International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

The Relations between Volatilities and the Extreme Stock Price Declines: A Test in the Japanese Equity Markets

Chikashi Tsuji (Ph.D.)
Graduate School of Systems and Information Engineering, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8573, Japan
E-mail: mail_sec_low@minos.ocn.ne.jp

ABSTRACT

The objective of this paper is to examine the predictability of the forecast volatilities for the extreme stock price declines in the Japanese stock markets. Our empirical tests reveal that the forecast volatilities from the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model and the GARCH-in-mean model statistically significantly predict the extreme stock price declines in the Japanese stock markets. Further, we also clarify that the forecast power of the volatilities from the GARCH-in-mean model is stronger than that from the standard GARCH model.

KEY WORDS Downside risk, Stock return volatility, Probit model

1. Introduction

There exist several exciting preceding studies regarding stock market crashes and the downside risk in stock markets. These researches are Leland and Rubinstein (1988), Greenwald and Stein (1991), Caplin and Leahy (1994), Hong and Stein (2003), Ang et al. (2006), Huang and Wang (2009), and Bates (2012), for example.

As far as we know, however, there seem to be few studies that directly examine the relationships between forecast volatilities and extreme stock price declines. With these backgrounds and motivations, this paper aims to clarify how degree the forecast volatilities from standard volatility models have the predictable power for extreme stock price declines in the Japanese stock markets. This is our objective and to answer this question, we exploit the volatilities from the standard Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model and the GARCH-in-mean model.

The followings are our study's contributions. First, we clarify that the forecast volatilities from the GARCH model and the GARCH-in-mean model well forecast the extreme stock price declines in the Japanese stock markets. The predict power of forecasts from these models are roughly 20% to 30%. Further, we also find that in comparison with the GARCH model, GARCH-in-mean model have the stronger forecast power for the downside risk in the Japanese stock markets.

The rest of the paper is organized as follows. First, Section 2 documents the data and research design, Section 3 describes our empirical results, and Section 4 concludes the paper.

International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

Table 1. The descriptive statistic of variables: Out-of-sample period from 4 January 2007 to 30 December 2011

	PCHG	GARCHF	GARCHMF	LJGB	SJGB	EX	DEF
Mean	−0.0462	43.4847	23.4639	1.3757	0.3252	96.4628	0.4731
Median	0.0100	26.1510	20.2974	1.3546	0.2218	93.2500	0.4138
Maximum	13.7300	511.998	90.9004	1.9639	0.7176	123.950	1.6414
Minimum	−9.5200	4	11.8651	0.8666	0.1160	0	0.1820
Standard	1.6902	8.8619	11.7311	0.2373	0.18037	75.8600	0.2182
deviation	−0.1046	63.8795	3.0783	0.1615	0.6029	13.7398	2.8057
Skewness	10.3970	4.9205	14.8867	2.4374	1.7787	0.3963	12.5330
Kurtosis	1223	30.0867	1223	1223	1223	1.9899	1223
Observations		1223				1223	

Notes: Our daily full sample period is from February 15, 1999 to December 30, 2011. We divide this period into two sub-periods of the in-sample period and the out-of-sample period. Our in-sample period is from February 15, 1999 to December 29, 2006 and our out-of-sample period is from January 4, 2007 to December 30, 2011.

Table 2. The correlation coefficients of variables: Out-of-sample period from 4 January 2007 to 30 December 2011

	PCHG	GARCHF	GARCHMF	LJGB	SJGB	EX	DEF
PCHG	1						
GARCHF	0.0230	1					
GARCHMF	0.0205	0.9594	1				
LJGB	0.0211	0.0942	0.0755	1			
SJGB	−0.0276	0.2623	0.2744	0.8129	1		
EX	0.0018	0.0162	0.0235	0.9052	0.8375	1	
DEF	0.0195	0.0544	0.1287	−0.1792	−0.2671	−0.2914	1

Notes: PCHG is the daily price changes of the TOPIX, GARCHF is the forecast volatilities from the GARCH model, and GARCHMF is the forecast volatilities from the GARCH-in-mean model. Further, LJGB is the 10-year Japanese government bond yields, SJGB is the six-month JGB yields, EX is the yen/US dollars rates, and DEF is the default spreads, which are the differences between the S&P BBB 10-year bond yields and 10-year JGB yields.

2. Data and Research Design

In this paper, we exploit the Tokyo Stock Price Index (TOPIX) data and several financial market data. These are daily data and supplied through the Nikkei Inc. By using these data, we construct the following variables. First, PCHG is the daily price changes of the TOPIX, GARCHF is the forecast volatilities of TOPIX returns from the GARCH (1, 1) model, and GARCHMF is the forecast volatilities of TOPIX returns from the GARCH-in-mean (1, 1) model. Further, LJGB is the 10-year Japanese government bond (JGB) yields, SJGB is the six-month JGB yields, EX is the

International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

yen/US dollars exchange rates, and DEF is the default spreads, which are the differences between the Standard & Poor's BBB 10-year bond yields and 10-year JGB yields.

Next, regarding the samples, our daily full sample period is from February 15, 1999 to December 30, 2011. We divide this period into two sub-periods of the in-sample and the out-of-sample periods. Our in-sample period is from February 15, 1999 to December 29, 2006 and our out-of-sample period is from January 4, 2007 to December 30, 2011. Volatility forecasts for the out-of-sample period are obtained after the in-sample estimation of the GARCH (1, 1) and GARCH-in-mean (1, 1) models by using the TOPIX returns.

Then by using the out-of-sample period, the forecast power of the above variables of GARCHF, GARCHMF, LJGB, SJGB, EX, and DEF is tested. In the tests, we use the Probit model, and the dependent variable of the probit model is one percent extreme events (which take 1 and otherwise zero) that mean the extreme price drops in the out-of-sample period. Namely, our research design is to examine the forecast power for the extreme stock price declines which occur with one percent probability by using the above variables and the Probit model.

3. Empirical Results

This section explains our empirical results. First, Table 1 shows the descriptive statistic of our seven variables and Table 2 displays the correlation coefficients of these seven variables. Table 2 shows that the correlations between SJGB and LJGB, EX and LJGB, and EX and SJGB are quite high. Interestingly, PCHG and GARCHF and PCHG and GARCHMF do not have strong relation in Table 2.

Then we examine the forecast power of each variable by using the Probit model and display the results in Table 3. This table indicates that GARCHF, GARCHMF, and SJGB have the predicting power of the extreme stock price declines in the Japanese stock markets.

Next, to further inspect the forecast power of volatilities of GARCHF and GARCHMF, by changing control variables, we perform the additional analysis and exhibit the results in Table 4. As this table clearly shows, the forecast volatilities by the GARCH-in-mean model have stronger predicting power for the extreme stock price declines which occur in one percent probability in our out-of-sample period.

4. Conclusion

This paper empirically inspected the forecast power of volatilities from the GARCH model and the GARCH-in-mean model for the extreme downside risk of stock markets in Japan. Our empirical tests implemented in this paper offered the following novel contributions. Namely, we found that the forecast volatilities both from the GARCH model and the GARCH-in-mean model well predicted the extreme price declines in the Japanese stock markets. Further, we revealed that in comparison with the GARCH model, forecasts from the GARCH-in-mean model had stronger forecast power for the downside risk in the TOPIX.

As above, our derived facts demonstrated in this research will contribute to the body of academic research in business and finance. We consider that future extended works exploiting our findings and related other data may be also valuable, and these are our future works.

International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

Table 3. Out-of-sample forecast of the extreme price declines in the TOPIX: Univariate tests for one percent extreme events by the Probit model

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	−2.7908***	−3.4429***	−3.1956***	−3.3994***	−2.4357***	−1.4872***
z-statistic	−16.8308	−13.3116	−4.5949	−9.1493	−3.0762	−3.0481
p-value	0.0000	0.0000	0.0000	0.0000	0.0021	0.0023
GARCHF	0.0048***					
z-statistic	6.1532					
p-value	0.0000					
GARCHMF		0.0332***				
z-statistic		6.2255				
p-value		0.0000				
LJGB			0.6091			
z-statistic			1.2814			
p-value			0.2001			
SJGB				2.5055***		
z-statistic				3.5378		
p-value				0.0004		
EX					0.0011	
z-statistic					0.1306	
p-value					0.8961	
DEF						−2.0478*
z-statistic						−1.6607
p-value						0.0968
McFadden R^2	0.2482	0.2797	0.0123	0.1210	0.0001	0.0327
AIC	0.0862	0.0827	0.1122	0.1002	0.1135	0.1099
SC	0.0945	0.0911	0.1205	0.1086	0.1219	0.1183

Notes: Our daily full sample period is from February 15, 1999 to December 30, 2011. We divide this period into two sub-periods of the in-sample period and the out-of-sample period. Our in-sample period is from February 15, 1999 to December 29, 2006 and our out-of-sample period is from January 4, 2007 to December 30, 2011. PCHG is the daily price changes of the TOPIX, GARCHF is the forecast volatilities from the GARCH model, and GARCHMF is the forecast volatilities from the GARCH-in-mean model. Further, LJGB is the 10-year Japanese government bond yields, SJGB is the six-month JGB yields, EX is the yen/US dollars rates, and DEF is the default spreads, which are the differences between the S&P BBB 10-year bond yields and 10-year JGB yields. ***, **, and * denote the statistical significance at the 1% level, 5% level, and 10% level, respectively.

International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

Table 4. Out-of-sample forecast of the extreme price declines in the TOPIX: Multivariate tests for one percent extreme events by the Probit model

	Model 1	Model 2	Model 3	Model 4
Constant	−4.6841***	−5.0074***	−4.4927***	−2.2280**
z-statistic	−3.1698	−5.5583	−2.9130	−2.2560
p-value	0.0015	0.0000	0.0036	0.0241
GARCHF	−0.0074	−0.0084	−0.0072	−0.0120**
z-statistic	−1.4617	−1.6005	−1.4478	−2.2262
p-value	0.1438	0.1095	0.1477	0.0260
GARCHMF	0.0803**	0.0822**	0.0798**	0.1159***
z-statistic	2.4202	2.3770	2.4142	3.1643
p-value	0.0155	0.0175	0.0158	0.0016
LJGB	0.2340			
z-statistic	2.4202			
p-value	0.7901			
SJGB		1.6209*		
z-statistic		1.7486		
p-value		0.0804		
EX			0.0014	
z-statistic			0.1060	
p-value			0.9156	
DEF				−7.2472**
z-statistic				−2.4443
p-value				0.0145
McFadden R^2	0.2964	0.3203	0.2960	0.3811
AIC	0.0841	0.0815	0.0842	0.0748
SC	0.1008	0.0982	0.1009	0.0915

Notes: Our daily full sample period is from February 15, 1999 to December 30, 2011. We divide this period into two sub-periods of the in-sample period and the out-of-sample period. Our in-sample period is from February 15, 1999 to December 29, 2006 and our out-of-sample period is from January 4, 2007 to December 30, 2011. PCHG is the daily price changes of the TOPIX, GARCHF is the forecast volatilities from the GARCH model, and GARCHMF is the forecast volatilities from the GARCH-in-mean model. Further, LJGB is the 10-year Japanese government bond yields, SJGB is the six-month JGB yields, EX is the yen/US dollars rates, and DEF is the default spreads, which are the differences between the S&P BBB 10-year bond yields and 10-year JGB yields. ***, **, and * denote the statistical significance at the 1% level, 5% level, and 10% level, respectively.

Acknowledgement
The author acknowledges the generous financial assistance of the Japan Society for the Promotion of Science. In addition, I greatly appreciate the repeated kind invitation from the Editors to write to this journal.

International Journal of Academic Research in Business and Social Sciences
April 2012, Vol. 2, No. 4
ISSN: 2222-6990

References

Ang, A., Chen, J., and Xing, Y. (2006). Downside Risk. Review of Financial Studies, 19, 1191–1239.

Bates, D. S. U.S. stock market crash risk. Journal of Financial Economics, forthcoming.

Caplin, A. and Leahy, J. (1994). Business as Usual, Market Crashes, and Wisdom After the Fact. American Economic Review, 84, 548–565.

Greenwald, B. C. and Stein, J. C. (1991). Transactional Risk, Market Crashes, and the Role of Circuit Breakers. Journal of Business, 64, 443–462.

Hong, H. and Stein, J. C. (2003). Differences of Opinion, Short-sales Constraints, and Market Crashes. Review of Financial Studies, 16, 487–525.

Huang, J. and Wang, J. (2009). Liquidity and Market Crashes. Review of Financial Studies, 22, 2608–2643.

Leland, H. and Rubinstein, M. (1988). Comments on the Market Crash: Six Months After. Journal of Economic Perspectives, 2, 45–50.