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Estimating fluctuating volatility time series returns for a cluster of international stock markets: A case study for Switzerland, Austria, China and Hong Kong

Suresh BADARLA
Assistant Professor, Department of Mathematics, Amity University Mumbai
Email: sbadarla.iitm@gmail.com

Bharti NATHWANI
Associate Professor, Department of Mathematics, Amity University Mumbai
Email: bharti.nathwani@yahoo.com

Jatin TRIVEDI
Associate Professor, National Institute of Securities Markets, India
Email: contact.tjatin@gmail.com

Cristi SPULBAR
University of Craiova, Faculty of Economics and Business Administration, Craiova, Romania
Email: cristi_spulbar@yahoo.com

Ramona BIRAU
C-tin Brancusi University of Targu Jiu, Faculty of Education Science, Law and Public Administration, Romania
Email: ramona.f.birau@gmail.com

Iqbal Thonse HAWALDAR
Department of Accounting & Finance, College of Business Administration, Kingdom University, Sanad, Bahrain, e-mail: i.hawaldar@ku.edu.bh

Elena Loredana MINEA
Faculty of Economics and Business Administration, University of Craiova, Romania
Email: loredana.minea@yahoo.com

Abstract

The major aim of this empirical study is to estimate the volatility time series returns for a cluster of international stock markets, such as: Switzerland, Austria, China and Hong Kong. The paper demonstrates statistical modeleling in order to capture volatility clusters and changes in long and short term volatility impact. The econometric approch is based on randomly selected daily closing return collected for the main indices of stock markets in Switzerland, Austria, China and Hong Kong for the sample period January 2003 to September 2021. We used various statistical properties to test normalities based on using GARCH family models for estimating financial market volatility. Moreover, the sampled time interval includes two extreme events such as the global financial crisis (GFC) of 2007–2008 and the recent COVID-19 pandemic.

Keywords: volatility forecasting, GARCH family models, COVID-19 pandemic, global financial crisis, extreme event, stock returns, volatility pattern, investor, risk

1. Introduction

Changes in asset prices motivates investors, researchers and observers. Financial market research provides vital information for present and future prospects. It is also one of the largest researched area across the world. However, with variation of methods and change in data structure, it changes the outcome for the analytical property. With rapid investment and return perception, the role of asset price modeling becomes more crucial. It has become part of financial risk management and measurement of investment risk with prospective returns. Considering important role of volatility forecasting, the usage of statistical applications such as econometrics are very important to abstract outcome from the time series returns or even data analysis. This paper is aimed to demonstrate usage of statistical tools to capture volatility impact from four randomly selected financial markets i.e. SMI, Swiss Market index, ATX, Austria market index, SSE, China market index and HangSang for Hong Kong market index. We capture daily closing prices from first trading day of January 2003 to last closing day of September, 2021. The study attempts to model the volatility effect using statistical applications such as Augmented Dickey Fuller test, KPSS test, Estimate Density, Loess fitness, Generalize Autoregressive Conditional Heteroskedasticy models (symmetric and asymmetric) models. Researchers from across the world used GARCH family models to demonstrate volatility behaviour based on time series returns.

The evaluation of risk and pricing of assets are most vital for any important decision makings. Hence, it invites detail study to understand the past movements. We propose to model the volatility and returns using advanced statistical methods. In the financial markets, it is very important to measure and estimate volatility so the to it can be hedged accordingly. It also helps to understand how much risk involved in any selective markets. Volatility can be defined as the changes in asset prices (which are considered unpredictable) over the period of time. It escalates prices to up and down side instantly. The detail study for specific markets provides insightful information about the past trends and previous volatility that support in any prospective decision making. Four financial markets i.e. SMI, ATX, SSE and HANGSANG considered for the study with their daily adjusted closing prices.

The SMI Swiss index represents Switzerland's blue-chip stock market index and considered as most followed index to observe movements financial markets. ATX, known as Austrian Traded index of Wiener Borse of Austria. SSE represents Shanghai Stock Exchange of China and HANGSANG considered for Hong Kong Stock exchange. The selection of financial markets is completely random and further not divided into continent-wise, instead they are considered to demonstrate usage of statistical tools to estimate empirical outcome. With introduction to autoregressive conditional heteroscedasticity models, popularly known as ARCH model and the generalized version GARCH model, both of the models used extensively to predict and forecast returns and volatility parameters. The main objective of investors is to gain maximum returns bearing minimum risk parameters. Thus, it is important to utilize one or more technical methods which allows detail review of returns for time-series data. Birau et al. (2021) examined the behaviour of stock markets from Spain and Hong Kong based on GARCH models. In addition, Spulbar et al. (2020) investigated the dynamics of stock market of Hong Kong based on short term momentum effects.

In another train of thoughts, is there any linkage between physics and financial markets? At first glance, these seem to be distinct areas of research. Nevertheless, statistical physics, as well as other tools and techniques in physics provide a complex framework for understanding the highly dynamic behavior of stock markets. However, researchers with theoretical and applied expertise in the field of physics can obtain representative results in the area of stock markets. In the complex area of modeling and forecasting the behavior of international stock markets, the so-called "rocket scientists" are distinguished considering their ability and knowledge in advanced physics, mathematical tools, technical methods or applied science. In other words, highly technical expertise in physics is a significant advantage in modeling stock market volatility, for example, based on advanced models.

2. Literature review

A large number of research studies have been conducted across the world indicating usage and application of GARCH model type autoregressive models. Each study has its novel outcome considering time-range and empirical discussion. Though the usage of such statistical methods makes outcome and interpretation of asset property at highest interest for researchers, academicians and practitioners. Engle (1982) introduced first ARCH model which further generalized by Bollerslev (1986) but the model was not capable to capture stylized facts and thus Nelson (1992), Gujarathi et al. (1993) and Engle (1993) introduced asymmetric GARCH models such as EGARCH, GJR and Asymmetric GARCH models that follows long process and captures leverage effect from time-series returns.

Alam and Rashid (2015) used GARCH type models to demonstrate impact of macroeconomics variables with KSA, Karachi Stock Exchange. Belcaid and El Ghini (2019) worked on changes in volatility pattern with international economic policy and related uncertainty and also capturing impact of global financial crisis. Kim and Won (2018) used GARCH models with neural network as an integrated model which delivered lowest prediction errors. Li and Wang (2013) studied Chinese stock markets using GARCH and GARCH type family models whereas Wong & Cheung (2011) studies Hong Kong Stock markets using GARCH models. Ejaz et al. (2020) highlighted the opportunity international diversified portfolio used by global investors.

Ardia et al. (2019) worked with Markov switching GARCH type models the proposed GARCH allows user to perform simulations and maximum likelihood. On the other hand, Endri et al. (2020) modelled Indonesian stock market with GARCH type models and concluded impact of positive and negative news on the stock market. Whereas Mohsin et al. (2020) used symmetric and asymmetric GARCH models to measure the volatility of bak stock prices and macroeconomic fundamental framework and policy. They concluded that market returns determine the various dynamics of conditional returns for banking sector stocks. Also, Sun and Yu (2020) worked with SVR – GARCH models worked on S&P500 index and daily exchange rate of British pound compared with the US dollars. GARCH and GARCH type models also used to forecast and estimate prices for cryptocurrencies. For instance, Kyriazis et al. (2019), Caporale and Zekokh (2019). Ardia et al. (2019) used traditional GARCH single regime specifications in predicting a day ahead value at risk. They found presence of strong evidence of regime changes in GARCH modelling process.

Haque and Shaik (2021) used GARCH models to predict crude oil prices during the pandemic period. They worked with comparative methodology with GARCH and ARIMA. Further financial modelling estimation also indicates explanatory variables with significance degree that helps researchers, investors and observers for further study and decision makings. With development of series of GARCH family models such as EGARCH, TGARCH, PGARCH, QGARCH and IGARCH models have been also used together to deliver best fitness of results. For instance, Kim et al. (2021) used series of GARCH family models to demonstrate best fit models. Also Ardia et al. (2019) worked with single-regime process using GARCH modelling to forecast volatility. On the other hand, Meher et al. (2020) used mixed ARIMA model for stock market prediction.

Trivedi et al. (2021) investigated volatility spillovers, cross-market correlation, and co-movements using a cluster of both developed and emerging stock markets, such as: Spain, UK, Germany, France, Poland, Hungary, Croatia, and Romania based on GARCH (1, 1) models for the time period from January 2000 to July 2018. Spulbar et al. (2019) investigated volatility patters and causality between selected developed stock markets of USA, Canada, France and UK for the sample time period from January 2000 until June 2018 by applying a variety of statistical tools and techniques and econometric models, including GARCH (1, 1) model, AF test, BDS test, Granger causality test/ Vector AutoRegression (VAR) model. Moreover, Spulbar and Birau (2018) investigated weak-form efficiency and long-term causality for a cluster of emerging capital markets, such as: Romania, India, Poland and Hungary for the selected period from January 2000 to July 2018.

Meher et al. (2020) investigated the impact of ESG criteria, such as: Environment, Society and Governance on Indian stock market returns and volatility and argued that a robust base model cannot be designed using ESG factors as independent variables in order to forecast financial returns and stock market volatility.

3. Data collection and research methodology

We used daily closing prices of selected stock market indices and applied Augmented Dickey Fuller (ADF) test, KPSS test and GARCH type models. First, we convert all series returns into log returns;

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \ln(p_t) - \ln(p_{t-1})$$

Augmented Dickey Fuller test

$$\Delta y_t = \alpha + \gamma y_{t-1} + \lambda_t + v_t$$

GARCH (1,1) model represents a model introduced by Bollerslev in 1986 that contains conditional variance represented as linear function of lags. ARCH coefficient ($a1$) suggests that there is significant impact of previous period volatility shocks on current period. Where the other coefficient GARCH (β_i) measures the impact of previous period variance on present volatility and also indicates presence of volatility clustering in series returns. GARCH (1,1) model by Bollerslev (1986) represented by following:

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i a_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}$$

As a result of conversion of log returns, we confirm significance of modeling and there is no longer any unit root problem with series returns. Figure 1 indicates stationary property of selected financial markets.

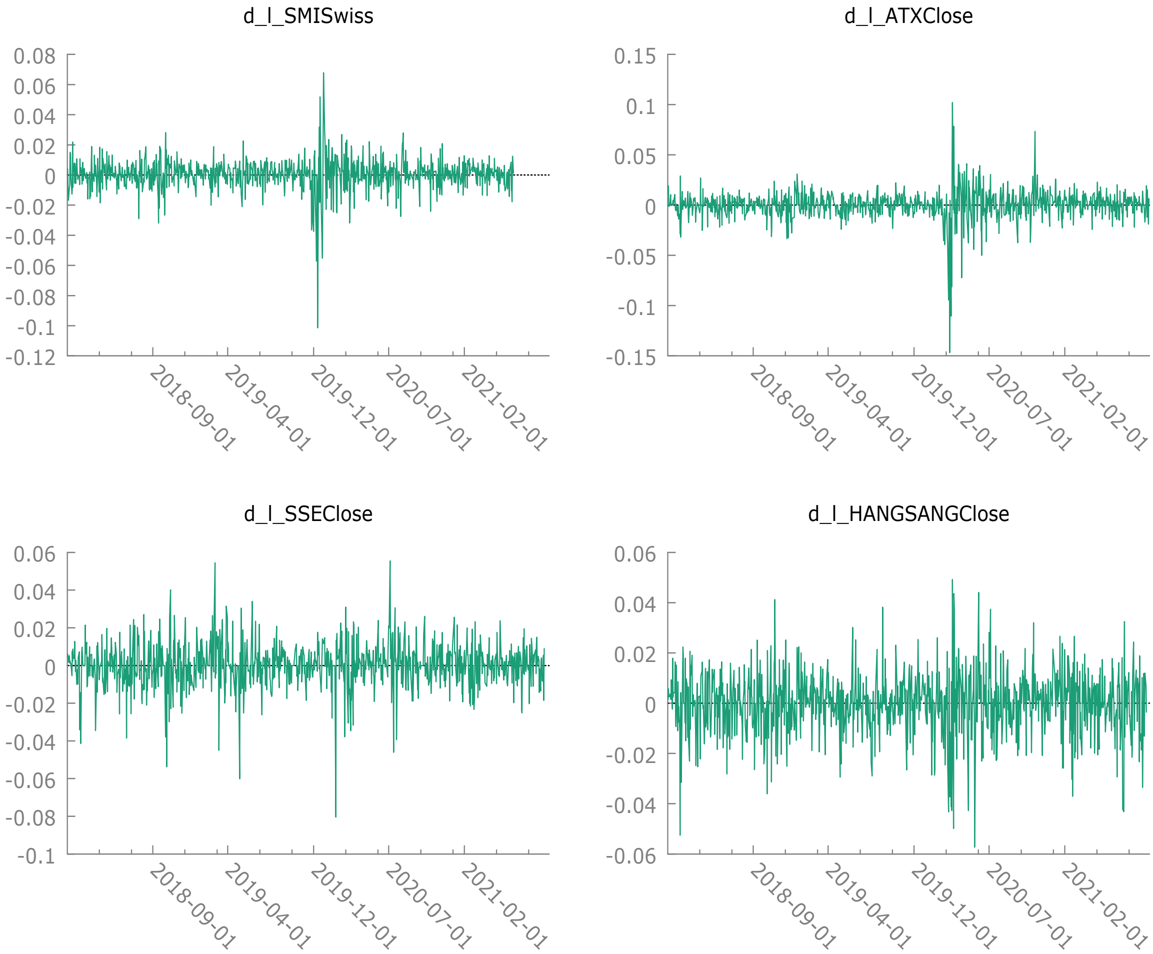

Figure 1. The trend of the stock return series of Switzerland, Austria, China and Hong Kong from January 2003 to September 2021

In the selected samples described in figure 1, Hang Sang, a Hong Kong financial market indicates the highest number of negative and positive volatility shocks compared to the stock markets from Switzerland, Austria and China. However, the global financial impact appears clearly on all sample data.

Table 1. Belsly-Kul-Welsch collinearity test statistics

Belsley-Kuh-Welsch collinearity diagnostics:

lambda	cond	const	SMIS~	ATXC	SSEC	HANG
1.823	1.000	0.000	0.002	0.112	0.128	0.138
1.030	1.331	0.503	0.465	0.000	0.000	0.001
0.968	1.372	0.496	0.531	0.001	0.000	0.001
0.771	1.537	0.000	0.001	0.701	0.296	0.011
0.408	2.114	0.000	0.002	0.185	0.576	0.849

Where

lambda = eigenvalues of inverse covariance matrix (smallest is 0.407817)
cond = condition index
note: variance proportions columns sum to 1.0
According to BKW, cond >= 30 indicates "strong" near linear dependence, and cond between 10 and 30 "moderately strong". Parameter estimates whose variance is mostly associated with problematic cond values may themselves be considered problematic.
Count of condition indices >= 30: 0
Count of condition indices >= 10: 0
There was no evidence of excessive collinearity found.

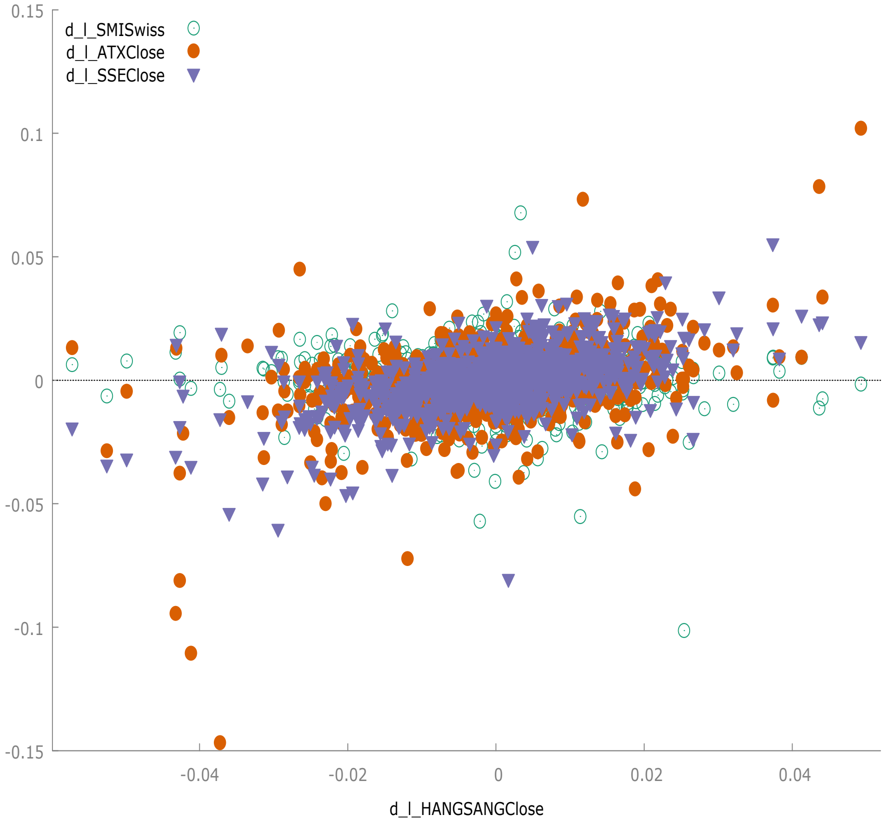

Figure 2. Correlation and market movement plot

The property of Table 1 indicates there is no evidence of excessive collinearity among the selected stock markets. Figure 2 demonstrates relevance of other financial market movements compared with Hang Sang which is the stock market of Hong Kong and provides scattered returns.

Table 2. Correlation coefficients

SMISwiss	ATXClose	SSE	HANG	
1.0000	-0.0239	-0.0391	-0.0190	SMIS
	1.0000	0.2391	0.4212	ATX
		1.0000	0.5504	SSE
			1.0000	HANGSANG

Note: Author's computation for correlation coefficients using the observations 5% critical value (two-tailed) = 0.0663 for n = 875

The correlation matrix indicated in Table 2 provides relevance of market movement from one country and its relevance to other country. Most relevance correlation found between China and Hong Kong at 55% correlation, whereas the other two European market negatively correlated.

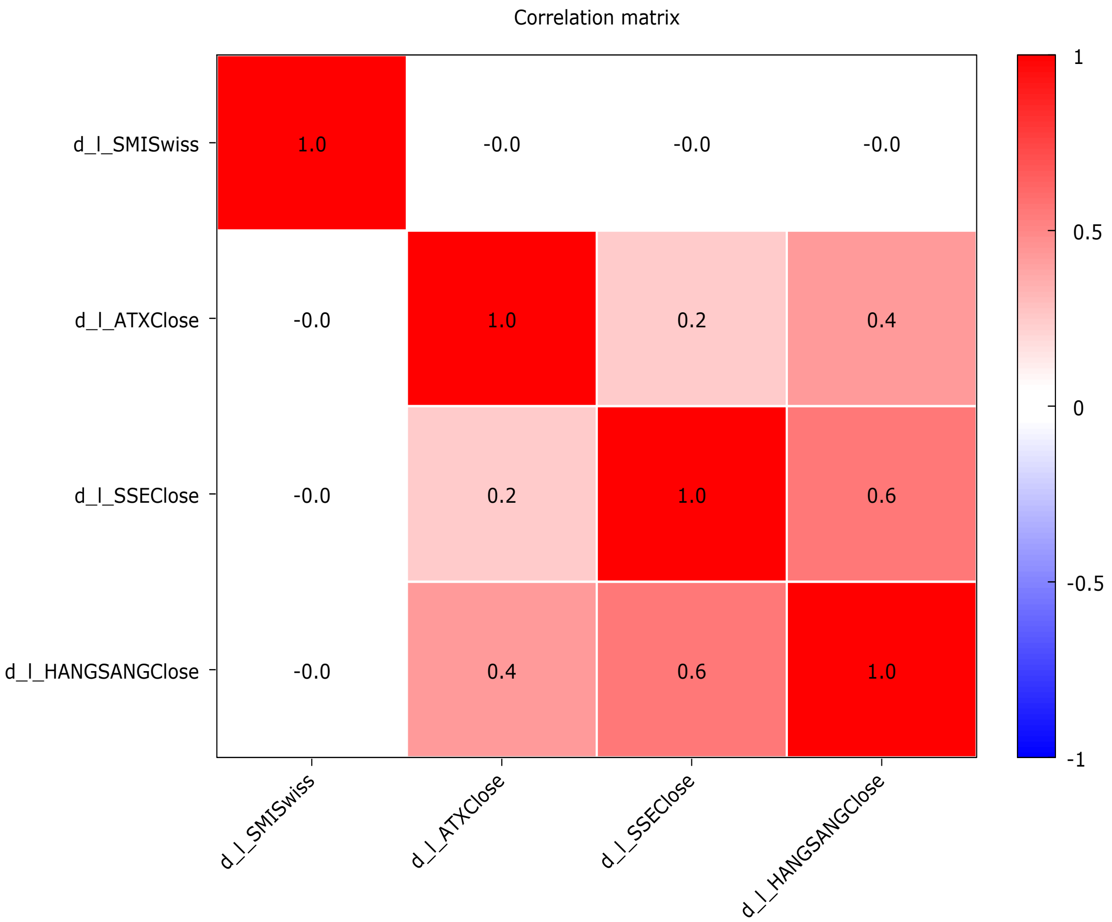

Figure 3. Correlation Matrix for selected stock market indices from Switzerland, Austria, China and Hong Kong

Table 3. Statistical property of GARCH (1, 1) model

	Switzerland		Austria		China		Hong Kong	
Constant	0.000624	5%	0.000436	-	8.84E-05		-0.0001	
Omega	5.77E-06	1%	5.85E-06	5%	7.95E-06	5%	6.52E-06	
Alpha	0.176284	1%	0.140828	1%	0.055316	1%	0.051784	1%
Beta	0.760508	1%	0.825378	1%	0.888499	1%	0.906208	1%
AIC	-5870.94		-5807.2		-5718.3		-5623.64	
BIC	-5851.84		-5787.79		-5698.93		-5604.25	

Table 3 regarding statistical property indicates that GARCH type models can be used to forecast and estimate financial market returns. We found that European market – SMI, financial market of Switzerland only fits with GARCH type models with lowest degree of Beta and highest degree of significant alpha. Other financial markets such as Austria, China and Hong Kong could not be estimated using GARCH model. Moreover, as a result statistics have not provided significant p-value, while outcome property exceeded the statistical parameters.

Table 4. Statistical property of EGARCH model

	Switzerland		Austria		China		Hong Kong	
Constant	0.000102	-	0.000577	1%	0.000384	1%	0.000307	5%
Omega	-0.421303	1%	-0.3395	1%	-0.1444	1%	-0.22692	1%
Alpha	0.157253	1%	0.16361	1%	0.1152	1%	0.11959	1%
Gamma	-0.145689	1%	-0.09587	1%	0.003083	1%	-0.05246	1%
Beta	0.968153	1%	0.976012	1%	0.99273	1%	0.98455	1%
AIC	-31099.85		-28894.33		-27773.94		-28991.97	
BIC	-31067.57		-28861.97		-27741.59		28959.62	

Considering the sample data for a cluster of four stock markets, the property of Table 4 indicates significant information about movement pattern and volatility clusters in financial markets. Sample markets of Switzerland, Austria and Hong Kong found presence of asymmetry (leverage effect) and only market SSE – China does not have leverage effect. Leverage effect considered as important measurement to look at the prospects in financial markets. It suggests reaction of negative news in past, and whether the market has tendency to carry forward negative shocks longer period of time than the positive shocks.

Conclusions

In this research paper we have investigated the long-term behaviour of a cluster which includes four randomly selected stock markets, such as: Switzerland, Austria, China and Hong Kong. We employed various statistical tools and econometric models in order to process the outcome. We found there is significant and valuable outcome can be derived using statistical property with data analysis. The use of correlation helped to understand the existing correlation between selected financial markets, the same also plotted and demonstrated as results. The ADF used with constant and trend and provides stationarity for all financial markets. GARCH (1,1) model was employed and fitted well with Switzerland stock market (SMI). Moreover, the stock markets of Switzerland, Austria and Hong Kong found with presence of leverage effect, and only SSE China have no significant presence of leverage effect. Stock markets represent a high challenge for physicists given the theoretical and applied background based on methods and techniques of advanced mathematics and applied sciences. For future research we aim to investigate the accuracy of statistical physics tools compared to financial econometrics advanced models based on a complex empirical study focused on European stock markets during COVID-19 pandemic.

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