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Effects of Econometric Softwares on US Stock Market

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***Abstract*— In this paper, the impacts of econometric software on stock market are studied. A new model is used, which is based on the EGARCH-type volatility in Nelson (1991), the 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. Following Ooms and Doornik(2006), we select 1965, 1970 and 1985 as the break points and divide data into 6 sub-samples. MLE and LR is used to estimate this model and test parameter restrictions, respectively. The residuals are checked by KS test.**
Empirical results show the Market factor, the Size factor and the Book-to-market factor are alive among 1965, 1970 and 1985 wave of econometric software. And the estimated results of 1985 wave of econometric software are compared with those of 1965 and 1970 econometric software generations, which shows both the similarity and difference those events have on the stock market.

***Index Terms*—Econometric Software, Fama-French 3-factor Model, Standized Standard AEPD, EGARCH**

I. INTRODUCTION

Growths of economics or stock markets are usually calculated using computer softwares. Although born in the 1940s and used first by economists during the early 1950s, these softwares become economic research tools only during the 1960s (see Klein [1]). For a list of econometric softwares, one can refer to Table I.

Renfro [2][3] values existing softwares for econometrics and provides a detailed summary. Ooms and Doornik [4] find out following 3 waves in the history of econometric softwares: In the 1960s, the 1st wave of new products can be connected with the availability of FORTRAN. In the 1970s, the 2nd wave corresponds with the appearance of computer terminal interfaces. In the 1980s, the 3rd wave is connected with the development of the first micro-computers and IBM-PCs.

Following previous researches, this paper studies the impacts of econometric softwares on financial market. Instead of using the traditional event study approaches, we use a new model based on the 3-factor model of Fama-French [5], the EGARCH-type volatility of Nelson [6]

TABLE I:
HISTORY OF ECONOMETRIC SOFTWARE

Software	Year	Developer
BDMP	1965	Statistical Solutions
SAS	1966	SAS Institute
SPSS	1968	IBM
AUTOBOX	1969	Automatic Forecasting Systems Inc.
Minitab	1972	Minitab Inc.
LIMDEP	1974	Econometric Software Inc.
JMP	1980	SAS Institute
MATLAB	1984	MathWorks
GAUSS	1985	Aptech systems
Stata	1985	StataCorp
SPlus	1988	Insightful Inc.
EVIEWS	1994	IHS
R	1995	R Foundation

and the non-Normal error of SSAEPD in Zhu and Zinde-Walsh [7]. This new model is first proposed by Yang [8][1]. The reason why we choose this new model is that it has better in-sample fit then that in the 3-factor model of Fama and French [5] (see Yang [8]). For more researches about Event Studies, one can refer to Table 2[2].

In this paper, following two hypotheses are tested.

- Does the experience of econometric software has a significant relevance with the US stock market return?

[1] Bian(2014) uses this methodology to study the impacts of oil crisis on the stock market.

[2] In 1969, Fama, Fisher, Jensen and Roll [9] introduce the event chain methodology. The traditional event study is a two-step procedure: 1) estimate model parameters with pre-event data; 2) calculate abnormal returns and their respective t-statistics for the "event window" (see Karafiath [10]). Bina and Vo [11] apply this event-study to explore the possible influences of OPEC decisions on output. Zhang et.al. [12] use an EMD-based event analysis to estimate the impacts of events on crude oil price volatility.

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Table II
Researches about the Econometric Softwares and Fama-French 3-factor Model

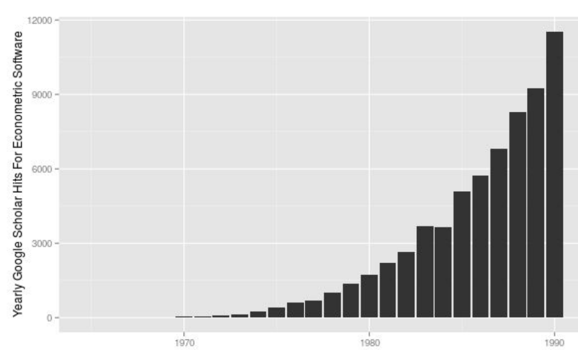
Author (Year)	Research Purpose	Model	Estimation Method	Computer Algorithm	Data		
					Country	Variables	Frequency
Panel A: Event Study and Researches about Econometric Softwares							
Fama (1969)	Model Empirical Analysis	FF 3-factor	OLS	-	USA	RP,DL	M1927:1959
Renfro (2004)	Literature Review	-	-	-	-	-	Y1965-2004
Ooms (2006)	Literature Review	-	-	-	-	-	Y1965-2004
Panel B: Extensions for Fama-French 3-factor model							
Carhart (1997)	Model Comparison	CAPM, FF, Carhart 4-factor	OLS	-	USA	ER,RP,SMB,HML,Momentum	M1962:1-1993:12
Charghori (2007)	Default Risk	FF with Default factor	GMM	-	Australia	ER,RP,SMB,HML,DEF	M1996-2004:12
He (2008)	Model Comparison	FF with State Switch	OLS	-	China	ER,RP,SMB,HML,State Switch	M1995:6-2005:12
Wang (2012)	Model Extension	FF with PE Factor	OLS	EVIEWS	China	ER,RP,SMB,HML,PE Factor	M2004:7-2011:6
Yu (2012)	World Price of Sustainability	FF with Sustainability Factor	GMM	-	Global	ER,RP,SMB,HML,SUS	M1999-2007
Yang (2013)	Model Extension	FF-EGARCH-SSAEPD	MLE	MATLAB	USA	ER,RP,SMB,HML	M1926-2011

- Are the 3 factors in Fama-French [5] still alive during pre- or post- waves of econometric products?
- Can we find any significant differences between these 3 waves of econometric softwares?

To answer these questions, data from the US stock market (1926-2014) are analyzed. We divide the data into 6 samples:
pre-1965 as Sample 1 (from 1926 to October 1965) and post-1965 as Sample 2 (from November 1965 to 2014), pre-1970 as Sample 3 (from 1926 to October 1970) and post-1970 as Sample 4 (from November 1970 to 2014), pre-1985 as Sample 5 (from 1926 to October 1985) and post-1985 as Sample 6. (from November 1985 to 2014) We analyze these 6 samples with MATLAB program. Likelihood Ratio test (LR) is used for testing parameter restrictions. Kolmogorov-Smirnov test (KS) is used for model diagnostics.

Empirical results show the Market factor and the Size factor are alive but the Book-to-market factor is not alive before and after 1965,1970 and 1985 waves of econometric software. The study of 1965, 1970 and 1985 waves yield remarkably similar conclusions. During the period after each generation, most of the 25 portfolios have smaller , and , indicating they become less sensitive to the market.

This paper is organized as follows. Section 2 tests the correlation of econometric product and the stock market return. Section 3 is the model and methodology. Section 4 is the empirical results. Section 5 is the conclusion. In the appendix is the simulation analysis of the FF-EGARCH-SSAEPD model on the stock market.



II. Relevance Analysis

Renfro [3] lists many econometric software and and Ooms and Doornik [4] gives the definition of three important waves of econometric software. However, we need numeric data of the software popularity to conduct the relevance analysis on the stock market. The prevailing popularity of econometric software are scraped from the Google Scholar hits for the products listed in Table I. The results are shown in Fig. I. The data (from 1965 to 1990) could largely reflect the world as large. US annual returns

Fig. I: Yearly data of econometric software popularity

on stock market are downloaded from NYU Stern database.

The p-value of the Pearson's product-moment correlation shows that the popularity of econometric software do not have a direct significant correlation with the market return, but the log value of econometric software popularity is correlated with the market return, which shows that the development of econometric software has a positive impact on the market return which contribute mostly to the market's volatility.

III. Model and Methodology

A. Model

Based on the 3-factor model in Fama and French [5], the EGARCH-type volatility in Nelson [6] and the non-Normal error of SSAEPD in Zhu and Zinde-Walsh [7], a new 3-factor model is proposed by Yang [8]. For simplicity, this model is denoted as FF-SSAEPD-EGARCH(r,s). The math formulas of this new model are:

$$R_t - R_{ft} = \beta_0 + \beta_1(R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + u_t,$$

$$u_t = \sigma_t z_t,\quad z_t \sim SSAEPD(\alpha, p_1, p_2),$$

$$\ln(\sigma_t^2) = a + g(z_{t-1}) + b\,\ln(\sigma_{t-1}^2),$$

$$g(z_{t-1}) = c_i z_{t-i} + d_i(|z_{t-i}| - E|z_{t-i}|) = \begin{cases} (c_i + d_i) z_{t-i} - d_i E|z_{t-i}| & \text{if } z_{t-i} \geq 0 \\ (c_i - d_i) z_{t-i} - d_i E|z_{t-i}| & \text{else.} \end{cases}$$

Here, R_t, R_{ft} and R_{mt} are the rates 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 (i.e, market capitalization) minus big size (i.e, market capitalization) and HML_t stands for high Book-to-market ratio minus low Book-to-market ratio. The conditional standard deviation is σ_t, i.e, volatility. $\theta = (\beta_0, \beta_1, \beta_2, \beta_3, \alpha, p_1, p_2, a, b_j, c_j, d_j)$ 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:

$$f(z_t) = \begin{cases} \frac{\alpha\delta}{\alpha^*} K(p_1) \exp\left(-\frac{1}{p_1}\left|\frac{\omega + \delta z_t}{2\alpha^*}\right|^{p_1}\right) & \text{if } z_t \leq -\frac{\omega}{\delta} \\ \frac{(1-\alpha)\delta}{1-\alpha^*} K(p_2) \exp\left(-\frac{1}{p_2}\left|\frac{\omega + \delta z_t}{2(1-\alpha^*)}\right|^{p_2}\right) & \text{if } z_t > -\frac{\omega}{\delta} \end{cases}$$

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

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

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

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

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

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

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

B. Maximum Likelihood Estimation (MLE)

We use the method of Maximum Likelihood Estimation (MLE) to estimate the parameters in FF-SSAEPD-EGARCH model. The maximum likelihood function is:

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

$$= \prod_{t=1}^{T} \begin{cases} \frac{\alpha\delta}{\alpha^*} K(p_1) \exp\left(-\frac{1}{p_1}\left|\frac{\omega + \delta z_t}{2\alpha^*}\right|^{p_1}\right) & \text{if } z_t \leq -\frac{\omega}{\delta} \\ \frac{(1-\alpha)\delta}{1-\alpha^*} K(p_2) \exp\left(-\frac{1}{p_2}\left|\frac{\omega + \delta z_t}{2(1-\alpha^*)}\right|^{p_2}\right) & \text{if } z_t > -\frac{\omega}{\delta} \end{cases}$$

$$z_t = \frac{R_t - R_{ft} - \beta_0 - \beta_1(R_{mt} - R_{ft}) - \beta_2 SMB_t - \beta_3 HML_t}{\sigma_t},$$

$$\ln(\sigma_t^2) = a + g(z_{t-1}) + b\,\ln(\sigma_{t-1}^2).$$

IV. Empirical Analysis

A. Data

In this paper, the effects of econometric software on stock

[3] The PDF of SSAEPD(α, p_1, p_2) is derived from standard AEPD(α, p_1, p_2) by changing variable techniques. If X is distributed as the standard AEPD, then its PDF is

$$f(z_t) = \begin{cases} \frac{\alpha\delta}{\alpha^*} K(p_1) \exp\left(-\frac{1}{p_1}\left|\frac{\omega + \delta z_t}{2\alpha^*}\right|^{p_1}\right) & \text{if } z_t \leq -\frac{\omega}{\delta} \\ \frac{(1-\alpha)\delta}{1-\alpha^*} K(p_2) \exp\left(-\frac{1}{p_2}\left|\frac{\omega + \delta z_t}{2(1-\alpha^*)}\right|^{p_2}\right) & \text{if } z_t > -\frac{\omega}{\delta} \end{cases}$$

where $\theta = (\alpha, p_1, p_2)$ is the parameter vector.

market are studied. Data of Fama-French 25 portfolios are used, which are downloaded from the French's Data Library. We select 1965, 1970 and 1985 as breakpoint and data is divided into 6 sub-samples: pre- Availability of FORTRAN as Sample 1,and post-Availability of FORTRAN as Sample 2, pre- Appearance of Terminal as Sample 3,and post-Appearance of Terminal as Sample 4, pre- Appearance of PCs as Sample 5, and post-Appearance of PCs as Sample 6. The descriptive statistics of these samples are calculated by MATLAB. For each observation, the skewness of the stock portfolio is not 0 and the kurtosis is more than 3. The P-value of Jarque-Bera test for each portfolio is 0, which is smaller than 5% significance level. Hence, we conclude that the asset returns in both samples do not follow Normal distribution.

TABLE III:
ESTIMATES FROM SAMPLE 2 (POST-AVAILABILITY OF FORTRAN)

		beta0					beta1					beta2					beta3		
-0.17*	-0.06*	0.16	0.12	0.10	1.03	0.91	0.87	0.83	0.92	1.13	1.36	1.06	1.01	1.00	-0.09*	-0.01*	0.13	0.18	0.40
-0.32*	0.08	0.18	-0.94	0.04	1.17	0.89	0.91	1.25	0.97	0.92	0.98	0.81	2.10	0.85	-0.34*	0.16*	0.23	1.69	0.50
-0.12*	0.06	0.11	0.16	0.34	1.07	1.01	1.04	0.92	1.07	0.81	0.57	0.58	0.40	0.63	-0.32*	0.12*	0.41	0.41	0.56
0.01*	-0.12*	-0.04*	0.17	-0.23*	1.19	1.07	1.05	0.95	0.95	0.33*	0.25	0.15	0.22	-0.11*	-0.40*	0.19*	0.40	0.37	0.48
0.07	0.19	-0.02*	-0.07	-0.11	1.00	1.09*	1.00	0.93	1.08	-0.22	-0.28	-0.26	-0.18*	-0.07	-0.27	0.13	0.23	0.46	0.71
		alpha					p1					p2							
0.48*	0.51*	0.50*	0.48*	0.49*	1.99*	2.02*	1.97*	1.96*	2.04	1.96*	2.01*	1.98*	2.01	2.01*					
0.50*	0.51*	0.50*	0.50*	0.50*	1.98*	2.00*	2.00*	2.60	1.93	1.97	1.97*	2.00*	1.99*	1.98*					
0.50*	0.50*	0.51*	0.50	0.50*	1.97*	2.00*	2.01*	2.00*	2.02	1.99*	2.00*	2.02*	2	2.03*					
0.50*	0.51*	0.501*	0.50	0.50*	2.04	2.00*	2.00*	2.00*	1.98	2.05	2.02*	2.01*	2	1.64*					
0.50*	0.50*	0.50	0.50	0.50*	2.00*	1.97	2.00	1.98	2.03	2.00*	1.876	1.98*	2.025	2.04*					
		a					b					c					d		
0.57*	0.60	0.68	0.42*	0.54*	1.01*	0.57	0.57	1.02*	1.02*	0.36*	0.44*	0.46*	0.34	0.33*	0.82	0.87	0.83	0.69	0.89
0.52*	0.61*	0.60	1.06	0.48	1.01*	1.01*	0.41	1.09	0.73	0.43*	0.29*	0.50*	0.80	0.33*	0.70	0.87	0.80	0.52	0.73
0.55*	0.60	0.47	0.60	0.75	0.56	0.40	0.73	0.41	0.74	0.47*	0.50*	0.55*	0.51*	0.60*	0.74	0.80	0.83	0.80	0.87
0.55*	0.59	0.56	0.60	0.45*	1.01*	0.65	0.57	0.40	1.03*	0.56*	0.54*	0.50*	0.50*	0.56*	0.60	0.88	0.74	0.80	0.96
0.60	0.64*	0.57	0.67*	0.74*	0.41	1.01*	0.69	1.01*	1.01*	0.50*	0.56	0.43*	0.59	0.35	0.80	0.64	0.72	0.91	0.75

Note: * means the data doesn't follow the specified distribution under 5% significance level.

TABLE IV:
ESTIMATES FROM SAMPLE 4 (POST-APPEARANCE OF TERMINAL)

		beta0					beta1					beta2					beta3		
-0.84	0.04	0.09	0.33	0.20	1.18	0.95	0.85	0.95	0.83	1.42	1.36	1.12	1.10	1.03	-0.24*	-0.09*	0.12	0.31	0.40
-0.25	0.02	0.15	0.16	0.17	1.10	1.04	0.93	0.78	1.00	1.01	0.94	0.78	0.63	0.76*	-0.32	0.04*	0.25	0.27	0.46
-0.08	0.14*	0.15	0.25	0.21	1.00	1.06	0.97	0.90	0.94	0.71	0.52	0.51	0.49	0.40	-0.19	0.18	0.33	0.55	0.53
0.05	-0.08*	0.05	0.16	-0.07*	1.06	1.04	1.02	0.95	0.90	0.40	0.32	0.18	0.20	0.23	-0.36	0.14	0.36	0.37	0.45
0.05	0.11	-0.04	0.01	-0.06	1.00	1.00	0.97	0.90	0.99	-0.24	-0.22	-0.19	-0.17	-0.17	-0.25	0.08	0.24	0.32	0.57
		alpha					p1					p2							
0.50*	0.50*	0.50*	0.50	0.50*	1.99	2.00*	2.00*	2.02	1.98	1.98	2.01*	1.99*	2.01	2.00*					
0.50*	0.50*	0.50*	0.50*	0.50*	2.00*	1.99*	2.01	2.01	2.01*	1.99	1.99*	2.01	1.98	1.97					
0.50	0.50	0.50	0.50*	0.50*	2.00	1.97	2.01*	2.00*	1.94	1.98	1.99	2.01*	1.97*	2.02*					
0.50*	0.50*	0.50*	0.50	0.50	2.00*	2.02*	2.00*	2.00	1.94	2.00*	2.01*	2.00*	2.00	1.96					
0.50*	0.50*	0.51	0.50	0.50	2.00*	2.00*	2.04*	1.97	2.01	2.00*	2.00*	2.02*	2.00	1.99					
		a					b					c					d		
0.64	0.64	0.59	0.68	0.58	0.73	0.58	0.53	0.73	0.57	0.37*	0.49*	0.53*	0.60	0.46*	0.72	0.80	0.83	0.86	0.80
0.62	0.62	0.62	0.53*	0.59*	0.48	0.63	0.49	1.02*	1.01*	0.51*	0.51*	0.51*	0.51	0.40	0.81	0.83	0.83	0.85	0.85
0.40*	0.64*	0.67	0.50	0.58	1.05*	1.01*	0.67	0.73	0.73	0.54	0.37	0.57*	0.58*	0.65*	0.92	0.74	0.84	0.83	0.86
0.56	0.67	0.70	0.60	0.57*	0.57	0.57	0.60	0.40	1.01*	0.47*	0.47*	0.45*	0.50*	0.58	0.77	0.85	0.87	0.80	0.70
0.60	0.60	0.62	0.38*	0.65*	0.40	0.40	0.59	1.03*	1.01*	0.50*	0.50*	0.56*	0.36	0.49	0.80	0.80	0.87	0.78	0.82

Note: * means the data doesn't follow the specified distribution under 5% significance level.

TABLE V:
ESTIMATES FROM SAMPLE 6 (POST-APPEARANCE OF PC's)

		beta0					beta1					beta2					beta3		
-0.74	0.02	0.13	0.26	0.33	0.88	0.83	0.84	0.73	0.73	1.55	1.31	1.01	0.93	0.93	-0.35*	-0.15*	0.13	0.12	0.33
-0.21*	-0.07*	0.25	0.16	0.06	0.98	1.01	0.86	0.86	0.85	1.11	0.94	0.76	0.73	0.97	-0.38*	0.03	0.22	0.328	0.33
-0.01	-0.16	0.15	0.27	0.39	0.92	1.04	0.90	0.81	0.80	0.16	0.53	0.38	0.52*	0.20	0.37	0.03*	0.27	0.55	0.36
0.11	0.10	-0.01	0.15	0.29	1.03	1.01	1.01	0.78	1.06	0.40	0.23	0.16	0.14	0.00	-0.33	0.18	0.34	0.31*	0.59
0.17*	0.14	0.03	0.06*	-0.03*	1.11	0.98	0.75	0.78	1.09	-0.35	-0.24	-0.15*	0.09*	-0.25*	-0.33	0.11*	0.33	0.17	0.50
		alpha					p1					p2							
0.52	0.50*	0.50	0.49	0.49*	1.96	1.94	2.00	1.98	1.99*	2.02	2.04	2.00	1.98	1.94					
0.51	0.50	0.50*	0.50*	0.49*	2.00	2.02	1.99*	2.00*	1.97	1.97*	2.01	1.99*	2.00*	1.99					
0.49	0.49*	0.50*	0.50	0.49	1.96	2.14*	1.99	2.14*	1.97	1.66	1.84*	2.00	2.11*	2.02					
0.49	0.50	0.50	0.49*	0.50*	1.99	2.00	1.99	1.99	2.00	1.92	2.00	1.99	2.03*	1.99					
0.51*	0.50*	0.49*	0.49	0.50	1.98*	1.99*	2.01*	1.92	1.99*	2.02	1.99*	2.00	1.84*	2.00					
		a					b					c					d		
0.00	0.35*	0.59	0.56	0.49	1.09	1.03*	0.66	0.57	0.73	-0.29*	0.57	0.51	0.46*	0.39*	1.05	0.78	0.80	0.75	0.75
0.39*	0.62	0.54	0.60	0.49	1.06*	0.60	0.48	0.40	0.77	0.35	0.55*	0.50*	0.50*	0.38*	1.02	0.84	0.80	0.80	0.80
-0.37	0.25*	0.59	0.37*	0.42*	1.08	1.057*	0.41	1.06*	1.03*	0.50	0.28*	0.50*	0.62*	0.28	0.58	0.80	0.80	1.00	0.82
0.59	0.60	0.58	0.70*	0.77	0.72	0.40	0.44	1.01*	0.73	0.30*	0.50*	0.48*	0.61	0.36	0.75	0.80	0.79	0.79	0.78
0.63*	0.59*	0.49*	0.29	0.64*	1.01*	0.41*	1.01*	1.02	1.01*	0.57*	0.49*	0.28*	0.14	0.58	0.78	0.80	0.39	0.55	0.80

Note: * means the data doesn't follow the specified distribution under 5% significance level.

B. Estimation Results

The estimation results for the splitting effect of three waves of econometric products based on FF-SSAEPD-EGARCH model with data from Fama-French 25 portfolios are listed in the Table 3-8. Most □ are close to 0 and □ are around 1. And the skewness parameter □ are all approximately equal to 0.5, which means that after considering the 3 factors in the model and EGARCH-type volatility, the error terms of the data show no obvious skewness. The left tail parameter p and right tail parameter p of all the 25 portfolios are approach to 2, and nearly all returns have different values of p and p , which means the split period of US stock market has the asymmetric kurtosis.

To test the significance of estimated coefficients for the 6 sample of econometric period, Likelihood Ratio test (LR) is applied. The primary estimations based on the FF-EGARCH model are used as the null hypothesis for the 11 coefficients.

a) Pre- and Post- 1965 Econometric Period

The estimation results for the new model in Sample 2 are listed in Table III. According to the results, all estimates of □ are statistically significant under 5% significance level. Most estimates of □ are statistically significant. Only estimates of □ in the High Book-to-market portfolios are statistically significant. Hence, we conclude the Market factor and the Book-to-market factor are alive but the Size factor is not alive in the data of pre-1965 econometric period. And the skewness parameter □ are all approximately equal to 0.5, which means that after considering the 3 factors and EGARCH-type volatility, the error terms of the data show no obvious skewness. The left tail parameter p and right tail parameter p of all the 25 portfolios are close to 2. Similar results are also documented in Sample 1.

b) Pre- and Post- 1970 Econometric Period

The estimation results for the new model in Sample 4 are listed in Table IV. According to the results, we find in the split-sample period, the Fama-French 3 factors are still alive. All estimates of □ are statistically significant under 5% significance level. Most estimates of □ are statistically significant. Only estimates of □ in the Low Book-to-market portfolios are statistically significant. Hence, we conclude the Market factor and the Size factor are alive but the Book-to-market factor is not alive in the data of pre-1970 econometric period. And the skewness parameter □ are all approximately equal to 0.5, which means that after considering the 3 factors and EGARCH-type volatility, the error terms of the data show no obvious skewness. The left tail parameter p and right tail parameter p of all the 25 portfolios are close to 2. Similar results are also documented in Sample 3.

c) Pre- and Post- 1985 Econometric Period

The estimation results for the new model in Sample 5 (pre- 1985 statistical technique) are listed in Table V. According to the results, all estimates of □ are statistically significant under 5% significance level. Most estimates of □ are statistically significant. Only estimates □ of in the Low Book-to-market portfolios are statistically significant. Hence, we conclude the Market factor and the Size factor are alive but the Book-to-market factor are not alive in the data of pre-1985 econometric period. And the skewness parameter □ are all approximately equal to 0.5, which means that after considering the 3 factors and EGARCH-type volatility, the error terms of the data show no obvious skewness. The left tail parameter p 1 and right tail parameter p 2 of all the 25 portfolios are close to 2. Similar results are also documented in Sample 6(post-1985 Statistical Technique, see Table 11.

d) Comparison

To compare 1962 and 1995 Statistical Technique, we plot the estimates of □ , □ , □ in Figure 1. We discover that the coefficients in these two oil crises present similar patterns. During the period after both Statistical

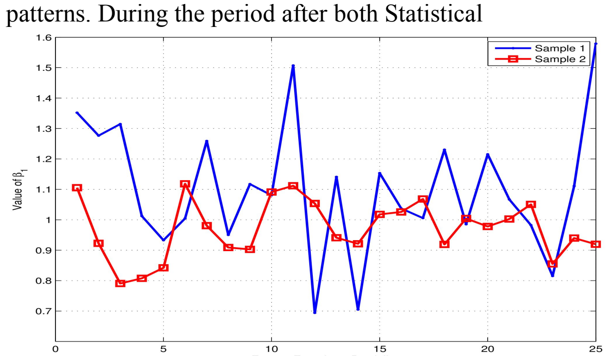


Fig II(a)

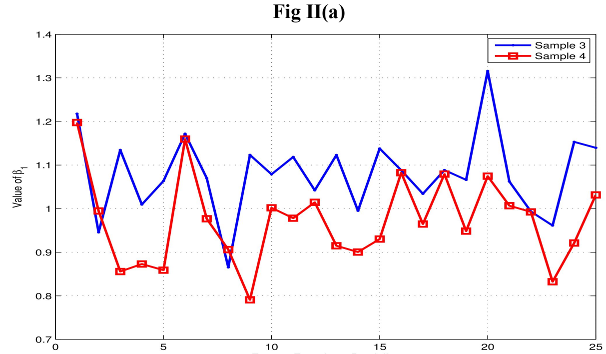


Fig II(b)

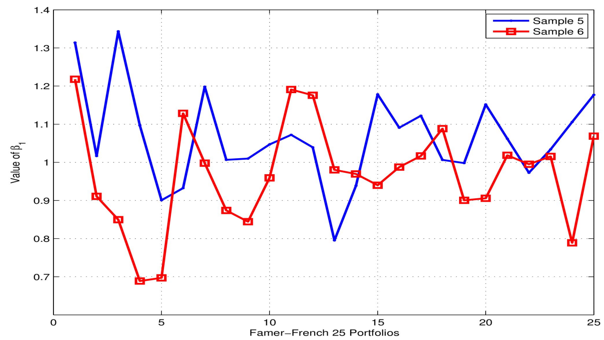


Fig II(c)

Fig II: Estimation Compare of 1965 Generation

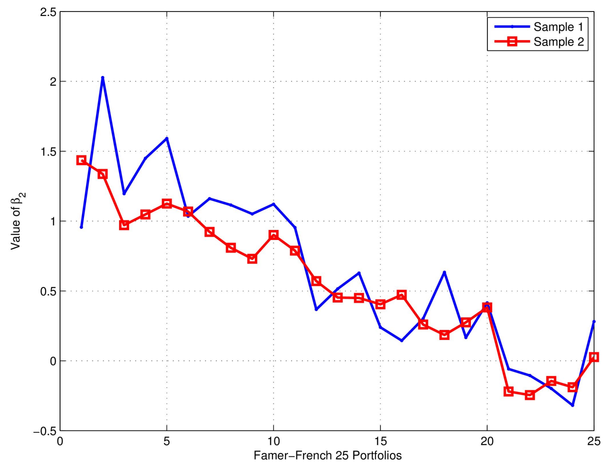


Fig III(a)

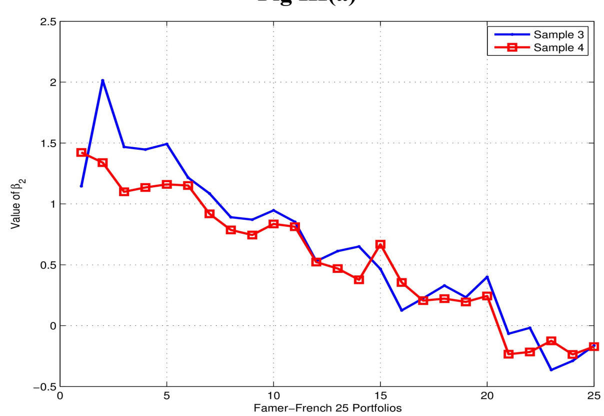


Fig III(b)

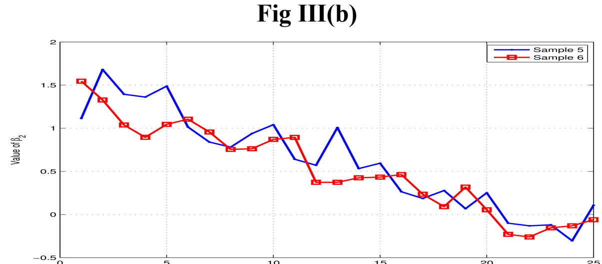


Fig III(c)

Fig III: Estimation Compare of 1970 Generation

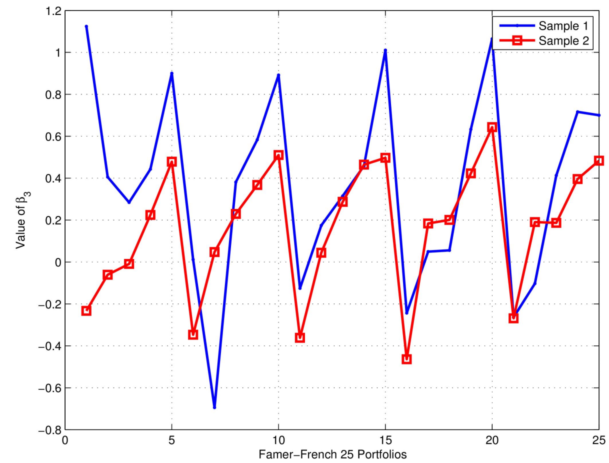


Fig IV(a)

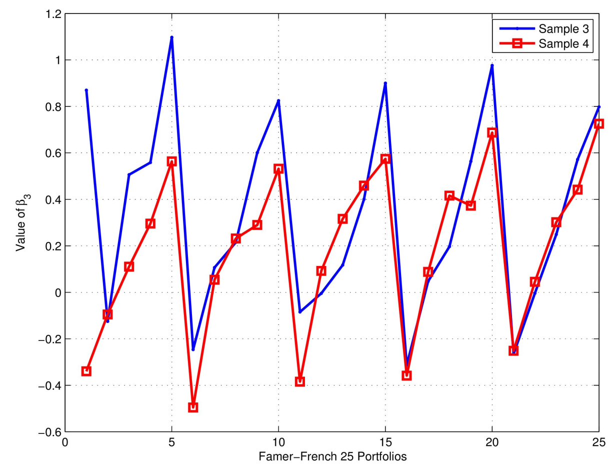


Fig IV(b)

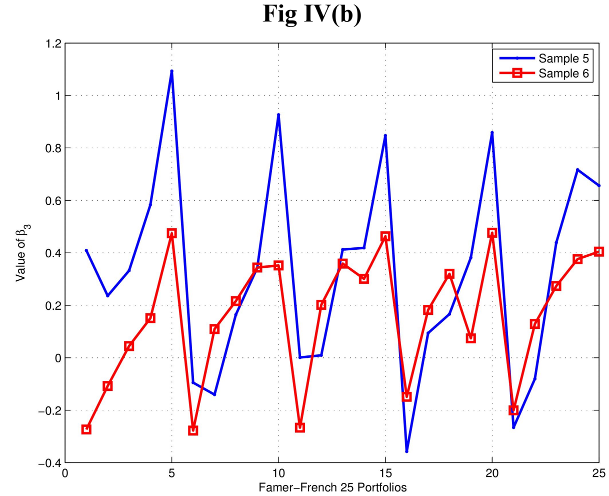


Fig IV(c)

Fig IV: Estimation Compare of 1965 Generation

C. Residual Check

We implement Kolmogovor-Smirnov test to check residuals for FF-SSAEPD-EGARCH model. For example, the P-value of the portfolio with Small Size and Low Book-to-market is 0.465, 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 6 sub-samples.

We then conclude that the errors of the model do follow SSAEPD, i.e., the FF-SSAEPD-EGARCH model is adequate for most Fama-French 25 portfolios.

CONCLUSIONS AND FUTURE EXTENSIONS

Based on 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), we compare the 1965, 1970 and 1985 waves of new econometric softwares with new technology which is different from traditional event chain methodology. Data of US stock market from 1926 to 2014 are split into 6 samples: pre-1965 econometric period as Sample 1 (from 1926 to October 1965), post-1962 econometric period as Sample 2 (from November 1965 to 2014), pre-1970 econometric period as Sample 3 (from 1926 to October 1970), post-1970 econometric period as Sample 4 (from November 1970 to 2014), pre-1985 econometric period as Sample5 (from 1926 to October 1985), post-1985 econometric period as Sample 6. Method of Maximum Likelihood Estimation is used to estimate this model and Likelihood Ratio test (LR) is used to test parameter restrictions. The residuals are checked by Kolmogorov-Smirnov test (KS).

Empirical results show that 1) With the split data, the Market factor, the Size factor and the Book-to-market factor are all alive in 1965, 1970 and 1985 Econometric Period. The estimated results of 1985 Econometric Period almost repeat those of 1965,1970 , which means that the shocks of statistical techniques may have similar impact on data.

Future extensions will include but not limited to follows. First, different data can be used to learn the impacts of different generation of econometric softwares on different countries. Also, more factors regarding of the impact of the econometric advance will be discussed in the new model.

APPENDIX: SIMULATION ANALYSIS

In this section, we simulate the data and analyze the results to confirm that the program in MATLAB is correct. Assumed to be an FF-SSAEPD-EGARCH(1,1) process , the data generation process (DGP) is simulated as follows:

$$R_t - R_{ft} = \beta_0 + \beta_1 (R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + u_t,$$

$$u_t = \sigma_t z_t, z_t \sim SSAEPD(\alpha, p_1, p_2),$$

$$ln(\sigma_t^2) = a + g(z_{t-1}) + b \cdot ln(\sigma_{t-1}^2),$$

$$g(z_{t-1}) = c_i z_{t-1} + d_i(|z_{t-1}| - E|z_{t-1}|) = \begin{cases} (c_i + d_i) z_{t-1} - d_i E|z_{t-1}| & if\ z_{t-1} \geq 0 \\ (c_i - d_i) z_{t-1} - d_i E|z_{t-1}| & else. \end{cases}$$

We choose $\beta_0 =$, $\beta_1 =$, $\beta_2 =$, $\beta_3 =$, $\alpha =$, $p_1 = p_2 =$, $a =$, $b =$, $c =$, $d =$ as the true values of the parameters. The simulation has following steps:

1. Generate an SSAEPD random number series $\{z_t\}$.
2. Set the initial value $\sigma_1 =$ $z_1 =$, and given $a =$, $b =$, $c =$, $d =$, we can generate $\{\sigma_t\}$ and $\{u_t\}$.

$$ln(\sigma_t^2) = a + g(z_{t-1}) + b \cdot ln(\sigma_{t-1}^2),$$

$$g(z_{t-1}) = c_i z_{t-1} + d_i(|z_{t-1}| - E|z_{t-1}|) = \begin{cases} (c_i + d_i) z_{t-1} - d_i E|z_{t-1}| & if\ z_{t-1} \geq 0 \\ (c_i - d_i) z_{t-1} - d_i E|z_{t-1}| & else. \end{cases}$$

3. Generate random number series $\{X_{1t}\}$, $\{X_{2t}\}$, $\{X_{3t}\}$, from Uniform(0,1).
4. Set $\beta_0 =$, $\beta_1 =$, $\beta_2 =$, $\beta_3 =$, and we can get $\{Y_t\}$

After getting the simulated data $\{X_{1t}, X_{2t}, X_{3t}, Y_t\}$, we use MLE and MATLAB to estimate the parameters in the FF-SSAEPD-EGARCH model. The estimates from MATLAB program are $\theta = (\beta_0, \beta_1, \beta_2, \beta_3, \alpha, p_1, p_2, a, b, c, d)$ =(0.3102, 0.4834 , 0.4839, 0.4989, 0.4997, 2.0009, 2.0008, 0.5882, 0.4023, 0.4904, 0.5030), which are very close to the true values of the parameters. For robustness exam, we also change the true values of the parameters and redo the simulation and estimation. All the simulation and estimation show the estimates are very closed to the true values of the parameters, since all errors are equal to or less than 9%. Hence, we conclude the MATLAB program can be applied to estimate and analyze empirical data for FF-SSAEPD-EGARCH model.

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