THREE ESSAYS ON INTERNATIONAL FINANCIAL MARKET LINKAGES

By

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Summary

This thesis investigates three cutting edge issues in empirical finance. The first, examined in Chapter 2, is an investigation of the hypothesis that macroeconomic uncertainty is a significant risk factor in explaining deviations from the uncovered interest parity (UIP) condition (or time-varying risk premium) using data from the G7 countries. To analyze the relationship between the risk premium and macroeconomic risk factors, we employ VAR-GARCH-in-mean models. The results show that the currency risk premium may be due to macroeconomic volatility.

The second issue (Chapter 3) concerns the causal linkages between monetary and financial market returns of the New Member States (NMS) with the euro zone following the introduction of the euro. To measure monetary convergence we employ UIP deviations and stock market integration is proxied by the differential of the risk-adjusted returns of the NMS countries versus a euro zone stock index. We look for a causal relationship between excess currency and excess stock market returns of the aforementioned countries. We employ Granger causality in mean and variance tests to assess this relationship. The main finding is that the excess currency return is a significant leading indicator of the excess stock market return, with stronger evidence of causality in the variance of the process.

Finally, the third issue (Chapter 4) examines the time-varying co-movements of equity returns within major sectors, for a number of developed and developing countries. In particular, we ask the question if the conditional return correlations have increased excessively by historical standards during the recent financial crisis. We utilize asymmetric multivariate GARCH models. The main finding is that correlations have increased over the recent period, but the levels of co-movements are not excessive by historical standards. There is little difference between the co-movements of financial and non-financial stocks across countries, implying that this shock is largely undiversifiable.

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CONFERENCES & PUBLICATIONS

I have presented **Chapter 2** titled "*Explaining Deviations from Uncovered Interest Parity: The Role of Macroeconomic Variables*" at the *Irish Economic Association* at its 21st Annual Conference in county Wexford, at the parallel section: "Financial markets" (2007). Earlier versions of this chapter have been presented at *NUIM Department of Economics Internal Seminars* (2006) and at *NUIM PhD Internal Seminars* (2007).

I have presented **Chapter 3** under the heading "*Linkages between Monetary & Stock Market Integration of the New European Member States: A Granger Causality in Mean & Variance Approach*" at the *6th INFINITI Conference on International Finance* in the parallel section: "Exchange Rates & Monetary Issues", hosted by IIIS Trinity College Dublin, (June, 2008). A shorter version of Chapter 3 has also been presented at the *Irish Economic Association* at its 22nd Annual Conference in Westport, county Mayo (April, 2008). An earlier version of this chapter has also been presented at *NUIM PhD Internal Seminars* (2007).

I have presented **Chapter 4** under the title "*Financial Stocks: Time-Varying Correlations & Risks*" at *NUIM Department of Economics Internal Seminar* (2009).

A shorter version of **Chapter 4** is published in the *Journal of Economic Asymmetries*, Special issue on "The Credit and Financial Crisis of 2007-2009: Causes, Lessons and Prospects", forthcoming, 2009, (with my supervisor Thomas J. Flavin).

Chapter 1: Introduction

This PhD thesis contains three essays on various aspects of international finance and in particular issues of international integration. It analyses three cutting edge issues in empirical finance. The issues examined include an empirical examination of a time-varying risk premium in the UIP condition across the largest of the world's financial markets; an analysis of causality between money and stock markets in European emerging markets and their integration with the Euro zone markets; and finally an investigation of time-varying correlations and risks between global markets and sectors within these markets during the recent credit and liquidity crisis.

All chapters involve empirical analysis and the implementation is based on state-of-the-art time series techniques. A common theme running through this thesis is the modeling of time-varying risks and correlations so the use of members of the (G)ARCH family features prominently, e.g. univariate GARCH (Chapter 3), multivariate GARCH in mean (Chapter 2) and asymmetric GARCH (Chapter 4) models. The GARCH models employed in Chapters 2 and 3 allow us to capture the volatility clustering and fat tails observed in volatility of asset returns: Large (small) changes in prices tend to be followed by large (small) changes of either sign. Whereas the asymmetric multivariate Glosten, Jagannathan & Runkle (1993) GJR-GARCH model developed in Chapter 4 accommodates the possibilities of asymmetries on the dynamic volatility of asset returns: the volatility of asset returns tends to increase more with the arrival of "bad news" in the market than with the "good news".

Other techniques are adopted to augment the GARCH structures where necessary. For example, unit root tests are employed to assess long-run equilibrium conditions in Chapter 2, while impulse response functions are generated in Chapter 3 to analyze dynamic cross-market linkages. Chapter 4 utilizes a Principal Components factorization of cross-market return correlations to allow us better understand their common driving factors.

The thesis is structured as follows:

Chapter 2 focuses on the cornerstone parity condition for foreign exchange market efficiency, *Uncovered Interest Parity* (UIP). Prior empirical research in this area generally reports results unfavorable to UIP and the efficient markets hypothesis (e.g. see comprehensive surveys of Engel, 1996; Sarno & Taylor, 2002; and Sarno 2005). A potential solution to the failure of UIP often cited in the literature is the consideration of time-varying foreign exchange risk premium (Fama, 1984). However, the challenge the researchers face is how to model the currency risk premium. The empirical literature has not yet convincingly identified the risk factors that drive these risk premia and fully solve the puzzle (Baillie & Bollerslev, 2000; Sarno, Valente & Hyginus, 2006). We investigate the hypothesis that macroeconomic uncertainty is a significant risk factor in explaining the deviations from the UIP condition, using data from the G7 countries. Two macroeconomic variables are used; inflation and industrial production (see also Wickens & Smith, 2001; Flavin & Limosani, 2007; Kočenda & Poghosyan, 2009). We utilize the Conditional Multifactor Asset Pricing Model. Bivariate VAR–GARCH(1,1) in mean models are employed as they capture the time variation in the covariance matrices and additionally permit us to evaluate the effects of the macro risk factors on both the conditional first- and second- order moments of the excess currency returns. The overall empirical evidence suggests that the risk premium observed in foreign exchange markets may be due partially to volatility stemming from the macroeconomic risk factors and that these factors exert both a direct and an indirect influence on an asset's risk premium.

Chapter 3 focuses on integration and causality in financial markets. In light of the recent accession of the New Member States (NMS) in the European Union (EU) and their potential entry in the Euro zone, it has become increasingly important to understand the latest developments in these markets (Poghosyan, 2009; Čihák & Fonteyne, 2009). This chapter evaluates the monetary and financial integration of the largest group of the Central Eastern European emerging markets, known as Visegrád group with the eurozone, after the launch of the euro. To assess the progression of the monetary convergence of these states with the Euro zone, we again focus on the UIP condition. To assess the process of equity market integration of the NMS with the Euro zone we adopt a new approach that might capture a different aspect of the stock market integration. The central point of the chapter is the causality between monetary and financial market integration, as defined above. Does money market integration lead stock market integration or does the causality flow in the opposite direction or does it work both ways? To test for causality between these two markets the traditional Granger (1969) causality test is used while to test for causality in variance a Cheung and Ng (1996) test is employed. Overall, we find limited evidence of causality in mean but strong Granger causality effects in variance for the NMS. The impulse response analysis further supports these findings. The main finding of this chapter is that excess currency return is a significant leading indicator of the excess stock market return. This finding is consistent with the findings of Fratzscher (2002), Baele et. al. (2004), Kim, Moshirian & Wu (2005), Masten et. al. (2008) who argue that the European monetary union (EMU) is the main driver of the time varying integration process in stock markets.

Another important issue examined in this thesis relates to banks and non-financial correlations and risks. Chapter 4 focuses on the current global financial crisis, originated in the US sub-prime and associated credit derivative markets (Brunnermeier, 2009). Such was the magnitude of this crisis that it has spread across national borders causing an infection of financial systems on a global scale and the emergence of the "credit crunch" (Blanchard, 2009). In this chapter, we examine the time-varying co-movements of equity returns within major sectors, across countries. We ask the question if the conditional return correlations have increased over the last decade. If so, are the observed correlations during the recent financial crisis large or excessive in a historical context? What are the common factors that drive the variation of these co-movements? Using an asymmetric bivariate GARCH model, the analysis is conducted for a number of developed and developing countries. Overall, the main finding is that correlations have increased over the recent period (Longin & Solnik, 2001; Ang & Bekaert, 2002; Chiang, Jeon, Li, 2007; Kizys & Pierdzioch 2009; Frank & Hesse 2009). However, the levels of co-movements are not excessive by historical standards. Principal components analysis reveals one common driver of these pair-wise correlations, which may be related to US returns and market liquidity (see also Brunnermeier, Nagel, & Pedersen, 2008; Brunnermeier, 2009). The importance of understanding the dynamic nature of the market correlations is crucial. From an investor's point of view, a better understanding of how markets move together may result in superior portfolio construction and hedging strategies, while regulators may mainly be interested in the actual causes and consequences of spillovers effects of shocks. The main conclusion of this chapter is that correlations between international financial and non financial sectors have increased over the period of the recent financial turmoil, however, the current levels of co-movement are not excessive by historical standards.

Finally, Chapter 5 presents an overview of the main contributions and results of this dissertation as well as proposing a number of future avenues of research that have arisen due from this work

Chapter 2: Explaining Deviations from Uncovered Interest Parity: The role of *macro*economic variables

2.1 Introduction

The uncovered interest parity condition (UIP, hereafter) is a cornerstone of international finance and macroeconomic literature. It implies that identical assets traded in different currency areas should yield the same returns to an investor when exchange rate movements are taken into account. If the risk-free arbitrage conditions[1] hold, then the expected change in the exchange rate should equal the interest rate differential between domestic and foreign securities. Combined with an assumption of risk neutral agents, therefore, arbitrageurs should be indifferent between holding home or foreign assets. The UIP condition for testing foreign exchange market efficiency can be expressed as follows:

$$\Delta_k s_{t+k}^e \equiv E_t\left(s_{t+k} - s_t\right) = i_t - i_t^* \tag{2.1}$$

where s_t denotes the logarithmic approximation[2] of the spot exchange rate (domestic price of foreign currency) at time t; i_t and i_t^* are the nominal interest rates on equal domestic and foreign assets correspondingly; $\Delta_k s_{t+k}^e = s_{t+k} - s_t$ is the expected depreciation (or appreciation) of the domestic currency over k periods; $E_t\left(\bullet\right)$ is the expectations operator conditional upon information available at time t; and k denotes the periods to

1 It is assumed that prices fully reflect information available to all market participants, there are no transaction costs and the default risks and tax treatments are the same across countries

2 The approximation of $\ln(1+i) \approx i$.

maturity of an underlying asset. Intuitively, equation (2.1) states that differences between nominal interest rates reflect expected changes in the exchange rate and that these rates adjust to equalize the return on domestic and foreign markets. Thus, the ex-ante expected home currency returns on foreign deposits in excess of domestic deposits should be zero.

In general, empirical research conducted on foreign exchange market efficiency commonly focuses on the relationship between spot and forward exchange rates, known as covered interest parity (CIP). This relationship can be presented as follows:

$$f_t^k - s_t = i_t - i_t^* \tag{2.2}$$

where f_t^k denotes the logarithm of the forward rate (e.g. a rate arranged in advance at the present time t, for an exchange of currencies to be delivered at a future time $t+k$) and $f_t^k - s_t$ denotes the forward premium (or forward discount) at maturity of an asset which is the percentage difference between the current spot rate (s_t) and the current forward rate k periods ahead (f_t^k). In this set-up, the interest rate differential equals the forward premium. If there are no unexploited arbitrage profit opportunities and transactions costs across international financial markets, then arbitrage should guarantee that the interest rate differential at a certain maturity of two identical assets would adjust to cover the movement of currencies in the forward market and thus would be equal to zero. In general, studies find that CIP tends to hold even though there have been some documented deviations which may reflect non-zero transaction costs, for instance, see Frenkel & Levich (1975, 1977), Taylor (1989), or the comprehensive surveys of Taylor (1995), Taylor & Sarno (2002) and Sarno (2005) amongst others. Taylor (1987) points out that the CIP condition tends to hold on average over a given time period, however, it does not hold continuously during the period. More recent studies document that profitable violations of the UIP condition exist during the recent financial crisis. For instance, Akram et. al. (2008, 2009) investigate the CIP deviations using tick data for three major exchange rate markets and find some economically significant deviations from the CIP condition albeit short-lived. Baba et. al. (2008, 2009) argue that deviations from CIP are primarily due to high counterparty/credit risk as well as to the liquidity risk prevailing in the foreign exchange swap markets.

A large body of literature has utilized CIP by replacing the interest rate differential, $i_t - i_t^*$, from equation (2.1) with the forward premium, $f_t^k - s_t$, from equation (2.2) to test the validity of the UIP condition. Hence, the regression based test of the spot and forward exchange rates relationship takes the following form:

$$\Delta_k s_{t+k}^e = a + b\left(f_t^k - s_t\right) + \eta_t \tag{2.3}$$

where a is a constant term, b is a slope coefficient and η_t is the disturbance term uncorrelated with information available at time t. Under the hypothesis of rationality and risk-neutrality, one would expect that the slope coefficient b equals unity and the constant term to equal zero. However, the majority of studies based on various theoretical models and on different econometric techniques as well as data sets and periods, tend to reject the UIP condition for more freely floating currencies against the US dollar. In particular, they find that the UIP slope estimate is negative, is often statistically insignificant and is closer to minus than to plus unity (seminal papers are Fama, 1984; Hodrick, 1987; Froot & Thaler, 1990; Backus, Foresi, Telmer; 1995, 2001; extensive surveys of this literature are Lewis, 1995; Engel, 1996 or more recent ones by Sarno & Taylor, 2003; Sarno 2005). The negativity of the estimated slope coefficient, b, in equation (2.3) is known as "forward discount bias" which means that the forward premium predicts the direction of the expected change in the spot rate wrongly. This result implies that the domestic currency tends to appreciate when domestic interest rates exceed the foreign rates, not to depreciate so as to cancel out the interest differential, as the UIP condition postulates.

If we relax the assumption of risk neutrality and we assume that the investors are risk averse –we maintain the assumption that the investors are rational- then the exchange rate volatility would cause risk averse investors to require a greater rate of return than the interest differential in exchange for the risk of possessing foreign currency. If we denote the risk premium as ϕ_t we have

$$i_t - i_t^* = \Delta_k s_{t+k}^e + \phi_t \tag{2.4}$$

where ϕ_t is risk-premium. The intuition behind equation (2.4) is straightforward. Investors require a higher compensation than that provided from the interest differential, for bearing risky investments by means of a risk premium. Fama (1984) argues that ϕ_t is very volatile, it is negatively correlated with the expected depreciation of the foreign currency and that the movement of the risk premium is larger than the expected depreciation of the exchange rate.

Nonetheless, there are studies that provide more favorable results for the UIP hypothesis at the short horizon. Chaboud & Wright (2005) find that "UIP works, but not for long" over very short time intervals of intradaily data. Bansal & Dahlquist (2000) show that the forward bias primarily characterizes the developed economies and it is much less likely to occur in low-income and emerging countries. Flood & Rose (2000) argue that the UIP condition during the 1990s holds better for countries that are in crisis, where either the exchange or interest rates display high volatility.

In general, studies find that the UIP condition performs poorly for floating currencies in the short term, more recent papers suggest that UIP tends to hold for financial assets of longer maturities. Chinn & Meredith (2004) use long horizon data and find that UIP is violated when using financial instruments with relatively short maturities, notably 12 months or less. For instruments of longer maturities (i.e. 5- or 10- year government bonds) the forward bias does not occur, the estimated UIP slope coefficient displays the correct sign (positive) and is closer to one than zero. The authors consider that the long horizon results are dominated by the model's "fundamentals" (i.e. output and inflation) which determine both exchange rates and interest rates in a manner consistent with the UIP hypothesis, whereas the short horizon results reveal the perverse relationship between interest rates and exchange rates. Alexius (2001) and Zhang (2006) report similar results. Lothian & Wu (2005) go along with this line of research. They create an ultra-long time series, spanning two centuries, to test UIP. They find that UIP holds better over ultra-long periods of time (as opposed to particular sub-periods) where the small-sample bias and peso-problems are eliminated. In general, empirical evidence supports the view that at long horizons the arbitrage conditions exert greater force on international financial markets and thus, UIP tends to hold.

More recent studies argue that the potential importance of nonlinearities is the key to understanding the forward premium anomaly and to potentially explain why UIP fails to hold empirically. Nonlinearity may arise in exchange rate data for several reasons, such as transactions costs, central bank interventions and the existence of limits to speculation (see Sarno (2005) for a survey). The challenge the researchers face is how to model these nonlinearities. Baillie & Bollerslev (2000) view the forward premium anomaly as a statistical artifact. They argue that the relationship between the spot rate and the forward discount is characterized by significant nonlinearities. If the forward discount is large in absolute value, then the forward discount is more likely to point in the right direction for the ex post exchange rate change. However, if the forward discount is small, it is likely to indicate wrongly the direction for the ex post exchange rate change, perhaps due to high transactions costs in relation to potential gains. It is implied that the anomaly may occur due to a high persistence (or long memory) in forward premium or to small-sample bias. On the contrary, Maynard (2003) is less certain that the forward premium anomaly can be entirely explained by the time series characteristics of the involved variables. After performing several tests, he finds that although the bias is decreased, the coefficient on the forward premium remains short of its value of unity. He confers that a statistical method alone is insufficient in explaining the puzzle. Sarno, Valente & Hyginus (2006), Baillie & Kiliç (2006), and Sarno (2005) explore the relationship between spot and forward rates within a smooth transition regression framework. They draw inspiration from the finance microstructure literature, limits to speculation hypothesis[3], focusing on some nonlinear and asymmetric aspects of the forward premium anomaly "without fully solving the anomaly". Their estimation results reveal significant evidence of nonlinearities in the relationship between the spot and forward exchange rates. They argue that the UIP condition does *not* hold all the time. When UIP deviations are considerably large, investors are willing to trade in this way forcing the spot-forward relationship to revert towards the UIP condition. However, when deviations are small, investors prefer alternative investment opportunities in which case the forward bias is persistent and statistically significant.

Many attempts have been made in an effort to explain the UIP deviations –or equally, foreign exchange excess returns- in the short run. Traditional explanations of the empirical failure of UIP may be classified into three main classes. The first class contains models that emphasize the way expectations are formed. For instance, the so-called peso-problem[4], learning, or bubbles occur when at the time of decision-making, rational investors expect the occurrence of a future event that fails to happen. Empirical studies

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[3] The "limits to speculation" hypothesis postulates that a market speculator selects the best trading strategy based on its Sharpe ratio (excess return per unit of risk). The higher Sharpe ratio attracts investors to the carry trade (for more details see Lyons, 2001; Sarno et. al., 2006). The carry trade may or may not be profitable. The carry trade positions yield positive profits when they are "large enough" and when maintained over long periods. Burnside et. al. (2008) claim that payoff to the carry trade remains positive and statistically significant. Brunnermeier et. al. (2008) argue that currency crash risk caused by sudden unwinding of carry trades may discourage speculators from taking on large enough positions to enforce UIP.

[4] The "peso" effect gets its name from the behaviour of the Mexican peso in the early 1970's. Agents strongly expected that the peso would be devalued for a number of periods before its actual, and sharp, devaluation in 1976.

usually reject the "peso-problems" theory as it does not solve the forward premium bias and it is furthermore considered a small-sample statistical phenomenon (Lewis, 1995 gives a comprehensive view). The second class includes models that reject the risk-neutral assumption and introduce a time varying risk premium component (e.g. Fama, 1984; Engle, Lilien & Robins, 1987). Our paper draws insights from this class of models, which assume that the deviations from UIP can be explained from the existence of a time-varying risk premium. Lastly, the third category refers to portfolio-balance models that seek to explain the excess returns within a mean-variance optimization framework. In these models, the risk premium depends on the supply of assets denominated in various currencies and the risk aversion of investors (e.g. Frankel, 1982; Giovannini & Jorion, 1989; etc). In general, these models perform poorly in explaining returns.

Variation in risk is a key issue in finance for understanding movements in asset prices. Most of the variation in asset returns stems from variation in risk premia (Cochrane, 2001). Risk premium rewards risk-averse investors for holding assets that are perceived to be risky. How to model the risk premium is the challenge. There is a large body of literature that models and applies risk premia to foreign currency data using a variety of techniques and data sets. Focusing on pricing risk, the literature features two main approaches. The first approach employs the traditional static Capital Asset Pricing Model (CAPM) originally proposed by Sharpe (1964) and Lintner (1965). The model predicts that the expected excess return on an asset is proportional to its nondiversifiable (systematic) risk measured by its covariance with the market portfolio. The general consensus emerging from the empirical tests of the static CAPM and its extensions[5] is that the risk aversion parameter is too large and in most cases is statistically insignificant (e.g. Adler & Dumas,

[5] For instance, Mark (1988) extends the static CAPM to the intertemporal setting, by adjusting the model in a conditional environment. He allows risk and return to vary over time, by specifying the betas as an ARCH-like process. Using the generalized method of moments (GMM) model, he finds supportive evidence in favour of the conditional beta measure of time-varying risk premia. His single-beta CAPM model can explain, but only to a small degree, the forward bias anomaly.

1983; Giovannini & Jorion, 1989; Engel, 1992; for a detailed survey see Sarno & Taylor, 2002).

The second approach is derived from the two-country general equilibrium model of Lucas (1982). The risk-premium in this type of model is determined by the conditional covariance of the excess currency return and the marginal utility of money. Already earlier attempts to explain the behaviour of foreign exchange risk premia do not have much empirical success and report mixed results. Extensive research in this area has been undertaken by Hodrick & Srivastava (1984), Domowitz & Hakkio (1985), Baillie & Bollerslev (1990), Kaminsky & Peruga (1990), Backus, Gregory & Telmer (1993), Bekaert (1996), Obstfeld & Rogoff (2001) to mention but a few. In general, studies find it difficult to generate large and volatile risk premia because either the general equilibrium models do not produce very variable pricing kernel factors or the aggregate consumption data does not vary adequately over time. In order for the risk premia to explain the ex-post excess returns in this type of models consumers should be implausibly risk averse (the coefficient of risk aversion is documented to be very large) or consumption should be highly correlated with the exchange rates (Sarno, 2005).

More recent research proposes some modifications to the baseline consumption-based asset pricing model which allows the marginal utility of consumption to be responsive to small variations in consumption in order to generate large and volatile foreign exchange risk premia. Campbell & Cochrane (1999) propose a consumption-based explanation that links consumption with asset prices to generate risk premia in the context of a habit formation model. They augment the basic power utility function with a time-varying reference point, or "habit" which evolves slowly and nonlinearly in response to consumption change and it is determined by the history of aggregate consumption. The underlying idea is that in recessionary times, bad shocks drive consumption down towards the habit level, risk aversion increases, stock prices decrease and the expected returns increase. The more risk-averse investors are- or the riskier the economic environment is- the higher the rewards are that investors demand for bearing particular risks. The model successfully combines the low standard deviation of consumption growth with a high equity premium, high volatility of returns, and a low and smooth risk-free rate. Verdelhan (2009) follows Campbell & Cochrane (1999) closely in exploring the UIP puzzle within the habit framework. He relies on two important assumptions such as time-varying risk-aversion and pro-cyclical interest rates, to show that a domestic investor earns a positive risk premium in bad times when consumption is low (and very close to the habit level), risk-aversion is high and interest rates are low. With respect to equity markets, Lustig & Verdelhan (2007) argue that aggregate consumption growth risk explains about eighty-seven percent of the variation in expected excess currency returns. They estimate a simple consumption-based asset pricing model, using data on the currency returns of eight portfolios of short-term foreign-currency denominated money market securities sorted according to their interest differential with the U.S. They reach the conclusion that investors who borrow in US dollars with higher interest rates to finance lending in other currencies with lower interest rates earn positive excess returns. They find that high interest rate currency portfolio yields, on average, higher returns than the low interest rate currency portfolio. However, during bad times when domestic consumption growth is low, high interest rate currencies tend to depreciate on average (but not as much as the interest differential) and, thus, the US investor who holds these currencies earns a positive excess return, a compensation for bearing this risk. In the same vein, Lusting, Roussanov & Verdelhan (2008) also find that for each portfolio they construct, the risk premia are large and time-varying.

Along with the consumption-based asset pricing theories, another strand of the literature attempts to generate quantitatively large and volatile risk premia. Engel (1999) discusses the role of the foreign exchange risk premium in two-country intertemporaloptimizing general equilibrium models with sticky nominal prices. In particular, he argues that risk premia arise due to the covariation of consumption and exchange rates in models with nominal rigidities. This implies that monetary variability (shocks) causes the correlation between consumption and exchange rates to change. Therefore, the risk premia are directly linked to the volatility of exchange rates. The combination of multiple costs or rigidities has been launched as a fruitful approach for generating risk premia. One category of these models includes "limited participation" on behalf of the agents. Agents are willing to participate in arbitrage only if the benefits exceed the costs sufficiently. For example, Alvarez, Atkeson, & Kehoe (2008) develop a general equilibrium monetary model which generates time-varying risk premium through endogenous asset market segmentation. They assume that exchange rates follow a near random walk process whilst interest rate differentials are largely variable and persistent. When monetary policy changes this is reflected in the interest rate differentials, which in turn reflect changes in risk. They explain the forward bias anomaly. They demonstrate that limited participation of agents in financial markets can account for time-varying risk premia, which is very important since standard monetary models with standard utility functions empirically fail to produce them.

Uncertainty also plays a crucial role in many macroeconomic models. The possibility of an important link between uncertainty (or risk) and the macroeconomic factors has long been understood: the higher the macroeconomic uncertainty, the more uncertain the payoff on an investor's asset portfolio and the greater the required level of compensation for the investor is. Literature on the different arbitrage pricing theories- e.g. CAPM of Merton (1973) and the Arbitrage Pricing Theory (APT) of Roll & Ross (1980)- have identified several macroeconomic factors whose fluctuations explain changes in market returns. According to Chen, Roll & Ross (1986) (CRR hereafter), macroeconomic state variables, such as unanticipated changes in the term structure, unanticipated changes in the spread between high- and low-grade bonds, unanticipated change in the growth rate in industrial production, as well as unexpected inflation systematically affect stock market returns (Chen, 1991; Ferson & Harvey, 1991 report similar results). More recently, Flannery & Protopapadakis (2002) explore the impact of macroeconomic series announcements (or "surprises"[6]) on equity return volatility. They use a GARCH model to identify among 17 macroeconomic variables that only the money supply (M1 or M2) significantly affects both the level and the conditional volatility of the aggregate stock returns whilst the two nominal variables that proxy inflation (CPI and PPI) affect only the level of the market portfolio's returns. Kizys & Spencer (2008) focus on the relation between the UK-US equity risk premia and macroeconomic volatilities. Building on stochastic discount factor (SDF) theory and using a multivariate exponential GARCH in-mean (EGARCH-M) statistical model, the authors show that i) the macroeconomic volatilities are driven by changes in inflationary expectations (e.g. the nominal long-term government yield variable is used to capture the inflationary expectations) and ii) the volatility of inflation, industrial production growth as well as the equity market volatility all have a significant effect on the equity risk premium.

Studies that focus on the foreign exchange markets find similar results to those obtained from the equity markets. Hu (1997) based on Lucas' theoretical model using a VAR-GARCH process, provides evidence that the risk-premium can be attributed to the time-varying volatility in industrial production and money supply. Wickens & Smith (2001) seek to identify if macroeconomic uncertainty is an important source of foreign exchange risk based on a SDF theory. They argue that the SDF can be proxied by observable macroeconomic variables. They use a multivariate GARCH in-mean framework to jointly estimate the excess returns (relative to the risk-free asset) and the macroeconomic factors. Among four different alternative SDF models they estimate, they find that the risk premium is best modelled by the traditional CAPM based on the monetary model of the

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6 Macro announcement "surprises" are based on market participant surveys instead of on econometric models, which have been conducted by the MMS international, a subsidiary agent of Standard & Poor's.

exchange rate, however, it does not fully solve the forward premium anomaly. Flavin & Limosani (2007) use a multivariate ARCH in-mean specification to show that domestic inflation rate, the debt/GDP ratios, and the expected rate of depreciation of the exchange rate help to explain movements in short-term interest rate differentials across European countries vis-á-vis Germany. Indeed, they find that macroeconomic variables exert both a direct and indirect influence on the short-term interest rate differential (or risk premia). Iwata & Wu (2006) focus on the sources of volatility of the foreign exchange risk premium. They believe that macroeconomic shocks, which drive output and inflation, may explain the currency risk premia. They employ a nonlinear structural Vector Autoregression (VAR) model to find that most of the volatility (e.g. more than 80% on average) of the currency risk premia is due to macroeconomic shocks. Morana (2009) puts forward a slightly different question. He investigates whether or not the volatility of macroeconomic factors (e.g. output, money growth, inflation and interest rate volatility) determine the exchange rate volatility in the long horizon. By employing a fractionally integrated factor vector autoregressive (FI-F-VAR) model that accounts for persistence (long-memory) and structural break characteristics of the variables, he finds that there is a significant long term relationship between macroeconomic and exchange rate volatility. This relationship exhibits strong bidirectional Granger causality (the direction of causality is much stronger from the macroeconomic volatility to the exchange rate volatility and is less strong in the converse. He concludes that macroeconomic stability can be of great significance for decreasing excess exchange rate volatility. In relation to the emerging markets, Kočenda, & Poghosyan (2009) empirically examine the impact of macroeconomic factors (e.g. consumption and inflation) on the foreign exchange risk premia for the new European member states (e.g. the Czech Republic, Hungary, Poland and Slovakia). Using the SDF theoretical approach and the GARCH in-mean framework for their empirical analysis, they find that most of the variability of the foreign exchange risk premia can be accounted for by macroeconomic factors. This result implies that investors price currency risks based on the macroeconomic conditions prevailing in emerging countries.

The present paper relates the presence of a time-varying risk premium to macroeconomic volatility. To accomplish this, we utilize the Conditional Multi-factor Asset Pricing Model, an extension of the Intertemporal Asset Pricing consumption-based model (Lucas 1982). We share the view that the deviations from UIP reflect the presence of rational, time-varying risk premia. In order to get a better insight into how returns are affected by the performance of the macroeconomy, we consider two macroeconomic factors that have been previously used in the applied finance literature, namely inflation and industrial production. To attain a direct estimate of the contribution to assets' risk premia we adopt the parsimonious parameterization of a multivariate GARCH in mean framework of Flavin & Wickens (2003) and investigate if the time-varying variances and covariances are priced in the foreign exchange market.

This paper differs from previous studies (e.g. Hu, 1997; Smith & Wickens, 2001; Tai 2001; Kočenda & Poghosyan, 2009) in the following ways. Firstly, we use the conditional multifactor asset pricing theoretical model to directly correlate the excess currency returns in deviations from the UIP condition to macroeconomic factors. This work offers a first attempt to model the above link in that context. Secondly, we focus on both the direct impact, through the conditional mean equation, and an indirect impact, through the GARCH in mean effects, of the macroeconomic risk factors on currency risk premium. A recent study by Flavin & Limosani (2007) employs the same specification, however, they put forward a different research question and use different macroeconomic factors.

The rest of the paper is organized as follows: Section 2 presents the theoretical model of the currency risk premium. Section 3 discusses the econometric methodology employed and presents the data. Section 4 reports and discusses the empirical results. Section 6 contains some concluding remarks.

2.2 Theoretical Model

A well-known theoretical model in international finance literature used to derive risk premia in the foreign exchange market is the *intertemporal asset pricing model*, proposed by Lucas (1982). Lucas' model assumes that there are two continuous infinitely living agents in a two-country world. Both of them have identical preferences over two consumption goods but display different stochastic endowments of these two goods. There is perfect substitutability between domestic and foreign goods as well as identical marginal utilities with respect to these goods. Securities markets are also considered to be perfectly competitive and complete and consequently there is a complete pooling of risk. Output is exogenous. Each agent is endowed with one unit of perfectly divisible security at the beginning of time, $t = 0$. Each agent is able to determine his/her consumption and portfolio decisions optimally. In this classic model, the intertemporal choice problem of the agent is how to maximize the present discounted value of utility function:

$$U_t = E_t \left[\sum_{t=0}^{\infty} \gamma^t u(c_{t+1}) \right] \tag{2.5}$$

where U_t defines the present discounted value of utility, $E_t = E_t(\bullet | \mathrm{I}_t)$ is the mathematical expectations operator conditional upon the full information set, I_t, available at time $t = 0$, which implies that investors are assumed to be rational; u represents utility; c_{t+1} defines the level of consumption at time $t+1$, and $0 < \gamma < 1$ is the common discount factor. We also assume that the utility function fulfills all the required properties, such as strict concavity (implying risk aversion), time separability, and is continuously differentiable. In such a setting, equation (2.5) implies that an investor is maximizing his utility function obtained from the present discounted value of current and future levels of expected utility, subject to a set of budget constraints. These constraints from period t to $t+1$ are: $w_{t+1} = R_t(w_t + y_t - c_t)$, where w_t defines the real wealth, y_t defines income gained from labour, and $y_t - c_t$ defines the savings from the labour income and lastly, R_t denotes one plus the real interest rate of asset returns. This implies that the change in the investor's real wealth from period t to the next period $t+1$ depends upon the rate of savings and the rate of interest. In equilibrium, the first-order (or Euler) condition of equation (2.5) subject to the above budget constraints is of the following form:

$$u'(c_t) = \gamma E_t\left[u'(c_{t+1})\, R_t \mid \mathrm{I}_\mathrm{t}\right] \tag{2.6}$$

where $u'(\bullet)$ denotes the marginal utility of consumption. Equation (2.6) represents the condition of welfare maximization and states that in a position of equilibrium when prices are set, the marginal utility from the current consumption in time t should equal the marginal utility of the future consumption in period $t+1$ discounted by the real rate of return. If we re-arrange equation (2.6) we get:

$$1 = \gamma E_t\left[\frac{u'(c_{t+1})R_t}{u'(c_t)} \mid \mathrm{I}_\mathrm{t}\right] \tag{2.7}$$

Suppose now that the domestic investor takes an uncovered investment in a foreign exchange market. The domestic investor faces risk through his holdings of foreign assets. Assume that R_t in (2.7) is the real return from taking an uncovered position in the foreign currency denominated security that matures one-period ahead. It is implied that

$R_t = i_t^* - (p_{t+1} - p_t) - (s_{t+1} - s_t)$ where p_t is the domestic currency price of the consumption good at time t; i_t^* is the nominal interest rate denominated in foreign currency at time t; and s_t is the spot exchange rate and $s_{t+1} - s_t$ is the exchange rate depreciation over the holding period. Thus, equation (2.7) becomes:

$$1 = \gamma E_t \left[\frac{u'(c_{t+1})}{u'(c_t)} (1+i_t^*) \frac{p_t}{p_{t+1}} \frac{s_{t+1}}{s_t} \mid I_t \right] \tag{2.8}$$

If we assume perfect substitutability between the domestic and foreign goods and identical marginal utilities in relation to the domestic and foreign goods, a similar Euler equation to equation (2.8) should hold for the nominally risk-free interest rate denominated in domestic currency, i_t, one period ahead at t[7]:

$$1 = \gamma E_t \left[\frac{u'(c_{t+1})}{u'(c_t)} (1+i_t) \frac{p_t}{p_{t+1}} \mid I_t \right] \tag{2.9}$$

Subtracting equation (2.8) from equation (2.9), we obtain:

$$E_t \left[\gamma \frac{u'(c_{t+1})}{u'(c_t)} \frac{p_t}{p_{t+1}} \left((1+i_t^*) \frac{s_{t+1}}{s_t} - (1+i_t) \right) \mid I_t \right] = 0 \Rightarrow$$

$$E_t \left[m_{t+1} \, r_{j,t+1} \mid I_t \right] = 0 \tag{2.10}$$

[7] If an investor chooses an alternative investment strategy, say for example, he takes a covered position in the foreign market, then equation (2.8) changes into $1 = \gamma E_t \left[\frac{u'(c_{t+1})}{u'(c_t)} (1+i_t^*) \frac{p_t}{p_{t+1}} \frac{f_t}{s_t} \mid I_t \right]$, where the forward rate, f_t, has been substituted for s_{t+1}.

where $m_{t+1} = \gamma \frac{u'(c_{t+1})}{u'(c_t)} \frac{p_t}{p_{t+1}}$ is the **intertemporal marginal rate of substitution** (**IMRS**) of domestic currency (or stochastic discount factor), and $r_{j,t+1} = (1+i_t^*) \frac{s_{t+1}}{s_t} - (1+i_t)$ is the **excess currency returns** from foreign market speculation for currency j, or equally, deviations from UIP for currency j. To empirically implement equation (2.10) we should expand it further. Exploiting the statistical property that the expectation of a product equals the covariance plus the product of expectations[8]

(e.g. $E\left[m_{t+1}, r_{j,t+1} | I_t\right] = Cov\left[m_{t+1}, r_{j,t+1} | I_t\right] + E\left[m_{t+1} | I_t\right] * E\left[r_{j,t+1} | I_t\right] = 0$), we can re-state equation (2.10) in terms of the expected profit from foreign speculation, which in this regard is the risk premium:

$$E_t\left[r_{j,t+1} | I_t\right] = \frac{Cov\left[r_{j,t+1}, -m_{t+1} | I_t\right]}{E_t\left[m_{t+1} | I_t\right]} \tag{2.11}$$

where $Cov(\bullet | I_t)$ is the conditional covariance. Equation (2.11) states that the conditionally expected excess return is proportional to the conditional covariance of IMRS and of the returns from foreign exchange speculation. Note that the IMRS is expected to be always positive. More precisely, equation (2.11) implies that a risk-averse investor will earn a positive risk premium if the return of an asset is negatively correlated with the IMRS. A negative correlation means that the return of an asset is likely to be higher than expected when the marginal utility in the next period $t+1$, (relative to the current period t) is lower than expected.

As mentioned above, various empirical attempts in the financial literature at estimating time varying risk premium models, building on the consumption-based asset

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[8] We apply the following statistical property: $Cov(xz) = E(xz) - E(x)*E(z) \Leftrightarrow E(xz) = Cov(xz) + E(x)*E(z)$

pricing model, perform poorly. Trying to avoid the empirical implications of the consumption-based asset pricing model, as given by equation (2.11), researchers were confronted with the problem of how to correctly specify the form of the unobservable component m_{t+1} (see for instance McCurdy & Morgan, 1991; Ferson, 1995; Campbell, 2000; Cochrane, 2001; Smith & Wickens, 2001; and Tai, 2000, 2004). In this paper, we re-state the consumption-based asset pricing relationship in equation (2.11) in terms of a **conditional multi-factor asset pricing model**, an extension of the intertemporal asset pricing model, which captures the time varying risk premium and gives further empirical context to equation (2.11). We assume that m_t^* and $\mathrm{r}_{j,t}^*$, at time t, have the following factor representations:

$$m_t^* = c + \sum_{k=1}^{\mathrm{K}} \beta_k F_{kt} + u_t \tag{2.12}$$

and

$$\mathrm{r}_{\mathrm{jt}}^* = \alpha + \sum_{k=1}^{\mathrm{K}} \theta_{jk} F_{kt} + \varepsilon_{jt} \qquad \forall\, j=1\ldots\mathrm{N}, \tag{2.13}$$

whereas before r_{jt}^* denotes the excess currency returns, i.e. return on foreign asset minus return on domestic for asset *j* at time t; F_{kt} indicates the common risk factors with $k = 1, 2...$ at time t; θ_{jk} indicates the loading on factors for asset *j*; u_t is an innovation term; and ε_{jt} is the idiosyncratic error term. It is assumed that conditionally on the information set at time $t-1$, u_t and ε_{jt} have conditional expectations of zero i.e. $E\left[u_t \mid I_{t-1}\right] = E\left[\varepsilon_{jt} \mid I_{t-1}\right] = 0$ and that they are conditionally orthogonal to the risk factor i.e. $E\left[u_t F_{kt} \mid I_{t-1}\right] = E\left[\varepsilon_{jt} F_{kt} \mid I_{t-1}\right] = 0$. As noted by Elder (2002) the statistical properties of the common risk factors are $E_{t-1}\left(F_{kt}\right)=0$, $Cov_{t-1}\left(F_{jt}, F_{kt}\right)=\sigma_{jk}(t) \quad for \; j \neq k$, and $Var_{t-1}\left(F_{kt}\right)=\sigma_{kt}^{2}$.

If we substitute equation (2.12) to equation (2.11) at time t, we obtain:

$$E_t\left[\mathrm{r}_{\mathrm{jt}} \mid I_{t-1}\right]=\frac{\operatorname{cov}\left(r_{jt}, -m_t \mid I_{t-1}\right)}{E_t\left[m_{\mathrm{t}} \mid I_{t-1}\right]}=$$

$$=\frac{\operatorname{cov}\left(r_{jt}, -\left(\sum_{k=1}^{\mathrm{K}} \beta_k F_{k,t}\right) \mid I_{t-1}\right)}{E_t\left[m_{\mathrm{t}} \mid I_{t-1}\right]}=$$

$$=\sum_{k=1}^{K} \frac{-\beta_k}{E_t\left[M_{\mathrm{t}} \mid \mathrm{I}_{\mathrm{t-1}}\right]} Cov\left[\mathrm{r}_{\mathrm{jt}}, \mathrm{F}_{\mathrm{kt}} \mid I_{t-1}\right]=$$

$$=\sum_{k=1}^{K} \lambda_{kt-1} \, Cov\left(\mathrm{r}_{\mathrm{jt}}, F_{kt} \mid I_{t-1}\right) \tag{2.13}$$

where $\lambda_{k,t-1}$ is defined as the time-varying price of factor risk. Equation (2.13) describes the equilibrium condition that relates the risk-premia to the macroeconomic risk factors. Equation (2.13) is a general conditional multi-factor asset pricing model, an extension of the intertemporal asset pricing consumption-based model (Lucas 1982). We regard this conditional multi-factor representation as an alternative approach with a broader capability to adequately capture the time-varying correlations of macroeconomic factors with the currency risk premia and to give empirical context to the time-varying risk-premia. It becomes imperative, therefore, to investigate these interactions.

The present study assumes that the only macroeconomic factors affecting excess currency returns are inflation and industrial production. The choice of these factors is based on existing literature. Flavin & Limosani (2007) suggest that the volatility prevailing in an economic environment can potentially be transmitted to returns on financial debt instruments (e.g. government bonds) affecting in this way the risk premium of an asset.

Recent studies have documented that inflation and industrial production, measured at monthly horizons, exhibit conditional heteroscedasticity (see for example Grier, Henry, Olekalns & Shields, 2004; and Shields, Olekalns, Henry & Brooks, 2005; Kizys & Spencer; 2008 amongst others). Based on this evidence, we investigate if our macroeconomic variables can capture the volatile macroeconomic conditions that potentially can influence an asset's risk premium.

A number of studies have looked for a link between macroeconomic variables[9] and asset returns. For instance, Shiller & Beltratti (1992) investigate whether or not the rate of inflation, through its effect on the interest rates, impacts excess stock returns. They report a marginally significantly negative link between the mean of excess stock returns and inflation in the US and the UK. More recently, Smith, Sorensen & Wickens (2007) explore the linkage between the equity risk premium and macroeconomic volatilities. Based on the SDF approach and on EGARCH with asymmetric BEKK, the authors identify potential asymmetries in the volatility of equity returns, inflation, industrial production growth rate and money growth rate. They argue that the inflation risk premium is priced by investors. Some other researchers focus on the dynamic relationship between the foreign exchange rates and stock market returns. Pan, Fok & Liu (2007) find a robust Granger causal relationship from the exchange rates to stock markets for most of the seven East Asian countries they tested (the inverse causal relation holds for fewer countries). They argue that some important factors (e.g. different exchange rate regimes, trade volume, the size of stock markets or capital controls) can affect the relationship between the exchange rates and equity markets. Other studies use a multivariate cointegration analysis in order to check for possible long-term dynamic relationships between macroeconomic variables and equity

[9] Friedman (1977) in his Nobel lecture argues that high levels of inflation increase macroeconomic uncertainty by distorting relative prices signals, causing an inefficient allocation of resources, and thus lower the growth rate of output. More recently, researchers have tried to empirically implement a link between the rate or/and variability of inflation and output growth. For instance, Grier & Perry (2000), Apergis (2004), Grier, Henry & Shields (2004) and Fountas, Karanasos & Kim (2006) present results which document that inflation uncertainty exerts a significantly negatively effect on output growth. By contrast, Clark (1997) reports that neither average inflation nor inflation volatility have a significant effect on output growth.

markets. Humpe & Macmillan (2007) report that inflation and the long-term interest rates are negatively cointegrated with the US stock prices whereas the money supply is negatively cointegrated with the Japanese stock prices. Industrial production is positively cointegrated with both of the equity markets. Hasan & Javed (2009) focus solely on the Pakistani equity market and find evidence of cointegration and causality (unidirectional) from monetary variables (e.g. money growth, interest rates, exchange rates, and inflation) to this market. Conducting also a variance decomposition analysis, they reach the conclusion that monetary variables constitute a considerable source of volatility for the stock returns. In short, there is adequate evidence in the financial literature that supports the view that macroeconomic variables are significant risk factors in determining market movements and returns. The next section deals with econometric analysis.

2.3 Econometric Model & Data

2.3.1 Econometric model

We relate our observable macroeconomic variables with the excess return observed in the foreign exchange market. The dynamic pattern of a changing risk premium over time, applied for *k=2* common risk factors (see equation 2.13) has the following form:

$$r_{jt} = \sum_{k=1}^{K} \lambda_{kt-1} h_{jkt} + \varepsilon_{jt} \text{ with } \varepsilon_t \mid I_{t-1} \sim N(0, H_t) \qquad (2.14)$$

where $h_{jkt} = Cov\left(\mathrm{r}_{\mathrm{j\,t}}\ F_{kt} \mid I_{t-1}\right)$ is the conditional (co)variance matrix of excess return with the macroeconomic risk factors. We consider that this modelling approach is appropriate for the following reasons. Firstly, as stated above, both CAPM and APT models have documented a positive linkage between asset risk and return where asset risk is measured by the conditional covariance of returns with the market or the conditional variance of returns. ARCH and generalized ARCH models (GARCH) are purposely designed to model the conditional variances of returns and furthermore, they provide more efficient estimators since they allow risk to be time varying. Secondly, as is well documented in the empirical literature, volatility clustering is observed in asset returns series. Large (small) changes in returns tend to be followed by other large (small) changes. An immediate consequence of volatility clustering is that volatility shocks today will affect the expectation of volatility in periods ahead. Therefore, GARCH models are specially designed to capture this property. Thirdly, given the computational difficulties in estimating large systems of asset returns and convergence problems, the choice of a parsimonious parameterization of a multivariate GARCH framework is vital. The present study adopts the parameterization of Flavin & Wickens (1998, 2003). This specification reduces the number of parameters to be estimated, it guarantees that the time-varying (co)variance matrices are symmetric and positive definite[10] and most importantly, it contemporaneously decomposes the conditional second-order moments into the sum of long-term and short-term elements. Receiving an estimate of both the long- and short- term dynamics allows us to assess i) if the short-term dynamics are important and ii) which parameters play a key-role in determining the departures from the long-term value. Finally, the main feature of GARCH in-mean models is that the conditional mean equation is a function of the conditional (co)variance of the process, allowing for interactions between expected returns and volatility while the risk-premium is changing over time. This directly relates the uncertainty in returns (and so the risk premium required by investors) with macroeconomic volatility. For the purpose of our analysis, we estimate the following multivariate GARCH (1,1) in-mean model with a VAR system augmented with the GARCH effects:

[10] Flavin & Wickens (1998, 2003) formulation is consistent with the covariance stationary originally proposed by Engle & Kroner (1995).

$$z_t = \gamma_0 + \gamma_1 z_{t-1} + \gamma_2 h_t + \varepsilon_t \tag{2.15}$$

$$\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$$

$$H_t = C'C + A'(\varepsilon_{t-1}\varepsilon'_{t-1} - C'C)A + B'(H_{t-1} - C'C)B \tag{2.16}$$

The variables in the mean equation (2.15) are defined as follows: $z_t = \left(r_{jt}, F_{kt}\right)'$ is a 2×2 vector of the excess currency returns or deviations from UIP at time t, with r_{jt} representing the excess return of an asset j at time t, and F_{kt} with $k=2$ denoting the two macroeconomic variables, namely inflation and industrial production; γ_0 is a 2×2 vector of constants; γ_1 is a 2×2 vector of estimated coefficients that capture the persistence of the macroeconomic variables in the conditional mean; γ_2 is an 2×1 vector of estimated coefficients which captures the effects of the conditional (co)variance, h_t, in the mean equation and ε_t is a 1×2 vector of error terms. The errors are normally distributed with zero mean and a time-varying conditional covariance matrix, H_t. H_t is modelled as a GARCH(1,1) process in equation (2.16) where C is a 2×2 symmetric matrix of constants or the unconditional (long term) matrix; A and B are 2×2 symmetric coefficient matrices which capture the short term dynamics, with A capturing the effects of shocks (lagged squared residuals) on current volatility and B capturing the effects of the past period's volatility on current volatility. Equation (2.16) specifies the conditional volatility of excess currency returns, H_t, as a function of its long run values, lagged error terms, and lagged variance-covariance terms and provides an estimate of both the unconditional (long-term) and the conditional (short-term) covariance matrices. If the conditional second moment process is covariance stationary, then matrix C can be written as follows $Vec\,(C) = \left(I - \left(A\otimes A\right)' - \left(B\otimes B\right)' \right)\cdot Vec(H_0)$ where H_0 is the unconditional covariance matrix of the residuals. The number of parameters to be estimated in the conditional second moment process are reduced and based on the formula: $n \times \left[n\,(n+1)/2 \right]$.

Using the assumption of conditional normality, we could estimate eq. (2.16) by maximum likelihood. For sample size T, the log-likelihood function is the sum of the conditional log-likelihood for each observation:

$$\ln L(\theta) = -\frac{NT}{2}\ln 2\pi - \frac{1}{2}\sum_{t=1}^{T}\ln\left|H_t(\theta)\right| - \frac{1}{2}\sum_{t=1}^{T}\varepsilon_t(\theta)'\,H_t(\theta)^{-1}\,\varepsilon_t(\theta) \qquad (2.17)$$

The vector θ contains the unknown parameters of the model and N is the number of variables. As violations of the normality assumption are often observed in financial time series, we use the quasi-maximum likelihood (QML) approach, proposed by Bollerslev & Wooldridge (1992). The main advantage of this approach is that under fairly weak conditions, the QML estimator is consistent even when the conditional distribution of the residuals is not normal and it allows us to make statistical inferences based on robust Wald statistics. Non-linear optimization is performed using the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm.

2.3.2 Data

We collect data from the G-7 countries. This set of wealthy nations is characterized by open and well-developed financial systems thereby reducing the effect of financial frictions in the analysis. Furthermore, these countries are unlikely to suffer from "peso problems" and political risk. Using the US as our benchmark, the sample consists of monthly data on spot exchange rates, short-term Treasury-Bills, Consumer Price and Industrial Production Indexes. In particular, we focus on the end-of-month dollar exchange rates of the Canadian Dollar (CAD), French Frank (FRF), German Mark (DEM), Italian Lire (ITL), Japanese Yen (JP¥) and on the British Pound (GBP). The annualized excess currency return (or deviations from UIP or nominal risk premium) is generated by $\left[\left(1+\left(i_t^*/100\right)\right)+\left(\ln\left(s_{t+1}/s_t\right)\right)*12\right]-\left(1+\left(i_t/100\right)\right)$ 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 short-term Treasury-Bill rate of the foreign country known at time t, and i_t is the US annualized short-term Treasury-Bill rate known at time t. For the United Kingdom the Eurodollar deposit rate is taken. For the purpose of this study, we consider two macroeconomic factors as the main determinants of the foreign exchange risk. To calculate inflation we have taken each country's annualized growth rate of the seasonally adjusted consumer price index and subtracted it from the equivalent US annualized growth rate of the seasonally adjusted consumer price index. Industrial production is a popular measure of the overall economic activity (see for example Grier, Henry & Shields, 2004; Don Bredin & Fountas 2008). Industrial production is calculated in a similar manner as inflation above, by taking the difference of the US and one of the other countries of our sample, using the analogous industrial production seasonal adjusted time-series. Monthly data is used because of the unavailability of higher frequency data (e.g. weekly) of these macroeconomic time-series. All the data has been obtained from International Financial Statistics (IFS) of the International Monetary Fund and covers the period from 1977:07 through 2007:01. Hansen & Hodrick (1983) argue that the flexible exchange rate system was formally ratified in January 1976 according to the IMF Articles of Agreement and any source of uncertainty concerning the operation of flexible exchange rates is eliminated. Combined with the fact that the data for Italy starts from 1977 onwards, we decided to choose this starting date for our analysis. However, the availability of data is not necessarily the same for all countries. For example, the data for the French T-bill series ends at 2004:10.

[Insert Table 2.1 about here]

Table 2.1 shows basic statistics and diagnostic tests carried out on the time-series. Panel A displays the summary statistics for the excess currency returns series for the G-7 countries. Italy shows the highest positive mean returns while Japan displays the lowest. This finding implies that, from the perspective of a US investor, on average, investing in Japan is less profitable than investing in Italy, France or Canada. For standard deviation, all countries display approximately the same values, with the highest displayed in Japan and the lowest in Canada. Panel A also reports skewness, excess kurtosis, and Jarque-Bera test statistics. All the excess returns exhibit significant excess kurtosis at 10% level, illustrating that the hypothesis of normality in returns is rejected in all cases. The Jarque-Bera test-statistics verifies this finding. Panel B of Table 2.1 displays the summary statistics for the growth of inflation (in relation to the U.S) series. On average, the highest mean is observed in Italy. However, Canada, Germany and Japan display negative means. This finding suggests that these countries have a lower inflation growth rate in relation to the US inflation growth rate. Concerning the standard deviations, the UK displays the highest. All the other countries follow closely. Skewness, kurtosis and Jarque-Bera tests also reject the normality hypothesis at 1% level. Finally, Panel C of Table 2.1 displays the summary statistics for the growth rate of industrial production (in relation to the U.S) series for the aforementioned group of countries. All the series display on average negative mean growth rates of industrial production relative to the US growth rates. This finding suggests that the economic activity of these countries is lower in relation to the US. Germany displays the highest standard deviation. The kurtosis and Jarque-Bera tests significantly reject the normality hypothesis at 1% level.

2.4 Discussion of Results

2.4.1 Unit Root Tests

We begin our analysis by performing unit root tests. A method employed extensively in the literature to infer whether data is stationary or not is the augmented version of the Dickey-Fuller (ADF)[11] test. Following the literature, all data series are in natural logarithms. Consistent with the presence of long-run UIP, we decisively reject the null hypothesis of a unit root for all countries. Also the inflation differential and industrial production growth differential are stationary. This makes sense from an economic point of view. In series with unit roots, an impact of a shock, which may have been caused from policy interventions for example, is permanent. In the opposite case, for stationary series, the impact of a shock has only a temporary effect and dies out over time. Hence, all our data series are stationary.

We can further use these results to garner more information regarding the speed of mean reversion or persistence of the variables we study. In particular, we calculate the half-life of a shock. The half-live is defined as the time needed for the shock to move halfway back towards its mean value following a deviation from it. We assume that the deviation of the excess currency return, r_t^*, from its long-run value, $\tilde{r}_0$, follows an $AR(1)$ process:

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11 A standard autoregressive model ($AR(1)$) is $X_t = \psi X_{t-1} + \varepsilon_t$, where X_t is the variable under investigation, ψ is the parameter coefficient and ε_t is a white noise innovation. The regression model can be re-stated as: $\Delta X_t = (\psi - 1) X_{t-1} + \varepsilon_t = \theta X_{t-1} + \varepsilon_t$ where Δ is the first difference operator (i.e. $\Delta X_t = X_t - X_{t-1}$) and $\theta = \psi - 1$ is the parameter coefficient of the variable we examine. This procedure can easily be generalized to the testing of a single unit root in an $AR(q)$ process where q is the number of extra lags added in the model. The inclusion of the additional lags (e.g. $\Delta X_{t-1}, \ldots, \Delta X_{t-q}$) is necessary in order to make the error term, ε_t, asymptotically a white noise process, which is crucial for the distributional results to be valid. Hence, the general form of the ADF test has the following form: $\Delta X_t = \mu + \theta X_{t-1} + \sum_{i=1}^{q} \phi_i \Delta X_{t-1} + \varepsilon_t$ where μ is a constant term, and ϕ is the parameter coefficient. The ADF test examines the parameter θ based on its regression $t = \dfrac{\theta - 1}{se(\theta)}$ ratio. The null hypothesis, that is $H_0 : \theta = 0$ implies no long-term equilibrium for the variable X_t (unit root) against the alternative $H_0 : |\theta| \prec 0$ (stationarity). The number of augmenting lags is determined by minimizing the Akaike information criterion.

$r_t^* - \tilde{r}_0 = \tilde{\beta}(r_{t-1}^* - \tilde{r}_0) + u_t$ where u_t again is the white noise. Then $\tilde{\beta}^{\vartheta}$ is the percentage deviation from equilibrium, calculated as $\tilde{\beta}^{\vartheta} = 1/2 \Rightarrow \vartheta = -\log 2/\log\tilde{\beta}$, where ϑ is the speed of adjustment halfway back to UIP equilibrium. Results are displayed in Table 2.2.

[Insert Table 2.2 about here]

The results in Table 2.2 suggest that the half-life of the shock varies from a low, of approximately two months in the case of Canada, to a high of just over 4 months in the case of Italy. Tanner (1998) also finds that half of the UIP deviation dies out at two- to three- months for both advanced and developing countries. This raises a number of points. Firstly, there is a certain amount of persistence in the shock and therefore this needs to be explained. Secondly, financial markets are characterized by lower shock persistence than goods markets, as the half-life reported in tests of purchasing power parity[12] (PPP) is usually about three-to-five years (Rogoff, 1996)[13]. Other studies report similar results. Frankel & Rose (1996) construct a broad panel of 150 countries and find that on average the half-life of a shock is four years. More recent studies find evidence of considerably shorter half-lives. For instance, Chortareas & Kapetanios (2004) develop an alternative measurement of half-lives for real exchange rates and show that the speed of adjustment to PPP is less than two years at best. Lothian & Taylor (2008) find that the half-life of deviations from PPP over two centuries for the dollar-sterling real exchange rate is reduced to two-and-a-half years, when nonlinear dynamics of adjustments towards PPP are accounted for. Norman (2009) also argues that the mean reversion of real exchange rates is nonlinear and this can potentially solve the PPP puzzle.

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12 The purchasing power parity (PPP) postulates that nominal exchange rates should adjust to equate the price of goods and services across countries. However, this condition does not apply in practice. Usually, PPP is perceived as a valid long-run condition (in determining the exchange rate in the long-run). The general consensus emerging from the empirical tests of PPP is that it does *not* hold for major exchange rates *continuously* (see Sarno, 2005 for a survey).

13 Rogoff, (1996) initially proposed the *PPP puzzle* which states the difficulty of reconciling very high short-term volatility of real exchange rates with very slow rates of mean reversion.

In summation, in terms of relative efficiency, the speed of adjustment towards UIP is much faster in financial markets, ranging from about two- to a maximum of four-months, compared to a much slower speed of convergence towards PPP in goods markets. This result is somewhat expected, if we consider that commodity prices are relatively sticky whilst exchange rates are much more volatile. Moreover, the changes in exchange rates as they adjust to the arrival of new information are more effective and faster than that of commodity prices.

2.4.2 Stability Tests

We are now returning to the short-run properties, as UIP is shown to be consistent in long-run. To assess the stability of our parameter estimates, we perform the Hansen (1992) stability test. Its main advantage is that it does not require selecting potential structural break points[14]. However, the test assumes that the variables are stationary (Hansen, 1992). We test each equation of the following bivariate system for parameter stability:

$$r_t^* = b_{11} + b_{12} r_{t-1}^* + b_{13} F_{kt-1} + u_{1t} \tag{2.18}$$

$$F_{kt} = b_{21} + b_{22} r_{t-1}^* + b_{23} F_{kt-1} + u_{2t} \tag{2.19}$$

recall that r_t^* stands for the excess currency returns, F_{kt} with $k = 2$ denotes the two macroeconomic risk factors, inflation differential and industrial production growth

14 We find no evidence of structural breaks within the sample for all series. We perform two structural breakpoint tests: the Andrews-Quandt and the Andrew-Ploberger tests (see for example Andrews (1993), Andrews & Ploberger (1994) for a nice discussion on these tests), with p-values using Hansen's (1997) approximations. Under the null hypothesis of no-structural break against the alternative of one-time unknown break, the Andrews- Ploberger test fits each equation individually in each sub-sample and tests whether the estimated equations differ significantly from each other. Any significant difference points out that there is a structural change in the relationship.

differential (see section 2), and u again denotes the disturbance term. The Hansen stability test rejects the null hypothesis of stable estimates if the individual t-statistics are significant. Results of the stability test for the excess currency return with the inflation differential are displayed in Table 2.3.

[Insert Table 2.3 about here]

Our results in Table 2.3 suggest that the majority of the parameter estimates in equations (2.18) and (2.19) are stable[15] over the sample. However, most of the evidence of instability is found in the variance parameters, implying that a GARCH modelling of the conditional second order moments of our series would be appropriate. We next test equation (2.19) for parameter stability after replacing the inflation differential with the industrial production growth differential variable. Results are reported in Table 2.4.

[Insert Table 2.4 about here]

Interestingly, we observe the same pattern. The results in Table 2.4 suggest that the vast majority of the coefficients in (2.18) and (2.19) are stable over the sample. Furthermore, we also find strong evidence of instability in the variance parameters. Hence, the overall findings add further support to the adoption of the GARCH in-mean model, implying that the conditional second-order moments exhibit time variation.

Since there is no unanimity in the literature about the optimal stability test, we support the Hansen (1992) test by the Breusch-Godfrey test (or Lagrange Multiplier test; LM hereafter), suggested by Breusch (1978) and Godfrey (1978) for testing the ARCH behaviour in the residuals. They propose a test where the null hypothesis of no-ARCH

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15 Even though a few parameters are unstable individually, they appear to be stable jointly over time. The joint tests are not reported.

errors is tested against the alternative of higher order serial correlation, which can be given in either autoregressive or moving average form. For the purpose of our analysis, we regress the squared residuals on a constant and to up six lagged values of the squared residuals. Table 2.5 reports the results. The p-values from the LM test are displayed in parenthesis.

[Insert Table 2.5 about here]

Overall, we find strong evidence of ARCH effects in our data. Table 2.5 clearly demonstrates that the null hypothesis of no-ARCH effects in the lagged squared residuals up to order six is strongly rejected at 1% significance level, in all series and across all countries. Therefore, we can conclude that the ARCH parameters are correctly specified and thus the conditional error variance is best modeled as an ARCH process. Having tested for unit roots and stability, we can now proceed further. The next section discusses the one-factor model for currency risk premium.

2.5 One-factor models

Ideally, we would like to allow a number of macroeconomic factors to simultaneously influence the excess currency return but we are limited by the dimensionality problem inherent in GARCH(1,1) in-mean models. Therefore, we initially allow the macroeconomic variables to exert their impact one by one. In the subsections 4.3.1 and 4.3.2 we present bivariate VAR-GARCH(1,1) in-mean specifications that jointly model the excess currency returns with each of the macroeconomic risk factors. We first discuss briefly the results obtained in the conditional mean equation and after we shift our attention to the conditional second-order moments of the excess currency returns. The implementation of the GARCH in mean model proved to be quite difficult due to unstable estimates and convergence issues which we discuss later. Therefore, we present results only for those countries where we are happy that we have found a global optimum and stable parameter estimates.

2.5.1 Time-varying risk premium and inflation differential

In this subsection, we consider the influence of the inflation differential (in relation to the US) on the excess currency returns, using a bivariate VAR-GARCH(1,1) in-mean setting. The estimated parameters for the mean equation are displayed in Table 2.6. In each case, associated robust t-values are reported in parentheses.

[Insert Table 2.6 about here]

The results as set out in Table 2.6 are satisfactory. There is no evidence of persistence of our variables in the excess currency return equation in most countries. This is shown from the statistically insignificant lags of both of our series, apart from Italy (the first two rows). With respect to the conditional variance of the excess return in the mean, we observe that it is highly significant and positive in all countries, apart from Canada (third row). The positive sign of the coefficients indicates a positive relationship between the excess return (UIP deviation) and the conditional variance, which implies that on average risk-averse investors would demand higher risk-premium when the uncertainty is greater. A possible explanation for the negative sign for Canada is that US asset return is more sensitive to money market volatility than the Canadian exchange adjusted return. This could result in a decreasing differential in response to increased money market volatility. Moreover, we find no evidence that the inflation differential exerts an influence through its co-variation with the currency risk premium in the mean in all countries considered in this study (fourth row). Therefore, the effect of this macroeconomic risk factor in explaining the behaviour of the currency risk premium in the conditional mean equation is not significant.

Turning to the conditional second-order moments, Table 2.7 reports the estimated coefficients for the conditional (co)variance processes in both the *short*- and *long*-run. In particular, Panel A and B present the estimated coefficients of the short-run ARCH and GARCH effects whilst Panel C displays the long-run effects of the conditional (co)variance process. Numbers in parentheses are robust *t*-statistics.

[Insert Table 2.7 about here]

In general, our specification performs well. The significant conditional heteroskedasticity inherent in our data is well captured by the short run coefficient matrices of A and B. In particular, a careful look at the ARCH effects (Panel A), suggests that the lagged squared innovations exert a significant impact on the conditional volatility of excess currency returns. The evidence for this can be seen in the diagonal elements of the A matrix, i.e. a_{11} and a_{22}, which are statistically significant across countries. Also, the off-diagonal elements i.e. a_{21}, indicate that the covariance effects are statistically significant in some countries, implying important time-variation in the co-movements between the volatility of currency risk premia and inflation differential in the short-run. The positive sign means that two shocks have a positive effect on the conditional covariance returns equation. In relation to the persistence effects of lagged volatility, the results are very interesting. All the diagonal elements of the B matrix, i.e. β_{11} and β_{22}, are statistically significant in all countries. This result implies that the previous period's effect of a shock is persistent and has a great impact on today's excess returns volatility. Additionally, the covariance effects as captured by the off-diagonal elements of B matrix i.e. β_{21}, are predominantly statistically significant and less than one, in all countries. This finding indicates a strong co-movement between the volatility of the currency risk premia and the inflation differential. Their magnitudes are all relatively high, implying a long memory in the conditional variance. Lastly, with regard to the long-run volatility, C matrix, only its diagonal elements, i.e. c_{11} and c_{22}, are statistically significant and positive, though their magnitudes are very small, suggesting all or nearly all volatility in currency risk premium is made up of time-varying components. In short, the overall evidence supports our choice of modeling the excess currency returns with the inflation differential as a GARCH in-mean process[16].

2.5.2 Time-varying risk-premium and industrial production differential

We next assess the influence of another macroeconomic variable, industrial production, on the excess currency return. For the purpose of our analysis, however, we take the difference of the industrial production growth rates (in relation to the US) and we investigate how this difference affects the risk premium. If the difference is negative, implying that the foreign country has lower production growth than the domestic (US), then the domestic investor may feel uncertain as to whether to invest in a foreign asset. In absolute terms, the bigger the variability in the production rates of countries, the higher the risk premium an investor would demand. Bearing this in mind, we expect that the covariance term between the currency risk premium and the industrial production

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16 As an alternative specification, we used Glosten, Jagannathan, & Runkle (GJR) (1993) asymmetric GARCH (1,1) model to allow for the asymmetric response of volatility to news. Engle & Ng (1993), Kim & Kon (1994) clearly prefer the GJR specification to others (e.g E-GARCH), after comparing different asymmetric volatility models. In contrast to findings in Kizys & Spencer (2008), who studied the UK equity risk premium using an E-GARCH in-mean model, we did not find evidence that a negative macroeconomic shock had a different effect on an asset's foreign exchange risk premium volatility than a positive shock.

difference would be significant. To test this, we again use a bivariate VAR-GARCH in-mean(1,1) model, as specified in equations (2.15) and (2.16). Table 2.8 reports the parameter estimates for the mean equations. Again, numbers in parentheses refer to the robust *t*-statistics.

[Insert Table 2.8 about here]

Results in Table 2.8 are very encouraging. In general, the excess currency returns are serially independent and unpredictable across countries. The effects of own lagged returns on current values are statistically indistinguishable from zero in the mean equation (first row). In the same manner, the lagged values of the industrial production differential are not statistically significant across all countries (second row). Interestingly, we find that the conditional variance of the currency risk premium is statistically significant and positive in all countries of our sample (third row). As was the case in section 4.3.1, the results confirm a positive relationship between the risk premium and its conditional variance, apart from Canada (third row). Where the conditional covariance terms in the mean are concerned, we find evidence that the industrial production exerts a strong influence through its co-variation with the risk premium for Italy and the UK (fourth row). The positive sign indicates a positive relationship between the excess currency returns and its covariation with the industrial production. In short, the second macroeconomic risk factor impacts strongly on excess currency returns in the mean equation.

With respect to the conditional variance equation of the excess currency returns, the estimates for both the *short*- and *long*-run, are reported in Table 2.9.

[Insert Table 2.9 about here]

Once again, we find that the parameter estimates of our series display significant evidence of time variation, which in turn provides strong evidence in favour of the specification adopted here. To be more specific, the ARCH volatility of each of our variables stemming both from the diagonal as well as from the non-diagonal elements of the A matrix, are all predominantly statistically significant across all countries in our sample (Panel A). This finding suggests that the past squared innovations of our series have an important effect on the conditional volatility of currency risk premium. In the same vein, the statistically significant covariance terms indicate strong co-movements between the volatility of currency risk premium and industrial production differential. In relation to the persistence effects of lagged volatility, the results are also pronounced (Panel B). We clearly find evidence of time variation in all persistence estimates of the B matrix across all countries. The magnitude of the estimates is big (but less than one) which indicates high persistence of volatility shocks. Moreover, the off-diagonal elements are also significant. This finding demonstrates a strong covariance between the volatility of excess currency returns and industrial production in the short run. Likewise, the long run results (Panel C) suggest that the long-run time-independent component of volatility of each of our variables is only significant for the diagonal elements, and to a lesser extent for the off-diagonal, across countries. To sum-up, we find similar results with those reported in the one-factor model (with the inflation differential) in section 4.3.1. Our results strongly suggest that the industrial production difference to a great extent explains the variability of currency risk premium.

2.6 Two-factor model

The results from the one-factor models presented in sections 4.3.1 and 4.3.2, highlight the fact that our specification as given in equations (2.15) and (2.16) captures the influence of our macroeconomic risk factors on currency risk premium in both the conditional mean and conditional variance–covariance process. However, a more complete knowledge of this relationship could potentially come from their simultaneous estimation. In the next subsection, we model the joint conditional distribution of both the macroeconomic risk factors with the excess currency returns using a trivariate VAR-GARCH (1,1) in-mean setting in order to explore their contribution in explaining the behaviour of the currency risk premium.

2.6.1 Time-varying risk-premium, inflation and industrial production differential

As stated above, in this section we employ a trivariate VAR-GARCH(1,1) in-mean analysis that jointly models the excess currency returns with the macroeconomic risk factors of our interest. As before, we allow the conditional mean of the distribution to be affected by lagged levels of the variables and by their conditional (co)variance matrices. As usual, we first present the results of the conditional mean and after we refer to the conditional second order moments. The results for the mean equation are displayed in Table 2.10.

[Insert Table 2.10 about here]

In general, the results are in accordance with those obtained from the bivariate models. Once again, we find that all time-series are largely serially independent and unpredictable. The lagged values of the coefficients do not significantly differ from zero, in the majority of cases (the first three rows). As expected, the conditional variance of returns is found highly significant in all countries of our sample (fourth row). Apart from Canada, the positive sign is consistent with the findings obtained from the bivariate models (see Tables 2.6 & 2.7). Interestingly, the inflation differential exerts a strong and positive influence on currency risk premium through its co-variation in the mean, ceteris paribus, in most countries (fifth row). That was not the case in the bivariate model (recall Table 2.6). The difference between the two specifications may be due to the interactions between the two macroeconomic variables and the trivariate case. For instance, the covariance term β_{15} (see Table 2.10) may pick up an indirect effect of the industrial production growth differential on the inflation differential. Also the precision of the estimates may have changed from the bivariate to trivariate specification as the information set expands. Lastly, the conditional covariance between excess returns and the industrial production differential is rather weak, ceteris paribus (sixth row). Combined together, our trivariate "in-mean" analysis suggests that the variability of excess return and its covariation with both the inflation differential and to a lesser extent with the industrial production differential are the main determinants of the currency risk premium in the mean equation.

Conditional second-order moments of the trivariate model follow next. Once again, Panels A and B in Table 2.11, present the conditional short-term (co)variance estimates while Panel C of the same table contains the conditional long-term (co)variance estimates. All panels have robust *t*–statistics in parenthesis.

[Insert Table 2.11 about here]

Interestingly, the results obtained from the trivariate model are compatible with those from the bivariate models. The short-run estimates (Panels A & B) indicate that the conditional variances are predominantly statistically significant as well as the vast majority of the conditional covariances, for all countries over the sample period. Therefore, our trivariate specification suggests that there is strong evidence of ARCH and GARCH effects in the excess currency returns model. This finding underlines the significance of our macroeconomic risk factors in determining the volatility of the currency risk premium. Likewise, the estimates for the long-run volatility (Panel C) are significant in most cases. The volatility of the variables comes both from their own past values (diagonal elements) and from some statistically significant covariance terms (off-diagonal elements). Taken together, the overall evidence demonstrates that the macroeconomic factors are important sources of volatility and help to explain deviations from the UIP condition through their impact on the conditional second-order moments.

In Figures 2.1, 2.2 and 2.3, the risk premia of the three models considered are shown together with the macroeconomic variables.

[Insert Figures 2.1 -2.3 about here]

There are a number of interesting features emerging in these figures. Firstly, the risk premium is particularly more volatile in the early and mid eighties and in the nineties than in the last decade. Consistent with the findings of Smith & Wickens (2001), we observe that periods of high exchange rate volatility are related with large risk premia. For Italy, the risk premia are particularly volatile in the early years of the exchange rate mechanism (ERM-I) and prior to the introduction of euro as a single currency in the eurozone. Even though the UK eventually did not join the eurozone, it displays the same pattern: the risk premia seem to be higher before the early nineties, but then steadily decrease towards the end of the sample. For Canada, the risk premium increases slightly towards the end of the sample. Secondly, to get a better understanding of the risk premium pattern, we refer to the time varying conditional covariances between risk premium and inflation differential. In the early nineties, countries like Canada, Italy, the UK and the US have all shifted to a new monetary policy regime, inflation targeting. Canada and the UK officially adopted the inflation-control targeting framework in 1991 and 1992 respectively whilst Italy began to publicize similar quantified inflation objectives to guide its monetary policy by 1994 (Baltensperger et. al., 2007). An immediate consequence of this policy is the decrease of the volatility in the inflation rates. In the case of Canada, inflation has dropped below US inflation (Groeneveld et. al., 1998) and stayed at these low levels for more than a decade. Our figures depict this negative inflation differential. Lastly, there is a considerable time-variation in the conditional covariance between risk premia and the industrial production differential in all countries. As in the case of inflation, this covariation is much more volatile at the early part of our sample.

We consider that our results shed some light on the on-going debate of the risk-premium in the foreign exchange market. Our findings are useful for investors and policy makers in several respects. Firstly, they underline the importance of modelling the joint distribution of currency risk premium and the macroeconomic risk factors, using a multivariate GARCH in mean framework, in order to obtain a direct estimate of their contribution in explaining the behaviour of an assets' risk premium. Secondly, quantifying the impact of changes in macroeconomic variables on risk premium will facilitate investors or portfolio managers- who form their expectations on the basis of macroeconomic information- to better assess their exposure to macroeconomic events when evaluating their investment opportunities. Lastly, the identification of the impact of the macroeconomic variables will enable the architects of the macroeconomic policies to carefully design policies that prevent shocks from hitting the financial or the economic system in general in order to promote stability.

However, to directly estimate the contribution of macroeconomic sources of risk to an asset's risk premium, using multivariate GARCH in mean models was not an easy process and had several drawbacks. The most important is the computational problems we came across while estimating large systems of asset returns. GARCH models tend to be heavily parameterized, which in turn can cause numerical convergence problems. The convergence of the associated likelihood function is sensitive both to extreme data values and to starting values of the iteration. When there are also GARCH in-mean effects, as in our case, then it gets even harder to achieve convergence. Therefore, estimations can be imprecise or unstable. This should not come as a surprise as it has been well documented by Bollerslev (2001) for example who states that multivariate models can be subject to severe specification error. Lastly, the lack of availability of high frequency macroeconomic data - and thus lack of adequate heteroskedasticity in the data- (Smith & Wickens, 2001) or mismeasurement of some macroeconomic data indexes (Hu, 1997) may cause some misspecification problems for the risk premium model and cause convergence problems. Similar considerations are also expressed in Kocenda & Poghosyan (2009). All the above reasons may explain why the results are not supportive in all cases, even when we choose different estimation periods, algorithms, or alternative specification models.

2.7 Summary & Conclusions

We explore the hypothesis that macroeconomic variables are important sources of volatility in explaining the behaviour of an asset's risk premium, using data from the G-7 countries. The Conditional Multifactor Asset Pricing Model is utilized as it relates the currency risk premium directly with two macroeconomic risk factors. We employ two factors namely inflation differential and industrial production differential (all in relation to the US). To jointly model the distributions of excess currency returns with the macroeconomic risk factors, we use multivariate VAR-GARCH-in-mean(1,1) models, a parameterization of Flavin & Wickens (1998). Its distinctive feature is that it obtains an estimate of both the unconditional (long-run) covariance matrix and the conditional covariance matrix (the short-run dynamics) and, thus, we are able to identify which macroeconomic variables exert a direct or an indirect influence.

Our empirical results support the time-varying risk premium hypothesis (Tai, 2001; Lustig & Verdelhan, 2007) and emphasize the essential role played by the macroeconomic risk factors in determining the behaviour of the currency risk premium (Smith & Wickens, 2001; Flavin & Limosani, 2007; Kocenda & Poghosyan, 2009). A key feature of our research is that the macroeconomic risk factors exert both a *direct impact*- through the conditional mean equation- and an *indirect impact*- through the GARCH in mean effects- on currency risk premium. The indirect effect is captured through the conditional variance, which includes covariance terms with each of the macroeconomic factors. The indirect effect is stronger than the direct.

In summation, the overall evidence provided by either the one-factor models or the two-factor model: i) supports our choice of modeling the conditional (co)variance matrix as a GARCH in mean process and ii) suggests that the time-varying risk-premium may be attributed, at least in part, to macroeconomic volatility. However, further research should investigate whether the volatility of other macroeconomic variables also help to determine the time-varying risk-premium in the foreign exchange markets.

Table 2.1: Summary Statistic

	CAD	FR	GRM	IT	JP	UK
Panel A: *Excess Currency Returns* (or *deviations from UIP*)						
Mean	0.01	0.01	-0.02	0.05	-0.05	-0.002
Std. Deviation	0.18	0.38	0.38	0.36	0.39	0.36
Skewness	0.07	0.23***	0.05	0.44*	-0.40*	0.10
Kurtosis	0.66*	0.91*	0.93*	1.38*	1.44*	1.91*
Jarque-Bera (J-B)	6.90**	14.35*	13.21*	39.77*	40.47*	54.72*
Panel B: *Inflation* (in relation to the US)						
Mean	-0.00069	0.001	-0.01	0.02	-0.02	0.009
Std. Deviation	0.04	0.03	0.04	0.05	0.05	0.06
Skewness	0.73*	1.11*	0.79*	1.02*	0.10*	1.75*
Kurtosis	3.88*	3.29*	2.42*	2.04*	1.61*	8.32*
Jarque-Bera (J-B)	254.97*	216.26*	124.40*	124.21*	39.04*	1206.92*
Panel C: *Industrial Production* (in relation to the US)						
Mean	-0.003	-0.012	-0.0073	-0.008	-0.001	-0.01
Std. Deviation	0.14	0.15	0.21	0.20	0.17	0.15
Skewness	0.98*	-0.14	0.23***	0.51*	-0.02	-0.19
Kurtosis	6.82*	0.71*	9.14*	4.61*	0.45***	4.58*
Jarque-Bera (J-B)	747.66*	8.22*	1239.69*	330.77*	3.14	312.54*

The asterisks *, **, *** denote the rejection of the null hypothesis at the 10%, 5% and 1% significance levels respectively.

Table 2.2: *Half-life* measurement on an annual basis

CAD	0.1389
FR	0.1810
GRM	0.1911
IT	0.3375
JP	0.2361
UK	0.2230

Table 2.3: *Stability* test results for Risk Premium & Inflation differential

Countries	Equation 2.18			
	b_{11}	b_{12}	b_{13}	σ_1
CAD	0.753***	0.057	0.155	2.061***
FR	0.119	0.302	0.147	0.368*
GRM	0.139	0.265	0.155	0.804***
IT	0.169	0.205	0.267	0.278
JP	0.164	0.028	0.199	0.379*
UK	0.090	0.069	0.352	1.127***

Countries	Equation 2.19			
	b_{21}	b_{22}	b_{23}	σ_2
CAD	0.649**	0.037	0.063	0.955***
FR	1.86***	0.116	1.065***	0.804***
GRM	1.568***	0.112	2.828***	0.745**
IT	2.691***	0.051	0.839***	1.930***
JP	0.217	0.042	0.055	2.172***
UK	0.595**	0.321	0.142	0.583**

Equation 2.18: $r_t^* = b_{11} + b_{12} r_{t-1}^* + b_{13} F_{1t-1} + u_{1t}$

Equation 2.19: $F_{1t} = b_{21} + b_{22} r_{t-1}^* + b_{23} F_{1t-1} + u_{2t}$

where F_{1t} denotes Inflation differential. The asterisks ***,**, * imply that the null hypothesis of stability is rejected at the 1%, 5% and 10% significance levels respectively.

Table 2.4: *Stability test* results for Risk Premium & Ind. Prod. differential

Countries	Equation 2.18			
	b_{31}	b_{32}	b_{33}	σ_3
CAD	0.806***	0.051	0.080	2.115***
FR	0.234	0.248	0.096	0.427*
GRM	0.127	0.242	0.102	0.790***
IT	0.571**	0.097	0.068	0.299
JP	0.165	0.027	0.060	0.411*
UK	0.099	0.075	0.087	1.142***

Countries	Equation 2.19			
	b_{41}	b_{42}	b_{43}	σ_4
CAD	0.095	0.223	0.052	1.143***
FR	0.065	0.107	0.492	1.771***
GRM	0.077	0.337	0.023	0.991***
IT	0.391*	0.129	0.095	3.675***
JP	0.724**	0.121	0.049	0.287
UK	0.195	0.472*	0.069	3.084***

Equation 3: $r_t^* = b_{31} + b_{32} r_{t-1}^* + b_{33} F_{2t-1} + u_{3t}$

Equation 4: $F_{2t} = b_{21} + b_{22} r_{t-1}^* + b_{23} F_{2t-1} + u_{2t}$

where F_{2t} denotes Industrial Production growth differential. The asterisks ***,**, * imply that the null hypothesis of *stability* is rejected at the 1%, 5% and 10% significance levels respectively.

Table 2.5: Test of the *ARCH errors*

	Excess Returns	Inflation	IP
CAD	106.87***	56.51***	48.94***
FR	86.36***	58.34***	94.74***
GRM	94.34***	69.92***	94.69***
IT	82.28***	115.65***	70.17***
JP	90.71***	77.90***	109.46***
UK	85.30***	34.77***	99.98***

The asterisks, ***, denote the rejection of the null hypothesis of *no-ARCH errors* at the 1% significance level.

Table 2.6: Conditional *mean* process of Risk Premium & Inflation differential

	CAD	**IT**	**JP**	**UK**
β_{11}	-0.03 (-0.62)	0.06 (1.38)	0.08 (1.56)	0.04 (0.91)
β_{12}	-0.04 (-0.22)	**1.02** **(3.26)**	-0.31 (-1.08)	-0.09 (-0.34)
β_{13}	**-5.70** **(-19.17)**	**1.78** **(12.32)**	**0.22** **(3.13)**	**0.69** **(5.92)**
β_{14}	5.85 (0.84)	10.22 (0.83)	4.30 (0.73)	6.55 (1.40)

The bivariate VAR(1,1) specification is:

$$Y_t = \beta_{10} + \beta_{11} \mathrm{Y}_{t-1} + \beta_{12} X_{t-1} + \beta_{13} H_{11,t} + \beta_{14} H_{12,t} + \varepsilon_{1,t}$$

$$X_t = \beta_{20} + \beta_{21} \mathrm{Y}_{t-1} + \beta_{22} X_{t-1} + \varepsilon_{2,t}$$

with $\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$ where Y_t stands for the excess currency returns and X_t stands or the Inflation differential. Optimization is performed using the BFGS algorithm. For France and Germany the maximum likelihood algorithm failed with the available data. Robust ***t**-statistics* are in parentheses. **Bold** numbers indicate the statistically significant values.

Table 2.7: Conditional *(co)variance* process of Risk Premium & Inflation differential

	CAD	**IT**	**JP**	**UK**
Panel A: Estimated coefficients of the *short-term* conditional (co)variance processes: *ARCH effects*				
a_{11}	**0.18** **(11.24)**	**0.16** **(5.04)**	**0.31** **(15.63)**	**0.34** **(21.25)**
a_{21}	-0.007 (-0.74)	-0.001 (-0.37)	**0.01** **(7.07)**	**0.02** **(4.07)**
a_{22}	**0.36** **(17.39)**	**0.27** **(27.91)**	**-0.14** **(-8.26)**	-0.006 (-0.12)
Panel B: Estimated coefficients of the *short-term* conditional (co)variance processes: *GARCH effects*				
β_{11}	**0.96** **(132.11)**	**0.92** **(28.92)**	**0.81** **(33.73)**	**0.81** **(76.75)**
β_{21}	**0.009** **(1.77)**	0.003 (1.25)	-0.02 (-25.11)	-0.05 (-20.50)
β_{22}	**0.88** **(62.44)**	**0.95** **(281.63)**	**0.97** **(146.95)**	**0.86** **(64.44)**
Panel C: Estimated coefficients of the *long-term* conditional (co)variance processes				
c_{11}	**0.17** **(24.94)**	**0.35** **(40.25)**	**0.40** **(21.47)**	**0.37** **(43.02)**
c_{21}	-0.003 (-1.21)	0.0004 (0.21)	-0.002 (-1.48)	-0.003 (-1.35)
c_{22}	**0.04** **(20.51)**	**0.04** **(7.50)**	**0.05** **(9.62)**	**0.06** **(50.52)**

The bivariate GARCH-in-Mean model is

$$H_t = C'C + A'(e_{t-1}e'_{t-1} - C'C)A + B'(H_{t-1} - C'C)B \text{ with } \varepsilon_t \mid I_{t-1} \sim N(0, H_t).$$

Optimization is performed using the BFGS algorithm. For France and Germany the maximum likelihood algorithm failed with the available data. Robust ***t-statistics*** are in parentheses. **Bold** numbers indicate the statistically significant values.

Table 2.8: Conditional *mean* process of Risk Premium & Ind. Prod. growth differential

	CAD	**IT**	**UK**
β_{11}	-0.04 (-0.82)	0.08 (1.51)	0.02 (0.45)
β_{12}	-0.11 (-1.55)	0.09 (0.98)	-0.19 (-1.69)
β_{13}	**-5.60** **(-19.11)**	**1.33** **(9.75)**	**6.99** **(17.75)**
β_{14}	0.94 (0.38)	**7.75** **(3.30)**	**7.65** **(3.65)**

The bivariate VAR(1,1) specification is:

$$Y_t = \beta_{10} + \beta_{11}\mathrm{Y}_{t-1} + \beta_{12}\Omega_{t-1} + \beta_{13}H_{11,t} + \beta_{14}H_{12,t} + \varepsilon_{1,t}$$
$$\Omega_t = \beta_{20} + \beta_{21}\mathrm{Y}_{t-1} + \beta_{22}\Omega_{t-1} + \varepsilon_{2,t}$$
with $\varepsilon_t \mid I_{t-1} \sim N\left(0,\ H_t\right)$

where Y_t stands for the excess currency returns and Ω_t stands for the Industrial Production growth differential. Optimization is performed using the BFGS algorithm. For France, Germany and Japan the maximum likelihood algorithm failed with the available data. Robust ***t**-statistics* are in parentheses. **Bold** numbers indicate the statistically significant values.

Table 2.9: Conditional *(co)variance* process of Risk Premium & Ind. Prod. differential

	CAD	IT	UK
Panel A: Estimated coefficients of the *short-term* conditional (co)variance processes: *ARCH effects*			
a_{11}	**0.17** **(10.74)**	**-0.19** **(-7.84)**	**0.21** **(5.04)**
a_{21}	**0.05** **(3.35)**	**0.03** **(4.55)**	**-0.11** **(-3.88)**
a_{22}	**0.33** **(24.87)**	**0.21** **(21.46)**	**0.24** **(10.03)**
Panel B: Estimated coefficients of the *short-term* conditional (co)variance processes: *GARCH effects*			
β_{11}	**0.96** **(131.46)**	**0.93** **(55.54)**	**0.80** **(10.45)**
β_{21}	-0.01 (1.57)	**0.01** **(2.75)**	**0.06** **(2.45)**
β_{22}	**0.92** **(141.05)**	**0.96** **(336.63)**	**0.93** **(60.68)**
Panel C: Estimated coefficients of the *long-term* conditional (co)variance processes			
c_{11}	**0.18** **(25.99)**	**0.35** **(35.74)**	**0.36** **(20.65)**
c_{21}	0.01 (1.61)	**-0.009** **(-3.85)**	-0.002 (-0.65)
c_{22}	**0.14** **(10.98)**	**0.12** **(7.60)**	**0.14** **(13.64)**

The bivariate GARCH-in-Mean model is:

$$H_t = C'C + A'(e_{t-1}e'_{t-1} - C'C)A + B'(H_{t-1} - C'C)B \text{ with } \varepsilon_t \mid I_{t-1} \sim N(0, H_t).$$

Optimization is performed using the BFGS algorithm. For France, Germany and Japan the maximum likelihood algorithm failed with the available data. Robust ***t**-statistics* are in parentheses. **Bold** numbers indicate the statistically significant values.

Table 2.10: Conditional *mean* process of Risk Premium, Infl. & Ind. Prod. differentials

	CAD	**IT**	**UK**
β_{11}	-0.02 (-0.56)	0.06 (1.30)	0.03 (0.86)
β_{12}	-0.01 (-0.07)	**0.94** **(3.15)**	-0.06 (-0.21)
β_{13}	**-0.12** **(-2.49)**	0.14 (1.61)	-0.18 (-1.57)
β_{14}	**-6.70** **(-3.39)**	**2.18** **(15.78)**	**2.88** **(22.82)**
β_{15}	**30.79** **(3.34)**	-17.93 (-1.40)	**13.14** **(2.07)**
β_{16}	-2.76 (-1.56)	**7.16** **(1.73)**	1.72 (1.29)

The trivariate VAR(1,1) specification is:

$$Y_t = \beta_{10} + \beta_{11} \Upsilon_{t-1} + \beta_{12} X_{t-1} + \beta_{13} \Omega_{t-1} + \beta_{14} H_{11t} + \beta_{15} H_{12t} + \beta_{16} H_{13t} + \varepsilon_{1t}$$

$$X_t = \beta_{20} + \beta_{21} \Upsilon_{t-1} + \beta_{22} X_{t-1} + \beta_{23} \Omega_{t-1} + \varepsilon_{2t}$$

$$\Omega_t = \beta_{30} + \beta_{31} \Upsilon_{t-1} + \beta_{32} X_{t-1} + \beta_{33} \Omega_{t-1} + \varepsilon_{3t}$$

with $\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$ where Y_t stands for the excess currency returns; X_t stands for the Inflation differential and Ω_t stands for the Industrial Production growth differential (all in relation to the US). Optimization is performed using the BFGS algorithm. For France, Germany and Japan the maximum likelihood algorithm failed with the available data. Robust ***t**-statistics* are in parentheses. **Bold** numbers indicate the statistically significant values.

Table 2.11: Conditional *(co)variance* process of Risk Premium, Infl. & Ind. Prod. diff.

	CAD	IT	UK
Panel A: Estimated coefficients of the *short-term* conditional (co)variance processes: *ARCH effects*			
a_{11}	**0.17** **(9.46)**	**-0.13** **(-7.84)**	**0.22** **(14.20)**
a_{21}	**0.005** **(1.70)**	0.0001 (0.04)	**0.01** **(3.65)**
a_{22}	**0.03** **(2.07)**	**0.32** **(23.13)**	0.006 (0.10)
a_{31}	**0.05** **(2.95)**	0.01 (0.71)	**-0.09** **(-9.73)**
a_{32}	**0.02** **(1.80)**	**0.02** **(7.47)**	**-0.05** **(-5.55)**
a_{33}	**0.40** **(4.16)**	**0.21** **(22.64)**	**0.45** **(23.72)**
Panel B: Estimated coefficients of the *short-term* conditional (co)variance processes: *GARCH effects*			
β_{11}	**0.96** **(365.88)**	**0.96** **(62.88)**	**0.85** **(58.10)**
β_{21}	**-0.006** **(-14.75)**	**0.006** **(2.13)**	**-0.03** **(-11.48)**
β_{22}	**0.98** **(764.32)**	**0.92** **(124.02)**	**0.84** **(70.11)**
β_{31}	**-0.10** **(-18.08)**	0.001 (0.51)	-0.005 (-0.83)
β_{32}	**-0.09** **(-23.16)**	**-0.0058** **(-3.30)**	**0.06** **(17.70)**
β_{33}	**0.17** **(3.06)**	**0.97** **(348.58)**	**0.77** **(71.83)**
Panel C: Estimated coefficients of the *long-term* conditional (co)variance processes			
c_{11}	**0.18** **(10.46)**	**0.35** **(42.05)**	**0.36** **(57.88)**
c_{21}	**0.005** **(1.82)**	-0.0002 (-0.22)	-0.002 (-1.10)
c_{22}	**0.06** **(4.97)**	**0.04** **(11.87)**	**0.06** **(52.13)**
c_{31}	0.001 (0.29)	**-0.006** **(-2.70)**	**-0.007** **(-1.85)**
c_{32}	-0.002 (-1.30)	0.003 (1.04)	**0.003** **(2.21)**
c_{33}	**0.13** **(11.76)**	**0.12** **(8.63)**	**0.16** **(26.52)**

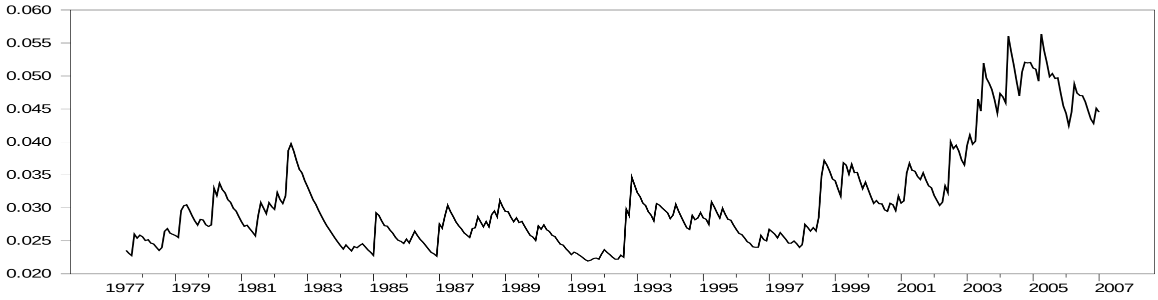
The trivariate GARCH-in-Mean model is

$$H_t = C'C + A'(e_{t-1}e'_{t-1} - C'C)A + B'(H_{t-1} - C'C)B \text{ with } \varepsilon_t \mid I_{t-1} \sim N(0, H_t).$$

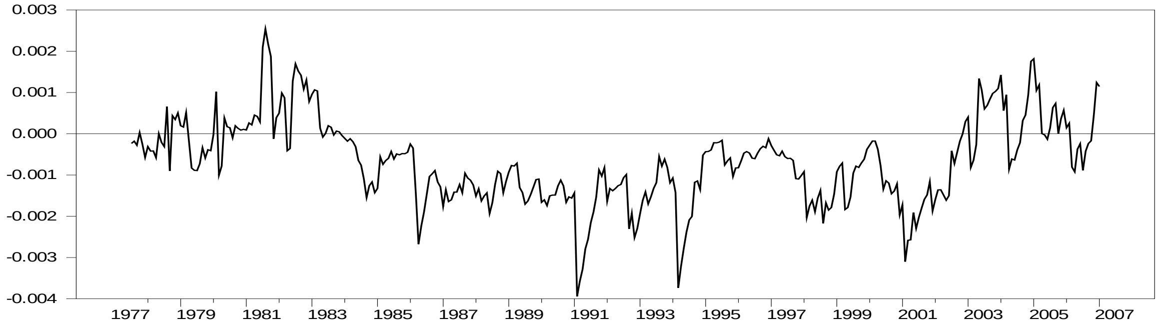
Optimization is performed using the BFGS algorithm. For France, Germany and Japan the maximum likelihood algorithm failed with the available data. Robust *t-statistics* are in parentheses. **Bold** numbers indicate the statistically significant values.

Figure 2.1: Conditional second-order moments of the *One-factor* model: Currency Risk Premium & Inflation differential

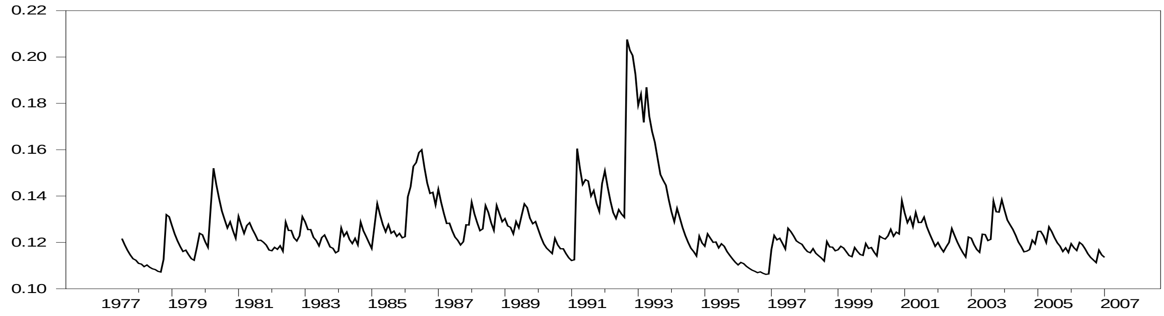
Conditional variance: *Canada*



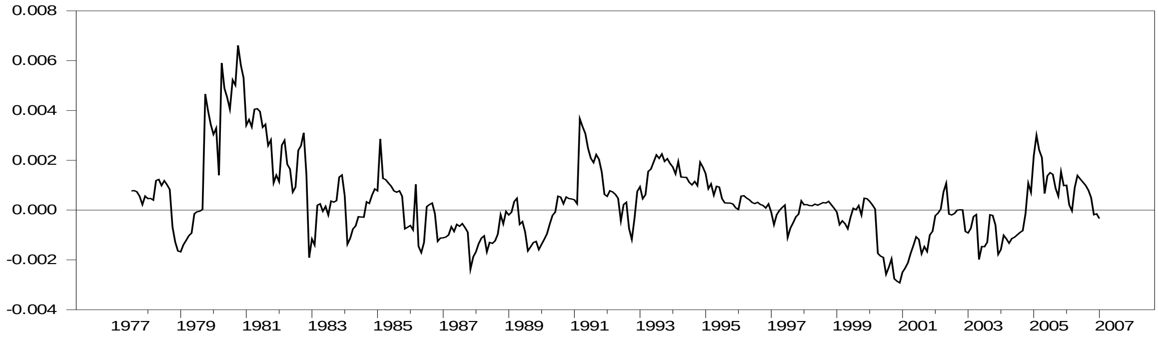
Conditional covariance: *US-Canada*



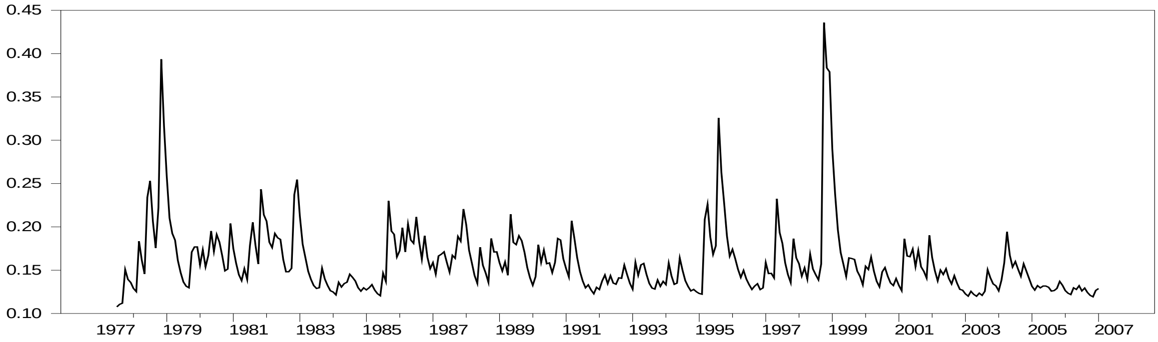
Conditional variance: *Italy*



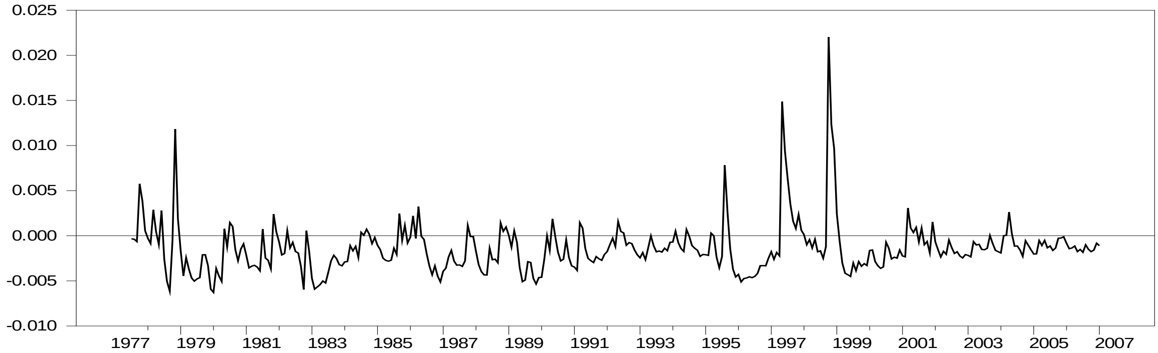
Conditional covariance: *US-Italy*



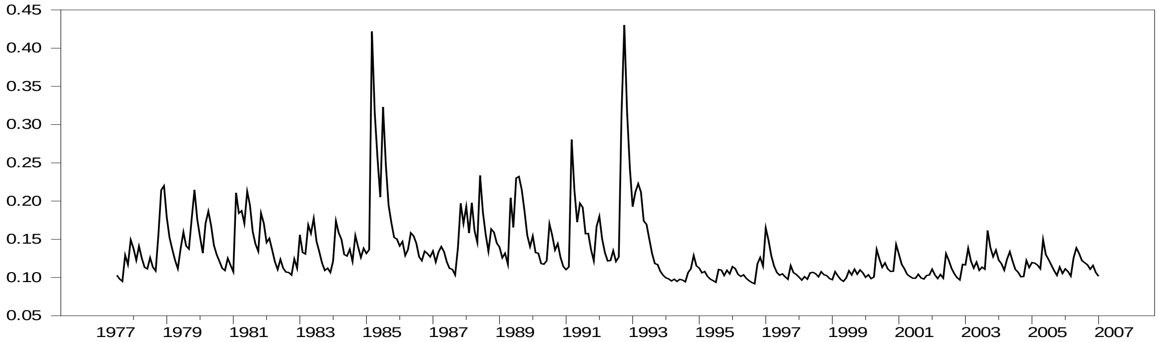
Conditional variance: *Japan*



Conditional covariance: *US-Japan*



Conditional variance: *UK*



Conditional covariance: *US-UK*

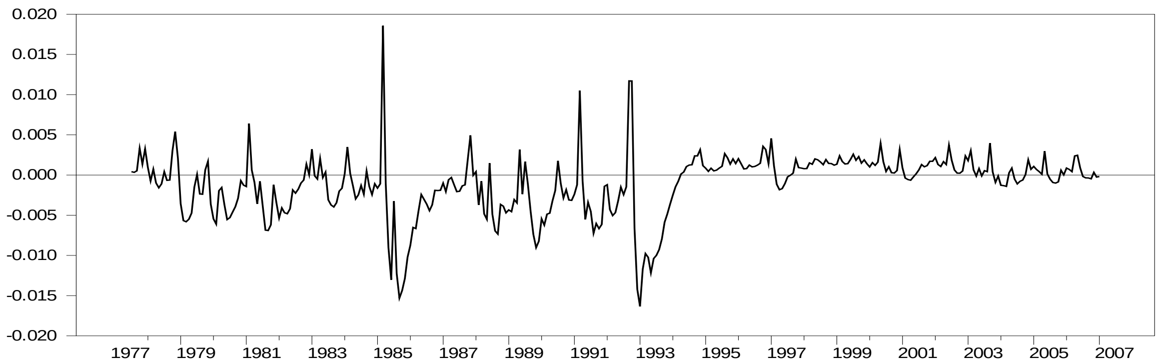
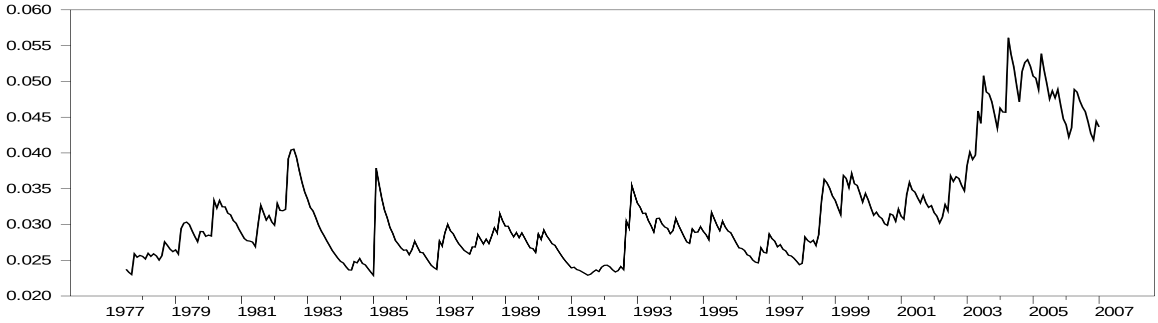
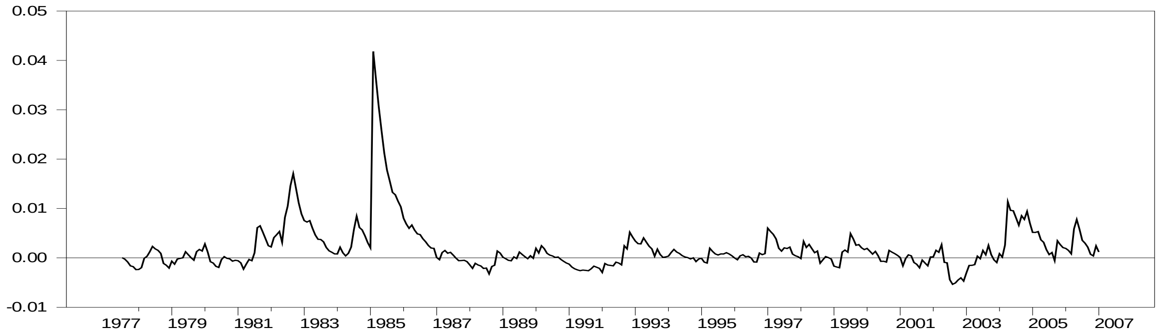


Figure 2.2: Conditional second-order moments of the *One-factor* model: Currency Risk Premium & Industrial Production growth differential

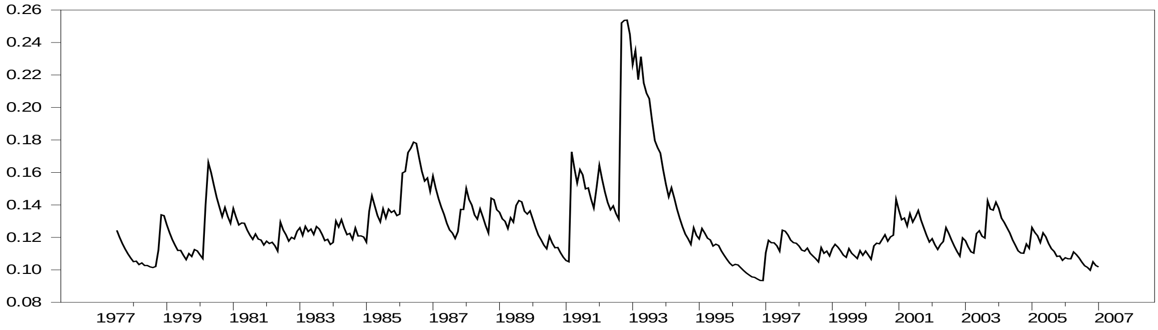
Conditional variance: *Canada*



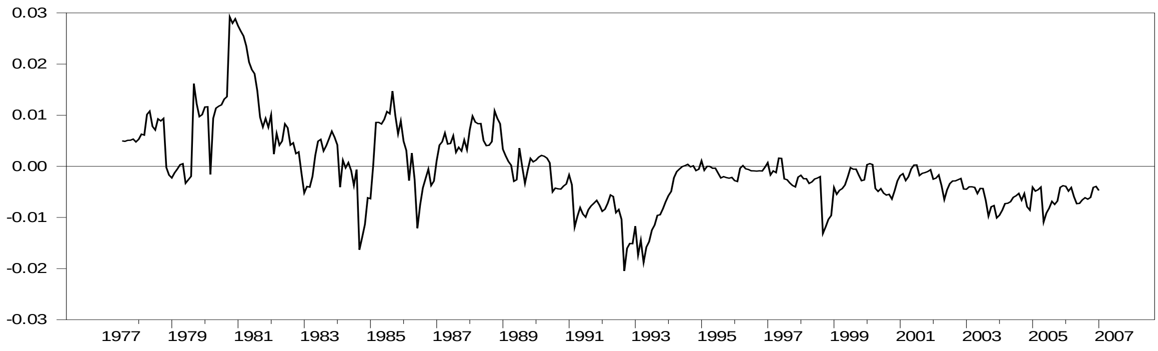
Conditional covariance: *US-Canada*



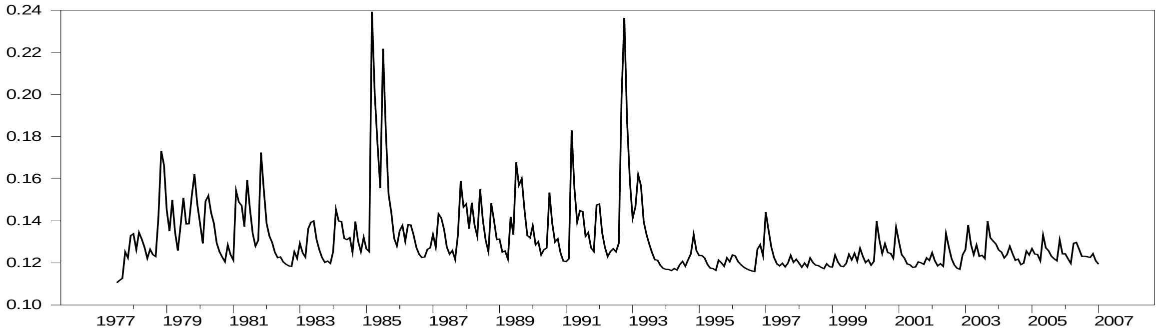
Conditional variance: *Italy*



Conditional covariance: *US-Italy*



Conditional variance: *UK*



Conditional covariance: *US-UK*

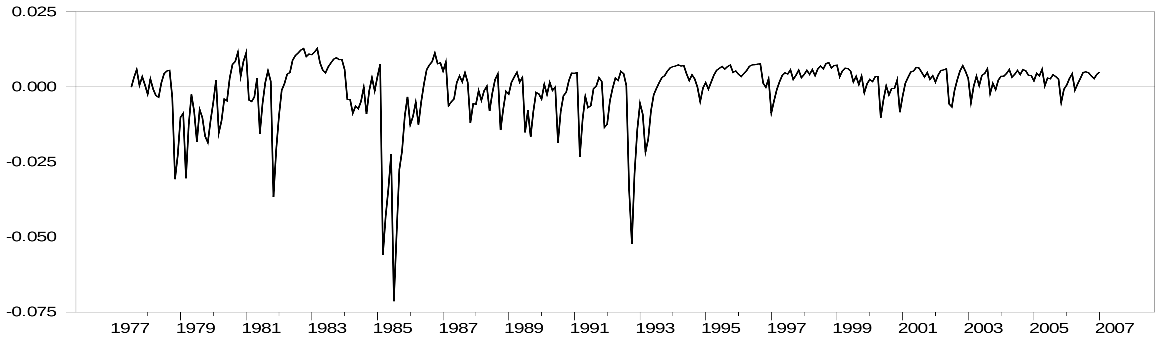
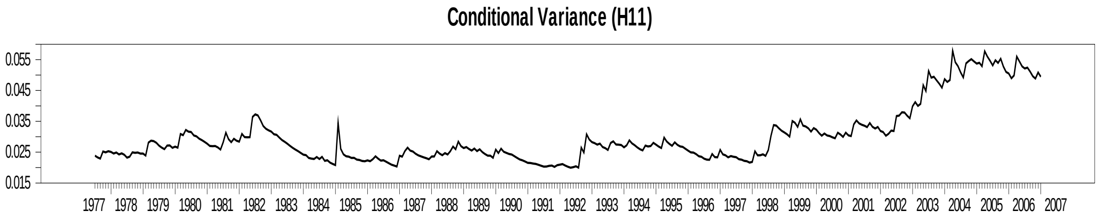
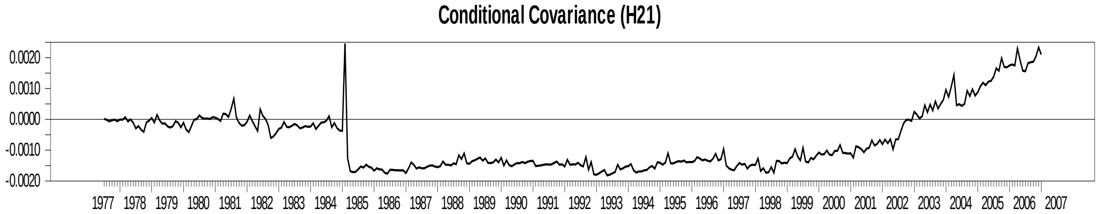
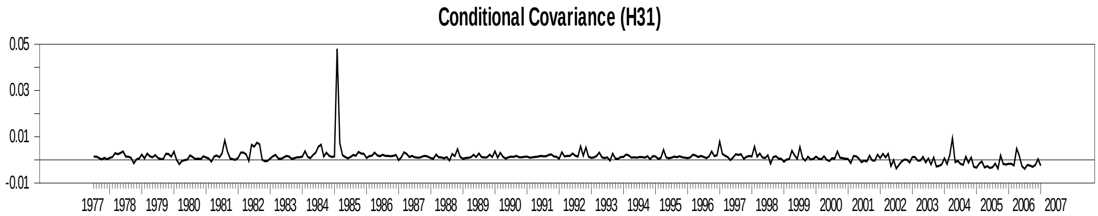


Figure 2.3: Conditional second-order moments of the *Two-Factor* Model: Risk Premium, Inflation & Industrial Production differentials

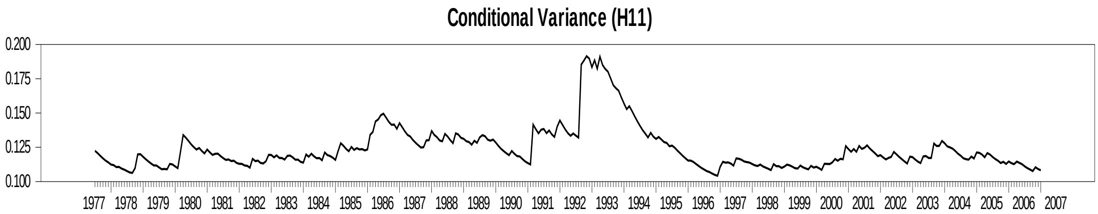
Conditional variance and covariances: *Canada*

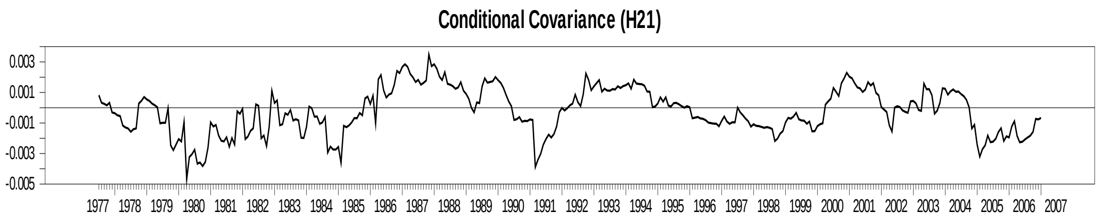


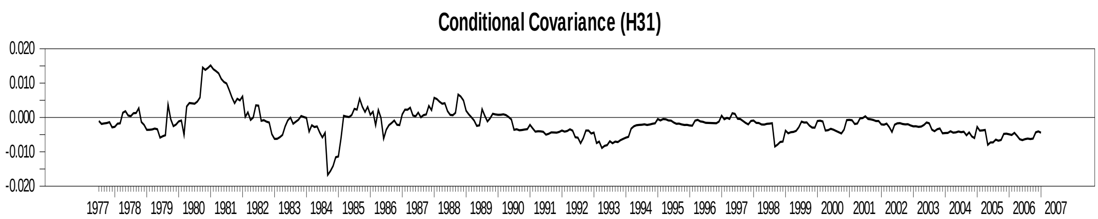




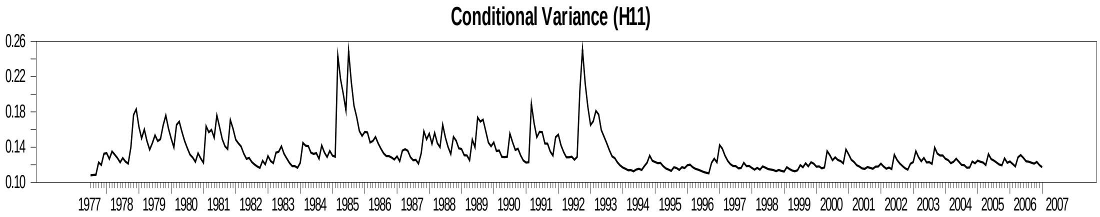
Conditional variance and covariances: *Italy*

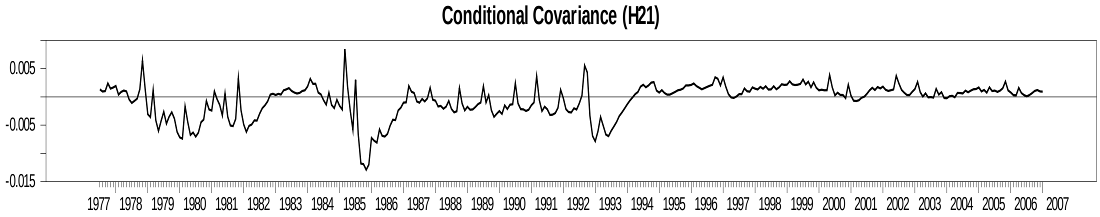


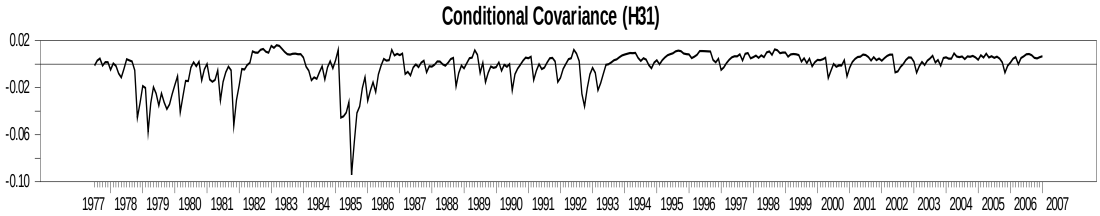




Conditional variance and covariances: *UK*







Chapter 3: Linkages between Excess Currency & Stock Market Returns: Granger Causality in Mean & Variance

3.1 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 15th member states[17] 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

[17] 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 (see appendix for more information).

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 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 chapter 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 markets 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. (2005) 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) examine 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[18] markets suggest that only the Czech Republic and 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

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18 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, 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.

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 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[19] this may

19 In Poghosyan (2009) transaction costs are generally defined and include all sorts of market frictions

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.

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

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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.

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. Lastly, to further the analysis, we construct a VAR model and we employ impulse response functions (IRFs) in order to evaluate the dynamic effect of innovations on both of the variables of interest and to shed light on the direction of the shocks.

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 3.2 explains methodological issues employed. Section 3.3 describes the data and summary statistics. Section 3.4 contains a discussion of the results. Section 3.5 summarizes the findings and concludes. Lastly, section 3.6 refers to the appendix which presents basic background information about the politico-economic situation of the NMS studied here.

3.2 Econometric Model

The aim of the paper is to investigate possible linkages between the excess currency and equity returns. Subsection 3.1 presents the traditional causality in mean test (Granger, 1969). We estimate simple AR models with OLS. Subsections 3.2 and 3.3 present the causality in mean and in variance respectively based on the two-stage procedure introduced by Cheung and Ng (1996).

3.2.1 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:

$$y_t = \vartheta_0 + \alpha_1 y_{t-1} + \ldots + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \ldots + \beta_q x_{t-q} + \varepsilon_t \tag{3.1}$$

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 (3.1) 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[20]. 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:

$$x_t = \zeta_0 + \gamma_1 x_{t-1} + \ldots + \gamma_q x_{t-q} + \delta_1 y_{t-1} + \ldots + \delta_k y_{t-k} + u_t \quad (3.2)$$

where again ζ_0 is a constant; γ, δ are coefficients; and u are zero-mean error terms. Equation (3.2) 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 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

20 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.

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.

3.2.2 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:

$$\dot{y}_{it} = a_0 + a_1 \dot{y}_{1t-1} + \ldots + a_k \dot{y}_{it-k} + e_{it} \qquad i = 1, 2 \tag{3.3}$$

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

$$h_{it}^2 = \mu_0 + b_1 e_{1t-1}^2 + \ldots + b_q e_{it-q}^2 + c_1 h_{1t-1}^2 + \ldots + c_p h_{it-p}^2$$

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 (3.3) 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 (3.3), are defined as follows:

$$z_{1t} = \frac{e_{1t}}{\sqrt{h_{1t}}}, \quad z_{2t} = \frac{e_{2t}}{\sqrt{h_{2t}}} \tag{3.4}$$

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:

$$\hat{\rho}_{1,2}(k) = \frac{\hat{\theta}_{1,2}(k)}{\sqrt{\hat{\theta}_{1,1}(0) * \hat{\theta}_{2,2}(0)}} \tag{3.5}$$

where
$$\hat{\theta}_{1,2}(k) = \begin{cases} T^{-1}\sum_{t=k+1}^{T}\left[\left(\hat{z}_{1t} - \overline{z}_{1t}\right) * \left(\hat{z}_{2t-k} - \overline{z}_{2t-k}\right)\right], & k \geq 0 \\ T^{-1}\sum_{t=-k+1}^{T}\left[\left(\hat{z}_{1t+k} - \overline{z}_{1t}\right) * \left(\hat{z}_{2t} - \overline{z}_{2t-k}\right)\right], & k < 0 \end{cases}; \tag{3.6}$$

where T is the sample size, $\bar{z}_{it}$ 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:

$$S = T\sum_{k=j}^{M} \hat{\rho}_{1,2}^{2}(k) \tag{3.7}$$

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.

3.2.3 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:

$$z_{1t}^2 = \left(\frac{e_{1t}}{\sqrt{h_{1t}}} \right)^2 \text{ and } z_{2t}^2 = \left(\frac{e_{2t}}{\sqrt{h_{2t}}} \right)^2 \qquad (3.8)$$

We first use (3.6) and (3.5) to compute the sample cross correlations of z_{1t} and z_{2t} given in (3.8). Afterwards, we can test for the existence of causality in the variance based on the same S-statistics described in (3.7). The null hypothesis of no Granger causality in variance implies that the cross correlations of the squared standardized residuals in (3.8) 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 employ the impulse response analysis to see how our variables react to their own shocks and those of other variables.

3.2.4 Impulse Response Functions

An impulse response function (IRF) is an essential tool in empirical causal analysis. It represents the reaction of the variables to shocks hitting the system. In particular, this technique enables us to see how a one standard deviation shock to any market has an impact on this and other markets, and how persistent the impact of this shock is. For the purpose of our analysis, we estimate the standard VAR model to analyze the interrelations of excess returns in money and equity markets and the dynamic impacts of random disturbances (or innovations) on the system on these variables. Taken together equations (3.1) and (3.2), the general VAR (p,q) model can be expressed as follows:

$$\begin{aligned} y_t &= \gamma_{10} + \sum_{k=1}^{k} \alpha_{1k} y_{t-k} + \sum_{q=1}^{q} \beta_{1q} x_{t-q} + \varepsilon_{1t} \\ x_t &= \gamma_{20} + \sum_{q=1}^{q} \beta_{2q} x_{t-q} + \sum_{k=1}^{k} \alpha_{2k} y_{t-k} + \varepsilon_{2t} \end{aligned} \tag{3.9}$$

The OLS is the appropriate method to estimate this VAR system[21] since only lagged variables are included on the right hand side of the each equation, and also disturbances are

[21] We do not include contemporaneous terms e.g. $\begin{aligned} X_{1t} &= a_1 + b_1 X_{2t} + \psi_{11} X_{1t-1} + \psi_{12} X_{2t-1} + u_{1t} \\ X_{2t} &= a_2 + b_2 X_{1t} + \psi_{21} X_{1t-1} + \psi_{22} X_{2t-1} + u_{2t} \end{aligned}$ because if we do so, it becomes a structural VAR and in this case we cannot use OLS to estimate it (the OLS estimation would yield inconsistent parameter estimates).

assumed to be serially uncorrelated with constant variance. However, care needs to be taken when determining the number of lags that should be included in the analysis. If the lag length is too small, the model will be misspecified; if it is too large, the degrees of freedom will be lost. The three most common methods for estimating the optimal lag length for a VAR, are the Akaike information criteria (AIC), Schwarz-Bayesian information criteria (SBC) as well as the likelihood ratio test (LR). The best fitting model is the one that minimizes the criterion function[22].

After estimating the VAR model, impulse responses are derived from the estimates. In this paper, we simply define the impulse response as measuring the effect of a one-standard deviation shock. The general form of the IRFs is defined as follows: $\frac{\partial \Phi_{i,t+s}}{\partial \varepsilon_{j,t}}$ with $i, j = 1,2$ where $\Phi_{i,t+s}$ is the full set of the impulse responses and $s = 1,2,3...$ denotes the periods ahead. In essence, this formula captures the reaction of the i *-th* series occurring at $t+s$ period ahead to one unit shock (or one standard deviation shock) of the j *-th* series. It is important to note that we generate simple IRFs to get a feel for the interactions between the financial asset returns. We do not place too much emphasis on these since they are generated from a constant covariance matrix but they can still give us an indication of the relationship between the excess currency and stock market returns.

Therefore, in order to avoid the so-called parameter *identification* problem we need to impose the following restriction: $b_1 = 0$ or $b_2 = 0$.

[22] We choose the optimal lag length that minimizes the following information criterion:
$$\text{AIC} = \text{T} \log|\Omega| + 2\text{ N}$$
$$\text{SBC} = \text{T} \log|\Omega| + \text{N} * \log(\text{T})$$
where Ω is the covariance matrix of the residuals, N is the total number of parameters in all equations and T is the sample size. We choose a model with the lower AIC value. The formal likelihood ratio test of two models one with u lags and the other with r lags $(u > r)$ is defined as follows: $\text{LR} = (\text{T - c}) \left[\log|\Omega_r| - \log|\Omega_u|\right] \sim \chi^2((\text{u-r})n^2)$ where c=np+1 is a small sample correction and u-r is the difference in the number of lags. We test the null hypothesis that the extra $u - r$ lags are statistically insignificant (the restricted model is preferable to the unrestricted one).

3.3 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 3.1 plots the exchange rates for the NMS (see appendix for more details). 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 3.9 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 3.1 about here]

Table 3.1 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 3.1 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).

3.4 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 3.4.1 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 and variance according to the Cheung & Ng (1996) approach. Some impulse response graphs are also shown. The analysis continues in subsection 3.4.2 by considering whether the causal relationships, found above, maintain their robustness when the excess stock market returns are adjusted for risk.

3.4.1 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 3.2. P-values are reported. The last column of Table 3.2 shows the number of lags included in each case.

[Insert Table 3.2 about here]

The results in Table 3.2 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 3.3 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 3.3 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 3.4 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 3.4

[Insert Table 3.4 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 3.2). 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 3.5.

[Insert Table 3.5 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[23]). Orlowski (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

23 See Appendix for more information on the frequent exchange rate regime adjustments of the NMS.

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.

To examine the short run dynamic relations of the excess returns in both currency and stock markets, we generate impulse response functions to a one-standard deviation shock. As previously mentioned in section 3.2.4, impulse responses show to what extent the shock of one market is transitory (or persistent) in terms of its effect on both its own market and other markets in the system. We plot four impulse response paths of the two markets from shocks to their own and other markets. Figures 3.2 and 3.3 display these responses.

[Insert figures 3.2 - 3.3 about here]

A careful inspection of figures reveals that the results from the IR analysis are in accordance with these of the Granger causality tests. This is to say, if the Granger causality test indicates excess currency return leads excess stock market returns, then the responses of excess currency returns from one-unit shock of excess stock returns should be negligible. Overall, three distinctive patterns can be identified from the IR analysis of our seven countries. Firstly, the most striking feature is that both variables display stronger responses to their own shocks (see figures 3.2-3.3). Secondly, one-unit shocks to the excess currency returns have strong responses on excess stock market returns (see figure 3.2). However, weak responses are shown for Hungary, and to a lesser extent for the UK. Thirdly, one-unit shocks to the excess stock market returns have a weak response on excess currency returns (see figure 3.3). In general, the effects from the shocks on both variables are dampening down quickly after less than a 5-week interval. Given these results, excess currency return seems 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.

3.4.2 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[24]: $\frac{\text{foreign stock return}}{\sqrt{h_{t,\,\text{foreign}}}} - \frac{\text{euro stock return}}{\sqrt{h_{t,\,\text{euro}}}}$. 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 3.6.

[Insert Table 3.6 about here]

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

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

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 3.7.

[Insert Table 3.7 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 3.8.

[Insert Table 3.8 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.

3.5 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 impulse response function analysis provides further support for the leading role of the excess currency return and also suggests that own shocks have strong impact on the markets.

These findings are very important, especially for the NMS that aim to benefit from the advantages of their participation in the EMU. They need credible exchange rate policy to aid convergence and prevent volatility spillovers affecting other markets. For future research, it would be of interest to incorporate other variables that may exert an impact on the excess returns in both markets of the NMS in order to get a better understanding of the causal linkages prevailing.

3.6 Appendix: Background Information on the NMS

3.6.1 Historical Heritage

In the context of transition economies in Eastern Europe and the former Soviet Union, certain similar socio-economic patterns emerge when considering the *Visegrád Group*: former Czechoslovakia, Hungary and Poland. The "Visegrád Group"[25] expression refers to the Northern Hungarian town in which the presidents of former Czechoslovakia, Hungary, and Poland met and signed a declaration on February 15, 1991. As a result of the dissolution of Czechoslovakia in 1993, the Visegrád Group thereafter consisted of four countries, as both resultant new countries, the Czech Republic and the Slovak Republic, became members of the group. All four countries committed themselves to a path of close collaboration as they moved from the post communist era into that of EU membership. There were four significant factors that contributed to the formation of the Visegrád group; 1) The aspiration to dispose of and transform what was left of the communist bloc in Central Europe; 2) the wish to subdue a long history of hostilities between Central European countries; 3) the principle that mutual cooperation would facilitate a greater rate of progress in reaching certain goals, for example, to achieve the desired social transformation and to progress the process of European integration; 4) the ideological similarities between the then ruling political elites.

Prior to 1918, Czech, Slovakia and Hungary had been part of the perplexing multilingual domain known as the Austro-Hungarian Empire, whilst Poland had been partitioned into Austro-Hungarian, Russian and German territories[26]. All countries emerged as independent countries from the demise of the Austro-Hungarian Empire at the end of World War I in 1918 and all stayed under communist control for forty one –forty two years. After the

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25 See http://www.visegradgroup.eu/main.php?folderID=938

26 There was a distinct contrast in so far as Hungary had been one of the constituent entities of the Union, since 1848, the Czech Lands (in modern days Czech Republic) were regarded as part of the Austrian territories, whilst Slovakia and Poland had very little control over their own affairs (see Fidrmuc et al., 2002 for a survey).

era of communist control came to an end in 1989, Hungary and Poland were first to shift from a centrally planned to a market economy. They proceeded to hold their first democratic multiparty elections in 1990 and immediately after they attempted to make the transition towards a free market economy. On 1 January 1993, the Slovaks and the Czechs came to the mutually agreed peaceful decision to undo their union and to move towards more liberal economic strategies. The Czech Republic, Hungary and Poland proceeded to join NATO in 1999 followed by the European Union in 2004, whilst Slovakia joined both NATO and the EU in 2004[27].

The Visegrád group share similar history and traditions, and lead the way among post-communist countries in accomplishing successfully macroeconomic stabilization and structural reforms. In addition to this, they are considered more developed than most of the other communist countries. However, despite the important similarities that their economies share, there are some fundamental differences in relation to their economic development. In light of these patterns there are clearly grounds upon which the Visegrád group must be considered a valuable field of analytical research concerning the relative effects their economic policies have on their economic performances.

3.6.2 Maastricht's convergence criteria

The European Union[28] (EU) was established by the Treaty of Maastricht in 1993. The Treaty stipulates what conditions must to be met by EU member states in order to enter the third stage of the European Economic and Monetary Union (EMU) and to adopt the Euro.

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27 see https://www.cia.gov/library/publications/the-world-factbook/

28 The origins of the EU were in the European Coal and Steal Community (ECSC), which was formed by the 1951 Paris Treaty, this subsequently evolved into the European Economic Community (EEC), created by the Treaty of Rome in 1957, which ultimately evolved into the EU.

The new EU members are required to join the EMU and are unable to deviate from this requirement as both the UK and Denmark had previously done, however EU membership does not automatically mean membership of the EMU. Membership of the EMU for these NMS is subject to certain convergence criteria being met, as specified in the Maastricht Treaty. There are four such criteria and they are as follows;

1. *Price Stability*: This requires that the average inflation rate (calculated with reference to the consumer price index) must not be more than 1.5% greater than that of the three highest performing member states.

2. *Sustainable Fiscal Position*: This requires that there is no excessive level of deficit. An excessive deficit level is considered to exist if:

- The budget deficit exceeds 3% of GDP, with the exceptions that either the ratio has significantly and consistently declined, approaching a point close to 3 per cent, or that the amount surplus to the 3% reference value is only exceptional and short term occurrence and a deficit value close to 3% is maintained.

- The ratio of gross government debt relative to GDP exceeds 60%, unless the ratio is decreasing at an acceptable rate towards the reference value.

3. *Exchange Rate Stability*: This requires that the currency has to maintain the ERM II normal fluctuation band of ± 15 % around a fixed central parity against the euro, without experiencing severe tensions (devaluing against the currency of any other member state) for a minimum 2 year period before the formal assessment. The emphasis thus is given on the exchange rate being close to its central rate.

4. *Interest Rates*: This requires that the average long-term interest rate must be no more than 2% greater than those of the three highest performing member states with regard to price stability.

3.6.3 History of the 5th Enlargement of the EU

May 1st 2004 marked the fifth and most ambitious membership enlargement of the EU, incorporating the accession of eight Central and Eastern European (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia) and two Mediterranean countries (Malta and Cyprus). Bulgaria and Romania applied for the membership in 2007 and are likely to join the EMU at a further stage, if they successfully fulfill the Maastricht criteria. Slovenia was the first of the acceding countries to meet the Maastricht convergence criteria for EMU membership and to adopt the euro on the 1st of January 2007. Cyprus and Malta followed a year after on January 1st 2008 and Slovakia on January 1st 2009.

The origins of this enlargement process date back to 1989. Following the break-up of the Soviet block the EU announced that it would, in principle, welcome the prospect of the Central and Eastern European countries joining the Union. The negotiations for the accession of the six "first-wave applicants" (Czech Republic, Estonia, Hungary, Poland, Slovenia and Cyprus), was opened immediately. However, the official invitation to join was issued few years later in 1993 by the Copenhagen European Council. This dialogue broadened further in October 1999 to negotiate the accessions of Slovakia, Latvia, Lithuania, Romania, Bulgaria and Malta. The negotiations concluded in December 2002 and in April 2003 Treaties of Accession were signed with the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia, Malta and Cyprus. 2003 saw nine countries hold referenda on the issue of membership of the Union. The 10th country, Cyprus, successfully put the decision to the legislature. In May 2004 all 10 accession countries became full members of the EU once all of the referenda were passed and the Accession Treaties were ratified by the EU-15 members[29].

[29] It is worth mentioning that during the negotiation period, the EU progressively introduced a series of measures in order to help the candidate countries to successfully make the transition from their controlled by their state economy to the free open market economy. These measures include: phased removal of import quotas, an extension of the Generalized System of Preferences, the completion of Trade and Co-operation Agreements

The main focus of this paper will be on the exchange rate stability and on interest rates convergence criteria. Numerous studies have concentrated on the issue of the appropriate exchange rate mechanism to adopt for the NMS from the point at which they join the EU to the stage at which they meet the criteria to become full members of the EMU. The exchange rate mechanism is a fundamental element of influence on a country's macroeconomic stability. In essence, there are three types of foreign exchange regimes currently existing. These are: 1. Floating exchange rates referring either to free or managed rates for Czech Republic, Poland, Slovakia and Slovenia; 2. Fluctuation bands around a central rate for Cyprus and Hungary; and 3. Pegged to the euro or fixed rates managed by Currency Boards for Estonia and Lithuania or pegged to IMF Special Drawing Rights for Latvia. Table 1 displays the current exchange rate regimes that NMS followed prior their entry in the ERM II by end of 2005.

Table 3.6.I: Exchange rate regimes in new EU member states

Country	Exchange Rate Regime prior ERM II	Entry ERM II entry	ERM II parity
Cyprus*	de jure: Peg to euro within band ±15 % since August 2001, (de facto: narrow range of fluctuation ±2.25 % from June 1992 to December 2000).	02/05/2005	0.585274 CYP/EUR
Czech Republic	Managed float to euro since May 1997 with inflation target of 2% - 4% by end of 2005	---	---
Estonia	Currency board peg since June 1992 (Estonian kroon initially pegged to German mark, since January 1st, 1999 to euro)	28/06/2004	15.6466 EEK/EUR
Hungary	Peg to euro within fluctuation bands ± 15 %, with inflation target of 3% - 5% by	---	---

and the introduction of the PHARE Program which aided transition to a market economy. The aim of these Association Agreements, or else European Agreements, was to provide the legal foundations necessary to conduct bilateral relations throughout the 1990s and, significantly, resulted in a free trade area for most industrial goods (Doyle & Fidrmuc 2006).

	end of 2005		
Latvia	Peg to euro (initially pegged to Special Drawing Rights with ± 1 % band from 1994 to 2004)	02/05/2005	0.702804 LVL/EUR
Lithuania	Currency board since 1994 (Lithuanian litas initially pegged to US dollar, since February 2002 to euro)	28/06/2004	3.45280 LTL/EUR
Malta*	Currency basket peg since 1971 (last weight of euro in the basket: 70 %, pound sterling 20% and US dollar 10%)	02/05/2005	0.429300 MTL/EUR
Poland	Free float since 2000 with inflation target of 1.5% - 3.5% by end 2003	---	---
Slovakia*	Managed float to euro since 1998; de facto: crawling peg (Hybrid system using the euro as an anchor with an implicit inflation target since September 1998)	28/11/2005	38.455 SKK/EUR
Slovenia*	de jure: managed float, de facto: exchange rates within crawling bands	28/06/2004	239.640 SIT/EUR

Source: Backé and Thimann (2004), European Central Bank (2004) & Various central banks via www.bis.org. *Updated* by the author
The asterisk denotes full membership in the EU (adoption of the Euro).

Table 1 presents the exchange rate regimes in NMS[30] after their entrance in the EU. As it illustrates, Estonia, Lithuania and Slovenia were the first to join the ERM II of the EMU on the 27th of June 2004. Cyprus, Latvia and Malta follow shortly after on the 29th of April 2005. Slovakia entered the ERM II a few months later on the 25th of Nov 2005 at the initial rate of 38.455. After Slovakia entered the ERM II, its currency appreciated, but subsequently stabilized between 1 and 2 per cent above the central rate. Slovenia was the first of the NMS that met the Maastricht convergence criteria for EMU membership and adopted the euro on the 1st of January 2007. Cyprus and Malta no longer belong to ERM II since January 1st 2008 when they officially adopted the euro. Slovakia becomes the second East European country (after Slovenia) to adopt the euro at a new strengthen rate of 30.126 on the 1st January 2009. It

30 Bulgaria and Romania (not included in the table) applied for ERM II membership in 2007 and are likely to join the eurozone in 2015.

is expected that the euro will replace the Hungarian forint and the Polish zloty on 1st January 2012 and the Czech koruna on 1st January 2015. Slovakia adopted the euro on 1st January 2009.

3.6.4 Benefits & Costs

The admission of the NMS countries, and particularly the four Visegrád economies, into the EU may result in both benefits and costs and may also have a significant impact on their growth prospects. Outlined below are the benefits and costs which EU membership may generate.

3.6.4. I Benefits of the Membership

There are numerous benefits to be obtained from EMU membership for the NMS and in particular the Visegrád economies, which are widely considered to be all "too small, too open and too vulnerable". Possibly, the most important advantage of participation in a well developed EU financial system like the EMU, is that it protects the smaller countries from the severe speculative attacks that their individual national currencies may be subjected to. Accordingly, the NMS are exposed to more protected and less volatile financial markets and are more likely to stand up against financial crises and speculative attacks. If this is not the case, then the medium to long term viability of these national currencies is cast into doubt (Buiter & Sibert; 2006).

An immediate consequence that argues in favour of the membership of the NMS is that it lowers the risk-premium that investors may demand in investing in assets with economic and/or political environment which are perceived as unstable (Baldwin, Francois & Portes 1997). Their membership guarantees the adoption of greater institutional transparency. This environment helps to foster many beneficial changes including property rights which are more clearly defined and the implication of codification and systematic organization of competition and state-aid policies. Domestic residents can also benefit with increased access to wider capital markets and the concerns of investors can be assuaged when it is seen how convertibility and more transparent capital markets positively benefit this process. Investors from longer standing EU member states find the NMS markets more attractive due in part to the reduction of the perceived investment risk which membership engenders. The economic prospects of the NMS increase in light of their membership and encourage more investment from both European neighbours and investors outside of the EU. It can then be seen that lower level risk premiums evolve from the betterment of the investment climate. As a result, nations augment their domestic capital stocks and facilitate foreign direct investment. In turn, financial resources are brought into their countries which allow for the transfer of skills, knowledge and technology and boost output in the long-run. An earlier study by Baldwin et. al. (1997) shows that an accession country's steady-state output is significantly augmented by the reduction in the perceived investment risk.

Lastly, membership of the EU enables a free movement of commodities, capital and labour amongst the member states within a single European Economic Market (Doyle & Fidrmuc 2006). These result in developments in trade, investment and employment opportunities for the new members. Improvements in the economic efficiency of NMS countries is further accelerated by factors such as allocation and/or accumulation effects of international trade, redistribution[31] funds, capital inflows, technology transfer and labour

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31 European Redistribution Funds includes the Structural and Cohesion Funds and the Common Agricultural Policy (CAP).

immigration. Additionally, all previously imposed long-standing tariffs and quantitative restrictions (or other distortions) no longer apply and thus the trade volume in agricultural and industrial products (for example textiles, machinery, steel and coal) that the NMS have comparative advantages is increased.

3.6.4. II Costs of the Membership

Although membership of the EU brings with it many benefits, there are elements of cost involved in the process.

One of the most prevalent would be that a NMS loses autonomy in regards to the control of its domestic monetary policy. This hampers a nation's ability to stabilize its country-specific shocks through internal monetary regulation of currency and monetary policy. As stated above, any NMS that wishes to enter into EMU must, in principle, meet all criteria laid down in relation to economic performance that have been in place since Maastricht. The European Central Bank formulated the single monetary policy with little regard given to country-specific shock unless the effect could be felt throughout the Eurozone or a significant portion of it. Membership of the EU may therefore not be as attractive to those NMS that currently use their national fiscal transfers to offset any negative effect caused by idiosyncratic shocks.

Additionally, EU membership may result costly adjustments of the NMS in order to adopt the EU norms and regulations regarding competition, environmental protection, quality standards and safety norms etc. A NMS that commences dismantlement of protectionist economic policies in favour of national industry may find itself coming under huge pressure from domestic commercial entities that are unused to being internationally competitive and have previously benefited from protection in the domestic market. Exposure to more aggressive and international competitors can lead to a long-term improvement in efficiency but the short-term costs may overshadow these in the immediate. A possible failure of domestic firms or/and local governments to adopt the new EU norms and regulations may drive some of the firms out of the market, increasing the unemployment level.

3.6.5 Macroeconomic Developments

3.6.5.I Exchange Rate Regimes of the Visegrád Group

The four Visegrád countries started their macroeconomic stabilization programs early 1990's with fixed exchange rate regimes. By choosing a fixed exchange rate regime to serve as a nominal anchor, the Visegrád countries further showed that they were dedicated to achieving price stability. This choice may be attributed to the relatively high level of international reserves that all Visegrád economies had. Poland and the former Czechoslovakia opted for pegged exchange rates in January 1990 and January 1991 respectively. Even after the division of Czechoslovakia in 1993, both Czech Republic and Slovakia continued to peg their currencies either to the US dollar or to the Deutsche Mark. Hungary introduced a crawling peg in March 1990.

At the beginning of the difficult transition period, the decision of all the Visegrád countries to set about economic reforms with a fixed exchange rate regime strategy was essential. Perhaps the most important advantage was to maintain inflation at a low level. This was aimed at preventing hyperinflation that was being seen in Poland. Furthermore, in order to ensure the credibility and sustainability of the peg, their national currencies underwent significant devaluation. This, in turn, induced changes in their economic efficiency i.e. boosted their exports, improved the efficiency and competitiveness of fundamental sectors of their economies. It also encouraged reallocation of valuable resources and as a result their foreign trade was gradually liberalized. However, the Czech Republic, Hungary and Slovakia, in contrast to Poland, experienced longer transitional problems in making the change, entering into a mild slow decline which ultimately culminated in a recession and in exchange rate crises (in 1995-1996 for Hungary, 1997-1998 for the Czech Republic, and 1998-1999 for Slovakia).

By early 2000, and given the perspective of joining European monetary union, the Visegrád group had made substantially progress in economic stabilization, including economic growth, substantial deflation and the liberalization of the capital account. In light of this, there were huge efforts made to attract substantial amount of capital flows. In countries with fixed exchange rates, these capital inflows required wide-scale and expensive interventions. This led the Visegrád countries to move towards a currency regime with greater flexibility. Experience shows that previous implementations of similar strategies (i.e. East Asia in 1997 and Russia in 2000) illustrate that fixed exchange rates in small open economies which are characterized by high capital mobility, may lead to a costly discontinuity of their financial system and to a sharp reduction of output (Fidrmuc et. al., 2002).

From 2000 onwards Poland, which shifted to inflation targeting and extended the fluctuation bands of its currency to ±15%, had officially adopted the float exchange rate. Hungary, after 2001, extended the fluctuation bands of its crawling peg from ±2.25 to ±15 with reference made to the euro under the terms of the ERM II. The Czech Republic began to float from 1999. After gaining admission to the European Union in 2004, the Czech koruna shifted to a managed floating regime to the euro. Also Slovakia shifted to more flexible regimes in 2000. This was all designed to allow for the future abandonment of the Slovak and Czech Koruna in favour of the Euro.

3.6.6 Demographic & Market Characteristics

The four Visegrád economies are notable among the post-communist countries, as having remarkably high economic growth performances. Obviously, this relative success can be attributed to certain factors. This section discusses in depth the economic characteristics of each of the four Visegrád countries while mentioning briefly the demographic characteristics.

3.6.6. I The Czech Republic

Among the former Communist states in Central and Eastern Europe, the Czech Republic is broadly considered to be a stable and prosperous economy going successfully through its transition period. Only after the end of the communism did democratic changes and economic reforms become important priorities. Capitalism's profile was on the rise and the more traditional ways of economic thinking were beginning to be overshadowed as was shown by how the state controlled industries started to lose their dominance in the market. Despite the fact the communism had provided former Czechoslovakia with relatively sound government finances and external debt that was not of huge concern, radical rather than gradual changes were introduced. Domestic and external markets were liberalized and a fixed exchange rate was introduced to serve as a nominal anchor. These reforms were seen as successful and were continued in almost identical measures by the Czech and Slovak administrations post disintegration. There were some differences however in the Czech and Slovak privatization policies and neither could completely stave off economic slow-downs. There was a lack of corporate guidance that failed to comprehensively restructure enterprise and industry. This lack of guidance and a series of unsustainable fiscal policies inevitably led to the exchange rate crises of 1997 and 1998 (Fidrmuc et. al., 2002).

Table 1 reports some basic demographic characteristics and some major economic factors that induce the economic performance of the Czech Republic.

Table 1: Czech Republic: Demographic & Economic Characteristics

	2000	**2005**	**2006**
Surface area (sq. km) (thousands)	78.9	78.9	78.9
Population, total (millions)	10.27	10.23	10.27
Population growth (annual %)	-0.1	0.3	0.4
GDP growth (annual %)	3.6	6.5	6.1
Inflation, GDP deflator (annual %)	1.5	-0.3	2.0
Gross capital formation (% of GDP)	29	26	27
Agriculture, value added (% of GDP)	4	3	3
Industry, value added (% of GDP)	38	38	39
Services, etc., value added (% of GDP)	58	59	58
Exports of goods and services (% of GDP)	63	72	76
Imports of goods and services (% of GDP)	66	69	73
Merchandise trade (% of GDP)	126	117	134
Market capitalization of listed companies (% of GDP)	19.4	30.7	34.0
Cash surplus/deficit (% of GDP)	-3.6	-3.5	-4.3

Source: World Development Indicators database, April 2008

As can be seen from Table 1 and subsequent tables, the Czech Republic is the third biggest country (78.9 thousands sq. km) amongst the Visegrád countries. It is located in Central Europe, southeast of Germany. Its population has grown at a steady rate and it consists of Czechs 90.4%, Moravian 3.7%, Slovak 1.9%, and other ethnic groups 4% (2001, estimation) (CIA, 2008).

The Czech Republic's economic transformation from the days of communist rule to the present day has been remarkable. After the recession in 1998, its recovery has been rapid, benefited by strong foreign investment, exports and privatization of several industries (CIA, 2008). It has almost doubled its GDP growth from 3.1% to 6.1% during the period 2000-2006. Indeed, as Table 1 displays, its exports (with primary exports consisting of vehicles, machinery equipments, iron, steel, electronics, ceramics and glass) to the EU, largely to Germany, the Netherlands and the United States cover 76% of the GDP. Imports are also high, 72% of GDP. The general merchandise trade to GDP ratio suggests that its economy is well open. Its economic performance was further supported by the newly privatized firms that entered the local market. The market capitalization of listed companies as a share of GDP has increased distinctly during the 2000-2006 period, reaching the level of 34% in 2006 from 19.4%. Its inflation has been low, around 2%, at the course of six years. Decomposing its GDP, the sector *Services* is the largest (58% of GDP) followed by the sectors *Industry* (39% of GDP) and *Agriculture* (3% of GDP) analogously. The gross capital formation -or else gross domestic investment- has declined slightly reaching the level of 27% of GDP in 2006 from 29% in 2000. Lastly, the Czech Republic has managed to keep at relatively low levels its budget deficit, 4.3% of GDP in 2006. However, in order to adopt the euro, it should reduce further the level of its deficit, to push it below 3% of GDP in 2009 as the Maastricht criteria recommend. The Czech Republic's target is to meet the eurozone criteria and to eventually adopt the euro in 2015. (CIA, 2008).

3.6.6. II Hungary

Hungary successfully introduced macroeconomic stabilization and structural reform programs and made progress in the transition from a centrally planned to a market economy, after the Soviet influence collapsed in 1989. Despite the fact that there was a significant shadow still falling on Hungary after its independence, by the end of the 1980s it had achieved a semi-liberalized economy, with a significant private sector presence. Hungary's seemingly stable macroeconomic environment fostered conditions that allowed the administration to implement reform gradually. The period of 1990-1993 saw a steady implementation of these despite the concerns that existed over external debt (Fidrmuc et. al., 2002).

Table 2 displays Hungary's demographic characteristics as well as some fundamental economic indicators that reflect its growth in the recent period.

Table 2: Hungary: Demographic & Economic Characteristics

	2000	**2005**	**2006**
Surface area (sq. km) (thousands)	93.0	93.0	93.0
Population, total (millions)	10.21	10.09	10.07
Population growth (annual %)	-0.3	-0.2	-0.2
GDP growth (annual %)	5.2	4.1	3.9
Inflation, GDP deflator (annual %)	12.9	2.2	3.7
Gross capital formation (% of GDP)	30	25	25
Agriculture, value added (% of GDP)	5	4	4
Industry, value added (% of GDP)	32	30	30
Services, etc., value added (% of GDP)	62	65	66
Exports of goods and services (% of GDP)	72	66	78
Imports of goods and services (% of GDP)	76	67	77
Merchandise trade (% of GDP)	126	117	134
Market capitalization of listed companies (% of GDP)	25.1	29.5	37.1
Cash surplus/deficit (% of GDP)	-2.7	-7.4	-8.6

Source: World Development Indicators database, April 2008

Hungary is the second biggest amongst the Visegrád group country (93 thousands sq. km). It is located in central Europe, northwest of Romania. Its population has decreased recently rate at a rate of 0.2% approximately. The main ethnic groups which make up its population are: Hungarian 92.3%, Roma 1.9%, and other or unknown ethnic groups 5.8% (CIA, 2008).

Hungary's GDP growth rate has undoubtedly grown since 1989. However, its annual growth rate has been low in recent years, being only 3.9% in 2006. Great progress has been made in inflation, which has been reduced remarkably from 12.9% in 2000 to a low of 3.7% in 2006. Gross capital investment has gradually decreased since 2000. Breaking down the general level of its GDP, *Services* is the dominant sector (66% of GDP) compared with *Industry* (30% of GDP) and *Agriculture* (4% of GDP). Exports, which are primarily to Germany, mainly consist of machinery, raw materials, vehicles, manufactured goods, fuels and food. The fact that exports amount to 78% of GDP while imports amount to 77% of GDP respectively, underline the fact that Hungary is an open economy. The merchandise trade to GDP ratio (134% of GDP) reinforces this fact. It has been a big increase of market capitalization. The ratio of market capitalization of listed companies has reached the level of 37.1% of GDP in 2006 from 25.1% in 2000. This may be due to domestic privatization and to foreign investments. One of the primary strategic objectives for Hungary is to reduce its large budget deficit that continued to be a problem in recent years. With public sector debt of 8.6% of GDP in 2006, the aim was to reduce it to 4% but there were challenges associated with this. Domestic consumer spending continued to decline in light of harsh governmental budgets that saw subsidization programmes being cut and taxes being considerably raised in order to reduce its deficit. In 2008 the government continues to face challenges in bringing its deficit to below 3% of GDP in order to be able to adopt the euro (CIA, 2008).

3.6.6. III Poland

Poland's record of economic liberalization policy since the break-down of the communism in 1989 highlights it as one of the success stories among the Visegrád group emerging economies. During the transition, Poland witnessed extreme macroeconomic imbalances with unsound government finances, excessive external debt, and hyperinflation. Drastic measures focused on delivering macroeconomic stability were necessary and were implemented in one year (1990). These measures were widely referred to as the "*shock-therapy*" programme. Internal and external markets were exposed to radical liberalization and macroeconomic stabilization was achieved by strict exchange rate policies which saw the Zloty continuing to be pegged until the second quarter of 1991 (Fidrmuc et. al., 2002).

Table 3 reports some demographic as well as some of the most important economic indicators showing the progress of the Polish economy during the recent years.

Table 3: Poland: Demographic & Economic Characteristics

	2000	2005	2006
Population, total (millions)	38.45	38.17	38.13
Population growth (annual %)	-0.5	0.0	-0.1
Surface area (sq. km) (thousands)	312.7	312.7	312.7
GDP growth (annual %)	4.3	3.6	6.1
Inflation, GDP deflator (annual %)	7.2	2.5	1.0
Gross capital formation (% of GDP)	25	19	20
Agriculture, value added (% of GDP)	5	5	5
Industry, value added (% of GDP)	32	31	32
Services, etc., value added (% of GDP)	63	65	64
Exports of goods and services (% of GDP)	27	37	41
Imports of goods and services (% of GDP)	34	38	41
Merchandise trade (% of GDP)	47	63	70
Market capitalization of listed companies (% of GDP)	18.3	31.0	44.0
Cash surplus/deficit (% of GDP)	..	-4.2	-3.6

Source: World Development Indicators database, April 2008

Poland is by far the biggest country (312.7 thousand sq. km) with the biggest population among the Visegrád group. It is located in central Europe, east of Germany. However, its population has been decreasing. The main ethnic groups are Polish 96.7%, German 0.4%, Belarusian 0.1%, Ukrainian 0.1%, other and unspecified ethnic groups 2.7% (CIA, 2008).

The economic performance of Poland is really notable. The GDP growth rate has rapidly increased since 2000 reaching the level of approximately 6.1% per capita in 2006 (from 4.3% in 2000). The apparent reasons for this increase are several; Strong foreign investment and EU structural funds inflows coupled with formerly government owned industries being very successfully privatized helped encourage consumer spending and saw a significant rise in corporate investment. Inflation has reduced remarkably from approximately 7.2% in 2000 to 1% in 2006, as Table 3 shows. Gross capital formation has been reduced since 2000 but not so much, reaching 20% in 2006. Polish GDP by sectors comprises *Services* (64%), *Industry* (32%) and *Agriculture* (5%). Exports as well as imports increased since 2000 reaching 41% of GDP in 2006. However, the overall merchandise trade to GDP ratio is the lowest (70%) compared to the rest Visegrád countries. Market capitalization has risen impressively and almost tripled from 2000 to 2006 as newly privatized firms entered the Polish market. Lastly, the budget deficit was 3.6% of GDP in 2006. Continued improvement in the Polish economic climate could be secured by tackling some of the outstanding shortcomings that prevail in its business environment (i.e. bureaucratic red tape, an inflexible labour code, continual low-level corruption, and ineffective commercial legal structures). These all prevent the private sector from reaching its full function. Nonetheless, Poland is aiming to achieve further reductions in its budget deficit and public sector spending with the eventual target of entering into EMU and adopting the euro (CIA, 2008).

3.6.6. IV Slovak Republic

Since the fall of the communism in 1989, Slovakia has successfully negotiated most of the complicated issues in relation to the macroeconomic stabilization and structural reform so as to shift from a centrally planned to a modern market based economy. However, it was not until the peaceful disintegration of Czechoslovakia in1993 (resulting in the contemporaneous independence of Slovakia) that the reforms were actually put into practice.

Table 4 shows some representative demographic and some important economic indicators if its economy.

Table 4: Slovak Republic: Demographic & Economic Characteristics

	2000	2005	2006
Population, total (millions)	5.39	5.39	5.39
Population growth (annual %)	-0.1	0.1	0.1
Surface area (sq. km) (thousands)	49.0	49.0	49.0
GDP growth (annual %)	0.7	6.0	8.3
Inflation, GDP deflator (annual %)	9.7	2.4	2.7
Gross capital formation (% of GDP)	26	29	29
Agriculture, value added (% of GDP)	4	4	4
Industry, value added (% of GDP)	32	32	32
Services, etc., value added (% of GDP)	64	64	65
Exports of goods and services (% of GDP)	70	77	86
Imports of goods and services (% of GDP)	73	82	90
Merchandise trade (% of GDP)	121	142	159
Market capitalization of listed companies (% of GDP)	6.0	9.3	10.1
Cash surplus/deficit (% of GDP)	..	-3.3	-3.4

Source: World Development Indicators database, April 2008

Slovakia is the smallest country amongst the Visegrád countries (49.0 thousands sq. km). It is located in Central Europe, south of Poland. Its population has grown at a steady rate of 0.1%. The main ethnic groups are: Slovak 85.8%, Hungarian 9.7%, Roma 1.7%, Ruthenian/Ukrainian 1%, other and unspecified ethnic groups 1.8% (CIA, 2008).

The economic growth of Slovakia was remarkable during the period 2000- 2006. It actually jumped from 0.7% to 8.3% per capita, irrespective of the fact that there was a general slowdown taking place in the rest of Europe at the time. Its high economic performance can be attributed to a great degree to some key factors such as large scale levels of privatization, business friendly policies that encourage foreign investment, tax allowances and liberalization of the labour market. It has also managed to lower inflation from 9.7 in 2000 to 2.7% in 2006.

As it is the case for the other countries of the group, the major sector of its economy is Services (65% of GDP), with Industry and Agriculture amounting to 32% and 4% respectively. However, in contrast with the other countries of the group, Slovakia seems to be import-orientated. Since 2000 its imports exceed exports. Its overall merchandise trade ratio as share of GDP is the highest amongst the group. The market capitalization of listed companies has been increased, almost doubled during the 2000-2006 period to 10.1% of GDP, due to the large scale private firms that entered the stock market. Lastly, its budget deficit was kept low at 3.4% of GDP in 2006. In 2009 Slovakia satisfied the Maastricht criteria and adopted the euro currency.

Table 3.1: 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 3.2: 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 3.1 and 3.2). Bold numbers indicate rejection of the null hypothesis of no-causality in mean.

Table 3.3: 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 (3.3) 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 3.4: 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 3.5: 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 3.6: 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 3.7: 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 3.8: 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 3.1: Exchange Rates of the Visegrád Group (V4)

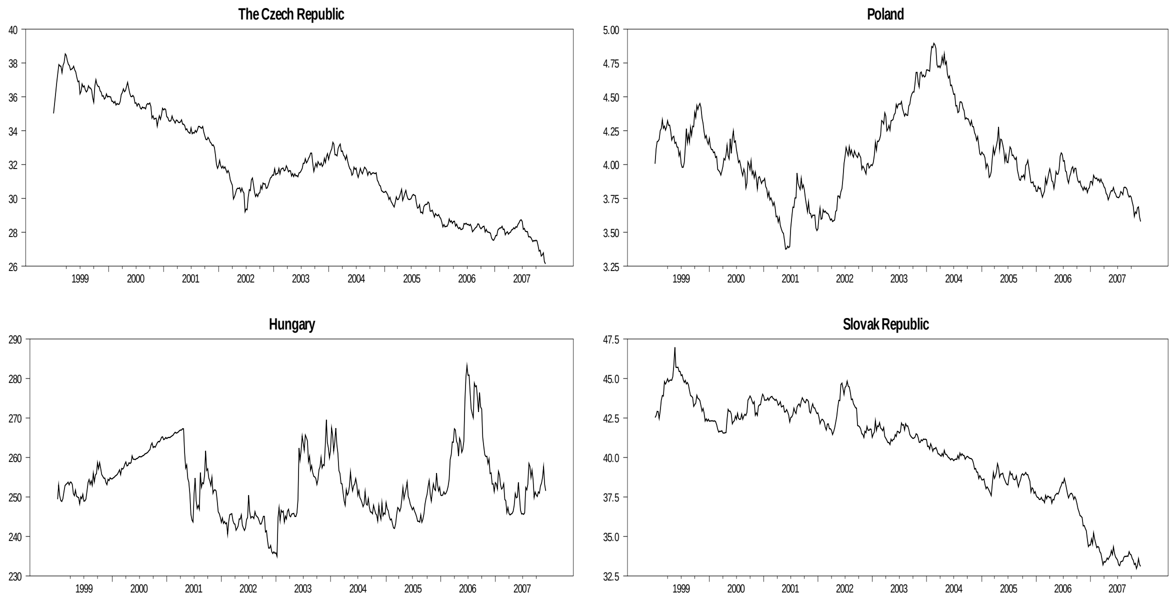
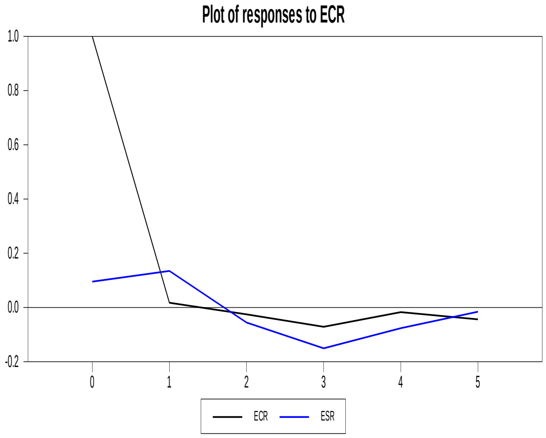
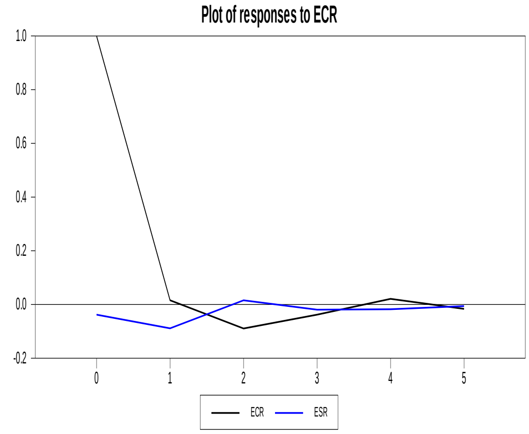


Figure 3.2: IRF: Responses of all markets to a one-standard deviation shock to Excess Currency Returns (ECR)

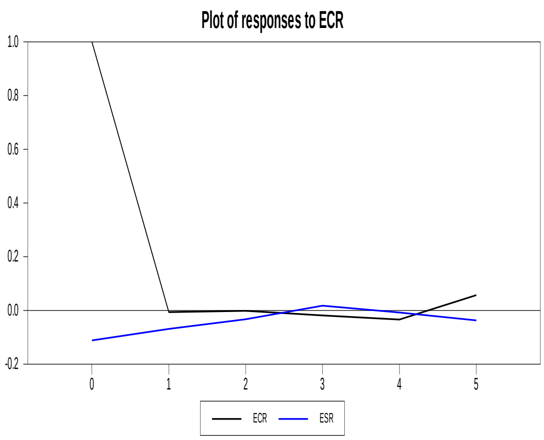
The Czech Republic:



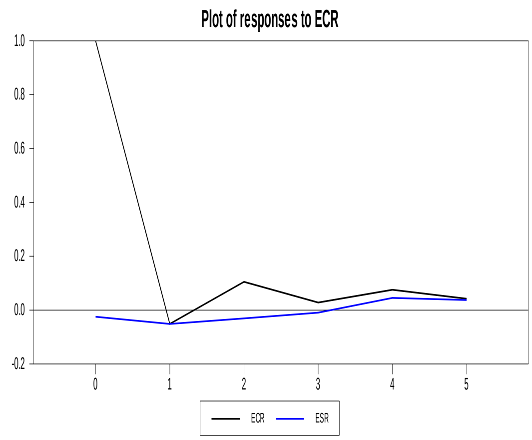
Denmark



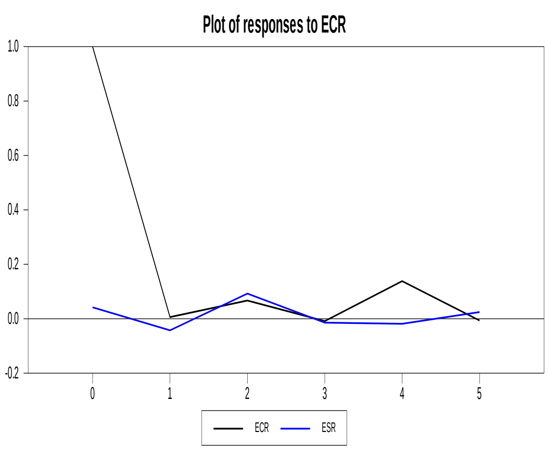
Hungary



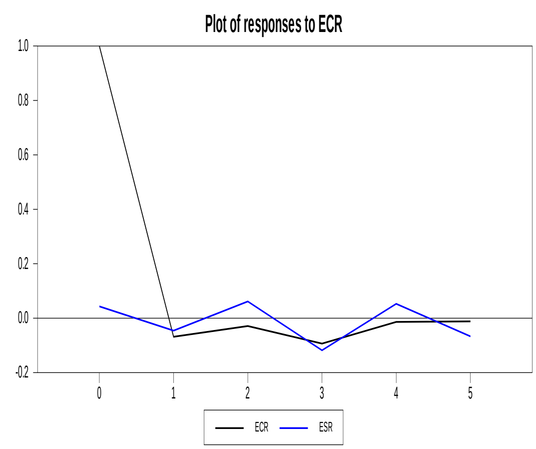
Poland



Slovakia



Sweden



UK

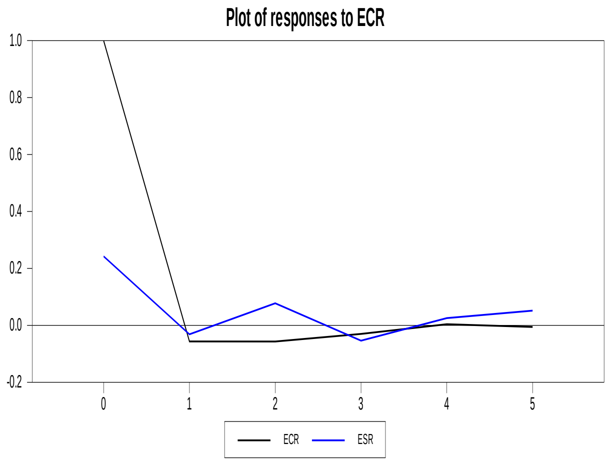
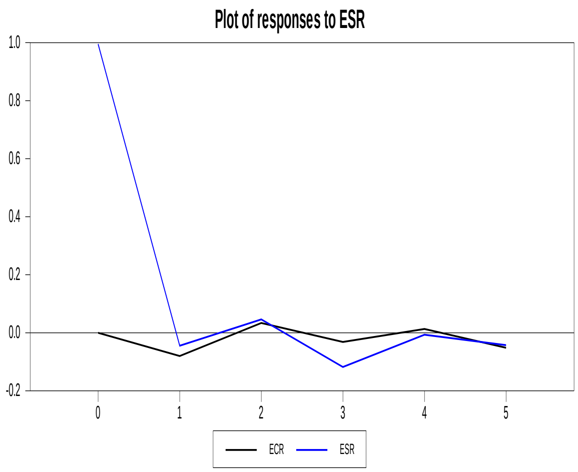
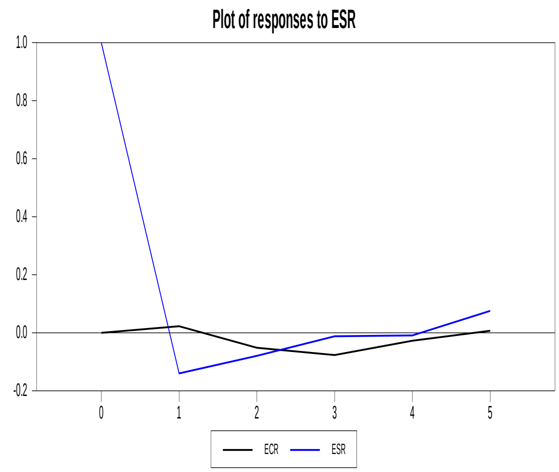


Figure 3.3: IRF: Responses of all markets to a one-standard deviation shock to Excess Stock Returns (ESR)

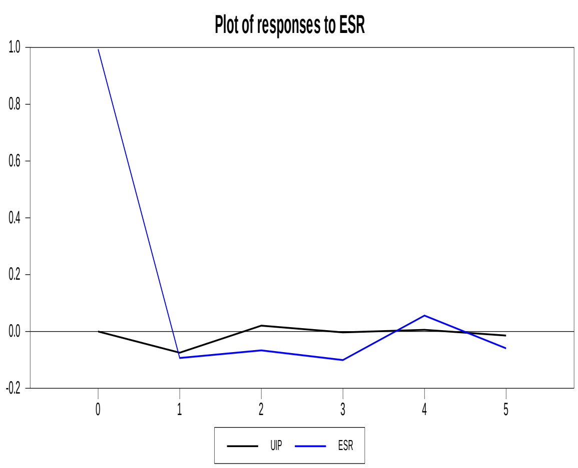
The Czech Republic



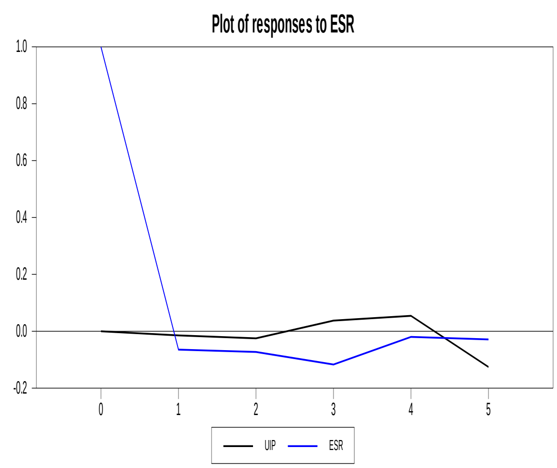
Denmark



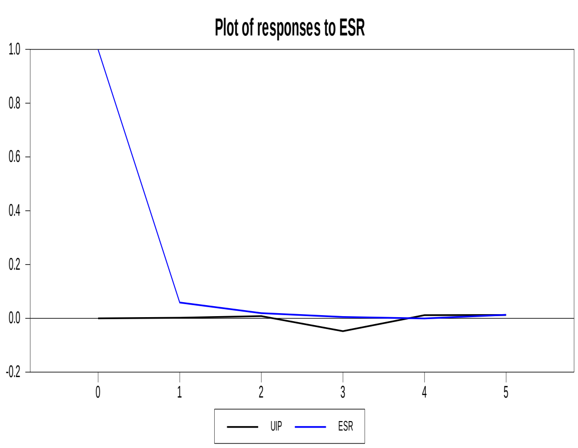
Hungary



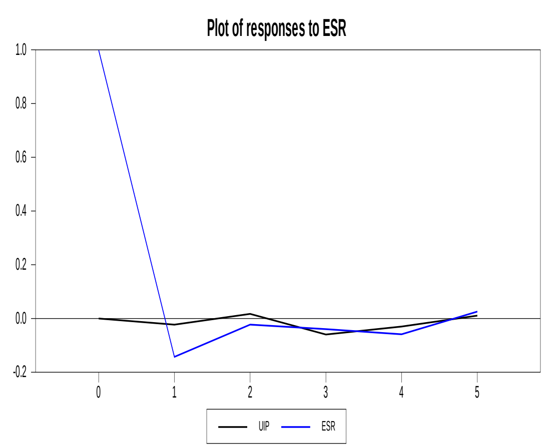
Poland



Slovakia



Sweden



UK

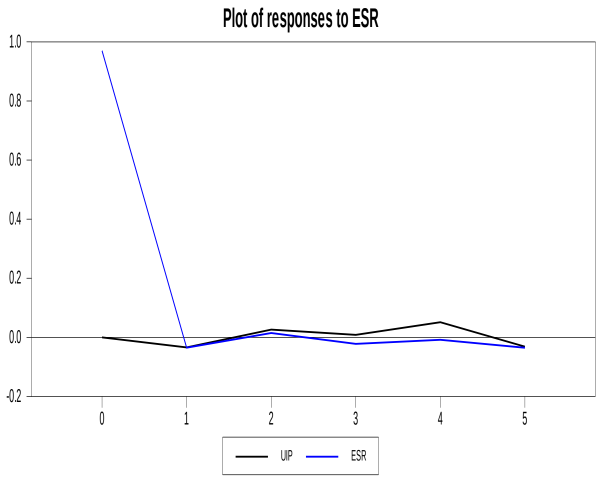


Table 3.9: Definition of Variables

	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.

Chapter 4: Financial Stocks: Time-Varying Correlations & Risks

4.1 Introduction

Fundamental weaknesses in financial systems around the world have been uncovered by the recent US financial crisis, illustrating how interconnected and interdependent today's economies have become. Since the early 1970s, eighteen bank-centered financial crises[32] have occurred at a regional level without including the East Asian and Russian crises of the late 1990s. In contrast to these episodes, the US subprime crisis has been truly global as it has spread across national borders causing an infection of financial systems on a global scale. Such was the magnitude of this crisis that financial markets led entire economies worldwide into the depths of recession or caused slow economic growth rates (e.g. widespread business contraction, decline in exports and commodity price levels, increase in unemployment, shrinking of GDP, and reductions in government revenues). This illustrates that no country is immune anymore. The current global economic climate is now considered to be the worst the world has experienced since the great depression. Benn (2009) mentions that this crisis will be remembered "*as one of widespread greed, corruption, and incompetence, enabled by a policy agenda dominated by an ideology of deregulation*".

[32] According to Reinhart & Rogoff (2008) the most catastrophic *"Big-5"* crises episodes occurred in Spain (1977), Norway (1987), Finland (1991), Sweden (1991) and Japan (1992). *Other Banking and Financial Crises*: Australia (1989), Canada (1983), Denmark (1987), France (1994), Germany (1977), Greece (1991), Iceland (1985), and Italy (1990), and New Zealand (1987), United Kingdom (1974, 1991, 1995), and United States (1984). All these crises caused severe declines in the economic growth rates of the states for a long period of time (e.g. a "lost decade" in Japan).

By common consensus, this crisis had its origins in the financial sector, with the initial shock traced to the US sub-prime and associated credit derivative markets. In particular, the rapid growth of securitized financial products in the early part of this decade had created pools of sub-prime assets which were 'rated and tranched' and sold around the globe. This process had been widely applied throughout the financial sector and due to a high demand for such products, the range of underlying assets expanded and ultimately encompassed sub-prime mortgages. The demand for these assets was fuelled by the offer of large absolute return compared to other assets in what was quite a low interest rate environment, easy global money and credit conditions from early 2002. The originators (creators or suppliers) of such products also had a great incentive to participate in this market as the margins charged to sub-prime mortgage holders reaped high returns and the risks could be 'distributed' throughout the financial system[33]. Brunnermeier (2009) provides an excellent review of the recent crisis.

However, the fragility of the sub-prime credit derivative market was savagely exposed as U.S. property prices began to fall from mid 2007. Mortgage holders found themselves unable to meet re-payments on houses that were starting to experience negative equity. The market prices for many subprime securities fell well below their "fundamental value" reflecting huge changes in expectations and the size of subsequent downgrades was enormous. Investors who had heavily relied upon the credit rating agencies[34] and lacked the ability to evaluate the

33 Purnanandam 2009 discusses in detail the *originate-to-distribute* mortgage lending model. In short, the originator of a mortgage sells it to a third party (e.g. provider of funds) who then securitizes it and sells the collateralized debt obligation to investors. When this model functions correctly, it allows the originating banks and mortgage brokers to distribute risk widely and to economize on the regulatory capital. However, some severe incentive problems occurred, broadly known as *principal-agent* problems. The agent (e.g. the originator of the loans) did not have the incentives to act fully in the interest of the principal (e.g. the ultimate buyer of the loan). Their main incentive was to maintain the origination volume but not the loan quality. When there was a large number of early payment defaults and warranty claims, they simply went out of business (see, e.g., Honohan & Stiglitz, 2001, Honohan 2008 for a better insight on *principal-agent* problem).

34 The role played by credit rating agencies in the evaluation of the true risk of structured products was crucial for the stability of the financial system. In essence, the credit rating agency values/assesses a debt obligor's creditworthiness_and this assessment reflects only credit or default risk. Credit ratings reports are meant to be directly comparable across countries and instruments. However, the credit rating firms had attributed too little weight to the likelihood of default in market prices and systematically had underestimated the risk on subprime

efficacy and validity of these ratings, experienced much larger losses than they initially thought at the time of purchase. In addition, many products offered to sub-prime borrowers were very complex and subject to misunderstanding and/or misrepresentation. This complex and opaque nature of the instruments made investors more unwilling to purchase the already undervalued subprime securities and CDOs (see Ashcraft & Schuermann 2008).

Consequently, defaults began to increase and buyers of tranched credit derivatives suffered losses. Financial institutions were greatly exposed to these risks due to significant cross-holdings of each other's securitized products. Many of those who had issued these securitized products through associated Special Purpose Vehicles (SPV) or conduits were forced to take these assets back on to their balance sheets, with devastating effects on their financial health. A liquidity crisis ensued as institutions began to hoard liquid assets due to uncertainty about their own future needs and fear of counterparty risk due to the pervasive nature of the shock. Debt maturities shortened and spreads increased until liquidity shortages began to impair the operation of many institutions. This crisis was an important factor in spreading the initial shock across different asset markets as good assets were sold off to help financial institutions raise cash to meet increasing capital requirements and offset their inability to raise capital in markets for short-term finance, such as asset backed commercial paper (ABCP). Brunnermeier & Pedersen (2009) present a model of this type of shock transmission.

This severe stress and loss of confidence in the global financial markets created market paralysis. Urgent need has arisen for a quick policy response. Governments and Central banks, in coordination with other relevant bodies, had to work closely to implement actions aimed to minimize losses to society, to restore market confidence, to stabilize and strengthen the financial system. Policy actions taken include financial rescue packages for firms considered to

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mortgages pools and on collateralized debt obligations (CDOs) because their rating methodologies were based on incomplete or even erroneous model assumptions (see Ashcraft & Schuermann 2008).

be "too big to fail", nationalization of certain financial institutions, government facilitation of mergers and acquisitions, full protection of bank deposits, credit guarantees, injections of capital, disposing of toxic assets, and restructuring debt.

In retrospect, the financial institutions did not adequately appreciate and address the risks building up in financial markets. Predatory borrowing and lending, weak underwriting standards, unsound risk management practices, increasingly complex and opaque financial products, and consequent excessive leverage combined to create vulnerabilities in the system. Too much trust was placed in the "due diligence" of originators and packagers in making loans, the false judgments of the credit rating agencies, and the capacity of modern technology and diversification to manage financial risks. Other underlying factors to the current situation were, amongst others, the inconsistent and insufficiently coordinated macroeconomic policies and the inadequate structural reforms, which led to unsustainable global macroeconomic outcomes (IMF, 2008; Blanchard, 2009). Therefore, even though securitization increased connectedness and correlations across financial institutions, the overall ability of the financial system to channel funds to those institutions with productive investment opportunities dramatically failed.

In this paper, we examine the time-varying co-movements of equity returns within major sectors, across countries. Our investigation is conducted on a sample of eleven countries over the past decade as we bid to ascertain if asset return correlations were higher during the current turmoil than previously recorded. We generate time-varying correlations by estimating an asymmetric bivariate GARCH model, whereby the US serves as a base or 'ground-zero' market and we analyze its co-movement with each of the remaining ten markets. The motivation for employing an asymmetric model stems from Cappiello, Engle and Sheppard (2006) who find significant asymmetries in conditional correlations, with a stronger reaction in stocks to common bad news events rather than good news events. Our results reveal a number of interesting facts. Firstly, while correlations between international financial sectors have increased over the period of the recent financial turmoil, current levels of co-movement are not excessive by historical standards. Secondly, the time variation inherent in the correlation of each country with the US exhibits a great deal of commonality across markets and one common factor accounts for almost all of the variation. Thirdly, the results from our analysis of the financial sector also pertain to the non-financial sector. This implies that the two sectors are inextricably linked and shocks to the financial sector are largely systematic. Fourthly, in terms of the aggregate index, the international co-movement of stock returns shows a tendency to increase since the early-mid 2000s. Lastly, the results of the financials and non-financials within each country suggest that both sectors are highly correlated and this is particularly the case for the emerging financial markets. This may imply that both sectors have been developing simultaneously since the early-2000s.

An understanding of the time varying nature of volatilities, covariances and correlations is of great importance in a portfolio allocation process for the following reasons. Firstly, correlations between asset returns are crucial ingredients for any portfolio selection. Theory predicts that if returns in different markets are not perfectly correlated gains can be achieved through the international portfolio diversification. However, a higher level of correlation implies that the benefit from market portfolio diversification diminishes, since holding a portfolio with diverse country stocks is subject to systematic risk. Studies of financial crises, volatility spillovers and contagion empirically establish that there is significant transmission of shocks across markets and that correlation and covariances have the tendency to increase more during downturns than during upturns. Consequently, the international diversification may not provide as much diversification against large return shocks when markets are highly correlated (see for instance Karolyi & Stulz, 1996; Kaminsky and Reinhart, 1998; Bae, Karolyi & Stulz, 2003; Goetzman, Li & Rouwenhorst 2005 among others).

Secondly, from a policymaker's perspective, understanding the nature of comovement across markets and across borders, identifying the channels of shock transmission and measuring the harmful impact of crises is vital, since the success or failure of the designed policies depend partially on the level of interaction or interdependence between markets.

The remainder of this paper is structured as follows: Section 4.2 reviews the literature. Section 4.3 presents our econometric methodology and Section 4.4 describes the data employed in our study. Section 4.5 reports our empirical findings for all financial sectors analyzed. Section 4.6 presents the principal component analysis (PCA) and discusses the communalities of countries' movement patterns. Section 4.7 contains our concluding remarks.

4.2 Literature Review on Asymmetric shocks

In the literature on volatility modeling there are two main theories that attempt to explain the observed asymmetry in the relationship between equity market returns and volatility. The first is the leverage effect hypothesis (see e.g., Black 1976). A negative stock price shock will increase a firm's debt-to-equity ratio (or financial leverage), making the stock riskier and increasing volatility. Therefore, the leverage effect claims that return shocks *lead to* changes in conditional volatility. However, recent studies find little support for this effect and often call it a "down market effect" that has little direct connection to firm leverage (see e.g., Figlewski & Wang, 2001). Even though the effect is found to be strongly linked with falling stock prices, it is much weaker (or even nonexistent) for positive stock returns. Changes in volatility associated with changes in leverage damp out quickly (see for example Aydemir, Gallmeyer & Hollifield, 2006 and Hens & Steude, 2009). The second explanation for the volatility asymmetry refers to a time-varying risk premium or volatility feedback effect theory (see e.g., French, Schwert, & Stambaugh 1987; Campbell & Hentschel 1992). If volatility is priced, an anticipated increase in volatility raises the required return on equity, leading to an immediate stock price decline. Therefore, the volatility feedback effect theory argues that return shocks are *caused by* changes in conditional volatility. Bekaert & Wu (2000) and Wu (2001) find that the volatility feedback effect clearly dominates the leverage effect empirically.

Empirical studies have documented that equity market (co)variances and correlations tend to vary over time and increase during periods of high market volatility. Already early papers have documented that correlations have increased significantly after the US stock-market crash in 1987 (see, for instance Bertero & Mayer, 1990; Lee & Kim, 1993). Similarly, King et. al. (1994) use the data of sixteen national stock markets and find that the increase in correlation is only a transitory effect caused by the 1987 crash. Erb, Harvey & Viskanta (1994) report that time-varying equity market correlations are closely linked to phases of the business cycle in different countries. In particular, they find that the correlations are at their highest when the business cycles of two countries are in the recessional phase, which could abolish the benefits of international portfolio diversification. Longin & Solnik (1995) use a bivariate GARCH model to specifically test the hypothesis of a constant international conditional correlation for seven developed countries for the period 1960- 1990 to determine if correlations have increased when markets are highly volatile. They reach the conclusion that correlations generally rise in periods of high volatility and also that a positive linkage between volatility and correlations exists. Karolyi & Stulz (1996) construct overnight and intraday returns of Japanese and US shares and report that correlations and covariances are high when "markets move a lot". Chesnay & Jondeau, (2001), Longin & Solnik (2001), Ang & Bekaert (2002) reach similar conclusions. They show that correlations tend to decline in "bull markets" and increase during "bear markets". Fobres & Rigobon (2002) use three events- the East Asian crises, the Mexican peso crises, and the 1987 stock market crash- and find little changes in correlation between asset returns in pairs of crisis-hit countries. They argue that the cross-market correlation coefficients are conditional on market volatility, and if they are not adjusted for heteroskedasticity, the estimated correlation coefficients can be biased and inaccurate. They propose a simple method for correcting this bias. They reach the conclusion that there is "no contagion, only interdependence". Corsetti et. al. (2005) challenge this view by questioning the Forbes–Rigobon methodology. Using a standard factor model of stock market returns, they show for the case of the Hong Kong stock market crisis of October 1997 that this conclusion can empirically not be generalized. They submit evidence of "some contagion, some interdependence". Baur & Lucey (2008) find evidence that during crises periods, the correlation between stock and bond markets becomes stronger and negative, and this was especially the case in the Asian crisis of 1997 and the Russian crisis of 1998. Chelley-Steeley (2005) estimates the speed at which the Eastern European stock markets are becoming integrated based on a smooth transition model and show that the degree of segmentation of these markets have declined significantly over the period 1994-1999. Goetzman, Li & Rouwenhorst (2005) examine the return correlations over the long run. They gather a long dataset on equity return correlations over the last 150 years, and analyse the extent to which these correlations have evolved over time. They find that correlations are time-varying and they provide evidence of an upward trend during the late 1990's. Chiang et. al. (2007) use a multivariate dynamic conditional correlation (DCC) GARCH model to explore the dynamic behaviour of stock market return correlations for nine Asian markets over the period from 1990 to 2003. They find that there is an increase in correlation during the financial crisis, which they referred to as a contagion effect, and a continued high correlation in the aftermath of the crisis, referred to as herding.

Likewise, Flavin & Panopoulou (2008) test for two different types of contagion, "shift" and "pure" contagion, within a bivariate regime-switching model in which both shocks move between low- and high- volatility states. They define pure contagion as idiosyncratic shocks being transmitted to other countries whereas shift contagion is defined as common shocks being transmitted between countries during periods of market turbulence. They provide strong statistical evidence for the existence of both types of contagion in most Asian emerging markets. In the same spirit, Flavin et. al. (2008) extended the above methodology to simultaneously test for the presence of both shift contagion and bi-directional pure contagion between stock and foreign exchange markets within a unified framework. They provide strong evidence of pure contagion and less evidence of shift contagion. However, the overall finding of the above papers is the increased correlations between domestic markets in East Asian emerging markets. Meric et. al. (2008) use weekly returns of the US, UK and six major Asian stock markets to test whether events of global magnitude (e.g. September 11, 2001) have a significant impact on the co-movement patterns of national stock markets. They find that correlations have increased and the global portfolio diversification benefits to investors have decreased in the aftermath of this particular event. Kizys and Pierdzioch (2009) based on a time-varying parameter (TVP) model report among other things that the international co-movements of stock market returns in developed countries over the period 1975-2004 are time varying and have increased since the mid- nineties.

To model asymmetric effects in (co)variances of returns, Kroner & Ng (1998) initially introduced the asymmetric dynamic covariance (ADC) model, which encompasses several other multivariate GARCH models. They apply it to weekly returns from a large-firm portfolio and small- firm portfolio in order to examine the dynamic behaviour of large- and small- firm returns. They report significant asymmetric effects in both the variances and covariances: bad news about large-firms can affect the volatility of both small-firm returns and large-firm returns. The conditional covariance also has the tendency to be higher and significant after the impact of bad news. De Goeij & Marquering (2005) further developed the ADC model of

Kroner and Ng (1998) -i.e. generalized asymmetric dynamic covariance (GADC)- by including *cross*-asymmetries[35] in the conditional volatility to show that the covariance terms also respond asymmetrically to return shocks. In particular, they find that the conditional variance of stock returns responds asymmetrically to stock market shocks, whilst the conditional covariance becomes fairly low after bad news hit the stock market. The same authors in a subsequent paper, De Goeij & Marquering, (2009) propose an asymmetric multivariate GARCH model that includes level effects and cross-asymmetries in conditional variances and covariances. Amongst other things, they find weak evidence of level effects for stock return volatility but strong (cross-) asymmetric effects in the conditional variances and covariances in stock returns.

The asymmetric effect in covariances and correlations in stock returns has also been explored in Cappiello, Engle and Sheppard (2006). Based on an asymmetric generalized dynamic conditional correlation (AG-DCC-)GARCH model, they find strong evidence of asymmetries in the conditional volatility of stock returns. They also report a significant presence of asymmetries in conditional correlations, to common bad news events. In the same spirit, Hyde, Bredin & Nguyen (2008) using the same specification (AG-DCC-GARCH) provide evidence of significant asymmetries in conditional volatilities and correlations in the equity markets of Asia-Pacific, the EU and the US. They also find that correlations have increased more during the end of this decade than in the early 1990s. They interpret this as evidence of increasing global market integration. The time-varying correlation in stock returns has also been investigated in Li & Zou (2008) who also capture the asymmetric responses in stock correlations to recent government policy decisions in China.

Several papers in the literature investigate whether stock or bond market yields are related to global events and tend to co-move, due to either contagion-like phenomena, or to

[35] They define the cross-asymmetries as follows: "the conditional variance and covariance between asset returns can be higher (or lower) after a negative shock in one asset and a positive shock in the other asset, rather than shocks of opposite signs of the same magnitude".

local idiosyncratic shocks. A methodology commonly applied with the aim of identifying the pattern of the co-movements when reducing the dimensionality of the data with minimal loss of information, is the principal component analysis (PCA). The PCA is known to provide a useful insight into asset co-movements. Volosovych (2005) focuses on international bond markets during the period 1875 to 2002. He employs PCA to argue that integration in the last period of globalization during the late 19th century was markedly lower than in the last twenty years. Similar data and methods were employed by Mauro et. al. (2002), who argue that contagion in modern-day (e.g. 1992-2000) bond markets has become much greater than it was historically (e.g. 1870-1913). Bordo & Murshid (2006) argue the opposite. Based on PCA on monthly spreads on long-term bond yields on both advanced and emerging countries, they provide evidence that financial market shocks were more globalized before 1914 than they are now. Also the relevance of this technique has been enhanced with extension to volatility GARCH modeling (see, e.g., Alexander, 2002; Geng, 2009).

Overall, the literature tends to confirm the view that in periods of uncertainty or distress or bad news, financial markets tend to co-move and their conditional correlations tend to increase and furthermore significant asymmetries exist. In the subsequent section we discuss the econometric methodology employed in this paper.

4.3 Econometric Methodology

Our aim is to explore the comovements of asset returns across different pairs of countries and sectors over the past decades in order to ascertain if their correlations have increased during the current turmoil. We seek a model that jointly estimates the time varying variance-covariance matrix of stock returns and additionally accounts for the asymmetric effects of return shocks on both in-mean and in-variance equations.

To accommodate the possibilities of asymmetries or threshold effects on the dynamic volatility of returns, multiple classes of GARCH models have been developed, since the original development of GARCH models by Engle (1982) and Bollerslev (1986). These include the univariate asymmetric models of Nelson (1991), Engle & Ng (1993), Glosten, Jagannathan & Runkle (1993) or more recently the AG-DCC model of Capiello, Engle & Sheppard (2006). In this study, we employ a multivariate GJR-GARCH specification with the BEKK parameterization of Engle & Kroner (1995). The asymmetric GJR-GARCH model is specifically designed to capture the potential larger impact of negative shocks on return volatility. Engle and Ng (1993) after comparing a number of stochastic volatility models find that the GJR-GARCH model captures asymmetries more accurately than others. Moreover, the GJR-GARCH models seem to better accommodate the existence of extreme values in the financial data. Lastly, the GJR-GARCH is consistent with the BEKK parameterization of Engle & Kroner (1995). This formulation guarantees the positive definiteness of the time varying conditional variance - covariance matrix. The BEKK parameterization does not impose any restriction on the dynamics of conditional second moments, including conditional correlations[36].

For computational reasons, we estimate an asymmetric bivariate GJR-GARCH(1,1) model which is structured in two equations: the conditional mean equation, and the conditional (co)variance equation. The conditional mean equation is written in a vector autoregression (VAR) form augmented with a term that captures the effects of adverse shocks on the level of returns. The conditional variance and covariance equation is structured according to the GJR-GARCH specification. Hence, our model is specified as follows:

[36] However, the BEKK formulation is sometimes difficult to estimate, because the number of unknown parameters increases rapidly with the number of markets.

$$R_t = \Omega + \Phi R_{t-1} + \varepsilon_t + \theta\eta_{t-1}$$

$$\varepsilon_t \sim N(0, H_t)$$

$$H_t = C'C + A\left(\varepsilon_{t-1}\varepsilon'_{t-1}\right)A' + BH_{t-1}B' + \Gamma\left(\eta_{t-1}\eta'_{t-1}\right)\Gamma' \tag{4.3.1}$$

Let's first focus on the conditional mean where $R_t = \left(r_{US,t},\, r_{i,t}\right)'$ is a vector of stock returns at time t, with $r_{US,t}$ representing the US stock market returns and $r_{i,t}$, $i = 1, 2, \ldots 10$ denoting the remaining foreign stock market returns at time t; $\Omega = \left(\omega_{US},\, \omega_i\right)'$ is a 2×1 vector of constants; $\Phi = \begin{pmatrix} \phi_{US,US} & \phi_{US,i} \\ \phi_{i,US} & \phi_{i,i} \end{pmatrix}$ is a 2×2 coefficient matrix that captures the persistence and cross-country effects in the conditional mean of returns; $\varepsilon_t = \left(\varepsilon_{US,t},\, \varepsilon_{i,t}\right)'$ is a 2×1 vector of error terms and is distributed normally with zero mean and a time varying conditional variance and covariance matrix H_t (see below) while η is defined as $Min\left(0, \varepsilon_t\right)$ and represents the negative shocks or the "bad" news that enter the market. $\theta = \begin{pmatrix} \theta_{US,US} & 0 \\ 0 & \theta_{i,i} \end{pmatrix}$ is a 2×2 diagonal coefficient matrix whose elements capture the asymmetric effects of adverse shocks on the level of returns. In essence, the conditional mean equation shows that the stock market return is a function of its own past returns, of the other market's past returns and of its own past negative shocks. The inclusion in our model of a matrix that picks up the negative error terms as an extra component may permit identification of any possible asymmetric effects in the mean. Engle and Ng (1993) suggest that error terms can be used as a measure of news. For example, an unexpected increase in stock returns indicates the arrival of good news ($\varepsilon_{t-1} > 0$), whilst an unexpected decrease in stock returns indicates bad news ($\varepsilon_{t-1} < 0$). It is interesting to explore, therefore, the effect of negative news on the mean return equation.

We next turn to the conditional second order moments where $H_t = \begin{pmatrix} h_{US,t} & h_{US,i,t} \\ h_{i,US,t} & h_{i,t} \end{pmatrix}$, $i = 1, 2, ...10$ is a 2×2 time-varying variance-covariance matrix of stock returns with $h_{US,i,t}$ denoting the covariance term of the US stock returns with one of the remaining foreign stock market returns, i, in a bivariate combination. $C = \begin{pmatrix} c_{US,US} & c_{US,i} \\ c_{i,US} & c_{i,i} \end{pmatrix}$ is a 2x2 symmetric matrix of constants, $A = \begin{pmatrix} a_{US,US} & a_{US,i} \\ a_{i,US} & a_{i,i} \end{pmatrix}$, $B = \begin{pmatrix} b_{US,US} & b_{US,i} \\ b_{i,US} & b_{i,i} \end{pmatrix}$, $\Gamma = \begin{pmatrix} \gamma_{US,US} & \gamma_{US,i} \\ \gamma_{i,US} & \gamma_{i,i} \end{pmatrix}$ $i = 1, 2, ...10$ are all 2×2 coefficient matrices. The matrix of negative error terms η is defined as before. Matrix A captures the effects of shocks (lagged squared residuals) on current volatility. Matrix B picks up the persistence effects of the past period's volatility on current volatility. Matrix Γ captures the extra effect of negative shocks on current volatility. The conditional volatility of returns equation, H_t, is a function of constants, lagged squared innovations, of its own lagged values, and of a term that takes into account the negative error terms at $t-1$. In this set-up, volatility tends to increase more with the "bad news" ($\varepsilon_{t-1} < 0$) than with the "good news" ($\varepsilon_{t-1} > 0$). Good news has an impact of A whereas bad news has an impact of $A + \Gamma$. If $\Gamma = 0$ this implies that the shock is symmetric (a positive return shock has the same effect on volatility as the negative return shock of the same magnitude) while if $\Gamma \neq 0$ the shock is asymmetric (e.g. if $\Gamma > 0$ then the asymmetric effect exists). Equation 4.3.1 captures both the asymmetric effects of return shocks on the conditional mean and variance equations.

It is well documented that in the estimation of regression models with ARCH errors, the regression coefficients for an ordinary least squares (OLS) are unbiased but not consistent (Engle, 1982). If the error terms are not conditionally normally distributed, the log likelihood function is misspecified, that is, does not correspond to the true conditional distribution of the dependent variable. In such instance, the estimator derived from maximizing the incorrect log likelihood function is not the maximum likelihood estimator. Following the literature, to deal with violations of the normality assumption often observed in financial time series, we use the quasi-maximum likelihood (QML) approach, proposed by Bollerslev and Wooldridge (1992). The main advantage of this approach is that under fairly weak conditions, the QML estimates are known to be consistent and asymptotically normal under regularity conditions. Non-linear optimization is performed using the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm.

4.3.1 Conditional Correlations

Modern portfolio theory attests that not only returns and volatilities are significant in the portfolio selection process, but also correlations between assets are equally important for optimal asset allocation. Correlations between international equity markets and dependences in asset returns are often found to vary over time and to increase during turbulent periods (Chesnay & Jondeau, 2001; Billio, Caporin & Goblo, 2006; Cappiello, Engle & Sheppard, 2006; Hyde, Bredin & Nguyen 2008). In this study, we examine the time-varying co-movements of stock returns across countries and we analyze the conditional correlations exhibited by cross- country pairs during the recent financial crisis. In particular, we compute the conditional correlation coefficient, based on equation 4.3.1. Let $\rho_{US,i,t}$ denote the conditional correlation coefficient between the US stock market return with one of the remaining foreign stock markets, given information available at time t-1. Hence:

$$\rho_{US,i,t} = \frac{h_{US,i,t}}{\sqrt{h_{US,US,t}} \cdot \sqrt{h_{i,i,t}}} \tag{4.3.2}$$

with $h_{US,i,t} = \text{cov}_t\left\{r_{US,t}, r_{i,t}\right\}$. Zero correlation between two assets is equivalent to their independence. If $\rho_{US,i,t}$ varies over time, this implies that both the conditional variances (e.g. $\sqrt{h_{US,US,t}}$ and $\sqrt{h_{i,i,t}}$) and the conditional covariance term (e.g. $h_{US,i,t}$) evolve over time. Consequently, the modeling of the time-varying conditional covariances is truly important for both portfolio managers and regulators who wish to perform an optimal allocation of their assets, since international diversification benefits decrease when correlations are high. This is particularly true in turbulent periods. Diversification cannot decrease the risk during periods of high volatility.

4.3.2 Principal Component Analysis (PCA)

Later, we analyse the degree of commonality exhibited by our cross-country co-movements. We employ a Principal Components analysis (PCA), which is explained here.

PCA is well known as a data reduction technique. It uses a lesser number of variables to represent the main information of the original variables, which brings convenience for process monitoring. Traditionally, the PCA linearly transforms a set of correlated variables into a smaller subset of uncorrelated variables, in order to capture most of the variation in the data. By reducing the dimensionality of the data, this technique is very useful for identifying the pattern of co-movements inherent in the data with minimal loss of information (see for example, Alexander, 2002; Volosovych, 2005; Geng, 2009).

To investigate the common driving factors underlying the time-varying conditional correlations of our sample, we do as follows: let $Z_t = (z_1, z_2, ..., z_{10})'$ denote a 10×1 vector of ten observable conditional correlation variables; $F_t = (f_1, f_2, ..., f_{10})'$ denote a 10×1 vector of ten unobservable variables called components; $\Lambda = (\lambda_1, \lambda_2, ..., \lambda_{10})'$ denote a 10×10 vector of loadings and u_j is a 10×1 vector of zero mean error term. The principal component analysis is of the following form:

$$Z_t = \Lambda F_t + u_t, \tag{4.3.3}$$

Equation 4.3.3 suggests that for any given Z_t variables, it is possible to extract F_t principle components, under the assumption that none of these variables are perfectly correlated with each other. These F_t principle components are just an orthogonal linear combination of the original variables. Each linear combination is an eigenvector of the matrix of correlations and the elements of the eigenvector are the loadings. The principal components are ordered according to the size of the eigenvalues. The first principal component, the one corresponding to the largest eigenvalue, accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible (the rest of the variation is ascribed to 'noise'). Consequently, only a few principal components are required to represent the original variables to a fairly high degree of accuracy, which brings convenience for process monitoring.

4.4 Data

The data used in this study consists of time series of stock-market price indices for 11 sample countries. All indices are value-weighted and denominated in local currencies. The indices are measured at weekly frequency to reduce the effect of non-synchronous trading. The total market indices are decomposed into two broadly defined sectors, namely financial and non-financial stocks. To begin with, we will concentrate on the financial sector, but will later broaden our study to include different categories of stocks across countries. We will also analyse the total market across all country-pairs as well as the financial and non-financial stocks within each country. We do so, as the harsh effects of the recent crisis were felt, not only in the banking[37] sector, but also in a wide array of non-banking financial services sectors across countries. The sample of countries is a mixture of developed and developing countries. These are: the United States (US), the United Kingdom (UK), Canada (CN), Germany (BD), Japan (JP), Ireland (IR), Greece (GR), Poland (PO), Hong-Kong (HK), Singapore (SG), and Malaysia (MA). To calculate the stock market returns, the first difference of the logarithmic stock price indices are taken. All series are stationary. Augmented Dickey-Fuller tests (not reported here) overwhelmingly reject the null of a unit root for the first difference of logarithmic price series. All the data is retrieved from Datastream International for the period January 1, 1999 through February 6, 2009 comprising of 528 observations. Table 4.1 displays descriptive statistics for the weekly returns.

[Insert Table 4.1 about here]

The statistics show that the financial returns (Panel A) of the US, UK, Japan, Germany, Ireland and Greece are on average negative compared to the non-financial returns (Panel B).

[37] Comparable patterns emerge when banking stocks alone are considered in the analysis.

Such a result can be largely attributed to the poor performance of the financial sector between 2007 and 2009. Combining together the financial and non-financial returns, the total market returns (Panel C) are on average negative only for those countries where the collapse of the financial sector was spectacular (i.e. Ireland and Greece).

More analytically, for financial stocks (Panel A) Poland and Malaysia have the highest average returns of 0.002 per week whereas the Germany has the lowest with -0.0006 per week. With regard to volatility, Hong Kong appears to have the highest volatility of around 0.002 per week, while Malaysia has the lowest of 0.0009 per week. For non-financial stocks (Panel B), the returns of Canada, Poland and Malaysia are the highest on average around 0.001 per week, whilst the US displays the lowest average returns of 0.00008 per week. In this category, the most volatile countries with a variance of 0.001 per week are Ireland, Greece, Poland and Hong-Kong while Germany is the least volatile with a variance of 0.0009 per week. Lastly, taking together the financial and non financial returns, the total market returns (Panel C) of Canada, Poland and of the three Asian emerging markets Hong-Kong, Singapore and Malaysia display the highest average returns of 0.001 per week whilst Ireland displays the lowest of -0.0006 per week. In relation to the variances, the markets of Ireland, Greece, Poland and Hong-Kong are the most volatile with a variance of 0.001 per week while Germany is the least volatile with a variance of 0.0009 per week.

The distribution of returns over the sample is skewed for the vast majority of countries in all three categories. The skewness coefficient decisively rejects the null hypothesis of a symmetric distribution, most often at the 1% significance level. Additionally, all stock returns are characterized by a statistically significant kurtosis. As can be seen in Table 4.1, all returns exhibit fatter tails and higher peaks in contrast with the normal distribution indicating that our series are leptokurtic. The excess kurtosis statistics for the financial returns in Panel A ranges in value from 1.08 for Japan to 18.81 for Ireland; for the non-financial returns in Panel B it ranges from 1.70 for Poland to 9.24 for the UK; and lastly for the total market returns in Panel C the kurtosis ranges from 1.65 for Poland to 10.77 for the UK. Accordingly, the Jarque-Bera test confirms that the distribution of all returns is non-normal.

Furthermore, we switch our attention to the relative importance of the financial and non-financial stocks in the total market index. Figure 4.1 depicts the proportion of total market value attributed to financial stocks, represented by the lower segment (darker colour) in all countries.

[Insert Figure 4.1 about here]

The general picture that emerges from Figure 4.1 is that the financial stocks account for between 20% and 30% of total value over the sampled period for the developed markets, such as the US, the UK, Canada, Germany, Japan, as well as Malaysia from the emerging markets. We observe that there is a modest decline in the relative importance of the financial sector during the recent crisis. The rate of its decline is slightly quicker compared with the non-financial sector over the same period. For the remaining markets, the pictures reveal that the relative contribution to market value from financial stocks is much greater. For example, the financial sectors of Poland and Ireland reach almost 60% in total market value. We also observe a modest rate of decline of market capitalization in both sectors. The only exception is Ireland, and to a lesser extent Greece, where the fall of its financial sector was spectacular - from a high of about 58% in late 2002 to about 6% in early 2009[38].

[38] Irish banks were hugely exposed to the housing and construction sector, which have experienced huge declines since 2007.

4.5 Empirical Results

Our goal is to empirically estimate the time-varying correlations of stock market returns between the various countries in our sample and the U.S, in bivariate combinations. In this section therefore we present results of a bivariate, adjusted for asymmetry, VAR model as well as the GJR-GARCH parameters that govern the dynamics on the variances and covariances. The main advantage of our specification is that it incorporates the asymmetry in both mean and variance into the specification, such that the effect of a return shock on both the conditional mean and the variance is simultaneously measured.

4.5.1 Financial Stocks

4.5.1. I Conditional Mean

Table 4.2 reports the parameter estimates for financial stocks. Panel A of Table 4.2 presents results from the conditional mean process of the asymmetric bivariate VAR(1,1) whilst Panel B presents results from the conditional variance and covariance process of the asymmetric GJR-GARCH(1,1) model. In each case, associated robust t-values are reported in parentheses. According to the Akaike Information Criterion[39] (AIC), the inclusion of one lag

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[39] AIC criterion is a simple formula that is broadly used to compare different statistical models and to identify which model explains the data best when using the minimum number of parameters. In the general form, the values of AIC are computed as follows: $AIC = -2\ln(L) + 2k$, where k is the number of the parameters in the statistical model and L is the maximized value of the likelihood function for the estimated model. A model with the lower AIC is the best model which uses smaller numbers of parameters and provides the higher goodness of fit. Rearranging the above formula, we obtain: $AIC = n\log(\frac{RSS}{n}) + 2k$, where $RSS = \sum_{i=1}^{n} \widehat{\varepsilon_i^2}$ are the i.i.d. estimated residuals of the fitted model.

of the stock returns is sufficient. Franses & Van Dijk (1996) and Choo (1999) document that models with low lag length order, such as GARCH (1,1) are sufficient to cope with the changing variance.

[Insert Table 4.2 about here]

We first consider the conditional mean model that jointly estimates the financial stock market returns across different market pairs. As can be seen in Panel A of Table 4.2, the constant terms (ω_{US} and $\omega_{i,t}$) are not statistically significant for the US mean return equation but sometimes they are for the mean returns of other countries. As expected, returns at this frequency are almost serially independent. The effects of own lagged returns on current values are largely not statistically significant (see e.g. $\phi_{US,US}$ and $\phi_{i,i}$). Nonetheless, the one-period lagged US financial stock returns, $\phi_{i,US}$, appear to have significant explanatory power and a positive impact over the other markets– apart from Malaysia which imposed capital controls during the Asian crisis in 1997 and appears to be segmented from global markets. The reverse relation i.e. market i to US, is not significant in our sample. This may be attributed to the fact that the United States is the main underwriter of the international financial system, the source of dollars, which are extensively used as currency reserves and as an international standard of exchange, and supplies a great deal of the financial capital that circulates the world seeking higher returns. The dummy variable introduced in the mean equation measures the asymmetric effect of an innovation of one market upon its own returns. For example, the $\theta_{US,US}$ component of Θ matrix measures the direct effect of past negative shocks of the US market upon its own financial returns. The asymmetric effect is statistically different from zero in eight out of ten cases for the US market but it is rather weak for the remaining markets (four out of ten). The negative sign of the asymmetric estimates implies that an unanticipated adverse shock exerts a positive influence on the conditional mean returns.

4.5.1. II Conditional Variance

Turning to the conditional second-order moments, Panel B in Table 4.2 presents the estimated coefficients for the conditional variances and covariance process of the financial returns. In this model, the diagonal as well as the non-diagonal elements of C matrix are all statistically significant, apart from a very small number of cases. A careful look at the ARCH coefficients shows that there is evidence of time variation. In particular, the diagonal elements of the A matrix, which signify the importance of the recent innovations or "news" in the market, are significant in many cases. The covariance terms, captured by the off-diagonal elements, are also statistically significant with a mix of positive and negative signs, in six out of ten cases considered. The positive sign of the covariance terms means that a shock of financial returns causes both markets to move in same direction. Hence, a significant increase of two negative shocks at time $t-1$, for example, leads to a significant increase of the covariances of returns at time t. Furthermore, all the lagged conditional variances as shown by the diagonal elements of B matrix are statistically significant across all market-pairs. This suggests a high persistence of shocks to the conditional volatility. However, the covariance effect- the off-diagonal elements- is significant in only two country pairs, implying a weak co-movement between the volatility of financial assets of the US with the rest of the markets. Lastly, the asymmetric response to positive and negative shocks, captured by Γ matrix, is very pronounced and provides support for the specification. The diagonal elements are significantly positive, as most of the off-diagonal elements are, in the conditional (co)variance of financial stock returns equation. This evidence reinforces the finding often found in the literature, that bad news increases volatility more than good news does.

4.5.1. III Time-varying Conditional Correlations

We focus next on the evolution of the conditional correlations of financial stock returns. We generate the time-varying conditional correlations for each market pair. For completeness, along with the conditional correlations, we also show a filtered[40] series (thick line), which is specifically designed to show the long-run trends in the series. All relevant graphs are displayed in Figure 4.2.

[Insert Figure 4.2 about here]

Our simple time series plot of return co-movements suggests a number of interesting points. Firstly, there is clear evidence that the conditional correlations across all country pairs

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40 The filtered series is extracted using the Hodrick-Prescott (HP) filter, originally developed by Hodrick-Prescott in 1981 and reprinted in Hodrick & Prescott (1997). The HP filter is used to determine the long-term trend and cycles of a macroeconomic time series by discounting the importance of short-term fluctuations. More specifically, Hodrick & Prescott (1997) assume that the original series, y_t^*, is composed of a trend component, τ_t^*, and a cyclical component, c_t^*. That is: $y_t^* = \tau_t^* + c_t^*$ where $t = 1, 2, \ldots, T$. The aim is to construct a filter free-off trend from data. Therefore, the problem is how to separate the two components and in particular, how to minimize the variance of the cyclical component which denotes the deviation of the original variable series from the long-run trend (i.e. $c_t^* = y_t^* - \tau_t^*$). Hodrick-Prescott (1997) propose a way to decompose c_t^* from y_t^* by minimizing the following sum of squares: $Min_{\{\tau_t\}_{t=1}^T} \left[\sum_{t=1}^{T} \left(y_t^* - \tau_t^* \right)^2 + \lambda^* \sum_{t=2}^{T-1} \left[\left(\tau_{t+1}^* - \tau_t^* \right) - \left(\tau_t^* - \tau_{t-1}^* \right) \right]^2 \right]$ where λ^* is the penalty parameter of incorporating fluctuations into the trend. Many papers set λ^* equal to 1600. The larger its value the smoother the trend. As λ^* approaches to zero, the sum of squares is minimized and the trend component becomes equivalent to the original series, $y_t^* = \tau_t^*$, while as λ^* diverges to infinity, τ_t^* approaches to the linear time trend. Intuitively, the HP decomposition guarantees that the change in the trend (i.e. $\Delta\tau_{t+1}^* - \Delta\tau_t^*$) would be as small as possible minimizing in this way the variance of the cyclical component.

are time-varying. Bordo and Murschid (2000) report similar findings. They provide evidence that the cross-country co-movements are time-varying during both financial crises episodes and periods of relative tranquility. Therefore changes in correlation are not exclusive to periods of high asset return volatility. Secondly, the patterns of co-movements are roughly similar across all market-pairs and can be classified into two groups. The first group of co-movements refers to advanced financial markets. This group is characterized by high return correlations- around 0.8 or higher- between the US and its traditional trading partners such as the UK, Canada and Germany. This strong pattern of dependence does not come as a surprise. This may be attributed to the fact that developed countries display a high degree of financial and trade integration, which in turn may have resulted in stronger interdependences between nations, captured by high degrees of co-movement. Nonetheless, the degree of co-movement, despite its increase, is not excessively large in a historical context during the recent financial crisis. The second group of co-movements refers to today's emerging financial markets. This group is characterized by rather small conditional correlations. For example, the correlations between the US and Malaysia, Poland or even Greece are around 0.2 and 0.4. The salient characteristic of the emerging capital markets is that their financial systems display a relatively low level of sophistication and development, which in turn may reflect lower co-movements with the US. Thirdly, the conditional return correlations exhibit a general upward trend towards the end of the sample period, across all country-pairs. In the early period of our sample, the graphs capture a spectacular decline in the correlations. In the aftermath of the Asian crisis of 1997-98, cross-country correlations decreased throughout '99 but began to increase again from 2000 onwards as shocks such as the bursting of the dot.com bubble, the 2001 Argentine crisis and the collapse of the long term capital management (LTCM) hedge fund caused further turmoil in the financial system. These crises affected market co-movements as international financial stocks responded to these shocks. Since 2001-02 returns have become more tightly correlated, displaying an increasing trend, which seems to maintain until the end of the sample, across all country-pairs. Only in the case of Japan, is this upward trend temporarily interrupted during 2003-2005. Berben and Jansen (2005) also find a relatively low co-movement of the Japanese stock market with other major stock markets.

4.5.2 Non-Financial Stocks

4.5.2. I Conditional Mean

We now shift our attention to the non-financial sector. We repeat the analysis to examine whether or not the non-financials can serve as a good hedge in diversifying financial risk. Modern portfolio theory suggests that international co-movement of stock returns is a key issue for international investors who seek to invest in a well-diversified global portfolio. In our case, an investor should be able to hold a well diversified portfolio of non-financial assets to hedge the risk of the financials, when "bad" news or events hit the market. Again, we use an asymmetric bivariate GARCH (1,1) model, as specified in equation (4.3.1). The results are displayed in Table 4.3. As above, Panel A reports the parameter estimates for the mean equation for non-financials, while Panel B of the same table reports the analogous estimates for the variance equation.

[Insert Table 4.3 about here]

We observe that the non-financial returns are serially independent and unpredictable in most of the country-pairs. The effects of own lagged returns on current values are statistically insignificant in the mean equation. The only exception is lagged US returns, $\phi_{i,US}$, which appears to be a statistically significant predictor of returns in other countries. This finding underlines the fact that the US plays a leading role in this sector. Lastly, there is weak evidence that adverse shocks have a persistent effect on current returns in the majority of cases, since the coefficients that capture the asymmetry in the mean, θs, are not significantly different from zero.

4.5.2. II Conditional Variance

As was the case for financials, the non-financial stocks also display significant evidence of time variation in the conditional second order-moments (Panel B of Table 4.3). In general, there is considerable evidence of ARCH effects in all market-pairs studied. The diagonal coefficients of the A matrix indicate that the lagged squared residuals are significantly positive in over half of our sample. Additionally, the covariance effect as captured by the off-diagonal elements is rather weak since all pairs, apart from two cases, are not statistically different from zero. In relation to the persistence effects of lagged volatility, the results are very strong, justifying the GARCH (1,1) specification. The diagonal elements of the B matrix are predominantly statistically significant and less than one, in all market-pairs. As for their magnitudes, they are all relatively high, implying a long memory in the conditional variance. However, the covariance terms are not significantly different from zero, apart from the two Asian countries. Lastly, the asymmetric impact of negative shocks on return volatility is pronounced. The diagonal elements of the Γ matrix are significantly positive in almost all cases. Also, the off-diagonal elements are found to be statistically significant in six out of ten cases. This finding indicates a strong co-movement between the volatility of the US non-financial returns with the rest of the markets. Furthermore, the relatively high magnitudes of the estimated coefficients suggest that negative return shocks are followed by a relatively high conditional variance. Once again, our results are consistent with the stylized fact that the negative shocks increase the return volatility more than positive shocks do.

4.5.2. III Time-varying Conditional Correlations

Figure 4.3 contains graphs of the estimated cross-country conditional returns correlations for the non-financial stock market returns.

[Insert Figure 4.3 about here]

In most cases, the dynamics of the co-movements are similar to those observed for financial stocks. Among all the country-pairs considered, we again detect significant variations in the conditional correlations of non-financial returns over the sample period. The co-movements show a strong tendency to increase since the early- 2000s, with a few exceptions. This phenomenon is prominent in correlations of the UK, Germany, Greece, Poland and Singapore paired with the US. This strong international co-movement of non-financial returns may also imply that the diversification benefits from investing in a portfolio of non-financials will tend to decline (Karolyi & Stulz, 1996; Merci et. al., 2008;). Furthermore, the similarity of co-movement patterns between financial and non-financial stocks suggest there will be little diversification benefits to holding portfolios of these sectors.

4.5.3 Total Stock Market Return across markets

4.5.3. I Conditional Mean & Variance

We proceed to Table 4.4 which refers to the weekly total market returns for all country-pairs. Panel A gives the parameter estimates of the conditional mean equation in the total stock returns while Panel B reports estimates for the variance equation.

[Insert Table 4.4 about here]

Once again, we find that the US acts as a global leader. The lagged US total market returns have a direct effect on the current returns of the other markets, apart from one case. All coefficients display a positive sign, which means that they have a tendency to move together in the same direction. We further observe that adverse shocks in the previous period have a persistent influence on current total stock returns but it is weak as suggested by the frequently statistically insignificant estimated coefficients ($\theta_{US,US}$ and $\theta_{i,i}$). This is to be expected given the differing results found for financial and non-financial stocks in the previous sub-sections.

Panel B of Table 4.4 reports the parameter estimates of the conditional volatility process of the total stock market returns. In general, the elements of the three coefficient matrices C, A and B are statistically significant in a considerable number of cases, across all country-pairs. To be more specific, there is strong evidence of persistence of the lagged squared innovations in the conditional variance equation since more than half of the diagonal estimates of the A matrix are significantly different from zero. The off-diagonal elements, however, indicate poor co-movements between the volatility of total market returns of the US with the rest of the markets, since only a few coefficients are statistically significant.

Furthermore, we find that lagged volatility is strongly persistent. The diagonal elements of the B matrix are all statistically significant across countries. This result suggests that past volatility seems to have a great impact on today's total market return volatility. The magnitude of the coefficients is reasonably big, implying a long memory in volatility. Nonetheless, the off-diagonal elements are not statistically different from zero in many cases. Lastly, we find that the asymmetric impact of shocks on volatility of returns is pronounced across countries. The off-diagonal estimates of the Γ matrix are statistically significant in nine out of ten cases. This implies that negative innovations lead to more volatility than positive innovations of similar magnitude. As regards covariances, the asymmetric effect is strong, since the corresponding estimated coefficients are statistically significant in six out of ten cases considered. As total market returns move together in the same direction, negative shocks involve higher risks. The positive sign of the coefficients indicates that the conditional covariance between stock returns is high when there are negative shocks. This makes sense, as it is riskier to invest in two assets that are highly correlated than to invest in two assets that are less correlated.

4.5.3. II Time-varying Conditional Correlations

We shift our attention to the analysis of the conditional correlations found in the total stock market returns. These co-movements are displayed in Figure 4.4.

[Insert Figure 4.4 about here]

As expected, in terms of the aggregate index, we find a clear upward trend across all country-pairs over the whole sample period. This evidence is consistent with what has commonly been found in recent literature, that there is an overall increase in international co-movements of stock returns since early-mid 1990s. For instance, Flavin & Panopoulou (2008) and Flavin et. al. (2008) report evidence of higher correlations of cross-country equity markets in East Asian emerging markets over the period 1990-2007. Berben & Jansen (2005) find that correlations amongst the US-German and the US-UK equity markets have more than doubled between 1980 and 2000. Ayuso & Blanco (2001) find that the degree of financial market integration among major stock markets has increased during the nineties. However, even though the total stock returns have risen substantially across all country-pairs in our sample, there are a number of downward segments, which suggest that there are also short periods of decline in the early-2000s. This is especially the case for the US with the following UK, Ireland and Japan. Lastly, we find strong evidence that during the current crisis episode, the conditional correlations have increased. Good examples are the US correlations with the UK, Germany, Poland, Greece, and Singapore. This finding provides an additional insight on the fact that the correlation between national stock markets tends to increase after events of global magnitude and importance (Meric et. al., 2008).

4.5.4 Financial & Non-Financial Stock Market Returns per country

4.5.4. I Conditional Mean & Variance

Lastly, we examine the conditional second order moments of financial and non-financial stocks within each market. Panel A of Table 4.5 reports the parameter estimates of the conditional mean equation whilst Panel B displays estimates for the variance equation.

[Insert Table 4.5 about here]

Results in Panel A suggest that both the financial and non-financial stock returns of each market are largely serially independent and unpredictable. The lagged values of the coefficients do not significantly differ from zero, in the majority of cases. Coupled with the fact that the negative innovations exert a weak influence on current returns, we can infer that predictability in the mean equation is rather weak.

The estimates for the variance equation, as reported in Panel B of Table 4.5, provide stronger evidence in favour of the asymmetric specification adopted in this study. The coefficient estimates of the lagged squared residuals display significant evidence of ARCH over the sample period. The diagonal elements of the A matrix are statistically different from zero in the vast majority of cases (seven out of eleven cases). In a similar manner, the off-diagonal elements are statistically significant, apart from a few cases. This indicates strong co-movements between the volatility of financial and non-financial returns within each country. Furthermore, we find clear evidence of time variation with most of the persistence estimates in the B matrix, statistically significant. This result is pronounced for the diagonal elements, since all lagged conditional variances are found to be statistically significant across all country-pairs. Also, the magnitude of the estimates is big which indicates high persistence of volatility shocks. However, the small number of statistically significant off-diagonal elements suggests a weak co-movement pattern. Lastly, we find that negative innovations have a large overall impact on the volatility of financial and non-financial returns (nine out of eleven cases). In relation to the asymmetric effects in the covariances, the effect is not statistically negligible. The corresponding estimated coefficients are statistically significant in six out of eleven cases, suggesting that the conditional covariances react more strongly to negative rather than positive shocks.

4.5.4. II Time-varying Conditional Correlations

Next, we focus on the co-movement pattern of financial and non-financial stocks within each country, as displayed in Figure 4.5.

[Insert Figure 4.5 about here]

Figure 4.5 depicts how the co-movement of stock returns within each market has changed over time. The integration of the financial and non-financial sectors within each country is worth mentioning. The strong upward trend of the co-movements suggests that both sectors have been developing in tandem since the early-2000s. Interestingly, this trend is not only noticeable in the traditionally advanced economies like the US, the UK, Germany or Japan, as expected, but also in the emerging financial markets of Hong Kong, Poland, and Singapore. However, the graphs suggest that there are also short periods of decline, as for example in Malaysia. It is likely that these downward segments reflect some regional or country-specific economic conditions (e.g. high inflation, recessionary pressures etc).

Taken all together, figures 4.2 to 4.5 show that this shock has been largely undiversifiable. This finding is consistent with Chiang et. al. (2007) and Wang & Moor (2008) who also find an increased level of the stock market correlations during and after the Asian financial crisis. The high level of correlation observed in most of our market pairs across countries and sectors implies that the benefit from market portfolio diversification diminishes, since holding a portfolio with stocks of different countries or sectors is subject to this systematic risk. Additionally, investors who exhibit "home-bias"[41] in portfolio selection do not

[41] "Home bias" implies that investors hold a substantially larger proportion of their equity in domestic equities rather than international assets, eventhough the benefits of international portfolio diversification are significantly positive. For instance, while the US share in the world portfolio is a bit less than 50%, the US investors' domestic equity holdings account for only about 80% of their total equity holdings. The literature offers

act optimally. Under a systemic crisis, superior portfolio construction and hedging strategies may fail. Consequently, by either diversifying into foreign equities or holding the majority of their financial portfolios in domestic assets, investors do not hedge for risk. The recent crisis was global and affected all sorts of portfolio compositions.

4.6 Principal Component Analysis (PCA)

In order to examine the contemporaneous co-movement patterns of the financial stocks across all country-pairs over the whole sample, we extract principal components from the covariance matrix. The underlying idea is to find common factors, which drive the variation of these co-movements when collapsing the dimensionality of data. We extend the analysis to all sectors. In each sector, the principal components analysis of the ten conditional correlations indicates that the bulk of the variation in conditional correlations can be attributed to the first principal component, with the remaining components much less significant and perhaps just constituting noise. The factor loadings of the first principal component in all different stock categories are displayed in Table 4.6. A detailed discussion of the PCA methodology can be found in Volosovych (2005).

[Insert Table 4.6 about here]

The feature of interest in Panel A of Table 4.6 is that the first principal component alone of financial, non-financial and total market stocks respectively captures approximately

a variety of explanations of international portfolio choice and the home-bias puzzle including transaction costs, taxes, information asymmetries, currency risk, legal or government restrictions, political risk and other controls. Hau & Rey (2008) document the presence of home bias in the portfolios of managers in financial institutions where as Ahearne, Griever & Warnock (2004) and more recently Van Nieuwerburgh & Veldkamp (2009) show how home bias results from poor or costly information and/or information asymmetries.

96% of the entire variation in conditional correlations, whilst for the "financial and non-financial within each country" category (Panel B) the first component captures 97% of the total variation. The factor loadings on the first component for all categories (Panel A) are all of the same sign and of roughly similar magnitude. Countries that are most integrated with the US (e.g. the UK, Canada and Germany) or had the greatest dependence on the financial sector (e.g. Ireland) display the largest loadings. On the contrary, the least integrated with the US is Malaysia from the emerging market countries.

A striking conclusion from the above results in relation to the non-financial sector is its correspondence to its financial counterpart, which may reflect its high dependence on the overall financial health of the global economy. Moreover, it highlights the difficulty in creating a hedge against shocks to the financial sector. The fundamental role of the financial sector in facilitating the operation of economic activity means that shocks hitting this sector behave like systematic shocks. Given the global nature and persistence of the 'credit crunch', it appears that much of the risk inherent in financial stocks was indeed systematic and could not be diversified away by holding stocks from other sectors. Due to the shortage of money and the unwillingness of the banking sector to issue risky loans, many non-financial companies were faced with increased costs of borrowing. In fact, the upward trend in correlations is greater for the non-financial sector at the end of our sample as the real economy began to feel the effects of the crisis and many countries experienced recession. Meric et. al. (2008), arrive at similar conclusions. They use principal component analysis, together with other techniques, to come to the conclusion that the correlations between stock markets have increased and, therefore, they provide a limited portfolio diversification benefit (see also Hyde et. al. 2008).

It is accepted that a combination of cheap credit and low lending standards, which resulted in the housing bubble, were the roots of the current financial crisis. As mentioned earlier, the capital erosion and the severe lending constraints pushed down prices and tightened funding even further. Fearing funding risk and wishing to protect themselves from cash shortages, financial institutions required more liquidity to cover their own positions and felt the need to hoard liquid assets, which in turn worsened the liquidity crisis. Brunnermeier (2009) underlines the significance of liquidity shortages in spreading this crisis. Brunnermeier, Nagel, & Pedersen (2008) find that liquidity is a key driver of currency crashes "when liquidity dries up, currencies crash". Lee (2009)[42] finds that the U.S. market liquidity is the main driving force of global liquidity risk. Liquidity has also been recognized as an important factor for bond pricing (see e.g., Pastor & Stambaugh, 2003). The issue of fight-to-quality has also been examined in Beber, Brandt & Kavajecz (2009) who show that allocating funds from one market to another can, at times, be motivated by liquidity considerations. In particular, they find that whilst rebalancing towards more liquid assets that are less risky, (e.g. fixed income securities) investors care both about credit quality and liquidity. However, during economic or stock market distress investors chase liquidity instead of credit quality. Goyenko & Ukhov (2009) argue that illiquidity has a cross-market effect. They uncover a two-way Granger causality illiquidity for the stock and bond markets over a long period of time. In particular, they find that the stock illiquidity impacts bond illiquidity, which is consistent with flight-to-quality or flight-to-liquidity episodes. At the same time, they demonstrate that monetary policy shocks can be transmitted through bonds to the stock markets and ultimately affect stock market illiquidity.

In an attempt to identify which observable factors cause the variation in the first component, we use measures of credit and liquidity risk. We regress the first principle component on both the US returns and the spread of 3-month LIBOR (London Inter-Bank

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[42] An earlier version of this paper can be found in http://www.cob.ohio-state.edu/fin/dice/papers/2006/2006-10.pdf

Offered Rate)[43] over the 3-month Treasury-bill rate (TED). The inclusion of the US returns is important since the US market exerts a positive impact over other markets considered and its leading role is undoubted. The inclusion of the TED spread (a measure of credit risk) is also crucial. The greater the spread, the greater the anxiety in the marketplace. The increase of the spread indicates a downturn in the U.S. stock market due to withdrawal of liquidity. Results are presented in Table 4.7.

[Insert Table 4.7 about here]

In each sector, both the US returns and the TED spread are statistically significant and they explain some of the variation of the ten conditional correlations captured by the first component. The underlying logic is that a liquidity shortage in the financial system depresses the activities of all financial institutions, which in turn increases the conditional correlation between all sampled pairs. Lee (2009) reaches similar results. Based on a liquidity-adjusted capital asset pricing model (L-CAPM) for 50 developed and emerging countries from 1988 to 2007, he finds that liquidity risks which arise from the co-variances of asset return (liquidity) with local and global market liquidity (returns) are priced in the US market. The long-run correlation movements presented here display similar patterns to the liquidity risks generated from bond markets in Fontaine and Garcia (2009).

[43] LIBOR is an indicator of the trust among financial institutions. This is the interest rate banks charge for short-term loans to each other. It forms the basis for many financial contracts world wide.

4.7 Conclusions

We analyze the risks and co-movements of stock returns over the past decade, paying particular attention to their behaviour around the time of the recent and on-going credit crunch. Firstly, we break the market into two broadly defined sectors, namely financial and non-financial stocks. We further investigate the cross-country effects of both sectors together by jointly estimating the total market returns, and lastly, we consider the evolution of both sectors within each country. We employ an asymmetric bivariate VAR in the conditional mean equation and an asymmetric GJR-GARCH (1,1) specification in the conditional variance, in order to capture the asymmetric effect of bad news events on the stock returns.

The general result that emerges from this study is that the conditional correlations exhibit significant time variation and increase during periods of financial turmoil, in all stocks and categories. However, correlations do not exceed previous highs (e.g. the levels recorded around 2001-02) during this current crisis. Our generated conditional correlations exhibit similar patterns of co-movement in all categories and a principal component analysis reveals that the first component accounts for almost all of the variation. We also find a statistically significant relationship between this factor and both US returns and an interest rate spread (LIBOR – T-bill rate). This is consistent with the leadership role of the US in the financial system and the importance of liquidity risk in propagating the current crisis across markets.

In relation to the non-financial sector, we find that it behaves remarkably like its financial counterpart. We find no evidence that this sector can offer a good hedge against financial shocks. In fact, it suggests that the shocks in financial markets that caused the initial crash became systematic and pervasive factors affecting all equities regardless of sector. The central role of the financial sector implies that such is its role in facilitating economic activity that its health is crucial to the whole economy. Any shocks it suffers are likely to be transmitted throughout the other markets through credit and liquidity channels. When we assess the co-movements of both sectors within each country, we find that the non-financial sector is highly integrated with the financial. This is not only the case for the developed markets, as expected, but also for the emerging markets. This further supports the hypothesis that the shock was largely systematic and strategies based upon either geographical or industrial diversification were unlikely to deliver much benefit in terms of risk reduction. Therefore, ensuring that financial markets are properly regulated is of paramount importance for the future prosperity of the global economy.

Table 4.1: Summary Descriptive Statistics

	Mean	Variance	Min	Max	Skewness	Kurtosis	Jarque-Bera
				Panel A: Financial Returns			
US	-0.0001	0.001	-0.20	0.26	0.25***	9.95***	2162.79***
UK	-0.0002	0.001	-0.24	0.16	-0.87***	8.92***	1800.40***
CN	0.001	0.0006	-0.18	0.18	-0.52***	13.04***	3727.41***
BD	-0.0006	0.001	-0.24	0.17	-0.57***	7.14***	1140.07***
JP	-0.0002	0.001	-0.18	0.11	-0.07	1.08***	25.97***
IR	-0.002	0.002	-0.46	0.35	-1.53***	18.81***	7900.99***
GR	-0.0003	0.001	-0.24	0.27	0.22**	6.18***	837.32***
PO	0.002	0.001	-0.17	0.19	-0.17	3.35***	247.45***
HK	0.001	0.001	-0.14	0.14	-0.20**	2.43***	133.16***
SG	0.001	0.001	-0.15	0.16	-0.31***	2.32***	126.33***
MY	0.002	0.0009	-0.12	0.18	0.45***	4.73***	506.52***
				Panel B: Non-Financial Returns			
US	0.00008	0.0007	-0.17	0.10	-0.85***	6.41***	958.80***
UK	0.0006	0.0005	-0.18	0.12	-0.58***	9.24***	1888.00***
CN	0.001	0.0008	-0.15	0.12	-0.79***	5.55***	726.16***
BD	0.0005	0.0009	-0.16	0.21	0.02	6.58***	942.73***
JP	0.0001	0.0007	-0.20	0.10	-0.87***	5.22***	660.31***
IR	0.0001	0.001	-0.18	0.10	-1.08***	4.82***	609.51***
GR	0.0001	0.001	-0.14	0.21	0.35***	5.39***	643.00***
PO	0.001	0.001	-0.12	0.19	0.31***	1.70***	72.15***
HK	0.002	0.001	-0.16	0.15	-0.05	2.18***	104.06***
SG	0.0009	0.0007	-0.16	0.14	-0.35***	4.08***	373.82***
MY	0.001	0.0006	-0.09	0.11	0.05	2.61***	148.97***
				Panel C: Total Market Returns			
US	0.00001	0.0007	-0.18	0.12	-0.71***	6.61***	995.25***
UK	0.0003	0.0006	-0.20	0.13	-0.77***	10.77***	2578.67***
CN	0.001	0.0006	-0.15	0.13	-0.74***	7.12***	1153.60***
BD	0.0002	0.0009	-0.18	0.18	-0.29***	5.90***	765.81***
JP	0.00002	0.0008	-0.19	0.08	-0.80***	4.18***	437.96***
IR	-0.0006	0.001	-0.26	0.13	-1.30***	10.49***	2541.98***
GR	-0.0001	0.001	-0.17	0.19	0.18*	5.28***	610.42***
PO	0.001	0.001	-0.15	0.15	0.03	1.65***	59.40***
HK	0.001	0.001	-0.15	0.11	-0.19*	1.80***	74.14***
SG	0.001	0.0007	-0.15	0.11	-0.43***	3.26***	248.32***
MY	0.001	0.0006	-0.09	0.12	0.13	3.17***	220.31***

Table 4.2: Estimates for model with *Financial* stock returns

Panel A: Mean Equation

	US-UK	US-CN	US-BD	US-JP	US-IR	US-GR	US-PO	US-HK	US- SG	US-MY
ω_{US}	0.0007 (0.73)	-0.00003 (-0.10)	0.0004 (0.58)	0.0002 (0.21)	0.0004 (0.41)	-0.0001 (-0.15)	-0.001 (-1.13)	-0.00006 (-0.05)	-0.0002 (-0.26)	-0.0008 (-0.97)
$\phi_{US,US}$	-0.008 (-0.14)	-0.01 (-0.16)	-0.04 (-0.76)	-0.01 (-0.26)	0.02 (0.38)	0.007 (0.11)	0.02 (0.43)	0.01 (0.36)	0.03 (0.85)	0.01 (0.20)
$\phi_{US,i}$	0.005 (0.08)	0.04 (0.49)	-0.01 (-0.28)	**-0.04** **(-1.71)**	**-0.05** **(-2.06)**	-0.02 (-1.10)	0.007 (0.27)	0.002 (0.06)	**-0.09** **(-2.63)**	0.005 (0.13)
$\theta_{US,US}$	-0.10 (-1.32)	**-0.16** **(-3.27)**	**-0.11** **(-1.83)**	-0.09 (-0.91)	**-0.17** **(-1.90)**	**-0.17** **(-1.79)**	**-0.21** **(-2.04)**	**-0.20** **(-2.19)**	**-0.19** **(-3.09)**	**-0.17** **(-2.07)**
ω_i	0.001 (0.76)	**0.003** **(1.69)**	**0.003** **(2.60)**	**-0.003** **(-2.79)**	0.0004 (0.26)	0.002 (0.99)	**0.004** **(1.75)**	-0.0005 (-0.49)	0.001 (0.90)	0.0004 (0.34)
$\phi_{i,i}$	**-0.13** **(-2.11)**	-0.14 (-0.98)	**-0.17** **(-2.60)**	0.04 (0.88)	-0.05 (-0.90)	-0.03 (-0.40)	-0.04 (-0.49)	**0.09** **(1.67)**	0.03 (0.54)	0.11 (1.32)
$\phi_{i,US}$	**0.20** **(3.60)**	**0.10** **(3.29)**	**0.09** **(1.92)**	**0.16** **(4.43)**	**0.21** **(6.25)**	**0.14** **(1.90)**	**0.09** **(2.31)**	**0.18** **(4.70)**	**0.19** **(3.97)**	0.15 (4.06)
$\theta_{i,i}$	-0.02 (-0.20)	0.04 (0.32)	**0.21** **(1.79)**	**-0.24** **(-3.53)**	**-0.15** **(-1.80)**	0.07 (0.60)	0.11 (0.75)	**-0.30** **(-3.36)**	-0.14 (-1.11)	-0.10 (-0.84)

Table 4.2 (*cont.*): Estimates for model with Financial stock returns

Panel B: Variance Equation

	US-UK	US-CN	US-BD	US-JP	US-IR	US-GR	US-PO	US-HK	US- SG	US-MY
$c_{US,US}$	**0.002**	**0.003**	**0.002**	**0.002**	**0.004**	**0.003**	**0.004**	**0.004**	**0.003**	**0.002**
	(3.02)	**(3.55)**	**(1.89)**	**(1.67)**	**(2.63)**	**(3.10)**	**(3.06)**	**(3.79)**	**(1.99)**	**(1.87)**
$c_{US,i}$	**0.002**	**0.001**	**0.004**	-0.0008	**0.003**	**0.003**	**0.002**	**0.002**	**0.003**	**0.002**
	(2.73)	**(3.37)**	**(5.34)**	(-0.47)	**(2.37)**	**(1.78)**	**(1.91)**	**(2.69)**	**(2.23)**	**(1.94)**
$c_{i,i}$	**0.004**	**0.003**	**0.006**	**0.01**	**0.005**	**0.01**	**0.01**	**0.004**	0.0007	-0.0003
	(5.11)	**(2.94)**	**(5.76)**	**(2.30)**	**(4.24)**	**(3.77)**	**(2.66)**	**(4.77)**	(0.23)	(-0.21)
$a_{US,US}$	**0.10**	**0.11**	0.08	**0.13**	-0.11	0.06	-0.11	**0.16**	-0.09	0.01
	(1.86)	**(1.87)**	(1.16)	**(1.97)**	(-1.34)	(1.01)	(-1.13)	**(3.77)**	(-1.18)	(0.16)
$a_{US,i}$	**-0.07**	**-0.13**	**-0.07**	**-0.07**	0.02	0.002	0.05	**-0.09**	**0.12**	0.03
	(-2.63)	**(-2.91)**	**(-2.40)**	**(-2.38)**	(0.38)	(0.08)	(0.91)	**(-3.34)**	**(2.91)**	(1.52)
$a_{i,i}$	**-0.09**	0.008	-0.11	**-0.25**	**0.20**	**0.29**	**0.19**	**0.14**	**0.19**	**0.23**
	(-2.40)	(0.18)	(-1.47)	**(-3.48)**	**(2.31)**	**(3.81)**	**(2.12)**	**(2.69)**	**(2.16)**	**(6.26)**
$\beta_{US,US}$	**0.94**	**0.93**	**0.93**	**0.92**	**0.90**	**0.91**	**0.91**	**0.90**	**0.89**	**0.93**
	(66.81)	**(36.65)**	**(63.99)**	**(37.12)**	**(21.53)**	**(34.23)**	**(19.79)**	**(33.27)**	**(28.66)**	**(31.89)**
$\beta_{US,i}$	-0.01	-0.009	**-0.04**	0.01	-0.03	-0.03	-0.03	**-0.02**	-0.02	-0.01
	(-1.02)	(-1.03)	**(-2.07)**	(0.82)	(-1.17)	(-1.13)	(-1.14)	**(-1.60)**	(-0.83)	(-0.73)
$\beta_{i,i}$	**0.91**	**0.91**	**0.87**	**0.89**	**0.92**	**0.87**	**0.79**	**0.94**	**0.95**	**0.96**
	(49.36)	**(23.16)**	**(39.19)**	**(15.13)**	**(43.19)**	**(17.97)**	**(5.63)**	**(65.74)**	**(27.74)**	**(97.78)**
$\gamma_{US,US}$	**0.36**	**0.35**	**0.44**	**0.51**	**0.46**	**0.47**	**0.48**	**0.48**	**0.48**	**0.46**
	(6.40)	**(5.70)**	**(7.94)**	**(7.51)**	**(5.34)**	**(7.53)**	**(5.60)**	**(7.52)**	**(8.32)**	**(5.05)**
$\gamma_{US,i}$	**0.14**	**0.25**	**0.12**	-0.02	0.13	**0.11**	0.13	**0.14**	**0.16**	0.05
	(2.63)	**(4.26)**	**(1.98)**	(-0.76)	(1.42)	**(2.48)**	(1.51)	**(3.08)**	**(2.56)**	(0.99)
$\gamma_{i,i}$	**0.40**	**0.13**	**0.53**	**0.25**	**0.38**	**0.25**	**0.43**	**0.31**	0.11	**0.09**
	(6.43)	**(2.07)**	**(7.21)**	**(2.84)**	**(4.50)**	**(2.14)**	**(4.39)**	**(4.78)**	(0.82)	**(1.79)**

Equation (4.3.1) for financial stock market returns is estimated by maximum likelihood with optimization performed using the BFGS algorithm. Robust ***t***- tests are reported in parenthesis. Entries that are statistically different from zero at the 10% confidence level are represented in bold.

Table 4.3: Estimates for model with *Non-Financial* stock returns

	Panel A: Mean Equation									
	US-UK	**US-CN**	**US-BD**	**US-JP**	**US- IR**	**US-GR**	**US-PO**	**US-HK**	**US-SG**	**US-MY**
ω_{US}	-0.0003 (-0.37)	-0.00004 (-0.04)	0.0001 (0.16)	0.0008 (0.81)	0.001 (1.07)	0.0007 (0.77)	-0.0003 (-0.43)	0.001 (0.63)	-0.0002 (-0.19)	0.0001 (0.18)
$\phi_{US,US}$	-0.08 (-1.28)	-0.08 (-0.81)	-0.07 (-0.90)	-0.08 (-1.31)	**-0.13** **(-2.38)**	-0.08 (-1.55)	-0.03 (-0.51)	-0.13 (-1.51)	0.01 (0.23)	**-0.14** **(-2.15)**
$\phi_{US,i}$	0.12 (**2.18**)	0.02 (0.39)	0.05 (0.88)	-0.03 (-0.77)	0.03 (0.93)	0.01 (0.44)	0.04 (1.51)	0.03 (0.92)	-0.01 (-0.27)	0.08 (1.20)
$\theta_{US,US}$	**-0.14** **(-1.78)**	-0.09 (-0.98)	-0.12 (-1.11)	0.06 (0.65)	0.03 (0.40)	-0.001 (-0.01)	**-0.13** **(-1.70)**	0.009 (0.05)	**-0.18** **(-1.66)**	0.02 (0.20)
ω_i	0.0008 (0.82)	**0.002** **(1.63)**	0.001 (0.92)	-0.002 (-1.26)	0.002 (0.88)	-0.00006 (-0.03)	-0.0003 (-0.15)	-0.0001 (-0.10)	-0.0001 (-0.13)	0.001 (0.87)
$\phi_{i,i}$	**-0.10** **(-1.80)**	-0.09 (-0.94)	-0.08 (-0.95)	0.02 (0.33)	-0.07 (-0.82)	0.09 (1.47)	0.07 (0.83)	0.04 (0.51)	**0.09** **(2.72)**	0.04 (0.28)
$\phi_{i,US}$	**0.10** **(2.15)**	0.06 (0.83)	**0.14** **(1.90)**	**0.18** **(3.46)**	**0.11** **(1.69)**	**0.18** **(2.44)**	**0.20** **(3.50)**	**0.35** **(4.41)**	**0.21** **(5.00)**	**0.09** **(2.70)**
$\theta_{i,i}$	-0.04 (-0.44)	0.001 (0.009)	-0.03 (-0.26)	-0.21 (1.48)	0.10 (0.49)	-0.10 (-1.02)	-0.10 (-0.76)	**-0.28** **(-2.91)**	**-0.24** **(-3.65)**	0.09 (0.32)

Table 4.3 (*cont.*): Estimates for model with Non-Financial stock returns

Panel B: Variance Equation

	US-UK	US-CN	US-BD	US-JP	US-IR	US-GR	US-PO	US-HK	US- SG	US-MY
$c_{US,US}$	0.002 (1.16)	0.002 (0.97)	0.002 (**1.98**)	0.002 (0.72)	0.001 (0.18)	0.003 (**2.68**)	0.0003 (0.19)	0.004 (1.47)	0.002 (**3.02**)	0.002 (1.29)
$c_{US,i}$	0.001 (1.58)	0.002 (**2.49**)	0.003 (**2.50**)	0.004 (**2.57**)	0.002 (1.28)	0.002 (**1.92**)	0.003 (0.92)	-0.0006 (-0.29)	0.003 (**5.03**)	0.002 (**2.07**)
$c_{i,i}$	0.003 (**5.39**)	0.0006 (0.49)	0.006 (**3.88**)	0.01 (**5.71**)	0.01 (**5.38**)	0.003 (**1.89**)	0.006 (**4.15**)	0.005 (**3.65**)	0.004 (**2.88**)	0.001 (0.73)
$a_{US,US}$	0.14 (**2.84**)	0.23 (**3.70**)	0.29 (**6.39**)	0.09 (**2.05**)	-0.09 (-0.59)	0.05 (1.18)	0.10 (1.40)	-0.06 (-0.35)	0.07 (**2.10**)	0.09 (1.22)
$a_{US,i}$	0.01 (0.30)	-0.001 (-0.03)	-0.11 (-1.30)	-0.19 (**-5.73**)	0.16 (**4.21**)	0.03 (0.87)	-0.02 (-0.71)	0.01 (0.11)	-0.004 (-0.14)	0.03 (1.46)
$a_{i,i}$	0.04 (0.66)	0.29 (**7.47**)	0.27 (**4.05**)	-0.03 (-0.62)	-0.01 (-0.04)	0.19 (**4.34**)	0.24 (**7.79**)	0.34 (**5.03**)	0.20 (**5.88**)	0.23 (**5.53**)
$\beta_{US,US}$	0.96 (**49.84**)	0.93 (**35.66**)	0.92 (**29.05**)	0.94 (**35.99**)	0.94 (**28.67**)	0.95 (**34.96**)	0.95 (**17.75**)	0.87 (**19.18**)	0.95 (**58.15**)	0.95 (**27.31**)
$\beta_{US,i}$	-0.01 (-0.42)	0.007 (0.55)	-0.003 (-0.12)	-0.02 (-0.99)	0.001 (0.04)	-0.02 (-1.38)	-0.01 (-0.54)	0.05 (**1.71**)	-0.04 (**-9.13**)	-0.01 (-1.13)
$\beta_{i,i}$	0.93 (**64.76**)	0.94 (**80.18**)	0.86 (**16.50**)	0.80 (**11.91**)	0.84 (**19.03**)	0.95 (**41.32**)	0.92 (**33.22**)	0.90 (**28.42**)	0.92 (**39.52**)	0.96 (**86.51**)
$\gamma_{US,US}$	0.22 (**2.76**)	0.31 (**4.47**)	0.16 (1.12)	0.31 (**4.63**)	0.35 (**1.85**)	0.29 (**3.24**)	0.30 (**1.95**)	0.30 (**2.05**)	0.22 (**2.43**)	0.34 (**2.70**)
$\gamma_{US,i}$	0.11 (1.35)	0.01 (0.25)	0.20 (**2.32**)	0.05 (1.50)	-0.02 (-0.14)	0.15 (**3.64**)	0.10 (**1.68**)	0.19 (**3.40**)	0.23 (**6.00**)	0.06 (**1.78**)
$\gamma_{i,i}$	0.34 (**6.79**)	0.12 (**1.91**)	0.40 (**3.60**)	0.38 (**3.71**)	0.55 (**3.33**)	0.18 (**2.44**)	0.27 (**2.47**)	-0.09 (-0.42)	0.24 (**4.92**)	0.06 (0.59)

Equation (4.3.1) for non-financial stock returns is estimated by maximum likelihood with optimization performed using the BFGS algorithm. Robust ***t***- tests are reported in parenthesis. Entries that are statistically different from zero at the 10% confidence level are represented in bold

Table 4.4: Estimates for model with *Total* Stock Market Returns

					Panel A: Mean Equation					
	US-UK	**US-CN**	**US-BD**	**US-JP**	**US-IR**	**US-GR**	**US-PO**	**US-HK**	**US-SG**	**US-MY**
ω_{US}	-0.0003 (-0.46)	-0.0004 (-0.37)	0.0006 (0.77)	0.0003 (0.33)	0.0009 (1.00)	0.0005 (0.51)	-0.001 (-1.25)	-0.0005 (-0.56)	-0.0005 (-0.52)	-0.0002 (-0.24)
$\phi_{US,US}$	-0.07 (-0.92)	-0.07 (-0.90)	-0.09 (-1.24)	-0.05 (-0.61)	-0.10 (**-2.10**)	-0.02 (-0.45)	0.01 (0.21)	-0.03 (-0.57)	0.01 (0.17)	-0.12 (**-1.61**)
$\phi_{US,i}$	0.11 (**1.63**)	0.05 (0.67)	0.02 (0.53)	-0.04 (-1.10)	0.03 (0.86)	-0.009 (-0.40)	0.03 (1.39)	0.05 (1.32)	-0.01 (-0.41)	0.08 (1.42)
$\theta_{US,US}$	-0.15 (**-2.25**)	-0.13 (-1.26)	-0.05 (-0.47)	0.008 (0.07)	-0.02 (-0.29)	-0.05 (-0.56)	-0.22 (**-2.08**)	-0.17 (**-1.84**)	-0.19 (**-1.91**)	-0.02 (-0.21)
ω_i	0.0004 (0.45)	0.002 (**1.64**)	0.002 (**2.09**)	-0.002 (**-1.63**)	0.0002 (0.16)	-0.00005 (-0.03)	0.001 (0.42)	-0.002 (-1.31)	-0.0003 (-0.30)	0.001 (0.83)
$\phi_{i,i}$	-0.08 (**-2.78**)	-0.08 (-0.82)	-0.17 (**-2.13**)	0.03 (0.35)	-0.02 (-0.48)	0.05 (0.93)	0.02 (0.30)	0.11 (1.42)	0.12 (**2.15**)	0.06 (0.50)
$\phi_{i,US}$	0.11 (**2.18**)	0.05 (0.89)	0.13 (**2.27**)	0.21 (**4.01**)	0.17 (**2.77**)	0.22 (**3.86**)	0.19 (**3.37**)	0.28 (**4.64**)	0.21 (**4.47**)	0.11 (**2.83**)
$\theta_{i,i}$	-0.06 (-0.54)	0.003 (0.03)	0.14 (1.17)	-0.27 (**-1.64**)	-0.04 (-0.42)	-0.09 (-0.88)	-0.02 (-0.19)	-0.38 (**-3.27**)	-0.24 (**-2.98**)	0.04 (0.18)

Table 4.4 (*cont.*): Estimates for model with Total Stock Market Returns

Panel B: Variance Equation

	US-UK	**US-CN**	**US-BD**	**US-JP**	**US-IR**	**US-GR**	**US-PO**	**US-HK**	**US- SG**	**US-MY**
$c_{US,US}$	0.001	0.003	0.002	-0.0004	0.001	0.003	0.002	0.004	0.003	0.003
	(1.42)	(**2.10**)	(**1.68**)	(-0.29)	(0.34)	(**2.72**)	(1.09)	(1.34)	(**3.28**)	(1.21)
$c_{US,i}$	0.001	0.001	0.004	0.004	0.002	0.003	0.003	0.003	0.003	0.002
	(**2.41**)	(0.82)	(**2.03**)	(1.30)	(1.38)	(**2.38**)	(1.57)	(**2.69**)	(**3.62**)	(**2.12**)
$c_{i,i}$	0.003	0.002	0.006	0.01	0.005	0.002	0.007	0.005	0.003	0.0003
	(**6.42**)	(**3.03**)	(**3.26**)	(**5.44**)	(**2.89**)	(1.25)	(**2.24**)	(**2.27**)	(**3.04**)	(0.15)
$a_{US,US}$	0.13	0.21	0.32	0.11	-0.08	0.24	0.04	0.09	0.14	0.13
	(**4.55**)	(**3.74**)	(**5.03**)	(**1.84**)	(-0.78)	(**7.74**)	(0.48)	(1.03)	(**2.43**)	(0.92)
$a_{US,i}$	-0.02	-0.01	-0.12	-0.14	0.13	-0.09	0.009	-0.05	0.04	0.03
	(-0.62)	(-0.26)	(-1.00)	(**-2.87**)	(**3.94**)	(**-3.59**)	(0.28)	(-0.82)	(1.28)	(0.77)
$a_{i,i}$	0.05	0.28	0.26	-0.02	-0.07	0.10	0.25	0.17	0.23	0.23
	(1.32)	(**5.18**)	(**4.60**)	(-0.44)	(-0.65)	(**4.07**)	(**5.71**)	(**4.16**)	(**5.37**)	(**4.97**)
$\beta_{US,US}$	0.96	0.92	0.91	0.94	0.96	0.90	0.95	0.92	0.92	0.93
	(**104.29**)	(**36.42**)	(**21.02**)	(**31.02**)	(**34.90**)	(**40.76**)	(**22.44**)	(**10.86**)	(**29.58**)	(**15.96**)
$\beta_{US,i}$	-0.005	0.01	0.008	-0.02	-0.004	-0.01	-0.02	-0.03	-0.05	-0.01
	(-0.33)	(0.32)	(0.53)	(-0.44)	(-0.14)	(-0.94)	(-0.88)	(**-1.72**)	(**-2.50**)	(-0.65)
$\beta_{i,i}$	0.92	0.93	0.84	0.85	0.91	0.96	0.91	0.93	0.93	0.96
	(**70.41**)	(**33.23**)	(**11.74**)	(**16.41**)	(**27.45**)	(**79.58**)	(**20.25**)	(**26.24**)	(**41.13)**	(**73.09**)
$\gamma_{US,US}$	0.21	0.37	0.22	0.32	0.29	0.33	0.32	0.34	0.30	0.41
	(**6.45**)	(**4.82**)	(1.34)	(**3.64**)	(**1.73**)	(**4.53**)	(**2.37**)	(**2.03**)	(**3.19**)	(**2.94**)
$\gamma_{US,i}$	0.12	0.02	0.12	0.09	0.04	0.15	0.12	0.18	0.22	0.05
	(**1.99**)	(0.21)	(**2.30**)	(0.87)	(0.49)	(**5.70**)	(**1.97**)	(**2.81**)	(**4.41**)	(0.73)
$\gamma_{i,i}$	0.35	0.16	0.49	0.30	0.42	0.21	0.29	0.29	0.19	0.09
	(**7.65**)	(**2.28**)	(**2.95**)	(**3.39**)	(**3.70**)	(**3.76**)	(**2.55**)	(**2.24**)	(**4.07**)	(1.13)

Equation (4.3.1) for total stock market returns is estimated by maximum likelihood with optimization performed using the BFGS algorithm. Robust ***t***- tests are reported in parenthesis. Entries that are statistically different from zero at the 10% confidence level are represented in bold.

Table 4.5: Estimates for model with *Financial & Non-Financials per country*

Panel A: Mean Equation

	US	**UK**	**CN**	**BD**	**JP**	**IR**	**GR**	**PO**	**HK**	**SG**	**MY**
ω_{US}	-0.00003 (-0.03)	0.0009 (0.30)	0.002 (**5.14**)	0.001 (1.43)	-0.0002 (-0.19)	0.001 (1.14)	0.003 (1.39)	0.003 (**3.40**)	0.001 (1.14)	0.0007 (1.24)	0.0009 (1.31)
$\phi_{US,US}$	0.02 (0.71)	0.003 (0.02)	-0.07 (**-1.71**)	-0.06 (-1.07)	0.02 (0.44)	-0.13 (-2.07)	-0.06 (-0.88)	-0.03 (-0.72)	0.19 (**2.84**)	-0.0004 (-0.009)	0.05 (0.66)
$\phi_{US,i}$	-0.07 (-1.08)	-0.05 (-0.35)	0.01 (0.37)	0.01 (0.18)	-0.10 (**-1.72**)	0.06 (1.32)	0.11 (1.31)	0.05 (1.43)	-0.11 (**-2.33**)	0.17 (**4.31**)	0.10 (1.03)
$\theta_{US,US}$	-0.10 (**-1.90**)	0.07 (0.87)	0.08 (1.53)	0.14 (1.59)	-0.02 (-0.28)	0.09 (1.04)	0.14 (**1.60**)	0.10 (**1.78**)	-0.07 (**-1.83**)	-0.11 (-1.45)	-0.06 (-1.03)
ω_i	0.0007 (1.00)	0.002 (0.69)	0.002 (**2.65**)	0.0004 (0.37)	0.001 (**2.33**)	0.002 (1.27)	0.001 (1.06)	0.001 (1.46)	0.001 (1.56)	0.001 (1.37)	0.0007 (1.19)
$\phi_{i,i}$	-0.08 (-1.18)	-0.20 (**-3.84**)	-0.10 (**-2.21**)	0.07 (0.97)	-0.12 (-1.37)	0.02 (0.28)	0.07 (0.95)	0.06 (1.10)	-0.09 (**-1.61**)	0.06 (1.13)	0.05 (0.77)
$\phi_{i,US}$	0.03 (0.92)	0.05 (1.00)	0.09 (**3.18**)	-0.02 (-0.51)	0.01 (0.39)	-0.03 (-0.64)	-0.02 (-0.48)	0.02 (0.48)	0.22 (**3.28**)	0.02 (0.67)	0.06 (1.28)
$\theta_{i,i}$	-0.03 (-0.55)	0.19 (**2.77**)	0.04 (0.52)	-0.08 (-0.86)	0.18 (1.53)	0.09 (0.77)	0.04 (0.44)	-0.01 (-0.18)	-0.07 (-1.22)	-0.05 (-0.50)	-0.05 (-0.88)

Table 4.5 (*cont.*): Estimates for model with Financials & Non-Financials per country

Panel B: Variance Equation

	US	UK	CN	BD	JP	IR	GR	PO	HK	SG	MY
$c_{US,US}$	0.003 (1.27)	0.003 (**1.63**)	0.001 (0.56)	0.006 (**4.99**)	0.008 (**2.38**)	-0.001 (-1.53)	0.007 (**3.55**)	0.004 (1.44)	0.001 (**2.10**)	0.001 (**3.01**)	0.002 (**3.08**)
$c_{US,i}$	0.002 (0.82)	0.003 (**5.43**)	0.001 (0.90)	0.005 (**4.17**)	0.004 (**2.02**)	0.004 (**1.84**)	0.0002 (0.26)	0.003 (1.49)	0.003 (**3.17**)	0.002 (**4.73**)	0.0008 (**1.76**)
$c_{i,i}$	0.003 (1.06)	0.003 (**2.88**)	0.003 (1.49)	0.006 (**5.01**)	0.005 (**3.50**)	0.009 (**3.63**)	0.0006 (0.16)	0.004 (**1.83**)	0.005 (**4.35**)	0.003 (**3.22**)	0.001 (**3.58**)
$a_{US,US}$	-0.003 (-0.03)	0.01 (0.09)	0.09 (1.57)	0.04 (0.83)	-0.16 (**-3.29**)	0.17 (**5.06**)	0.21 (**4.22**)	0.13 (**3.03**)	0.11 (**2.02**)	0.20 (**3.26**)	0.11 (**2.68**)
$a_{US,i}$	-0.15 (**-3.10**)	-0.12 (-1.16)	-0.09 (**-3.09**)	-0.19 (**-5.04**)	-0.21 (**-5.92**)	-0.17 (**-2.66**)	-0.07 (**-2.98**)	-0.002 (-0.11)	-0.06 (**-2.08**)	-0.06 (**-1.90**)	0.18 (**5.06**)
$a_{i,i}$	0.06 (0.87)	0.18 (**8.30**)	0.25 (**6.06**)	0.06 (**1.93**)	0.28 (**6.97**)	0.12 (**2.08**)	0.24 (**6.74**)	0.19 (**4.00**)	0.27 (**4.73**)	0.28 (**4.55**)	-0.004 (-0.10)
$\beta_{US,US}$	0.92 (**14.81**)	0.93 (**25.21**)	0.94 (**49.37**)	0.88 (**28.74**)	0.89 (**24.52**)	0.92 (**64.02**)	0.93 (**35.97**)	0.96 (**36.28**)	0.93 (**96.17**)	0.96 (**71.34**)	0.96 (**64.54**)
$\beta_{US,i}$	-0.01 (-0.18)	-0.02 (**-2.13**)	0.006 (0.22)	-0.05 (**-1.99**)	0.02 (0.87)	0.01 (0.39)	0.02 (**1.98**)	-0.007 (-0.42)	0.009 (0.73)	0.004 (0.43)	-0.002 (-0.28)
$\beta_{i,i}$	0.94 (**19.89**)	0.92 (**26.02**)	0.95 (**44.80**)	0.89 (**32.05**)	0.85 (**23.08**)	0.84 (**14.11**)	0.94 (**66.26**)	0.96 (**35.39**)	0.91 (**65.99**)	0.91 (**25.44**)	0.96 (**102.84**)
$\gamma_{US,US}$	0.47 (**2.93**)	0.42 (**2.62**)	0.32 (**5.54**)	0.53 (**6.54**)	0.20 (**2.73**)	0.42 (**7.68**)	0.20 (**4.73**)	0.27 (**3.76**)	0.26 (**4.77**)	0.09 (0.83)	0.08 (**2.46**)
$\gamma_{US,i}$	0.05 (0.40)	0.15 (**2.64**)	0.08 (1.11)	0.14 (**2.02**)	0.12 (**2.27**)	0.07 (0.88)	0.08 (**1.73**)	0.03 (1.45)	0.14 (**3.69**)	0.20 (**2.50**)	0.03 (1.24)
$\gamma_{i,i}$	0.30 (**2.04**)	0.32 (**2.16**)	1.16 (**1.63**)	0.46 (**7.54**)	0.26 (**3.96**)	0.37 (**2.79**)	0.05 (0.93)	0.15 (**2.03**)	0.25 (**2.51**)	0.14 (1.15)	0.17 (**5.96**)

Equation (4.3.1) for financial and non-financial stock returns within each market is estimated by maximum likelihood with optimization performed using the BFGS algorithm. Robust ***t***- tests are reported in parenthesis. Entries that are statistically different from zero at the 10% confidence level are represented in bold.

Table 4.6: Results of *PCA*

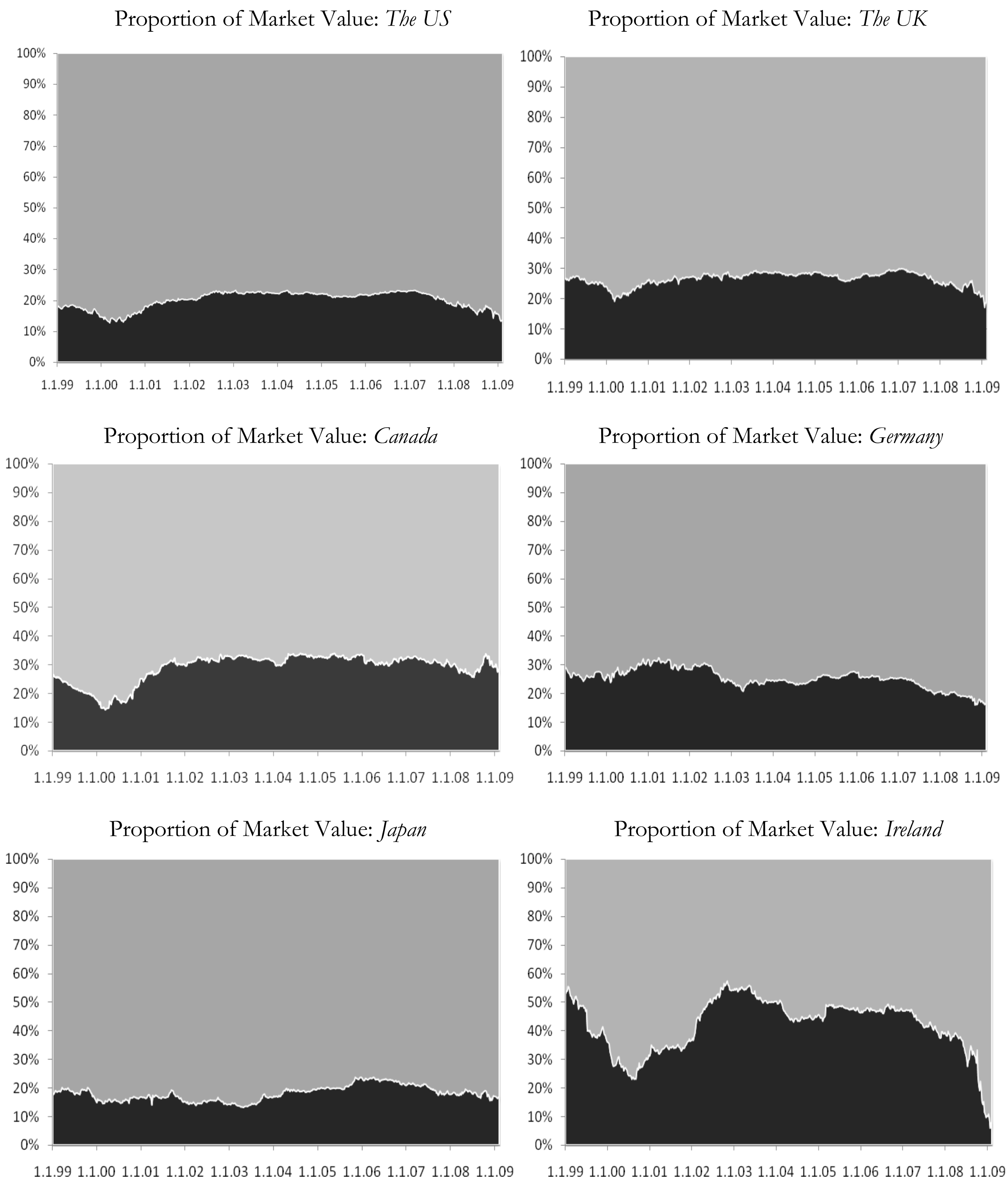
	Factor loadings on First PC				
	Panel A			Panel B	
Country Pair	**Financials**	**Non-Financials**	**Total Market**	**Country**	**Financial & Non-Financial**
US - UK	0.446	0. 421	0.416	US	0.320
US - Canada	0.441	0.415	0.412	UK	0.298
US - Germany	0.428	0.424	0.418	CN	0.210
US - Japan	0.196	0.290	0.265	BD	0.310
US - Ireland	0.322	0.281	0.308	JP	0.308
US - Greece	0.239	0.237	0.243	IR	0.210
US - Poland	0.246	0.264	0.268	GR	0.313
US - Hong Kong	0.293	0.265	0.280	PO	0.299
US - Singapore	0.239	0.284	0.275	HK	0.341
US - Malaysia	0.145	0.177	0.171	SG	0.315
				MY	0.352
Variability explained by First PC	0.963	0.962	0.968		0.975

Table 4.7: Linear Regression of the *First PC* on liquidity risk measure & US returns

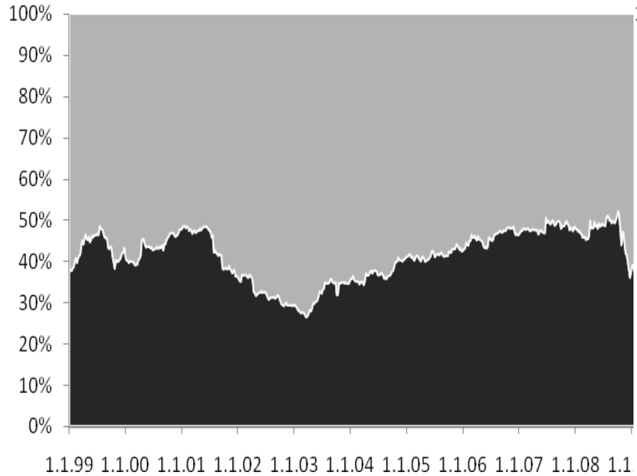
	TED	US Returns
Financials	0.06 (**2.44**)	-2.21 (**-5.97**)
Non- Financials	0.13 (**7.18**)	-0.69 (**-2.59**)
Total Market	0.13 (**6.40**)	-0.96 (**-3.21**)

t- tests are reported in parenthesis. **Bold** numbers indicate the statistically significant values.

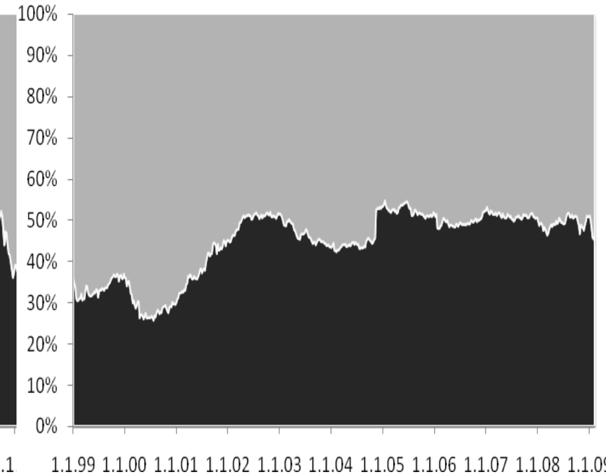
Figure 4.1: Market Capitalization of Financial and Non-Financial stocks



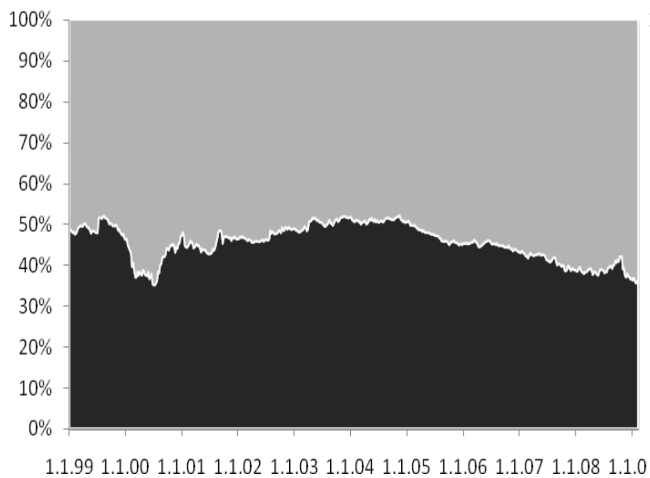
Proportion of Market Value: *Greece*



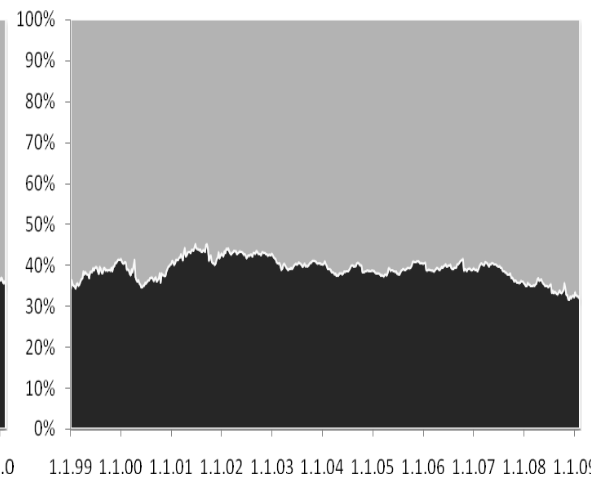
Proportion of Market Value: *Poland*



Proportion of Market Value: *Hong Kong*



Proportion of Market Value: *Singapore*



Proportion of Market Value: *Malaysia*

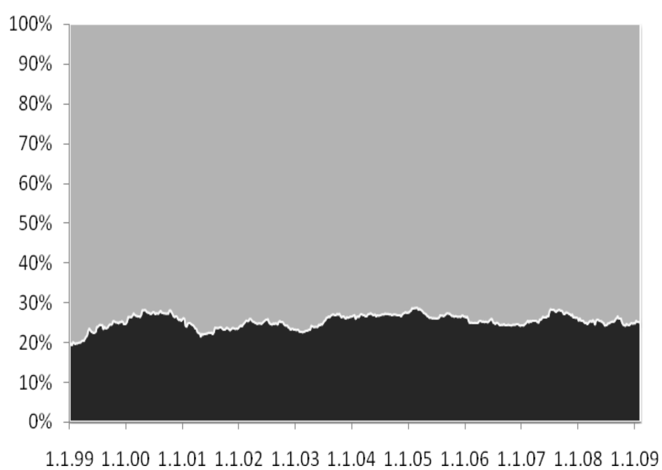


Figure 4.2: Time-Varying Conditional Correlations of *Financial* Stock Market Returns

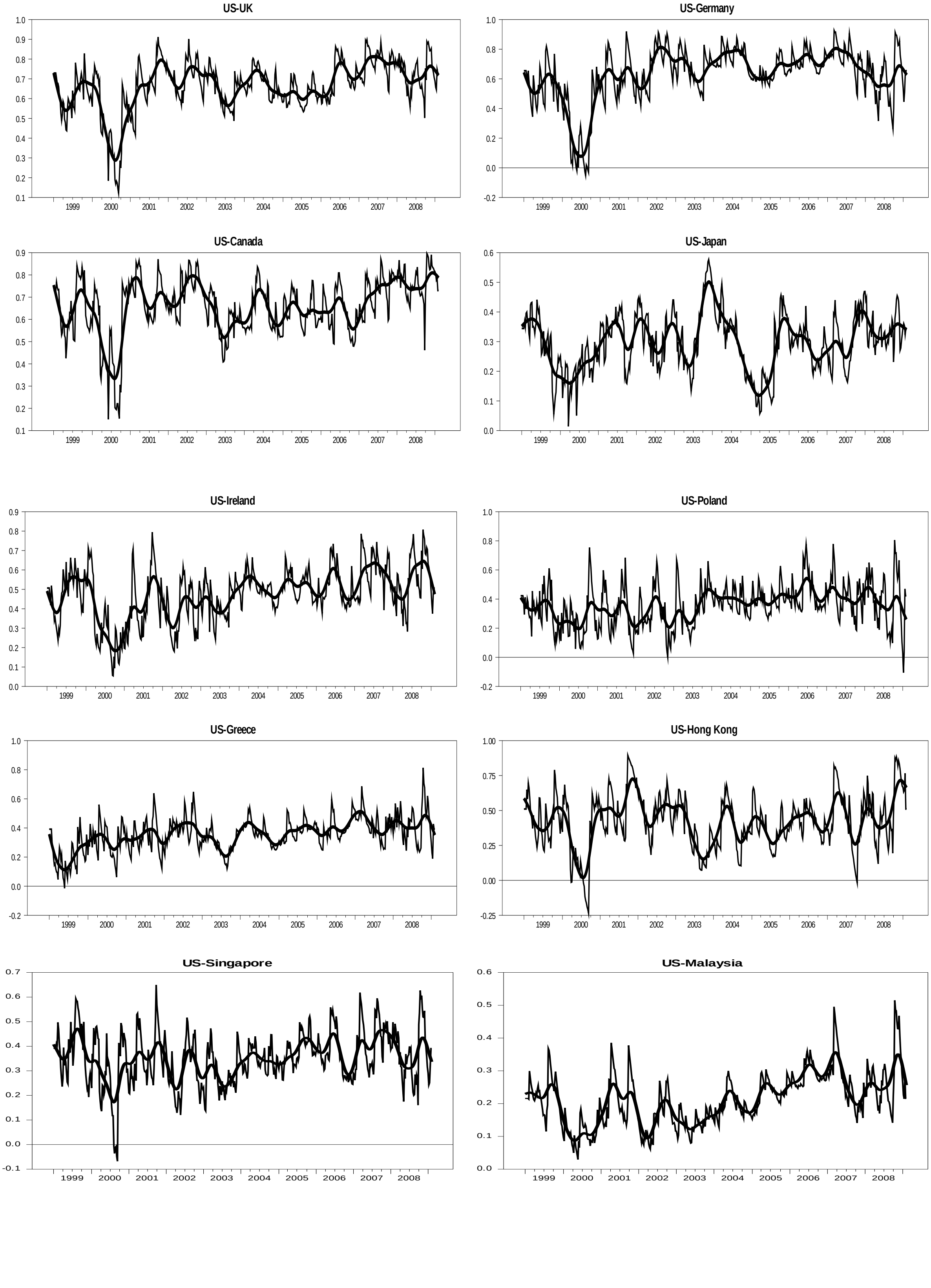


Figure 4.3: Time-Varying Conditional Correlations of *Non-Financial* Stock Market Returns

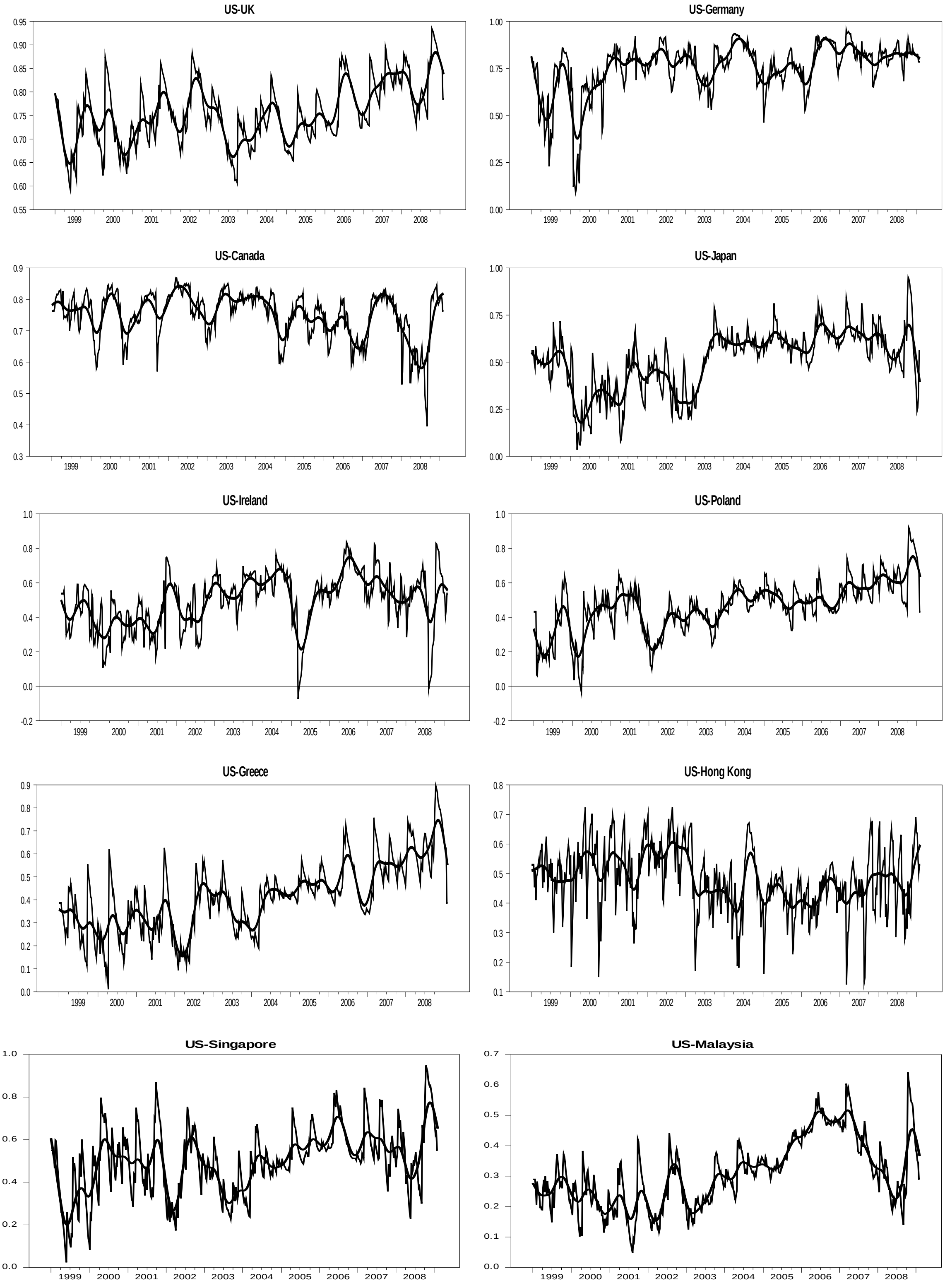


Figure 4.4: Time-varying Conditional Correlations of *Total* Stock Market Returns

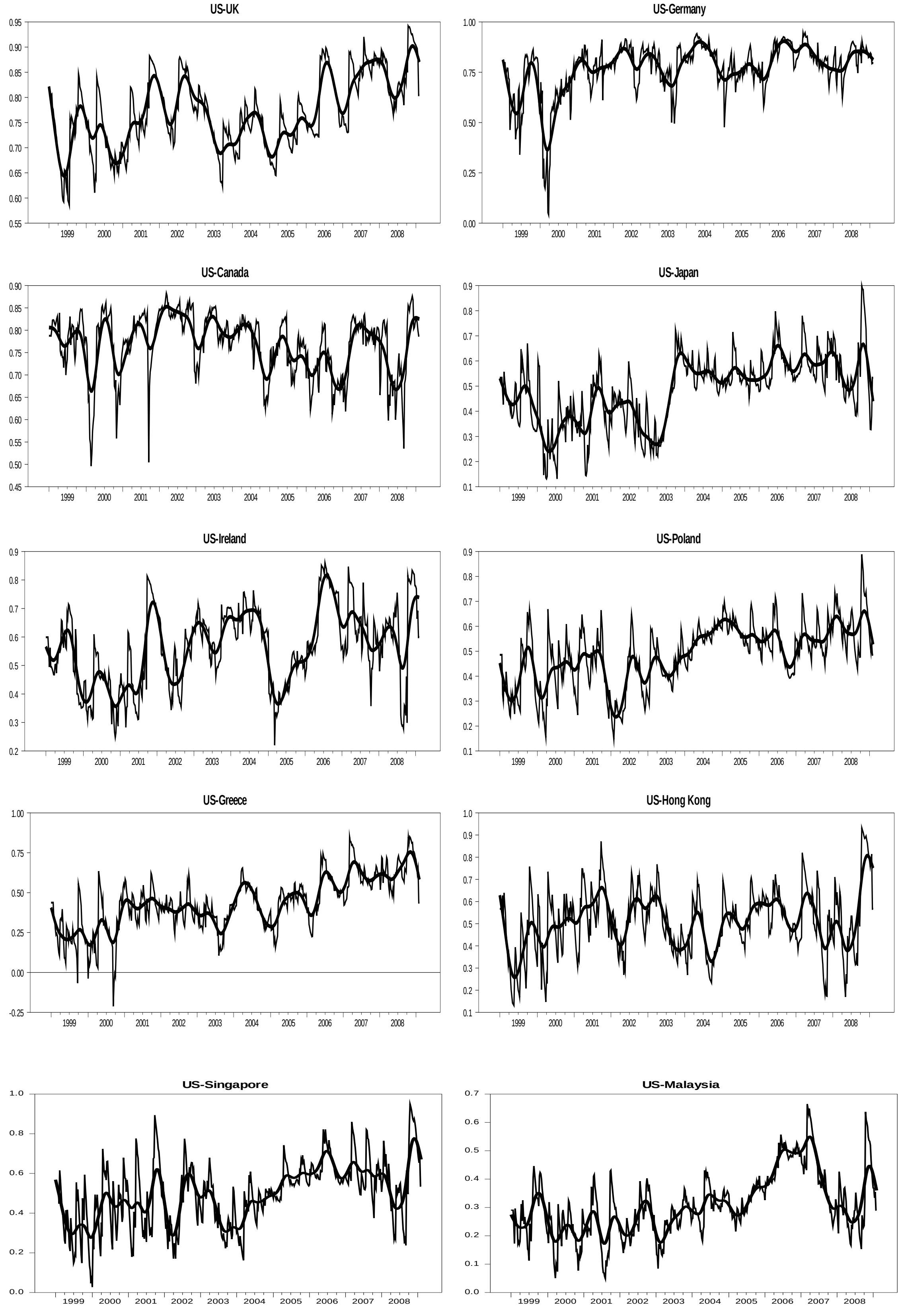
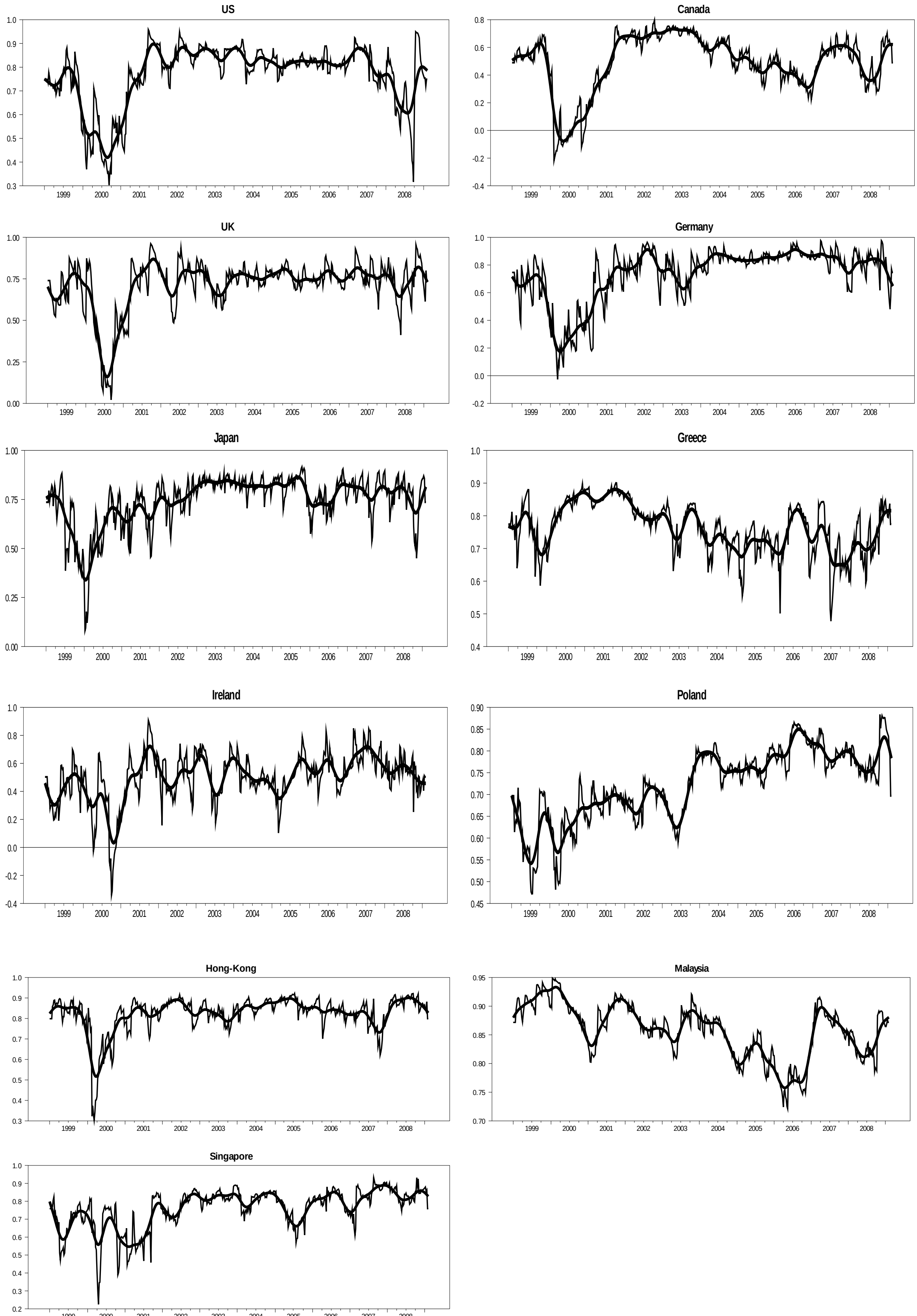


Figure 4.5: Time-varying Conditional Correlations of *Financials & Non-Financials Stock Market Returns per country*



Chapter 5: Concluding Remarks

5.1 Overview of Thesis

This thesis focuses on three topical issues in international finance, undertaking a thorough investigation of three fundamental issues in international finance and financial market integration. International finance is a rich field of study and the recent credit and liquidity crises have only served to re-focus efforts to better understand cross-country financial flows and financial linkages. We have empirically examined the time-varying risk premium in the UIP condition across the most developed financial markets in the world. We have explored the causal linkages between the monetary and financial integration of the European emerging markets with the euro zone markets. Finally, we have investigated the time-varying correlations and risks between global markets and sectors within these markets during the recent credit and liquidity crisis. As the thesis is predominantly an empirical analysis, we adopt and employ a range of modern time-series econometric techniques that capture the dynamics of asset market returns.

In particular, Chapter 2 assesses the link between foreign exchange risk premium and macroeconomic volatility. To rationalize this link, we make the first attempt to use the Conditional Multifactor Asset Pricing Model, as it directly relates the excess currency returns to macroeconomic variables. We utilize multivariate VAR-GARCH-in-mean(1,1) models to obtain a direct estimate of the contribution of the macroeconomic risk factors on an asset's risk premium. Our research emerges a number of interesting points. Firstly, we provide significant evidence of a *time-varying risk premium* in foreign exchange markets. This finding is consistent with the findings of Tai (2001, 2004) and Lustig & Verdelhan

(2007). Secondly, our half life measurement indicates that for all countries, half of the deviations from UIP damp out within two to four months (Tanner 1998). This result suggests that foreign exchange markets are more efficient relative to goods markets since shocks are less persistent and do not take three- to five- years (Rogoff, 1996) or two and a half years (Lothian & Taylor 2008) to move towards their equilibrium value, as typically found in tests of PPP. Thirdly, we find that the macroeconomic volatility significantly explains the behaviour of an asset's risk premium. We report significant evidence that macroeconomic risk factors exert both a *direct impact*- through the conditional mean equation- and an *indirect impact*- through the GARCH in mean effects- on currency risk premium. This result suggests that macroeconomic volatility is a priced factor by investors and explains to a great extent the variability of the foreign exchange risk premium (Smith & Wickens, 2001; Flavin & Limosani, 2007; Kizys & Spencer, 2008; Kocenda & Poghosyan, 2009). By quantifying the impact of macroeconomic volatility on assets, investors can better instrument their assessment of investment opportunities and their exposure to macroeconomic events.

Chapter 3 investigates the causal linkages between monetary and equity market integration of the largest Central Eastern European emerging markets with the euro zone, after the official launch of the euro. The traditional Granger (1969) causality in mean and causality in variance by Cheung & Ng (1996) 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. Fourth, the causality works in reverse but for fewer countries. Our results are consistent with Fratzscher, 2002; Baele et. al., 2004; Kim, Moshirian & Wu, 2005; and Masten et. al. 2008, who find that the European monetary union (EMU) is the main driver of the time varying integration process in stock markets. The findings of this chapter 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 position themselves for membership of the single currency.

Chapter 4 focuses on the current global financial crisis and ascertains whether asset return correlations were higher during the current turmoil than previously recorded. We employ an asymmetric bivariate GARCH model to account for asymmetric responses to positive and negative shocks. Our results emerge a number of interesting facts. Firstly, the correlations of equity returns within major sectors, across developed and developing countries are time-varying and have increased over the recent period (Longin & Solnik, 2001; Ang & Bekaert, 2002; Chiang, Jeon & Li, 2007; Frank & Hesse 2009). However, the levels of co-movements are not excessive by historical standards. Secondly, our principal components analysis reveals that the dynamic nature of the market correlations exhibits a great deal of commonality, and one common factor accounts for almost all of the variation, which may be related to US returns and market liquidity. This result is consistent with Brunnermeier, Nagel, & Pedersen (2008) who argue that liquidity is a key driver of currency crashes: "*when liquidity dries up, currencies crash*". Lastly, we find that financial and non-financial sectors are inextricably linked and shocks to the financial sector are largely systematic. These results have obvious implications for investors and policy-makers. Under largely systematic shocks, investing in highly correlated assets would provide a limited portfolio diversification benefit to investors. Therefore, strategies based upon either geographical or industrial diversification are unlikely to deliver much benefit in terms of risk reduction. Prudential supervisor, proper regulation and security market overseers are required from governments and policy makers in order to secure markets and guarantee the prosperity of the global economy.

5.2 Future Research

A number of promising avenues for future research emerge from this thesis. Firstly, the realization of time-varying deviations from UIP can be analyzed in a number of ways. We propose to represent these deviations in a continuous time framework. It would be interesting to construct a continuous-time model of UIP in which the exchange rate and the interest differential follow Brownian motion processes (see for instance Mark & Moh, 2003; Moh, 2006). The methodology will be implemented in two stages. At the first stage, we will estimate the volatility of asset returns using GARCH models. At the second stage, we will employ a smoothing window to investigate big or small deviations from UIP volatility and calculate the probability density function of different volatility regimes observed in the data. Our aim is to estimate the dominant price(s) for each volatility regime.

Secondly, another interesting direction for future research is the extension of the conditional multifactor asset pricing model to incorporate asymmetry. This would involve adapting eq. 2.13 to allow for these potential effects. We propose to implement this in the conditional multifactor APT as follows

$$E_t\left[\mathrm{r}_{\mathrm{j,\,t}} \mid I_{t-1}\right]=\sum_{k=1}^{K} \lambda_{k,t-1}\, Cov\left(\mathrm{r}_{\mathrm{j,\,t}}\ F_{k,\mathrm{t}} \mid I_{t-1}\right)+\delta_{t-1}\sum_{k=1}^{K}\theta_{k,t-1}\, Cov\left(\mathrm{r}_{\mathrm{j,\,t}}\ F_{k,\mathrm{t}} \mid \mathrm{I}_{\mathrm{t-1}}\right)$$

where δ is our dummy variable: $\delta_{t-1}=\begin{cases}1, & if\ "bad"\ news\ or\ events\\ 0, & if\ "good"\ news\end{cases}$ and θ is the parameter estimate of the covariance term. Moreover, to test whether the expected conditional return of our country, say r_j, is affected by another country's past shocks, defined as η_{it}, we can write the following:

$$E_t\left[\mathrm{r_{j,t}}|\, I_{t-1}\right]=\sum_{k=1}^{K}\lambda_{k,t-1}\,Cov\left(\mathrm{r_{j,t}}\ F_{k,t}|\, I_{t-1}\right)+\delta_{t-1}\sum_{k=1}^{K}\theta_{k,t-1}Cov\left(\mathrm{r_{j,t}}\ F_{k,t}|\mathrm{I_{t-1}}\right)+\sum_{i=1}^{N}\zeta_{i,t-1}Cov\left(\mathrm{r_{j,t}}\ \eta_{i,t}|\mathrm{I_{t-1}}\right)$$

where ζ is the coefficient on the covariance term. The last term captures contagion effects. Empirically, to test for asymmetry we can use the GJR-GARCH specification as specified in Chapter 4 (see equation 4.3.1). To test for contagion in asymmetric volatility shocks, i.e. to test whether the conditional volatility of one country's returns is affected (or not) by another country's negative shocks, we can write:

$$h_{j,t}=\underbrace{c_0+c_1\,\varepsilon_{j,t-1}^2+c_2\,h_{j,t-1}+c_3\,S_{j,t-1}^-\,\varepsilon_{j,t-1}^2}_{GJR\text{ asymmetric version of the GARCH(1,1) specification}}+\underbrace{\sum_{i=1}^{N}c_4\,\eta_{i,t-1}^2+\sum_{i=1}^{N}c_5\,\phi_{i,t-1}\eta_{i,t-1}^2}_{\text{(asymmetric) impact of shocks of other markets}}$$

where: $c's$ are parameter estimates and in particular, c_4 estimates the impact of another country's specific innovations $(\eta_{i,t-1}^2)$ on our market volatility; $\phi_{i,t-1}$ is the asymmetric response of volatility to shocks (dummy): $\phi_{i,t-1}=\begin{cases}1, & if\quad \eta_{i,t-1}<0\\ 0, & if\quad \eta_{i,t-1}>0\end{cases}$.

Extending the model and including a wider range of asset classes may be useful, particularly because the significance of asymmetric or contagion effects vary from market to market and appear to affect asset returns in different ways. Therefore, this theoretical model makes it possible to directly account for bad events or contagion effects that impact asset returns.

Finally, it would be interesting to investigate if a trading strategy can be formed from the results in Chapter 3 to exploit the causality in mean and variance between money and stock markets. We wish to investigate if such a trading rule would allow us to beat the market in 'out-of-sample' periods.

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