−19.90
4	20.79	20.58	23.93	24.32	27.9	−19.84	−17.25	−14.37	−12.04	−16.48
Big	22.35	14.39	19.08	19.76	15.66	−14.73	−12.72	−10.91	−11.30	−12.89
			Standard Deviation					Skewness		
Small	7.56	6.45	5.76	5.49	5.92	−0.02	0.02	0.13	0.30	0.41
2	6.51	5.59	5.15	5.05	5.67	−0.21	−0.01	−0.02	0.26	0.34
3	5.88	4.92	4.74	4.67	5.41	−0.19	−0.21	−0.24	0.18	0.30
4	5.21	4.67	4.44	4.66	5.48	−0.18	−0.22	0.12	0.31	0.34
Big	4.39	4.05	3.91	4.17	4.76	0.00	−0.01	0.39	0.37	0.27
			Kurtosis				P-value of Jarque-Bera Test			
Small	1.15	1.69	2.60	2.67	3.58	0.00	0.00	0.00	0.00	0.00
2	1.60	1.99	3.10	2.59	3.03	0.00	0.00	0.00	0.00	0.00
3	1.63	2.59	1.94	1.89	2.99	0.00	0.00	0.00	0.00	0.00
4	1.32	1.73	2.18	1.81	2.01	0.00	0.00	0.00	0.00	0.00
Big	1.66	0.61	1.62	1.30	0.60	0.00	0.06	0.00	0.00	0.01
					Sample 2: 4/1982-3/2007					
			Mean					Median		
Small	0.49	1.34	1.47	1.65	1.71	1.02	1.65	1.42	1.71	1.60
2	0.86	1.22	1.52	1.55	1.50	1.55	1.77	1.73	1.73	2.08
3	1.03	1.34	1.32	1.40	1.63	1.88	1.58	1.56	1.46	1.86
4	1.23	1.27	1.36	1.42	1.50	1.34	1.40	1.67	1.83	1.90
Big	1.15	1.27	1.20	1.20	1.29	1.02	1.51	1.40	1.31	1.42
			Maximum					Minimum		
Small	39.80	38.64	26.98	19.89	16.31	−34.18	−30.93	−28.53	−28.96	−28.73
2	29.71	17.00	13.47	11.02	13.85	−32.82	−31.56	−27.76	−26.36	−29.32
3	24.47	13.54	13.00	15.02	13.17	−29.57	−29.19	−24.47	−22.71	−26.22
4	25.67	14.88	15.99	12.64	14.01	−25.94	−28.83	−24.67	−18.26	−23.84
Big	15.39	16.50	13.07	15.51	13.55	−21.64	−22.36	−21.71	−14.88	−18.99
			Standard Deviation					Skewness		
Small	8.03	6.73	5.31	4.91	5.06	0.20	0.18	−0.38	−0.72	−0.92
2	7.26	5.62	4.75	4.65	5.15	−0.34	−0.94	−1.16	−1.27	−1.20
3	6.72	5.19	4.49	4.43	4.69	−0.45	−0.92	−0.96	−0.79	−1.20
4	6.05	4.87	4.69	4.31	4.64	−0.23	−0.91	−0.82	−0.60	−0.95
Big	4.76	4.53	4.27	4.11	4.69	−0.41	−0.61	−0.75	−0.26	−0.58
			Kurtosis				P-value of Jarque-Bera Test			
Small	3.76	5.63	5.21	6.19	4.71	0.00	0.00	0.00	0.00	0.00
2	2.10	4.02	5.33	5.16	5.13	0.00	0.00	0.00	0.00	0.00
3	1.85	4.31	4.34	3.88	5.41	0.00	0.00	0.00	0.00	0.00
4	2.39	5.50	3.85	2.27	3.94	0.00	0.00	0.00	0.00	0.00
Big	1.74	2.97	3.39	1.55	1.60	0.00	0.00	0.00	0.00	0.00

Table 3. Estimates from sample 1 (pre-SP500 index futures).

Size quintile	Book-to-market quintiles																			
	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High
	β_0					β_1					β_2					β_3				
Small	−0.11	−0.12	−0.05	0.07	0.13*	1.08*	1.00*	0.92*	0.92*	0.96*	1.44*	1.29*	1.16*	1.09*	1.17*	−0.24*	0.12*	0.31*	0.47*	0.66*
2	−0.14	−0.04	0.10	0.02	0.15*	1.09*	1.00*	0.95*	0.98*	1.06*	1.03*	0.93*	0.85*	0.76*	0.88*	−0.45*	0.07*	0.23*	0.51*	0.69*
3	−0.07	0.04	0.03	0.07	−0.09	1.08*	0.96*	0.96*	0.97*	1.04*	0.77*	0.66*	0.55*	0.50*	0.74*	−0.38*	0.08*	0.28*	0.53*	0.76*
4	−0.05	−0.03	0.14*	0.00	−0.15	1.07*	1.00*	1.00*	1.03*	1.12*	0.36*	0.26*	0.25*	0.32*	0.49*	−0.36*	−0.01	0.30*	0.57*	0.76*
Big	0.04*	−0.05	0.18*	−0.12	−0.23*	1.07*	0.98*	0.88*	1.01*	1.08*	−0.16*	−0.16*	−0.17*	−0.17*	0.02	−0.35*	0.03	0.26*	0.63*	0.87*
	α					p_1					p_2									
Small	0.42	0.40	0.60	0.40	0.76*	1.25*	1.70	2.00	2.15	3.14*	1.40*	2.00	1.24*	2.30	0.79*					
2	0.50	0.40	0.40	0.50	0.50	1.60	1.40	1.60	1.50	1.60	1.70	1.90	1.75	1.50	1.45					
3	0.50	0.70	0.60	0.60	0.45	1.75	2.20	1.80	1.90	1.30*	2.05	1.15	1.60	1.30	1.20*					
4	0.50	0.60	0.60	0.30*	0.30*	2.21	1.90	2.20	1.15*	1.15*	1.76	1.30	1.45*	1.90*	2.19					
Big	0.50	0.70	0.50	0.60	0.60	1.60	2.20	1.59*	2.10	2.00	1.50	1.16	1.27*	1.40	1.40					
	a					b					c					d				
Small	0.04	0.01	0.06	0.01	0.41*	0.98*	0.99*	0.93*	0.94*	−0.40*	−0.05	−0.04	−0.05*	−0.03*	0.00*	0.21*	0.16*	0.27*	0.11	0.00
2	0.03*	0.54*	0.01	0.02	0.10*	0.97*	0.04	0.96*	0.93*	0.77*	−0.13*	−0.05	0.02	−0.19	0.04	0.07	0.40	0.13*	0.12	−0.02
3	0.12*	0.02	0.02	0.14*	0.07*	0.82*	0.96*	0.96*	0.65*	0.92*	−0.05	−0.04	−0.05	−0.03	0.00	0.13	0.11	0.12	0.29	0.12
4	0.14*	0.03	0.05	0.45*	0.04*	0.70*	0.97*	0.92*	0.42*	0.96*	−0.13*	−0.05	0.02	−0.19*	0.04*	0.39*	0.20*	0.21*	0.11	0.04
Big	0.01	0.02*	0.10*	0.02*	0.05*	0.96*	0.93*	0.88*	0.96*	0.96*	−0.04	0.06	0.06	0.03	−0.01	0.26*	0.21*	0.30*	0.08	0.15*

Notes: *means the data reject the null hypothesis under 5% significance level. $H_0:\beta_0 = 0$, $H_0:\beta_1 = 0$, $H_0:\beta_2 = 0$, $H_0:\beta_3 = 0$, $H_0:\alpha = 0.5$, $H_0:p_1 = 2$, $H_0:p_2 = 2$, $H_0:a = 0$, $H_0:b = 0$, $H_0:c = 0$, $H_0:b = 0$.

Table 4. Estimates from sample 2 (post-SP500 index futures).

Size quintile	Book-to-market quintiles																			
	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High
	β_0					β_1					β_2					β_3				
Small	−0.79*	−0.06	0.11*	0.21*	0.35*	1.08*	0.98*	0.88*	0.84*	0.87*	1.28*	1.17*	0.99*	1.00*	1.03*	−0.11*	0.05*	0.09*	0.26*	0.44*
2	−0.38*	−0.13	0.27*	0.17*	−0.12	1.12*	1.03*	0.94*	0.89*	1.07*	0.98*	0.90*	0.80*	0.78*	0.91*	−0.43*	0.02	0.26*	0.30*	0.63*
3	−0.06	0.15	0.02	0.05	0.12	1.07*	1.04*	0.96*	0.97*	1.03*	0.71*	0.64*	0.51*	0.48*	0.50*	−0.49*	0.01	0.27*	0.48*	0.63*
4	0.04	−0.08	−0.08*	0.07	0.11	1.08*	1.05*	1.05*	0.98*	1.03*	0.40*	0.34*	0.26*	0.17*	0.17*	−0.39*	0.08*	0.21*	0.35*	0.59*
Big	0.08	−0.01	−0.09	−0.09	−0.01	1.00*	1.05*	1.01*	0.99*	1.03*	−0.24*	−0.19*	−0.20*	−0.22*	−0.14*	−0.29*	0.07	0.23*	0.43*	0.64*
	α					p_1					p_2									
Small	0.30	0.60	0.70*	0.50	0.30	1.30	1.90	2.34*	1.60	1.30	2.10	1.13*	1.03*	1.45	2.35					
2	0.50	0.40	0.40	0.60	0.50	1.70	1.60	1.45	1.70	1.00*	1.30	2.20	1.75	1.49	1.16*					
3	0.30*	0.60*	0.60	0.70	0.50	1.14*	2.20	1.74	2.20	1.60	2.35	1.16*	1.31	1.45	1.45					
4	0.60	0.40	0.70*	0.50	0.50	1.45*	1.60	1.91	1.30*	1.75	1.01*	2.05	1.02*	1.30*	1.59					
Big	0.50	0.60	0.60	0.60	0.40	1.75	1.90	2.20	2.06	1.30	1.45	2.05	2.05	1.16	1.74					
	a					b					c					d				
Small	0.05	0.05*	0.00	0.03	0.04	0.96*	0.92*	0.94*	0.95*	0.96*	−0.03	0.08	0.01	0.07	0.07	0.37*	0.41*	0.36*	0.32	0.30*
2	0.02	0.03	0.05	0.02*	0.06	0.98*	0.93*	0.92*	0.95*	0.94*	−0.02*	−0.03	−0.10	0.06	0.08	0.17*	0.36*	0.39*	0.34*	0.42*
3	0.02	0.09*	0.05	0.08	0.04	0.98*	0.94*	0.95*	0.91*	0.96*	−0.03	0.08	0.01	0.07	0.07	0.23*	0.30*	0.31*	0.45*	0.26*
4	0.10	0.06	0.03	0.07*	0.24*	0.92*	0.93*	0.95*	0.95*	0.82*	−0.02	−0.03	−0.10*	0.06	0.08	0.25*	0.41*	0.35*	0.18*	0.43*
Big	0.04	0.03	0.01	0.07	0.06	0.89*	0.98*	0.97*	0.94*	0.97*	−0.10*	−0.08	−0.03	0.08	0.03	0.16	0.25	0.25*	0.37*	0.36*

Notes: *means the data reject the null hypothesis under 5% significance level. $H_0:\beta_0 = 0$, $H_0:\beta_1 = 0$, $H_0:\beta_2 = 0$, $H_0:\beta_3 = 0$, $H_0:\alpha = 0.5$, $H_0:p_1 = 2$, $H_0:p_2 = 2$, $H_0:a = 0$, $H_0:b = 0$, $H_0:c = 0$, $H_0:b = 0$.

(a)

(b)

(c)
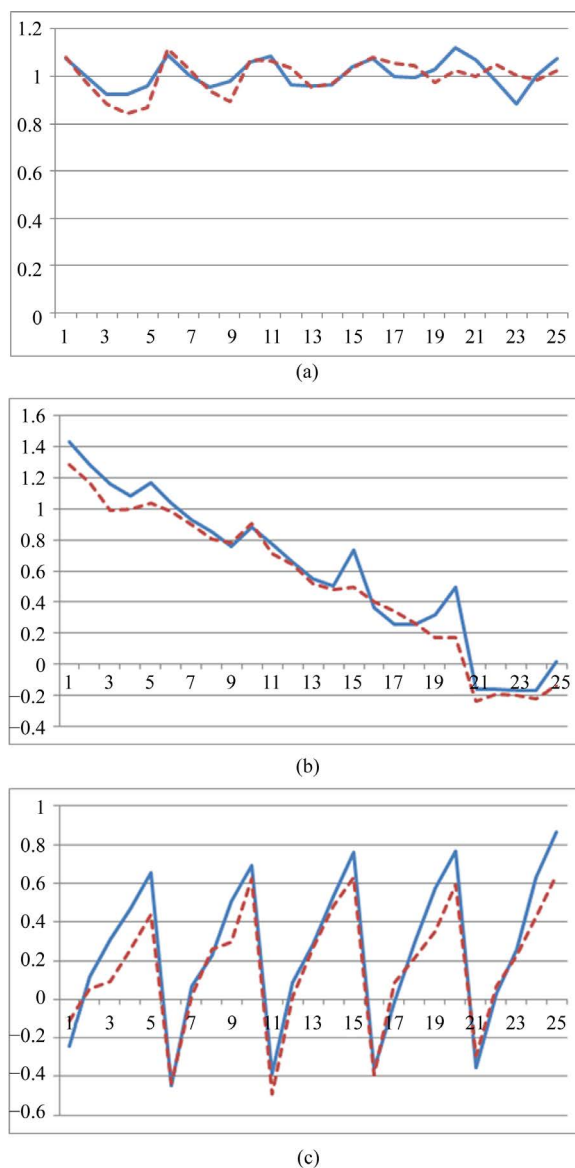
Figure 1. Comparisons of slope coefficient estimates in the mean equation during Pre- and Post-SP500 index futures (Y-axis is the value of β_i ($i = 1, 2,$ or 3). X-axis is the Fama-French 25 Portfolios. Solid line represents Pre-SP500 index futures and dotted line represents Post-SP500 index futures). (a) β_1 values; (b) β_2 values; (c) β_3 values.

standard deviation depends mostly on the values of *c, b* and *d*. We discover that the estimates of both *b* and *d* are bigger in sample 2. So we conclude that the volatility becomes higher after the introduction of index futures.

3.3. Model Diagnostics (Residual Check)

In this section, we implement Kolmogorov-Smirnov test to check residuals for FF-SSAEPD-EGARCH model. Our results show the residuals of all the 25 portfolios from the model do follow SSAEPD, which means that the model is adequate for the Fama-French 25 portfolios.

The P-values of KS tests[7] are displayed in **Table 5**. For example, the P-value of the portfolio with Smal Size

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[7]The null hypothesis of KS test is H_0: FF-SSAEPD-EGARCH residuals are distributed as $SSAEPD\left(\hat{\alpha}, \hat{p}_1, \hat{p}_2\right)$. If the P-value of KS test is smaller than 5% significance level, the null hypothesis is rejected. Otherwise, the null hypothesis is accepted.
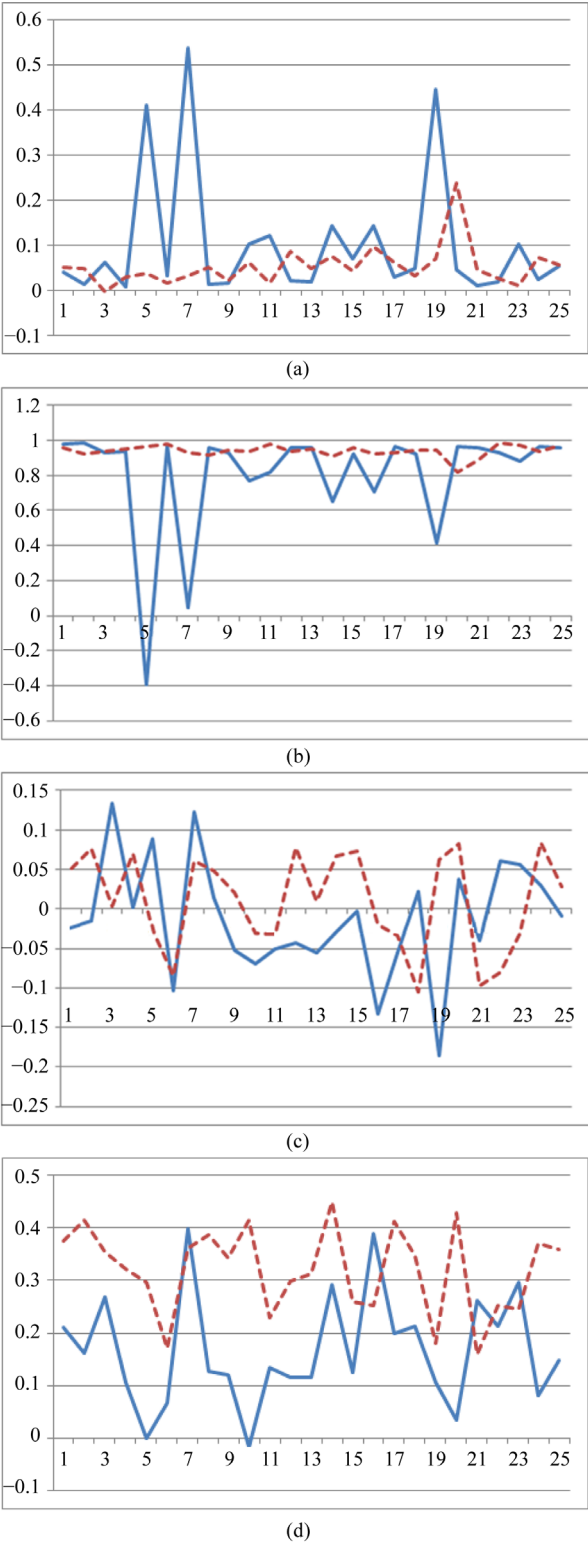
Figure 2. Comparisons of estimates in the GARCH equation during Pre- and Post-SP500 Index Futures (Y-axis is the value of *a*, *b*, *c* or *d*. X-axis is the Fama-French 25 portfolios. Solid line represents Pre-SP500 index futures and dotted line represents Post-SP500 index futures). (a) *a* values; (b) *b* values; (c) *c* values; (d) *d* values.

Table 5. P-values of KS test for residuals.

Size qunintiles	Book-to-market quintile									
	Low	2	3	4	High	Low	2	3	4	High
	Sample 1: 1951-1982					Sample 2: 1982-2007				
Small	0.77	0.92	0.61	0.98	0.86	0.20	0.81	0.52	0.73	0.84
2	0.98	0.96	0.96	0.96	0.89	0.93	0.98	0.84	0.90	0.50
3	0.99	0.57	0.86	0.83	0.99	0.61	0.96	0.97	0.76	0.75
4	0.85	0.96	0.82	0.65	0.73	0.46	0.69	0.86	0.90	0.93
Big	0.98	0.98	0.63	1.00	0.84	0.97	0.94	0.89	0.88	0.62

and Low Book-to-market in sample 1 is 0.77, greater than 5%. That means, under 5% significance level, the null hypothesis is not rejected and the residuals from the FF-SSAEPD-EGARCH model do follow the SSAEPD. Similar results are documented for all portfolios in two samples. Hence, we conclude the errors of the model do follow SSAEPD. *i.e*., the FF-SSAEPD-EGARCH model is adequate for most Fama-French 25 portfolios.

4. Conclusions and Future Extensions

In this paper, we study the effect of SP500 Index Futures on stock returns with a new model. This new model considers the EGARCH-type volatility in Nelson (1991), non-normal error of SSAEPD in Zhu and Zinde-Walsh (2009), and the 3-factor model of Fama and French (1993). Data of Fama-French 25 portfolios are used. We divide data into 2 samples: sample 1 (pre-SP500 Index Futures, from September 1951 to March 1982), sample 2 (post-SP500 Index Futures, from April 1982 to March 2007). Method of Maximum Likelihood Estimation is used to estimate this model and Likelihood Ratio test (LR) is used to test parameter restrictions.

Empirical results show Fama-French three factors are alive in both samples. After the introduction of SP500 Index Futures, the estimates for Fama-French three factors become lower and show less fluctuating and the volatility of the stock market becomes higher.

Future extensions will include but not limited to follows. First, different data can be used to study the influence of index futures. Second, different methods such as dummy variables could be used. Last but not least, subsample periods can be changed to check the robustness of our results.

Acknowledgements

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