Linkages between Excess Currency and Stock Market Returns: Granger Causality in Mean and Variance

Eirini Syngelaki*

(NUI Maynooth)

Abstract

This paper investigates the causal linkages between monetary and equity market integration of the new member states (NMS) as well as of the non economic monetary union (Non- EMU) member states with the euro zone, after the official launch of the euro. Granger causality in mean and in variance tests are utilized. Our results reveal a number of interesting facts that can be summarized as follows. Firstly, there is little evidence of causality in mean effects for all countries. Secondly, there are significant spill over effects for the NMS. Thirdly, the excess currency return is the chief variable which leads the excess stock market return volatility of the NMS. Our findings have obvious implications for both investors and policy makers.

Keywords: monetary market integration, equity market integration, Granger causality in-mean and in-variance, AR, Univariate GARCH

JEL Classification: F36 C22, G15

* Correspondence to: Eirini Syngelaki, Department of Economics, Finance & Accounting, NUI Maynooth, co. Kildare, Ireland. Fax: + 353 1 7083934, Email: rensyg@yahoo.com

1 Introduction

The replacement of independent, national currencies by a common, single currency within Europe generated enormous expectations about its future international role and was expected to re-form financial markets, financial institutions and the behaviour of investors and asset creators. Officially launched on January 1st 1999 within the Euro zone of 15 member states[1] its objective was to primarily promote long-term economic growth, increase living standards and ensure political stability. The process of European integration supported the single market and the single currency had initially featured in the 1990 European Commission report "*One Market, One Money*" in which an economic union is defined as a single market for goods, services, capital and labour, implemented with common policies and coordination on several economic and structural areas (European Commission, 1990). The euro since its introduction as a single currency has become the world's second most important international currency, placing it amongst the US dollar and the Japanese yen (Detken & Hartmann, 2002).

Immediate consequences of the adoption of the single currency have been the convergence of euro zone interest rates and the reductions and/or eliminations of exchange rate risk in cross-border holdings of euro assets (see Hartmann et al., 2003). Also, several capital market imperfections, such as regulation, taxes, transaction costs etc have been dramatically reduced, or even removed. This in turn has induced better allocation of capital across investment opportunities in different countries, has created more opportunities for risk sharing and diversification for assets and capital, and fostered higher economic growth (Levine et al., 2000; Demirguc-Kunt & Levine, 2001; Levine, 2004 etc). Other studies demonstrate that

[1] On January 1, 1999 eleven countries replaced their national currencies with the euro: Belgium, Germany, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Spain. On January 1, 2001 it also replaced the national currency of Greece. In May 2004, eight Central and Eastern European countries, i.e. the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia and two Mediterranean islands, i.e. Cyprus and Malta, joined the European Union. The entry of these NMS was the biggest enlargement of the EU. Slovenia joined the eurozone in 2007 while Cyprus and Malta were admitted in 2008. Lastly, Slovakia became a full EMU member in 2009.

the introduction of the single currency has been beneficial for the economic development and growth of the EU states who have adopted it (see Giannetti et al., 2002; Guiso et al., 2004 etc).

This paper focuses on the linkages between money markets and stock markets within a country. Does money market integration, an immediate consequence of EMU, drive stock market integration and thus the decision of the NMS to join the euro-currency union could stabilize exchange rate fluctuations and would create the necessary conditions of a stronger and more integrated capital market? Or does the stock market integration that by definition eliminates many obstacles to cross border portfolio allocation and creates more opportunities for risk sharing reinforce the integration of money markets and foster the economic growth of the NMS? Or both? On the other hand, we may not find causality either way but independence. Thus, there is a clear need for a further examination of the causalities that prevail between money and stock market integration for the NMS (with reference to the EU). This is the contribution the present paper aims to make.

In recent years, great attention has been given to the integration process of the European markets. There is a general notion that European economies have become more integrated, since the launch of the euro as a single currency. Jappelli & Pagano (2008) report that in the EMU, both money and bond markets experienced a rapid rate of convergence across countries, almost immediately after the introduction of the euro. However, in relation to the equity, repo, corporate bond and credit markets the rate of convergence is much slower and has not been fully achieved. In the same vein, Baele et al. (2004) find similar results. The authors classify existing measures of financial integration into three broad groups: (a) price-based, (b) news-based, and (c) quantity-based measures in order to assess the evolution of financial integration in the euro area. The first group of measures is based on the law of one price interest parity condition of the financial markets. If this condition holds, then financial market integration can be measured by comparing the returns of assets that are issued in different countries and generate identical cash flows. The second group is based on the asset pricing theory and distinguishes between common (or systematic) and local (or idiosyncratic) risks. Under this theory, the markets are assumed to be fully integrated only when the common risk factors determine the returns. Lastly, the third group of measures of integration is based on quantity-based indicators that relate to the evolution of the home bias phenomenon. The lower the barriers to cross-border investments, the higher the gains from international diversification. The authors study five important markets such as money, corporate-bond, government-bond, credit, and equity markets. They reach the conclusion that the money markets are fully integrated, while the government- and corporate-bond markets, along with the equity markets, have experienced relatively high levels of integration. The credit markets, due to the diversity of borrowers and the local nature of the information that lenders need, are the least integrated. Very similar to this line of research is an earlier paper by Adam et al. (2002) who review and compare existing methodologies and indicators in order to measure the capital market integration in the EU area. They report similar results.

Kim et al. (2005) investigate if the establishment of the EMU and the adoption of the euro caused the integration of the developed European stock markets since the early 1990's. They estimate an exponential GARCH (EGARCH) model, allowing for time variations in conditional correlations. Their main finding is that the European stock markets have become more integrated after the EMU. They conclude that the launch of the euro has undoubtedly changed the monetary and financial environment in the euro area since a clear regime shift in stock market co-movements is found after adoption of the euro, and an overall macroeconomic integration process in relation to the single currency (rather than to the elimination of the exchange rate risk) has been realized. Fratzscher (2002) also explores the question of whether or not EMU has raised substantially the degree of financial integration of the developed European equity markets who have adopted the single currency, and if it has, then which factors of EMU have driven this integration process. He employs a trivariate GARCH model to estimate the relative significance of three key variables- namely, exchange rate stability, real convergence and monetary policy- in explaining the time variations of the European equity market integration. He identifies that the elimination of exchange rate volatility between participating states, and to a lesser extent the monetary policy convergence of interest and inflation rates, are perhaps the main driving forces towards integration of European equity markets. He also finds that the European equity markets have experienced a high level of integration since the mid-1990's and this is largely attributed to the movement towards the EMU. Similar in spirit to this, Baele (2005) argues that European stock market returns are largely driven by factors (or news) common to all European investors and that the variance in domestic return has been increasingly explained by common European shocks since the early 1980s. Markets display common trends because markets are hit by common shocks (i.e. oil prices or monetary policy). The author concludes that the integration of European equity markets has proceeded more rapidly than the global equity market integration. Aggarwal et al. (2004) use a set of dynamic cointegration analysis along with some complementary techniques to assess the dynamic process of the equity market integration in Europe and how it changes over the 1985-2002 period. They find that it was not until 1997-1998 when the increased degree of integration among the European stock markets actually occurred. They also provide evidence that Frankfurt's equity market dominates amongst the European equity markets. Hardouvelis et al. (2006) examines the speed of integration among the European stock markets. They ask the question if EMU and consequently the introduction of the euro, has led to increased integration of European stock markets. They consider, in particular, if the adoption of the single currency in the Euroland has removed certain constrains in relation to the currency composition of investors' portfolio (i.e. decrease of the cost of hedging currency risk, increase in cross-border equity holdings, decrease of home equity bias, etc). They estimate a conditional asset pricing model, allowing for a time-varying degree of integration that measures the significance of EU-wide risk relative to country-specific risk. They find that the degree of integration of European markets is closely related to the forward interest rate differentials vis-à-vis Germany and that the integration has increased substantially over time, especially since 1995 when these differentials started to become smaller. The main conclusion they reach is that integration increases substantially over time and the stock markets seem to converge towards complete integration by mid 1998, six months before of the official introduction of EMU, suggesting that the expected returns are largely driven by EU wide market risk and to a lesser extent by local risks.

From studies already conducted on financial integration in the Euro area, there are only a few that have focused on the NMS. For instance, Cappiello et al. (2006) assess to what extent the degree of integration of NMSs amongst themselves, and with the euro area, are integrated. In particular, they consider the integration of seven NMS' stock and bond markets, using quantile regressions to make so-called co-movement plots. They show that the degree of equity market integration both within the NMS and with the euro zone increased during the process leading towards EU accession. The three largest markets (the Czech Republic, Hungary, and Poland) vis-à-vis Germany display strong co-movements amongst each other and with the euro zone whereas evidence on bond[2] markets suggest that only the Czech Republic and

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2 Similar results for the bond markets are found in Orlowski & Lommatzsch (2005) who employ a TGARCH-M analysis and find that the NMS's bond markets are becoming increasingly integrated with the euro area bond markets. Reininger & Walko (2006) who employ various measures of bond market integration show that there is a similar pattern of convergence in rates of return of 10-year government bonds between the NMS (e.g. the Czech Republic, Poland, and Hungary) and a number of established EU countries (e.g. Greece, Italy, Portugal and Spain) vis-à-vis Germany in the run-up to the euro adoption. Among the three NMS under consideration, the Hungarian bond market is found to be the least integrated with the euro area. However, a less optimistic view is expressed in Holtemöller (2005) who analyzes the monetary convergence of the NMS by means of the UIP condition and shows that interest rate risk premia in the Czech Republic, Poland and Hungary (over the equivalent euro area rates) are still too excessive and very volatile to conclude that convergence in bond markets has successfully been achieved. In the same spirit, Kim et al. (2006) perform a dynamic cointegration analysis to study the level and dynamics of integration of the government bond markets amongst the existing EU members (and the UK) and the three NMS (i.e. the Czech Republic, Hungary and Poland). In short, they find strong long-term cointegration relationships between the individual EU bond markets and Germany's market,

Poland display a high degree of integration. Égert & Kočenda (2007) examines the co-movements between the mature EU (e.g. Germany, France and the UK) and NMS (e.g. the Czech Republic, Hungary and Poland) stock market returns. They employ the dynamic conditional correlation (DCC)-GARCH model, using high frequency data (e.g. five-minute tick intraday stock price data) to find strong correlations amongst the stock markets of the developed European countries. However, in contrast with Cappiello et al. (2006), they provide little evidence of intraday co-movements both between the three largest CEE countries themselves and within the three developed European countries studied, suggesting that the stock markets are not fully integrated. As they state, the results indicate that it is transmission of volatility of returns, not linkages in the levels of returns. Baltzer et al. (2008) consider the same broad categories of financial integration measures of Baele et al. (2004) in order to gauge the degree of financial integration in the NMS (along with Cyprus, Malta and Slovenia who recently joined the EMU). They provide evidence of a low level of integration in NMSs stock markets and additionally they argue that NMSs vulnerability to shocks transmitted from the euro area is pronounced. In relation to the money and banking markets, they report that these markets are becoming increasingly integrated both among themselves and vis-à-vis the euro area. Lastly, regarding the bond markets, they find some evidence of integration for only the largest economies (e.g. the Czech Republic, Poland and to a lesser extent for Hungary). Their overall findings suggest that even though the financial markets in the new EU Member States (including Cyprus, Malta and Slovenia) are significantly less integrated than the corresponding euro area markets, nonetheless, the process of integration has already taken place and has accelerated with the EU accession. Babecký et al. (2008) investigate the financial integration both at the country and sector levels for four NMS (i.e. the Czech Republic, Hungary, Poland

however, they provide little evidence of strong contemporaneous and dynamic linkages between the three NMS and the EU markets. They conclude that the degree of integration in the government bond markets for the NMS is rather weak but stable over the sample.

and Slovakia) with the euro area. They find evidence of convergence for the Czech Republic, Hungary, and Poland and the euro area. In the same fashion, Masten et al. (2008) based on a threshold analysis also use both macro- and industry- level data to consider the non-linear effects of international financial integration on economic growth in Europe. Their major finding is that the euro adoption process has played a crucial role in the financial integration of the NMS and has stimulated their growth both directly through access to foreign finance, which in turn has increased their macroeconomic stability, and indirectly through stimulus measures given to the development of their national financial markets. However, financial integration becomes beneficial for growth only for the most advanced of the NMS who have already sufficiently developed their domestic financial sectors and financial instruments and institutions. Wang & Moore (2008) employ the DCC approach and find that since the entry of the three largest emerging Central European Eastern European stock markets of the Czech Republic, Hungary and Poland to the EU in 2004, there is clear evidence of an increasing trend of integration towards EMU. Poghosyan (2009) uses a threshold vector error-correction (TVECM) model for the 1994–2006 period in order to evaluate the degree of the financial integration for a selected number of "new" EU member states with Germany and its evolution over time. The author conjectures that when not accounting for transaction costs[3] this may lead to biased results in the evaluations of the degree of financial integration. The declining dynamics of the transaction costs is interpreted as evidence in favour of stronger financial integration. The main message of this paper is that the financial linkages are getting stronger and they are anticipated to strengthen further with the introduction of the euro due to elimination of transaction costs. Overall, the common finding of the above studies is the high level of integration that has emerged in the era after the introduction of the euro.

[3] In Poghosyan (2009) transaction costs are generally defined and include all sorts of market frictions related to capital regulations, asymmetric information, differences in legal and institutional structures, exchange rate risks, barriers to trade, and other obstacles that prevent markets from integration.

In existing empirical literature the two major driving forces behind monetary and financial integration are exchange rates and stock prices. The theoretical justification on whether exchange rates Granger-cause stock prices or vice versa has been attempted via the traditional (see for instance, the flow-oriented model by Dornbusch & Fisher, 1980) and the portfolio balance approaches. The traditional approach postulates that changes in exchange rates will lead to changes in stock prices. For instance, a depreciation of the local currency would increase the indebtedness of the foreign denomination currency, would raise the cost of capital and would result in a loss in price competitiveness and the firms' revenues and ultimately local firms have to pay more. Consequently, the deterioration of a firm's cash flows would affect its stock prices. Therefore, the impact of varying exchange rate systems may be channeled to the behaviour of stock markets and therefore the Granger-cause direction should run from foreign exchange market to stock exchange market (see for instance, Abdalla & Murinde, 1997; Wu, 2000).

On the other hand, it is also possible that changes in stock returns can cause changes in foreign exchange rates. Portfolio balance approach puts emphasis on the role of capital account transaction. According to this point of view, a change in stock market prices- say for instance, a rise in expected future stock prices- would attract capital inflows from foreign investors, who sell the foreign currency in substitute for local currency. Thus, an increase in stock prices would lead to an increase in demand for the local currency, pushing up the local interest rates. With relatively higher domestic interest rates, foreign capital inflows will result in a subsequent appreciation of domestic currency. This suggests that stock prices lead exchange rates and the Granger-causality should flow from stock returns to exchange rates (see, for instance, Broome & Morley, 2004). Of course, there is also a possibility that changes in one market which lead to changes in another will have a feedback effect if both the traditional and portfolio approaches work simultaneously. Therefore, it is possible to observe bi-directional Granger-causality between foreign and stock exchange markets (see, for instance, Granger et al., 2000). Lastly, there is a possibility that these two markets are independent of each other, meaning that there is no Granger-causality relationship between them.

However, the picture is not so clear for the NMS. Although most of the existing studies on EU financial integration document that the European countries have become more financially integrated over time, and that the degree of integration has accelerated following the launch of the single currency in 1999 (Fratzscher, 2002; Baele et al., 2004; Hardouvelis et al., 2005; Kim et al., 2005) they do not offer a clear evidence of a causal relationship and in addition they do not explicitly focus on the NMS. In fact, questions about causality need to be further investigated.

The aim of this paper is implemented in three stages. In the first stage, money market integration is measured by the magnitude of deviations from the UIP condition. The underlying principle is that all participating currencies in a currency union are essentially identical reflecting identical risk and return characteristics (Solnik, 1974). Consequently, the foreign currency risk premium, a measure of the degree of uncertainty associated with each currency, should be the same across all currencies. The evolution of convergence of the NMS's risk premium relative to the euro, the anchor currency, can be used as a gauge of the degree of monetary convergence (González & Launonen, 2005).

In the second stage, our analysis switches to the stock market integration of the NMS with the EU since the introduction of the euro. We adopt a measure that might capture a different aspect of stock market integration. In particular, we compute the deviations between the stock returns of the NMS's national equity indices and the eurozone equity index (all in local returns). To provide convincing evidence of the robustness of our results, we conduct the Granger causality analysis using risk adjusted stock market returns. As segmented markets start to integrate, risk adjusted returns should deliver a zero differential. Consequently, we would expect the difference in adjusted for risk returns to become smaller over time, as a further indication of monetary convergence being on the right track and financial markets of the NMS becoming increasingly integrated. On the other hand, a divergence of local stock returns versus the benchmark euro returns (all adjusted for risk) would allow us to conclude that convergence is far from complete. We project, therefore, that a compression in risk adjusted return, may serve as an indicator of the degree of convergence.

Finally, to detect a causal relationship of excess currency and stock market returns, Granger causality tests in mean and variance are utilized. In particular, we employ the traditional Granger (1969) causality test to capture the causation in mean, using a simple autoregressive (AR) model. To take account of ARCH effects, we employ the pioneering causality in mean and variance approach, put forward by Cheung & Ng (1996). We are particularly interested in the causation pattern in variance since it provides an insight into the characteristics and dynamics of financial returns.

Our results reveal a number of interesting findings. Firstly, we find strong evidence that the excess currency return is the leading variable and *Granger causes* the excess stock return volatility in the NMS. Secondly, we find that the reverse direction of causality (i.e. from excess stock return to excess currency return) also holds true but for fewer countries. Lastly, the causal relationships maintain their robustness when the excess returns in stock markets are adjusted for risk. Understanding the interaction of causality of these two important dynamic processes is essential for corporate managers as it influences the cost of capital and for investors as it influences international asset allocation and diversification benefits.

This study proceeds as follows: Section 2 explains methodological issues employed. Section 3 describes the data and summary statistics. Section 4 contains a discussion of the results. Lastly, section 5 summarizes the findings and concludes.

2 Econometric Model

The aim of the paper is to investigate possible linkages between the excess currency and equity returns. Subsection 2.1 presents the traditional causality in mean test (Granger, 1969). We estimate simple AR models with OLS. Subsections 2.2 and 2.3 present the causality in mean and in variance respectively based on the two-stage procedure introduced by Cheung & Ng (1996).

2.1 Granger (1969) Causality test

Causal relationships in systems of economic time series variables have attracted considerable interest in financial literature. The Granger causality technique has become a standard procedure when analyzing linear relationships among variables or systems. This subsection focuses solely on Granger (1969) causality test.

To find a causal relation (or lead/lag linkage) between markets, we specify a model that depends not only on its own lagged values but also on lag values of other markets. If past values of one market, say x, help to predict the current values of another, say y, in addition to past y, then we say that x Granger causes y (see Wooldridge, 2000; pp.13 and pp. 598-599). Such linear models can be estimated by ordinary least square (OLS) once we have included enough lags of all variables and the equation under investigation satisfies the homoskedasticity assumption for time series regressions. Let y denote the excess currency returns and x denote the excess equity returns. The AR model of y augmented with lags of x is as follows:

$$y_t = \vartheta_0 + \alpha_1 y_{t-1} + \ldots + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \ldots + \beta_q x_{t-q} + \varepsilon_t \qquad (1)$$

where ϑ_0 is a constant; α, β are coefficients; ε_t are zero-mean error terms, serially uncorrelated and independent; k and q denote the number of lags. Equation (1) states that the excess currency return y is a function of its own past returns as well as of the past returns of x plus the error terms.

It is important to note that care needs to be taken on the selection of the optimal lag length of each variable. Here, to correctly specify the number of the lags for y, we perform both t- and F- tests. Once an AR model is carefully chosen for y, then we test for lags of x. Wooldridge (2000) argues that the choice of lags of x is of less importance because when x does not Granger cause y no set of lagged x's should be significant[4]. Bearing this in mind, the null hypothesis which states that x does *not* Granger cause y simply implies that none of the lags of x added in the equation of y are statistically significant (their coefficients are zero) and do not predict y. Only in the case where we find that past returns of x help to predict y, in addition to past y, can we say that x Granger causes y. Similarly, to test if y Granger causes x the following equation is used:

$$x_t = \zeta_0 + \gamma_1 x_{t-1} + \ldots + \gamma_q x_{t-q} + \delta_1 y_{t-1} + \ldots + \delta_k \, y_{t-k} + u_t \qquad (2)$$

where again ζ_0 is a constant; γ, δ are coefficients; and u are zero-mean error terms. Equation (2) declares that the excess equity return, x, is a function of its own past values, of the past values of y and of error terms. As stated above, we carefully select first the significant lags for x and afterwards we choose the lags for y (see Wooldridge, 2000). The null

4 By using an F -test to jointly test for the significance of the lags on the explanatory variable X, this in effect tests for 'Granger causality' between these variables. The null hypothesis is $Ho = \beta_1 = \ldots = \beta_q = 0$ which implies that none of the explanatory variables has an effect on (or explain) y against the alternative hypothesis which states that *at least one* of the β_q 's is different from zero. The usual F -test applies to test the hypothesis.

hypothesis of no-causality from y to x states that y does *not* Granger cause x. If we find that at least one of y's past values is different from zero then we prove causality. It is also possible to have causality running from both variables x to y and y to x although, in this case, interpretation of the relationship is difficult and should be interpreted with caution. It says nothing about contemporaneous causality between the variables. The Granger causality test can also be used as a test for whether a variable is exogenous. i.e. if none of the explanatory variables in a model affect a particular variable it can be viewed as exogenous.

Since the traditional (OLS) Granger causality approach fails to take account of ARCH effects, Cheung & Ng (1996) propose a methodology to deal with this. Applying their approach, we analyze causality in both the first- and second-moment dynamics in the next subsection.

2.2 Granger causality in Mean

In this section, we consider the causality effects in the conditional mean. Cheung & Ng (1996) introduced a method for testing the existence of Granger causal relations in the mean of two series. The proposed test is based on the sample cross correlations function of the standardized residuals. In particular, the method is implemented in two stages. In the first stage, AR models with a GARCH specification in the conditional variances are estimated for both the excess currency return and excess stock return. The selection of the lags is based on the Akaike (AIC) information criteria. In a general form, the AR(k)-GARCH(p,q) is the following:

$$\dot{y}_{it} = a_0 + a_1\dot{y}_{1t-1} + ... + a_k\dot{y}_{it-k} + e_{it} \qquad i = 1,2 \tag{3}$$

$$e_{it} = h_{it}z_{it}, \qquad z_{it} \text{ is } N(0,1)$$

$$h_{it}^2 = \mu_0 + b_1e_{1t-1}^2 + ... + b_qe_{it-q}^2 + c_1h_{1t-1}^2 + ... + c_ph_{it-p}^2$$

where $\dot{y}$ is the excess return of markets i=1,2; a_0, μ_0 are constants; b_q, c_p are coefficients where p, q denote the lags and e_{it} is a zero mean, independent white noise with unit variance. This specification allows for time variation in both the conditional mean and the conditional variance. In essence, $\dot{y}$ is the conditional mean of the excess return that is a function of its own past returns and error terms. Also, equation (3) describes the general dynamic process for the conditional (co)variances of the asset returns, h_{it}^2, as a function of constants, lagged error terms, and lagged variance-covariance terms.

In the second stage, the sample cross correlations of the standardized residuals are used to test for causality in mean. The standardized residuals of univariate GARCH(1,1) models, a specific case of (3), are defined as follows:

$$z_{1t} = \frac{e_{1t}}{\sqrt{h_{1t}}}, \quad z_{2t} = \frac{e_{2t}}{\sqrt{h_{2t}}} \tag{4}$$

Accordingly, the sample cross-correlation function of z_{1t} and z_{2t} is denoted by $\hat{\rho}_{z1,z2}(k)$ and is defined as follows:

$$\hat{\rho}_{1,2}(k) = \frac{\hat{\theta}_{1,2}(k)}{\sqrt{\hat{\theta}_{1,1}(0) * \hat{\theta}_{2,2}(0)}} \tag{5}$$

where

$$\hat{\theta}_{1,2}(k)=\begin{cases} T^{-1}\sum_{t=k+1}^{T}\left[\left(\hat{z}_{1t}-\overline{z}_{1t}\right)*\left(\hat{z}_{2t-k}-\overline{z}_{2t-k}\right)\right], & k\geq 0 \\ T^{-1}\sum_{t=-k+1}^{T}\left[\left(\hat{z}_{1t+k}-\overline{z}_{1t}\right)*\left(\hat{z}_{2t}-\overline{z}_{2t-k}\right)\right], & k<0 \end{cases}; \tag{6}$$

where T is the sample size, $\overline{z}_{it}$ is the sample mean of z_{it} and finally, $\hat{\theta}_{i,i}(0)$ is the sample variance of z_{it}, $i=1,2$. The test statistic introduced by Cheung and Ng (1996) is:

$$S=T\sum_{k=j}^{M}\hat{\rho}_{1,2}^{2}(k) \tag{7}$$

The S-statistics asymptotically follows the X_{M-j+1}^{2} distribution and is asymptotically robust to distributional assumptions. If we set $j=1$, then S tests whether $\dot{y}_{2t}$ Granger causes $\dot{y}_{1t}$ in mean. The null hypothesis states that there is no Granger causality from $\dot{y}_{2t}$ to $\dot{y}_{1t}$. Alternatively, we can use $S=T\sum_{k=-M}^{-1}\hat{\rho}_{1,2}^{2}(k)$ to test whether $\dot{y}_{1t}$ Granger causes $\dot{y}_{2t}$ in mean. Lastly, we use $S=T\sum_{k=-M}^{M}\hat{\rho}_{1,2}^{2}(k)$ to test for bidirectional causality in mean.

We now turn to the next subsection to describe how the same methodology (based on the squared standardized residuals) can be utilized to test for causality in second order moments.

2.3 Granger causality in Variance

The methodology analysed in this subsection can be considered as an extension of the previous. To test the Granger causality in variance, Cheung & Ng (1996) calculate the sample cross-correlation functions of the squared standardized residuals. The squared standardized residuals are defined as follows:

$$z_{1t}^2 = \left(\frac{e_{1t}}{\sqrt{h_{1t}}} \right)^2 \quad \text{and} \quad z_{2t}^2 = \left(\frac{e_{2t}}{\sqrt{h_{2t}}} \right)^2 \tag{8}$$

We first use (6) and (5) to compute the sample cross correlations of z_{1t} and z_{2t} given in (8). Afterwards, we can test for the existence of causality in the variance based on the same S-statistics described in (7). The null hypothesis of no Granger causality in variance implies that the cross correlations of the squared standardized residuals in (8) are zero.

The main advantage of the Cheung & Ng (1996) procedure to test for causality in both first and second order moments is that it is based on (squared) standardised residuals of simple univariate GARCH models, which can be estimated without difficulty. Univariate GARCH models are known to provide efficient estimates since the number of parameters to be estimated is limited. Consequently, estimation of heavily parameterized series, computational difficulties and convergence problems resulting from the estimation of multivariate GARCH models are avoided.

It is important to note that accounting first for causality in mean effects is essential before testing for causality in variance because it ensures that the causality in variance tests will be robust and will not suffer from severe size distortions if significant causality in mean effects do exist but are ignored. Therefore, it is crucial to select a correct specification in the conditional mean before proceeding to test for causality in variance (see Pantelidis & Pittis, 2004). It is also important to have a correct specification in the conditional variance, since the asymptotic results about the behaviour of the statistics assume that the conditional variance is correctly specified.

So far, we have conducted tests based on the residual cross correlation function to gain a useful insight into the causal relationship in the first- and second- order moments between excess returns in money and equity markets. In the next subsection, we present the summary statistics of our data set.

3 Data & Summary Statistics

This empirical analysis is conducted for the NMS and non EMU member states. As a measure of money market integration, we compute the UIP deviation between the local currency and the euro. The paper analyzes weekly data for the exchange rates of Czech Republic (CzK), Hungarian Forint (HF), Polish Zloty (PZ), Slovak Koruna (SkK), Danish Krone (DK), Swedish Krona (SK), and UK Pound (GBP), all in relation to euro. Figure 1 plots the exchange rates for the NMS. Interest rate data for six currency deposits are employed, which are 1-week interbank rates for the Czech Republic, Hungary, Poland, Slovakia and 1-week euro-deposit rates for Denmark, Sweden and the UK. The excess currency returns (or equally, deviations from UIP) are computed as: $\frac{i_t^f}{100} - \ln\left(\frac{s_{t+1}}{s_t}\right) * 52 - \frac{i_t}{100}$, where s_{t+1} is the natural logarithm of the spot exchange rate at time *t+1* expressed as the domestic price of one unit of foreign currency; i_t is the annualized weekly interest rate of domestic (euro) currency known at time t; i_t^f is the annualized weekly interest rate of the foreign currency known at time t.

The major equity indexes are used in this study. By taking the major equity index of each country, more than 75% of market capitalization is covered. Table 9 displays the equity price indexes for all the aforementioned countries. The excess stock returns are measured as: $\log\left(\frac{p_{t+1}^f}{p_t^f}\right) * 52 - \log\left(\frac{p_{t+1}}{p_t}\right) * 52$ where p_t^f and p_t are the annualized logs of changes in equity index levels. The superscript f denotes the foreign yields of the equity index. The sample period expands from January 8th, 1999, to December 7th, 2007. All the data is extracted from Datastream.

[Insert Table 1 about here]

Table 1 reports summary statistics of excess currency returns (Panel A) and excess equity returns (Panel B). As can be seen from Panel A, the highest annualized weekly mean excess currency returns are given by Hungary, 0.06, and Poland, 0.04, following closely. Slovakia, Denmark and Sweden display on average low returns with the exception of the Czech Republic, which displays negative mean return of -0.028. The highest variance is given by Poland, 0.38, with the UK and Hungary following closely behind with 0.23 and 0.21 respectively. The Czech Republic, Slovakia and Sweden display on average the same level of variance, around 0.13. Denmark displays the lowest variance, 0.0003.

Comparing the performance of seven excess equity returns in panel B, the Czech Republic and Slovakia give the highest annualized weekly excess stock returns, 0.14 each. Poland and Hungary also have high positive mean excess stock returns. The UK is the only country in the sample that displays negative excess stock returns, -0.01. Panel B displays the second moment (variance) of the excess equity returns. All the emerging NMS display higher variances compared to the developed non-EMU members across the sample. Specifically, Slovakia reports the highest, 4.06. Hungary, Poland and the Czech Republic display on average roughly the same level of variance i.e. 2.96, 2.56 and 2.32. Even though the UK displays the lowest variance, 0.62, it generally behaves as well as the average non-EMU countries. It may be worth noting that Table 1 reports skewness, excess kurtosis, and Jarque-Bera statistics. Panel A and B suggest that skewness, the excess kurtosis and the Jarque-Bera test statistics strongly reject the null hypothesis of normally distributed returns at 1% significance level (except for the UK in Panel A).

4 Discussion of the Results

Our aim is to examine whether or not there exists a causal linkage between the excess currency and equity market returns of the NMS (with reference to the EU). We particularly focus on the four largest emerging economies of Central Eastern Europe, known as Visegrád group or *V-4*. These countries comprise of the Czech Republic, Hungary, Poland, and Slovakia, which joined the EU on May 1st 2004. The common feature of these economies is that they all have successfully made the transition from a centrally planned to a free market economy, after adopting severe macroeconomic stabilization and structural reform programs (Baltzer et al. 2008). To compare and contrast, we conduct the same analysis for the non-EMU states, namely Denmark, Sweden and the UK.

We present the results in the following order: In section 4.1 we present results from the traditional Granger (1969) causality test, using OLS regressions. The analysis progresses by displaying the (G)ARCH estimates of the excess currency and excess stock returns. After accounting for ARCH effects, we then present the Granger causality test in both mean & variance according to the Cheung & Ng (1996) approach. The analysis continues in subsection 4.2 by considering whether the causal relationships, found above, maintain their robustness when the excess stock market returns are adjusted for risk.

4.1 Results

To uncover the causal relationship in excess currency and equity market returns we employ the Granger causality test (Granger, 1969). If past returns of the excess stock returns statistically improve the prediction of the excess currency returns (in addition to its own lag returns) then we have proven causality and thus we say that excess stock returns Granger causes excess currency returns. We also test for causality running from the opposite direction. All the examined series are stationary and do not exhibit statistically significant structural breaks. Granger et al. (2000) states that the traditional Granger causality test "would suffice for studying the relations" between variables in spite of structural breaks in data (see pp. 344). The results of the Granger causality tests are shown in Table 2 P-values are reported. The last column of Table 2 shows the number of lags included in each case.

[Insert Table 2 about here]

The results in Table 2 are interesting as they show some signs of causality in mean between our variables. In particular, we find that excess money returns Granger causes excess stock returns in four out of seven cases (i.e. the Czech Republic, Slovakia, Denmark and Sweden) at less than 10% significance level. In addition, we find evidence of causality running from excess stock returns to excess currency returns for two out of seven cases (i.e. the Czech Republic and Poland). Lastly, the Czech Republic displays a bi-directional causality at less than 10% significance level. Overall, the results show that there is an association between the excess market returns. This implies that an investor, knowing past stock returns in addition to past currency returns can predict, on average, the excess currency returns. However, we should interpret these results with caution.

The traditional Granger causality test, when estimated with OLS, does not take into account the existence of ARCH effects. Engle (1982) argues that under the conditional heteroscedasticity of the error terms, OLS estimates do not remain desirable due to their poor efficiency. OLS estimators of the standard errors are inconsistent estimators of the true standard errors, under the presence of conditional heteroscedasticity. Therefore, test statistics based on these standard errors may lead to incorrect inferences. To account for the ARCH effects (i.e. volatility clustering, fat tails) in the data many studies on financial asset returns have used different specifications from the (G)ARCH family of Engle (1982) and Bollerslev (1986). Following the literature, we employ univariate GARCH(1,1) models, to estimate the time varying volatility of our series. Table 3 displays the ARCH and GARCH estimates that govern the evolution of the conditional second order moments of the excess currency and stock market returns series.

[Insert Table 3 about here]

In general, panels A and B demonstrate that the excess currency and stock return series exhibit strong (G)ARCH effects in all of our sample countries. The ARCH terms, e_{t-1}^2, show the impact of shocks or "news" (one period lagged squared residuals) on current volatility. For all of the markets analyzed, the estimated ARCH coefficients, b_1's, are all positive, less than one, and statistically significant. Moreover, the GARCH terms, h_{t-i}^2, which show the persistence effects of the past period's volatility on current volatility, are also present. In particular, the estimated GARCH parameters, c_1's, are all positive and statistically significant (except for Slovakia in panel A). Their magnitude is very large, are all close to one, indicating a high level of persistence in shocks to the conditional volatility. Therefore, we provide strong evidence of time-variation for both ARCH and GARCH effects for the excess currency and stock market returns. Our results are in line with Fratzscher (2002), Baele (2004), Kim et al. (2005), Baltzer et al. (2008) who find that currency and financial market integration display strong variations over time.

The above results from the GARCH estimates can be used to shed more light on the concept of causation in the first- and second- order moments of our series. Cheung & Ng (1996) develop a two-stage procedure based on the residual cross correlation function from univariate GARCH to test for causality in variance. The Monte Carlo study of Pantelidis & Pittis (2004) shows that the neglected causality in mean effects could lead to great size distortion on the causality in variance tests whereas Vilasuso (2001) finds that in several cases, tests for causality in mean may suffer from severe size distortion in the presence of causality in variance. The proposed causality test in variance by Cheung & Ng (1996) takes into account the causality in mean effects. Table 4 reports the results for the causality in mean between the excess currency and excess stock return series due to Cheung & Ng (1996). The optimal lags which minimize the AIC criterion are reported in the last column of Table 4

[Insert Table 4 about here]

At first glance, the results from the cross correlation of standardized residuals are in accordance with those obtained from the traditional Granger causality test (see Table 2). Even the direction of causality is revealed as being the same. In short, we again find that the excess returns in currency markets lead those in stock markets for the Czech Republic and Denmark, since the null hypothesis of no-causality is rejected at 5% and 1% significance levels respectively. However, there is no more significance for Sweden and Slovakia. The opposite direction of causality holds true for Poland and the Czech Republic at 1% and 5% significance levels accordingly. We also account for a bi-directional (feedback) causality in mean for the

Czech Republic at 5% significance level. The overall results suggest that there is limited evidence of causality in mean.

In order to gather more information on the interactions and on short run dynamics of the excess return in money and equity markets we next turn to the causality in variance test. This test is very important because it shows how changes in variance, which reflect the arrival of new information in a market, spillover in others affecting the excess returns. Results for Cheung & Ng (1996) causality in variance test are reported in Table 5.

[Insert Table 5 about here]

Overall, the results indicate volatility spillover effects. A more refined investigation suggests that excess currency returns lead those in stock markets for four out of seven cases, including the Czech Republic, Hungary, Poland and Slovakia. There are also two cases out of seven showing that excess stock returns significantly lead excess currency returns, including Slovakia and Denmark. However, only Slovakia exhibits a bidirectional causal relation. No evidence of causal relation in variance between the excess currency and stock returns for Sweden and the UK is found.

A number of interesting findings emerge from the above analysis. Firstly, there is much more causation in variance than in the level of returns. The causation pattern in variance is mostly concentrated in NMS countries. In these countries, the excess returns in money markets take the lead and Granger cause the excess returns in equity markets. This is not surprising given that under the perspective of joining the EMU, the NMS have experienced frequent shifts of their exchange rate regimes (i.e. from pegged exchange rate regimes with varying bands to managed or free float exchange rate regimes). Orlowski et al. (2005) argues that the nominal exchange rates and interest rates of the NMS were very volatile especially when their national currencies underwent significant devaluations against the euro. UIP implies that an expected devaluation (appreciation) of a currency would affect the levels of interest rate differential between domestic and foreign assets. This in turn may affect the cost of capital, competitiveness and earnings of a firm and eventually its share prices. This is exactly what the traditional approach postulates: changes in exchange rates will lead to changes in stock prices. Hence, the effect of varying exchange rate regimes, in aggregate, may have been channeled to stock markets affecting ultimately the excess returns of these markets (Moore, 2007; Wang & Moore, 2008). Secondly, we find evidence for causality in variance running from the excess stock returns to excess currency returns but for fewer countries. This result may partially be explained by the capital market liberalization in facilitating cross-border capital flows (both foreign direct investment and portfolio investment) or by the EU membership, which promotes the free trade and free movement of capital within the euro area. Lastly, there is little evidence of volatility spillovers in developed markets. This may be partially attributed to the fact that the developed countries display lower volatility compared to the NMS markets.

The main conclusion we can draw from the above results is that the excess currency return appears to be an important cause for excess stock returns. These results make sense if we consider that exchange rate movements (the main ingredient of excess currency returns) influence movements in stock prices and thus their excess earnings. Our results are consistent with the traditional approach (see Granger et al., 2000; Pan et al., 2007). The next subsection deals with the robustness of the results.

4.2 Robustness of Results

Joining the EU implies an increase in capital market integration among member states through the free trade and free movement of capital within the euro area (Baltzer et al., 2008). Financial market integration contributes to the development of more liquid and more transparent markets, facilitates many complex and sophisticated operations and offers more opportunities for firms to diversify portfolios and share idiosyncratic risks across countries (Jappelli & Pagano, 2008). However, the common shocks also increase, leading to higher correlations in asset returns and potentially a reduction in diversification benefits. We expect that the excess stock returns per unit of risk would be equalized across countries, if financial integration has taken place.

We now consider whether the causal relationship from excess currency returns to excess stock market returns is robust or not, when the excess stock returns are adjusted for risk. In this study, the risk-adjusted returns are simply measured by the following formula[5]: $\frac{\text{foreign stock return}}{\sqrt{h_{t,\text{ foreign}}}} - \frac{\text{euro stock return}}{\sqrt{h_{t,\text{ euro}}}}$. The first term captures the stock returns adjusted for risk of a foreign country. This is the foreign stock price index growth rate divided by the square root of the conditional variance obtained from univariate GARCH model. The second term captures the stock returns per unit of risk of the DJ-Euro50 price index growth rate. The excess risk adjusted return is obtained by subtracting the difference of the two terms, a rough proxy to calculate the deviations that may exist in stock returns of foreign and euro markets. The only drawback with adopting this formula (or measurement) is that it is more difficult for maximum likelihood to converge, since most of the variation has been removed from the data. Thus, in some countries it is harder to estimate the GARCH model since the variation decreases quite dramatically after risk adjustment, resulting in a constant variance in several cases. The traditional Granger (1969) causality in mean results, using excess risk adjusted stock returns are reported in Table 6.

[Insert Table 6 about here]

[5] We adopt this method of adjusting the return series for risk as it is consistent with the univariate approach of Cheung & Ng (1996) and it is also relatively simple to implement.

We again find a clear causality linkage in mean between markets running from the excess currency returns to excess risk adjusted stock returns. The null hypothesis of non causality in mean is strongly rejected in all meaningful significance levels for almost all the countries. However, the excess stock market returns per unit of risk have no causality for any country, apart from the Czech Republic. The analysis is also supported by reporting the Granger causality in conditional mean and variance tests based on Cheung & Ng (1996) methodology. The excess stock returns are adjusted for risk. The causality in mean results, are firstly presented in Table 7.

[Insert Table 7 about here]

Our results are essentially unchanged. We find the same pattern in the conditional mean as above. When stock returns are adjusted for risk, then they do not Granger cause the excess currency returns (except from the Czech Republic). On the other hand, five out of seven cases display a significant causal relationship in mean, which flows from the excess currency returns to the excess, risk adjusted, stock market returns. The greater evidence of causality from excess currency to equity returns when using risk-adjusted stock returns may be due to the fact that the latter series is now less volatile and there is a better 'fit' between the two series. Importantly, evidence of causality still remains from currency to equity markets only. This significant and consistent result across countries is evidence that excess return in money markets leads those in stock markets, adjusted or not for risk. It therefore seems unlikely that both risk-unadjusted and risk-adjusted excess return models are not well specified since they yield similar and consistent results.

We next present causality in variance test results, when stock market returns are adjusted per unit of risk. Results are displayed in Table 8.

[Insert Table 8 about here]

The same definitive pattern between the excess returns in money and equity markets is again identified when risk stock return adjustments are taken into account. For most markets (i.e. the Czech Republic, Hungary, Slovakia and Denmark) a significant unidirectional causality in variance is observed where the excess currency return leads to the excess stock return adjusted for risk. Causation in the reverse direction has not been identified. Slovakia is characterized by interactions based on mutual feedback in which the excess currency return can take the lead, and vice versa. As in the case of risk-unadjusted returns, Sweden and the UK display no causality-in-variance. It is important to note that the results for causality in variance change little when we employ risk-adjusted returns. There is less evidence of causality but this is due to the elimination of much of the stock market when constructing the variable.

The significance of our results may be helpful for the policy-makers of the NMS who make an effort to meet the challenges of European integration as they form macroeconomic and stabilization policies in response to the European economies. Moreover, our results may be important for investors and financial companies who construct different portfolios to better assess their exposure to risk and make significant cross-border financing decisions.

5. Conclusions

The aim of this paper is to explore possible linkages between monetary and financial market integration of the NMS as well as some non-EMU states, with reference to the euro zone, after the introduction of the euro. Monetary convergence is measured and tracked over time by computing the uncovered interest parity (UIP) deviation whereas stock market integration is measured by deviations in stock returns of foreign and domestic markets. It addresses the issue of causality in mean and variance between the monetary and equity market integration.

The analysis indicates that there is limited evidence of causality in mean. As regards the causality in variance, we find that the excess currency return is the leading variable and *Granger causes* the excess stock return volatility in the NMS. The causality works in the opposite direction for fewer countries. We did not find strong spillover effects for the developed non-EMU countries. The causality is robust when the stock returns are adjusted for risk. The findings of this paper have obvious implications for both investors and policy makers. For portfolio managers and investors, information appears to be more quickly processed by money markets and they tend to lead stock markets, especially in the NMS countries. This may be the basis for the development of a trading strategy but we leave this for future research. For the policy makers of the NMS, who form macroeconomic and stabilization policies, it is important to develop policies that reduce exchange rate volatility and prevent volatility spillovers towards (or from) other markets.

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Table 1: Preliminarily Statistics

	Mean	Variance	Skewness	Kurtosis	Jarque-Bera (J-B)
	Panel A: Excess Currency Returns (ECR)				
Czech Republic	-0.028	0.13	-0.24*	2.17**	96.35**
Hungary	0.06	0.21	0.99**	4.25**	427.93**
Poland	0.04	0.38	0.51**	0.96**	38.56**
Slovak Republic	0.005	0.12	0.34**	1.74**	68.38**
Denmark	0.002	0.0003	0.07	2.12**	88.19**
Sweden	0.003	0.13	0.25*	2.37**	114.29**
UK	0.01	0.23	0.19***	0.20	3.59
	Panel B: Excess Stock Returns (ESR)				
Czech Republic	0.14	2.32	0.04	1.37**	36.96**
Hungary	0.12	2.96	-0.20***	0.73**	13.52**
Poland	0.13	2.56	-0.15	1.15**	27.56**
Slovak Republic	0.14	4.06	0.29**	1.29**	39.58**
Denmark	0.06	1.44	-0.08	0.46*	4.72***
Sweden	0.02	0.90	-0.56**	2.21**	119.58**
UK	-0.01	0.62	-0.17	4.53**	401.69**

The asterisks *, **, *** denote the rejection of the null hypothesis at 5%, 1% and 10% significance levels respectively. Weekly Data From 1999:01:08 To 2007:11:30.

Table 2: Granger (1969) causality in *mean* test based on OLS estimations

	ECR → ESR	ESR → ECR	Lags
Czech Republic	**0.07**	**0.003**	*k*=5, *q*=1
Hungary	0.11	0.11	*k* =5, *q* =1
Poland	0.69	**0.07**	*k* =5, *q* =5
Slovak Republic	**0.09**	0.99	*k* =5, *q* =2
Denmark	**0.05**	0.44	*k* =5, *q* =1
Sweden	**0.05**	0.64	*k* =5, *q* =3
UK	0.62	0.45	*k* =5, *q* =1

ECR stands for excess currency returns (or UIP deviations) and ESR stands for excess stock returns. P-values are displayed. *k*- and *q*- refer to the number of lags (see equations 1 and 2). Bold numbers indicate rejection of the null hypothesis of no-causality in mean.

Table 3: Univariate GARCH estimates

Panel A: Excess Currency Returns (ECR)

	Czech Republic	**Hungary**	**Poland**	**Slovak Republic**	**Denmark**	**Sweden**	**UK**
μ_0	0.007 (1.38)	**0.004 (4.78)**	0.03 (1.65)	**0.09 (13.62)**	**0.00002 (2.51)**	0.003 (1.54)	0.003 (0.75)
b_1	**0.04 (1.83)**	**0.08 (4.51)**	**0.10 (2.87)**	**0.16 (3.12)**	**0.07 (2.68)**	**0.04 (2.75)**	**0.04 (2.02)**
c_1	**0.89 (15.04)**	**0.90 (54.65)**	**0.81 (10.62)**	0.00 (0.00)	**0.84 (17.48)**	**0.92 (29.64)**	**0.94 (26.05)**

Panel B: Excess Stock Returns (ESR)

	Czech Republic	**Hungary**	**Poland**	**Slovak Republic**	**Denmark**	**Sweden**	**UK**
μ_0	0.01 (1.04)	0.10 (1.15)	0.02 (1.08)	**0.09 (1.73)**	0.02 (1.29)	**0.008 (1.84)**	0.002 (0.98)
b_1	**0.06 (3.78)**	**0.04 (1.71)**	**0.05 (2.55)**	**0.09 (3.53)**	**0.10 (3.10)**	**0.07 (3.26)**	**0.07 (5.00)**
c_1	**0.92 (44.73)**	**0.92 (17.49)**	**0.93 (37.48)**	**0.88 (29.36)**	**0.87 (20.71)**	**0.91 (38.79)**	**0.92 (61.86)**

t- tests are reported in parenthesis. **Bold** numbers indicate the statistical significant values. The univariate case of (3) is:

$$\dot{y}_{it} = a_0 + a_1\dot{y}_{1t-1} + e_{1t} \qquad i = 1,2$$

$$e_{1t} = h_{1t} z_{1t}, \qquad z_{1t} \sim N(0,1)$$

$$h_{1t}^2 = \mu_0 + b_1 e_{1t-1}^2 + c_1 h_{1t-1}^2$$

where $\dot{y}$ denotes the excess returns.

Table 4: Granger causality in *mean* test (Cheung & Ng, 1996) between ECR & ESR

	ECR → ESR	**ESR → ECR**	**Lags (k, q)**
Czech Republic	**11.17****	**4.88****	k=3, q=3
Hungary	2.54	11.46	k=3, q=3
Poland	10.22	**11.24***	k=3, q=3
Slovak Republic	3.50	2.31	k=4, q=4
Denmark	**2.74***	5.10	k=2, q=2
Sweden	12.00	6.00	k=3, q=3
UK	0.73	14.89	k=1, q=1

ECR stands for excess currency returns (or UIP deviations) and ESR stands for excess stock returns. ***S*-** test statistics are reported. The asterisks *, **, *** denote the rejection of the null hypothesis of no causality in mean at 10%, 5% and 1% significance levels respectively. **Bold** numbers indicate the statistically significant values.

Table 5: Granger causality in *variance* (Cheung & Ng, 1996) between ECR & ESR

	ECR → ESR	**ESR → ECR**
Czech Republic	**6.91****	5.63
Hungary	**5.29***	1.82
Poland	**7.08***	5.11
Slovak Republic	**17.54****	**7.20*****
Denmark	15.39	**15.27***
Sweden	0.60	4.49
UK	1.01	0.96

S- test statistics are reported. The asterisks *, **, *** denote the rejection of the null hypothesis of no causality in variance at, 10%, 5% and 1% significance levels respectively. **Bold** numbers indicate the statistically significant values.

Table 6: Granger Causality in *mean* test based on OLS

	ECR → ERAR	**ERAR → ECR**	**Lags**
Czech Republic	**0.01**	**0.09**	k=5, q=1
Hungary	**0.06**	0.20	k=5, q=1
Poland	**0.08**	0.80	k=5, q=1
Slovak Republic	**0.09**	0.86	k=5, q=2
Denmark	**0.02**	0.20	k=5, q=1
Sweden	**0.05**	0.71	k=5, q=3
UK	0.99	0.85	k=5, q=1

ECR stands for excess currency returns or UIP deviations. ERAR stands for excess risk adjusted returns. P-values are displayed. **Bold** numbers indicate rejection of the null hypothesis of no-causality in mean.

Table 7: Granger Causality in *mean* (Cheung & Ng, 1996) between ECR & ERAR

	ECR → ERAR	**ERAR → ECR**	Lags (k, q)
Czech Republic	**10.08****	**3.89****	k=1, q=1
Hungary	**6.22****	11.26	k=3, q=3
Poland	2.30	6.10	k=3, q=3
Slovak Republic	**5.13****	2.16	k=4, q=4
Denmark	**3.85****	1.61	k=2, q=2
Sweden	**4.93***	7.66	k=3, q=3
UK	1.99	7.06	k=1, q=1

S- test statistics are reported. The asterisks *, **, *** denote the rejection of the null hypothesis of no causality in mean at 10%, 5% and 1% significance levels respectively. **Bold** numbers indicate the statistically significant values.

Table 8: Granger Causality in *variance* (Cheung & Ng, 1996) between ECR & ERAR

	ECR → ERAR	**ERAR → ECR**
Czech Republic	**4.85***	4.18
Hungary	**5.78***	1.48
Poland	4.00	5.20
Slovak Republic	**4.35****	**45.60*****
Denmark	**9.38****	3.76
Sweden	2.25	0.52
UK	3.05	4.54

***S*-** test statistics are reported. The asterisks *, **, *** denote the rejection of the null hypothesis of no causality in variance at, 10%, 5% and 1% significance levels respectively. **Bold** numbers indicate the statistically significant values.

Figure 1: Exchange Rates of the Visegrád Group (V4)

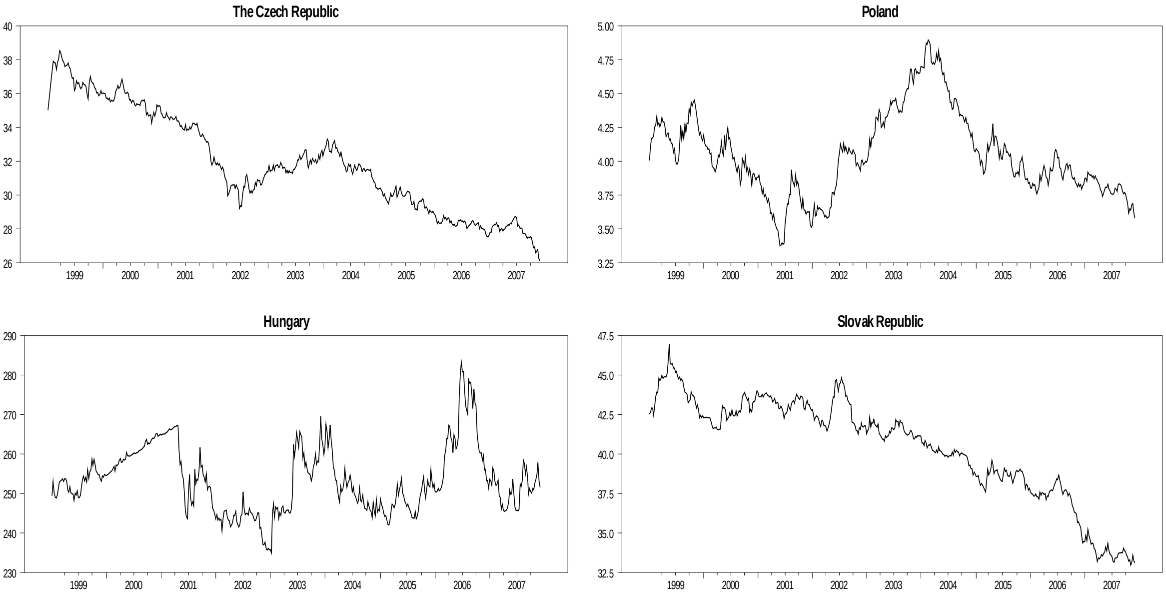

Table 9: Definition of Variables

	Czech Republic	Hungary	Poland	Slovak Republic	Euro	Denmark	Sweden	UK
Exchange Rates	CZECH KORUNA TO EURO (WMR) - EXCHANGE RATE	HUNGARIAN FORINT TO EURO (WMR) - EXCHANGE RATE	POLISH ZLOTY TO EURO (WMR) - EXCHANGE RATE	SLOVAK KORUNA TO EURO (WMR) - EXCHANGE RATE	---	DANISH KRONE TO EURO (ECB) - EXCHANGE RATE	SWEDISH KRONA TO EURO (ECB) EXCHANGE RATE	UK £ TO EURO - EXCHANGE RATE
(Code):	(CZEURSP)	(HNEURSP)	(POEURSP)	(SXEURSP)		(DKECBSP)	(SDECBSP)	(STERECU)
Interest Rates	INTERBANK 1 WEEK - MIDDLE RATE	INTERBANK 1 WEEK - MIDDLE RATE	POLAND INTERBANK 1 WEEK - MIDDLE RATE	SLOVAKIA INTERBANK 1 WEEK - MIDDLE RATE	EURO EURO - CURRENCY 1 WK (LDN:GS)	DENMARK EURO - KRONE 1 WK (LDN:GS)	SWEDEN EURO - KRONA 1 WEEK (FT/ICAP)	UK EURO - £ 1 WK (LDN:GS)
(Code):	(PRIBK1W)	(HNIBK1W)	(POIBK1W)	(SXIBK1W)	(GSEUR1W)	(GSDKK1W)	(ECSWE1W)	(GSGBP1W)
Equity Indexes	PX GLOBAL INDEX - PRICE INDEX	BUDAPEST (BUX) - PRICE INDEX	WARSAW GENERAL INDEX - PRICE INDEX	SLOVAKIA SAX 16 - PRICE INDEX	DJ EURO STOXX 50 - PRICE INDEX	OMX COPENHAGEN (OMXC20) - PRICE INDEX	OMX STOCKHOLM 30 (OMXS30) PRICE INDEX	FTSE 100 - PRICE INDEX
(Code):	(CZPXGLB)	(BUXINDX)	(POLWIGI)	(SXSAX12)	(DJES50I)	(DKKFXIN)	(SWEDOMX)	(FTSE100)

Start: 1/1/1999
End: 12/7/2007
Frequency: Weekly
Source: DataStream.

References

[1] Abdalla, I.S.A., & Murinde, V. (1997). Exchange Rate and Stock Price Interactions in Emerging Financial Markets: Evidence on India, Korea, Pakistan, and Philippines. *Applied Financial Economics* 7, 25−35.

[2] Adam, K., Japelli, T., Menichini, A., Padula, M., & Pagano, M. (2002). Analyze, Compare, and Apply Alternative Indicators and Monitoring Methodologies to Measure the Evolution of Capital Market Integration in the European Union. Report to the European Commission carried by the Centre for Studies in Economics and Finance (CSEF), Department of Economics and Statistics, University of Salerno.

[3] Aggarwal, R., Lucey, B., & Muckley C. (2004). Dynamics of Equity market Integration in Europe: Evidence of Changes over time and with events. *The Institute for International Integration Studies* (IIIS) Discussion Paper Series No. 19.

[4] Babecký, J., Komárek, L., & Komárková, Z. (2008). Financial Integration of Stock Markets among New EU Member States and the Euro Area., *University of Warwick*, Department of Economics Working Paper No 849.

[5] Baele, L. (2005). Volatility Spillover Effects in European Equity Markets. *Journal of Financial and Quantitative Analysis* 40(2), 373-401.

[6] Baele, L., Ferrando, A., Hordhal, P., Krylova, E., & Monnet, C. (2004). Measuring European Financial Integration. *Oxford Review of Economic Policy* 20 (4), 509–530.

[7] Baltzer, M., Cappiello, L., De Santis, R.A., & Manganelli, Simone. (2008). Measuring Financial Integration in New EU Member States. *European Central Bank*, Working Paper No 81.

[8] Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, 31, 307–327.

[9] Broome S., & Morley, B. (2004). Stock Prices as a Leading Indicator of the East Asian Financial Crisis. *Journal of Asian Economics* 15, 189–197.

[10] Cappiello, L., Gérard, B., Kadareja, A., & Manganelli, S. (2006). Financial Integration of New EU Member States. *European Central Bank,* Working Paper No. 683.

[11] Demirguc-Kunt, A. and Levine, R. (2001). Financial Structure and Economic Growth: A Cross-country Comparison of Banks, Markets, and Development. *MIT Press*, Cambridge, Massachusetts.

[12] Detken, C., & Hartmann, P. (2002). Features of the Euro's Role in International Financial Markets. *Economic Policy,* 24, 555–575.

[13] Dornbusch, R., & Fischer, S. (1980). Exchange Rates and Current Account. *American Economic Review* 70, 960−971.

[14] Égert B., & Kočenda, E. (2007). Time-Varying Co-Movements in Developed and Emerging European Stock Markets: Evidence from Intraday Data. *William Davidson Institute*, Working Paper No. 861.

[15] Engle, R.F., (1982). Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation. *Econometrica* 50, 987–1007.

[16] European Commission. (1990). One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union. *European Economy*, Working Paper No. 44.

[17] Fratzscher, M. (2002). Financial Markets Integration in Europe: On the Effects of EMU on Stock Markets. *International Journal of Finance & Economics* 7, 165–193.

[18] Giannetti, M., Guiso, L., Jappelli, T., Padula, M., & Pagano, M. (2002). Financial Market Integration, Corporate Financing and Economic Growth. *European Commission*, Economic Papers No. 179.

[19] González, F., & Launonen, S. (2005). Towards European Monetary Integration: The Evolution of Currency Risk Premium as a Measure for Monetary Convergence prior to the Implementation of Currency Unions. *European Central Bank*, Working Paper No. 569.

[20] Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Model. *Econometrica* 37, 424–438.

[21] Granger, C.W.J., Huang, B.N., & Yang, C.W. (2000). A Bivariate Causality between Stock Prices and Exchange Rates: Evidence from Asian Flu. *The Quarterly Review of Economics & Finance* 40, 337-354.

[22] Guiso, L., Jappelli, T., Padula, M., & Pagano, M. (2004). Financial Market Integration and Economic Growth in EU. *Centre for Economics Policy Research* (*CEPR*) Discussion Paper No. 4295.

[23] Hardouvelis, G., Malliaropulos, D., & Priestly, R. (2006). EMU and European Stock Market Integration. *Journal of Business* 79(1), 365-392.

[24] Hartmann, P., Maddaloni, A., Manganelli, S. (2003). The Euro Area Financial System: Structure, Integration and Policy Initiatives. *Oxford Review of Economic Policy* 19, 180–213.

[25] Holtemöller, O., (2005). Uncovered Interest Rate Parity and Analysis of Monetary Convergence of Potential EMU Accession Countries, *Journal of International Economics and Economic Policy* 2(1), 33-63.

[26] Jappelli, T., & Pagano, M. (2008). Financial Market Integration Under EMU. *European Commission*, Economic Papers No. 312 (http://ec.europa.eu/economy_finance/publications).

[27] Kim, S.J, Lucey, B., & Wu, E. (2006). Dynamics of Bond Market Integration between Established and Accession European Union Countries. *Journal of International Financial Markets, Institutions & Money* 16(1), 41–56.

[28] Kim, S.J., Moshirian, F., & Wu, E. (2005). Dynamic Stock Market Integration Driven by the European Monetary Union: An Empirical Analysis. *Journal of Banking & Finance* 29, 2475-2502.

[29] Kim, S.J., Moshirian, F., & Wu, E. (2006). Evolution of International Stock and Bond Market Integration: Influence of the European Monetary Union, *Journal of Banking and Finance* 30, 1507-1534.

[30] Levine, R. (2004). Finance and Growth. In Aghion, P. and Durlauf, S. (eds.) Handbook of Economic Growth.

[31] Levine, R., Loayza, N., & Beck, T. (2000). Financial Intermediation and Growth: Causality and Causes. *Journal of Monetary Economics* 46, 31–77.

[32] Masten, B.A., Fabrizio, C., & Masten, I. (2008). Non-Linear Growth Effects of Financial Development: Does Financial Integration Matter? *Journal of International Money and Finance* 27(2), 295-313.

[33] Moore, T. (2007). Has Entry to the European Union Altered the Dynamic Links of Stock Returns for the Emerging Markets? *Applied Financial Economics* 17, 1431–1446.

[34] Orlowski, T.L., & Lommatzsch, K. (2005). Bond Yield Compression in the Countries Converging to the Euro. *William Davidson Institute* at the University of Michigan Stephen M. Ross Business School, Working Paper No 799.

[35] Pan, M.S., Fok, RC.W., & Liu, Y.A. (2007). Dynamic Linkages between Exchange Rates and Stock Prices: Evidence form East Asian Markets. *International Review of Economics & Finance* 16, 503-520.

[36] Pantelidis, T. & Pittis, N. (2004). Testing for Granger Causality in Variance in the Presence of Causality in mean. *Economics Letters* 85, 201-207.

[37] Poghosyan, T. (2009). Are "New" and "Old" EU Members Becoming More Financially Integrated? A Threshold Cointegration Analysis. *International Economics & Economic Policy* 6(3), 259–281.

[38] Reininger, T. & Walko, Z. (2006). The integration of the Czech, Hungarian and Polish Bond Markets with the Euro Area Bond Markets – a déjà vu of the club-med convergence plays? in Liebscher, K., Christl, J., Mooslechner, P. and Ritzberger-Grünwald D. (eds), *Financial development, integration and stability*, Cheltenham and Northampton, MA: Edward Elgar.

[39] Solnik, B. (1974). Why Not Diversify Internationally Rather than Domistically? *Financial Analysts Journal* 30, 3-25.

[40] Vilasuso, J. (2001). Causality Tests and Conditional Heteroskedasticity: Monte Carlo evidence. *Journal of Econometrics* 101, 25-35.

[41] Wang, P., & Moore, T. (2008). Stock Market Integration for the Transition Economies: Dynamic Conditional Correlation Approach. *The Manchester School* 76(1), 116-133.

[42] Wooldridge, M.J. (2000). Introductory Econometrics: A Modern Approach. The South-Western College edition: Publishing a division of Thomson Learning.

[43] Wu, Y. (2000). Stock Prices and Exchange Rates in a VEC Model—The Case of Singapore in the 1990s. *Journal of Economics & Finance* 24, 260−274.