VOLATILITY SPILLOVER: DYNAMIC REGIONAL AND WORLD EFFECTS

Ming-Chieh Wang[1]
National Chi Nan University, TW.
mcwang@ncnu.edu.tw

Feng-Ming Shih[2]
National Chi Nan University, TW.
s2212903@ncnu.edu.tw

ABSTRACT

This paper investigates the dynamic nature and determinants of volatility spillovers from European region and world to the five emerging European equity markets that are not members of the European Monetary Union. Using a multi-factor model with time-varying loadings estimated in three stages, our results show significant world and regional effects on volatility. The influence of economic determinants on the regional effect seems to be greater than that on the world effect. Furthermore, this study provides evidence that economic growth and exchange rate can predict the volatility spillover intensities in the Czech Republic, Hungary, and Poland as well as in the developed European region, by controlling the variables of foreign capital flows and trade. World effect on region becomes stronger when the world and European region are simultaneously in recession.

Key words: volatility spillover, economic growth, exchange rate
JEL code: G12; G15

[1] Wang: Assistant Professor, Department of International Business Studies, National Chi-Nan University, 1 University Rd, Puli, Nantou 545, Taiwan. Phone 886-49-2910960 ext. 4646, Fax 886-49-2911595, E-mail mcwang@ncnu.edu.tw

[2] Shih: Candidate, Doctor's Degree, Department of International Business Studies, National Chi-Nan University, 1 University Rd, Puli, Nantou 545, Taiwan. Phone 886-49-2910960 ext. 4646, Fax 886-49-2911595, E-mail s2212903@ncnu.edu.tw

I. INTRODUCTION

Over the last few decades, liberalization and integration of the financial markets have increased the co-movements of international capital markets. The research of comovements between stock returns is at the heart of finance (Bekaert, Hodrick and Zhang, 2009). An examination of the volatility spillover process also enhances the understanding of information transmission between international markets. The objective of this paper is to test whether there are economic growth and exchange rate components in the shock spillover intensities. This paper claims that the increasing impact of world and regional factors on volatility in emerging European markets is consistent with increased global and regional integration. A comparison between our research and previous studies is given below.

First, this paper focuses on emerging European markets. Other emerging markets such as those in Asia have been extensively studied (see, e.g., Ng, 2000; Gallo and Velucchi, 2009), but evidence of stock market integration in Central and Eastern Europe remains relatively scarce (Babetskii, Komárek and Komárková, 2007). In practice, financial market behavior of emerging European markets can be different from other emerging markets. Therefore, it would be interesting to gain an insight into the working of these countries' financial markets.

Second, from a methodological point of view, the European situation provides an excellent case study for regional analysis owing to the differences in culture, economy, geography, and polity compared with Asia. The method in this paper allows for time-varying parameters and further gives us the possibility to address world effect and regional (developed Europe) effect on emerging European markets. Previous studies on international market linkages in emerging European markets focused mainly on the effects of a single international market (see, e.g., Chelley-Steeley, 2005) or on the influence of the EMU (see, e.g., Baele, 2005; Babetskii et al., 2007). However, in the case of emerging European markets, very few papers discuss the volatility spillover effects from both the world and the developed European region (Bekaert, Harvey and Ng, 2005).

Third, this paper tests the economic circumstances that have an impact on the spillover effects from the world and the European region. With the degree of international correlation changing over time, a more appropriate method of investigating the behaviors of return and volatility spillovers is to allow the spillover weight parameters to be driven by certain local information variables that might capture the time variation in correlations (Ng, 2000). Previous studies indicate that the macroeconomic variables can explain the relationship between risk and returns and predict the excess returns[3] and show the importance of currency effects on equity prices and volatility (see, e.g., Cumperayot et al., 2006). Investors focus more on the movements of exchange rates during large shocks, which may propagate across markets. Therefore, we investigate whether the economic growth and exchange rate components affect the size and pattern of volatility spillovers from the world and the European region. Thus far, to our knowledge, the existing literature has focused primarily on world market integration; however, regional integration on the basis of economic growth conditions in emerging European markets has scarcely been analyzed. Our analysis is therefore a first look on this issue.

Our result suggests that foreign shocks from the world and the region are both important. Furthermore, this study provides some evidence of exchange rate and economic growth effects on the degrees of spillover in emerging European markets and the European region.

This paper is organized as follows. Section 2 describes the settings of the econometric models of volatility spillovers. Section 3 provides data for five emerging European equity markets. The empirical results are presented in Section 4. Section 5 provides the conclusion.

II. METHODOLOGY

A. The Model

This paper intends to test the time-varying effects of volatility spillovers from the world and the European region to five emerging European markets. Considering that the degree of international correlation is unstable, we assume that the spillover effects change over time. We extend the two-factor model of Bekaert et al. (2005) by allowing for different degrees of spillover effects on mean and volatility. Thus, the model takes the following general form:

$$R_{i,t} = \delta_i' Z_{i,t-1} + \beta_{i,t-1}^{world} u_{world,t-1} + \beta_{i,t-1}^{reg} u_{reg,t-1} + \gamma_{i,t-1}^{world} e_{world,t} + \gamma_{i,t-1}^{reg} e_{reg,t} + e_{i,t} , \quad (1a)$$

$$\sigma_{i,t}^2 = E\left\langle e_{i,t}^2 \middle| I_{t-1} \right\rangle = \theta_i + \phi_i \sigma_{i,t-1}^2 + \varphi_i e_{i,t-1}^2 + \zeta_i \eta_{i,t-1}^2 , \quad i = 1,2,..N \quad (1b)$$

where $R_{i,t}$ represents the stock index returns in excess of the 30-day Eurodollar rate on market i in US dollars, and $u_{world,t-1}$ and $u_{reg,t-1}$ denote the conditional expected excess returns on the world and European

3 For instance, Fama (1981) provides the evidence of a negative relationship between inflation and stock returns.

regional stock markets, respectively. The vector $Z_{i,t-1}$ includes a constant term, security transactions per GDP, the ratio of total trade to GDP, exchange rate components, business cycle components, and the stock excess return for market i, all of which are lagged by one month. The variance of the idiosyncratic return shock $e_{i,t}$ follows a GARCH process in eq. (1b) with asymmetric effects in the conditional variance, similar to those of Glosten, Jagannathan and Runkle (1993). Finally, we let $\eta_{i,t}$ represent the negative shock of market i, that is, $\eta_{i,t}$ = min {0, $e_{i,t}$}.

The expected excess returns on market i can be shown as a linear function of the local information set as well as the world and regional excess returns. Then, we have the model as follows:

$$\mu_{i,t-1} = E\left\langle R_{i,t} \middle| I_{t-1} \right\rangle = \delta_i' \, Z_{i,t-1} + \beta_{i,t-1}^{world} \mu_{world,t-1} + \beta_{i,t-1}^{reg} \mu_{reg,t-1}$$

$$= \delta_i' \, Z_{i,t-1} + \left(\beta_{i,t-1}^{world} + \beta_{i,t-1}^{reg} \beta_{reg,t-1}^{world} \right) \left(\delta_{world}' Z_{world,t-1} \right) + \beta_{i,t-1}^{reg} \left(\delta_{reg}' Z_{reg,t-1} \right). \quad (2)$$

The set of regional financial variables $Z_{reg,t-1}$ are similar to $Z_{i,t-1}$, except that we use the regional variables to replace the local variables. For the world market, $Z_{world,t-1}$ contains a constant term, the world market dividend yield in excess of the 30-day Eurodollar rate, default spread (Moody's Baa minus Aaa bond yields), changes in the term structure spread (US 10-year bond yield minus 3-month US bill), and changes in the 30-day Eurodollar rate.

The unexpected portion of the market returns composed of increasing local shocks and the world and regional shocks can be described as follows:

$$\varepsilon_{i,t} = \gamma_{i,t-1}^{world} e_{world,t} + \gamma_{i,t-1}^{reg} e_{reg,t} + e_{i,t} . \quad (3)$$

B. Parameterizations for Mean and Volatility Spillovers

We allow the spillover effects to be influenced by economic situation. Hence, the model can be expressed as

$\beta_{i,t-1}^{world} = a_i' \, \chi_{i,t-1}^{world}$, $\beta_{i,t-1}^{reg} = b_i' \, \chi_{i,t-1}^{reg}$, $\beta_{reg,t-1}^{world} = c_i' \, \chi_{reg,t-1}^{world}$,

$\gamma_{i,t-1}^{world} = d_i' \, \chi_{i,t-1}^{world}$, $\gamma_{i,t-1}^{reg} = v_i' \, \chi_{i,t-1}^{reg}$, and $\gamma_{reg,t-1}^{world} = w_i' \, \chi_{reg,t-1}^{world}$,

where a_i, c_i, d_i, and w_i are (7×1) vectors of the parameters that measure the impact on the spillover effect from the world, while b_i and v_i measure the effects from the European region.

The vectors of $\chi_{i,t-1}^{world}$ and $\chi_{i,t-1}^{reg}$ consist of the instrument variables that capture the covariance risks of market i with respect to the world and region portfolios, while the variable of $\chi_{reg,t-1}^{world}$ reflects the risk of the European region with respect to the world portfolio. The instruments in $\chi_{i,t-1}^{world}$ and $\chi_{reg,t-1}^{world}$ include a constant, security transactions per GDP, the ratio of total trade to GDP, exchange rate components (against US), and economic growth components, while $\chi_{i,t-1}^{reg}$ contains a constant, the ratio of total trade to GDP, exchange rate components (against Euro), and economic growth components.

C. Instrumental Variables on Spillovers

Foreign capital flows. The variable of security transactions per GDP, ST, is the data of gross foreign purchases and sales obtained from the US Treasury International Capital (TIC) reporting system and considered as a proxy for financial integration that is increased by liberalization. Bekaert, Harvey and Lumsdaine (2002) use the data as the proxy for foreign capital flows. The mobility of international capital flows may lead to financial market integration.

Trade. We use the ratio of total trade to GDP as the proxy for economic integration. The variable may affect equity return correlations through an assembly of cross-country cash flows. Chen and Zhang (1997) found that countries with heavier external trade to a particular region tend to have higher return correlations with that region.

Exchange rate components. Variable Ex1 indicates the movements of exchange rates, and Ex2 is a dummy variable for the depreciation of local currency.[4] Several theoretical links between equity prices and exchange rates are well known, and the effect of exchange rate on the

4 The variables, Ex1 and Ex2, are measured by the exchange rate against US dollar for the world effect and against euro for the regional effect.

relative importance of international factors over time can be found in Bekaert and Harvey (1997).

Economic growth components. For the economic growth components, we create two dummy variables, Gth1 and Gth2, to represent two states: the state when emerging Europe and the world (European region) are simultaneously in recession and the state when the local business cycle is in a recessionary phase. To explore the effect of business cycle deviations on cross-market correlations, we include the dummy to record the economy when it is in the recessionary phase. The dummy is calculated as follows. First, a quadratic trend is fitted for the composite leading indicator of each country as well as for the world (European regional market). Second, the deviations from this trend are generated. Positive deviations indicate boom; negative deviations, recession. Third, for each country, a below-phase dummy is created. This dummy takes a value of one when the deviation of a country's composite leading indicator from its trend has the same sign as the world (European region), and zero otherwise.

D. Estimation Method

Our model is estimated in three steps. In the first step, a univariate GJR-GARCH model is estimated for the world return. In the second step, an extended univariate GJR-GARCH model is estimated for the aggregate European return. The world residual from the first-step regression is included as an explanatory variable. Finally, conditioning on the effects of the world and regional markets, we examine the model for local markets in eqs. (1a) and (1b). To avoid non-normality in excess returns, we adopt the quasi-maximum likelihood (QML) method to estimate the model, as proposed by Bollerslev and Wooldridge (1992).

III. DATA COLLECTION

Our data set from Datastream contains the Morgan Stanley Capital International (MSCI) stock indices in terms of US dollars for computing monthly continuously compounded rates of return for the world, region, and emerging European markets. The sample period is from September 1996 to December 2006. We use MSCI world index as the world market and MSCI Europe index[5] as the European regional market. Among all emerging European markets,[6] we select those that are not members of the EMU to test the depreciation effect on world and regional spillover intensities. Thus, the emerging markets include the Czech Republic, Hungary, Poland, Russia, and Turkey.

5 The MSCI Europe Price index tracks 16 of the major stock markets in Europe by capturing approximately 85% of the market cap of each country.

6 The International Finance Corporation (IFC) now classifies seven countries in Europe as emerging markets: the Czech Republic, Poland, Russia, Hungary, Greece, Slovakia, and Turkey.

IV. EMPIRICAL RESULTS

A. World and Regional Models

A correct specification for the models is important for investigating the influence of world and European regional shocks on emerging European markets. Table 1 presents the results of the specification tests for the world and regional models. All the models for the world and regional markets exhibit no autocovariance in the standardized residuals and squared terms. The Jarque-Bera tests for normality indicate that the standardized residuals for all models are generally normally distributed. All the results of the joint tests are far above their critical values. Negative news from the world may increase the volatilities of the equity returns in the regional market and emerging European markets. For the world model estimation, the likelihood ratio test (at a 10% level) and the Wald test (at a 5% level) reject the null hypothesis of no asymmetry. We find no evidence of asymmetric volatility in the regional model estimation. The results are similar to Bekaert et al. (2005), who find strong asymmetric volatility in the United States, yet fail to reject symmetry in the European, Asian, and Latin American region.

Table 1. Specification and Normality Test

	Model	Specification Tests				Asymmetry Test	
Market	Asy/Sym	$LB(4)$	$LB^2(4)$	Jarque-Bera	Joint test	LR test	Wald test
World	Symmetry	1.825	2.941	3.921	25.108***		
	Asymmetry	3.112	1.253	4.969*	22.008***	3.579*	6.531**
Europe	Symmetry	5.113	1.025	1.435	215.168***		
	Asymmetry	4.323	0.599	1.723	191.272***	1.257	1.023

** and *** denote statistical significant at 5% and 1% level, respectively.

B. Time-varying Volatility Spillover Effects

Table 2 reports time-varying volatility spillover effects on the European regional market and emerging European markets. In the European regional market, the volatility spillover from the world decreases when the currency depreciates or when the European economy is in recession. However, we find that the world effect becomes stronger when the world and European regions are simultaneously in recession or when the size of trade with the world increases in the European region. The Wald tests indicate that exchange rate and economic growth may significantly influence the world effect.

In the Czech Republic, the result shows that the world effect on volatility is larger when security transactions decline or when the trade with the world increases. However, the European effect is weaker when the Czech economy is in recession (at a 10% level) and is stronger when currency depreciates, or when the European region and the Czech Republic are simultaneously in recession. Then, the Wald tests show that exchange rate can influence the world effect (at a 10% level), and both exchange rate (at a 5% level) and economic growth (at a 1% level) can change the European effect.

Table 2 shows that in Hungary, the world effect is weakened when the total trade with the world increases and when the world and Hungary are simultaneously in recession. Nevertheless, the European effect becomes more important when the trade increases, when Hungary is in recession, and when the European region and Hungary are simultaneously in a recessionary phase. The Wald tests show that exchange rate (at a 10% level) and economic growth (at a 1% level) are the important determinants for the shock spillover intensity from the world, and economic growth (at a 5% level) is important for the European effect.

The world effect on volatility of Poland diminishes when the world and Poland are simultaneously witnessing recession or when only the economy of Poland faces recession. However, the European effect on volatility of Poland decreases during currency depreciation and increases when the economy of Poland is in recession. The Wald tests indicate that economic growth is an important driver of world effect; furthermore, exchange rate and economic growth have a significant impact on the European effect in Poland.

For the Russian market, the world effect extends when the total trade with the world reduces or when currency depreciates. Additionally, less trade with the European region (at a 5% level) or currency depreciation (at a 10% level) degrades the European effect.

In Turkey, currency depreciation declines the European regional volatility spillover. The Wald test indicates that exchange rate effect is important for the European effect at a level of 5%.

Interestingly, Table 2 also shows that the absolutes of the coefficients of the latent variables on the European effect are larger than those on the world effect in most of the emerging European markets. That is, the variables of trade, exchange rate, and business cycle components exhibit a stronger impact on shock spillover intensities from the European region than on those from the world.

In sum, the size of trade appears to have a positive effect on the shock spillover intensities from the European region and a negative effect on the volatility spillover from the world to emerging European markets, except the Czech Republic, although the coefficients are not all significant. The possible reason is that developed European countries are the largest export markets for emerging European markets. As a result, increases in the trade with the European region leads to less diversified trade structure for emerging European markets. Chambet and Gibson (2008) find that countries with less diversified trade structure have more integrated stock markets.

Furthermore, in Table 2, the coefficients of business cycle components on world effect have a negative sign, indicating that when the world and emerging

European markets are simultaneously in recession or when only emerging European markets are in recession, there is a lower degree of integration, except in Turkey, although the coefficients are not all significant. The result conforms to Ragunathan et al. (1999), who study the correlation and integration of the Australian and US markets by using single-factor methodology. On the other hand, our paper reveals that growth effect can predict the regional effect in the Czech Republic, Hungary, and Poland, and most signs are positive. In other words, the regional effect is stronger during recession. The Czech Republic, Hungary, and Poland joined the European Union on May 1, 2004. Thus, a possible explanation for the result may be that increased economic integration with the European region and the links connecting regional trade lead to more integration with European region for Czech, Hungary and Poland.

Table 2. Time-varying Volatility Spillover Effects

	Europe	Czech	Hungary	Poland	Russia	Turkey
World effect						
S. T.	-0.004	-118.854***	97.275	-306.075	-0.004	116.056
Trade	0.010*	21.574**	-25.626***	-16.386	-0.064**	-0.207
Ex 1	-0.056***	0.076	-0.134	-0.211	0.208*	0.01
Ex 2	-0.099	-0.196	0.102	-0.748	0.661	0.706
Gth 1	0.217***	-0.372	-0.689***	-1.058***	-0.038	0.685
Gth 2	-0.165**	-0.232	-0.589	-0.873***	-1.005	0.845
Regional effect						
Trade		51.166	196.089***	129.168	0.282**	31.25
Ex1		0.555	-0.554*	-0.585**	-0.246	-0.138
Ex 2		2.608**	-1.438	-0.941	-2.454*	-6.078***
Gth1		2.486***	1.998**	0.57	-0.206	-1.568
Gth 2		-1.125*	1.307**	1.635**	-1.873	-0.07
Wald test						
World(Ex)	16.093***	5.378*	5.756*	2.433	3.444	0.454
World(Gth)	20.770***	2.59	9.649***	18.670***	1.935	2.011
Eu(Ex)		6.424**	3.55	11.398***	3.223	8.894**
Eu(Gth)		20.059***	7.841**	6.157**	2.044	1.356

** and *** denote statistical significant at 5% and 1% level, respectively.

Table 3 displays the summary statistics of the Wald tests for the time-varying spillover effects. All emerging markets as well as the European regional market have significant spillover effects from the world market with respect to volatility. The world and the European factors are both important for emerging European market integration.

The effects of currency depreciation can predict the volatility spillover intensities at the 5% level in four of five emerging European countries. Table3 also show that shock spillover intensities are significantly related to the state of the business cycle in three emerging European countries. At the significant level of 1%, business cycle components can influence the spillover intensities for the Czech Republic, Hungary, and Poland.

Table 3. Wald Tests Table

	Europe	Czech	Hungary	Poland	Russia	Turkey
Word effect	2703.896***	61.305***	89.934***	58.382***	30.987***	71.687***
Regional effect		56.691***	50.205***	33.690***	14.966**	14.071**
Exchange Rate		11.729**	10.800**	15.284***	4.597	9.522**
Economic Growth		20.908***	14.601***	24.596***	4.201	3.311

** and *** denote statistical significant at 5% and 1% level, respectively.

V. CONCLUSIONS

This paper measures the volatility spillover effects from the world and the region for five emerging European equity markets. Our results suggest that there are significant volatility spillover effects from the world and the European region. In addition, our result shows that economic determinants of shock spillover intensities from the European region seem to be more powerful than those from the world, although the directions of impact are not the same. This study also provides evidence of exchange rate effect on the degree of spillover for most emerging European markets and growth effect on the shock spillover intensities from the European region for the Czech Republic, Poland, and Hungary. The findings may reflect that economic integration promotes financial integration in the three markets. For the European region, world effect becomes stronger when the world and European regions are simultaneously in recession. We suggest that world and regional economic instability may also change the degree of the world effect on European regional volatility. Overall, our results are helpful for understanding the sources and behavior of volatilities in emerging European markets. The findings in this paper are also important for portfolio managers and international investors to price securities and to manage risk.

REFERENCES

1. Babetskii, I., Komárek, L. & Komárková, Z. (2007) Financial integration of stock markets among new EU member states and the Euro area, *Finance a úvěr-CZECH Journal of Economics and Finance,* 57, 341-362.
2. Baele, L. (2005) Volatility spillover effects in European equity markets, *Journal of Financial and Quantitative Analysis,* 40, 373-401
3. Bekaert, G. & Harvey, C. R. (1997) Emerging equity market volatility, *Journal of Financial Economics,* 43, 29-77.
4. Bekaert, G., Harvey, C. R. & Lumsdaine, R. L. (2002) The dynamics of emerging market equity flows, *Journal of International Money and Finance,* 21, 295-350.
5. Bekaert, G., Harvey, C. R. & Ng, A. (2005) Market integration and contagion, *Journal of Business,* 78, 1-32.
6. Bekaert, G., Hodrick, R. J. & Zhang, X. Y. (2009) International stock return comovements, *Journal of Finance,* 64, **2591-2626.**
7. Bollerslev, T. & Wooldridge, J. M. (1992) Quasi-Maximum Likelihood estimation and inference in dynamic models with time-varying covariances, *Econometric Reviews,* 11, 143-172.
8. Chambet, A. & Gibson, R. (2008) Financial integration, economic instability and trade structure in emerging markets, *Journal of International Money and Finance,* 27, 654-675.
9. Chelley-Steeley, P. L. (2005) Modeling equity market integration using smooth transition analysis: a study of Eastern European stock markets, *Journal of International Money and Finance,* 24, 818-831.
10. Chen, N. & Zhang, F. (1997) Correlations, trades and stock returns of the Pacific-Basin markets, *Pacific-Basin Finance Journal,* 5, 559-577.
11. Cumperayot, P., Keijzer, T. & Kouwenberg, R. (2006) Linkages between extreme stock market and currency returns, *Journal of International Money and Finance,* 25, 528-550.
12. Fama, E. (1981) Stock returns, real activity, inflation and money, *American Economic Review,* 71, 545–565.
13. Gallo, G.M. & Velucchi, M. (2009) Market interdependence and financial volatility transmission in East Asia. *International Journal of Finance and Economics,* 14: 24-44.
14. Glosten, L. R., Jagannathan, R. & Runkle, D. (1993) On the relation between the expected value and the volatility of the nominal excess return on stocks, *Journal of Finance,* 48, 1770-1801.
15. Ng, A. (2000) Volatility spillover effects from Japan and the US to the Pacific-Basin, *Journal of International Money and Finance,* 19, 207-233.
16. Ragunathan, V., Faff, R. & Brooks, R. (1999) Correlations, business cycles and integration, *Journal of International Financial Markets, Institutions & Money,* 9, 75-95.