FINAL REPORT

# THE CHANNELS OF FINANCIAL MARKET CONTAGION IN THE NEW EU MEMBER STATES

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19/11/2009

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# 1 Executive summary

The key aim of the study is to provide a toolkit to assess the exposure of the new EU member states[1] to risks of financial crises, and to assess the expected costs of a crisis were one to materialise. Financial contagion and fragility have a number of dimensions, and they are all of relevance for the analysis of New Member States (NMS). Fragility in the face of shocks is a precursor of crises and a cause of the contagion of crises. There is a growing realisation that such crises have a generic nature, which renders construction of a toolkit a useful exercise. For example, vulnerability to crises often emerges from the effects on the economy of a positive shock that raises growth and investment, which is accompanied by credit and asset price booms. Deregulation or innovation in financial or in production markets may raise growth and the complexity of financial structure, also raising vulnerability. A negative shock may then precipitate a crisis in a vulnerable economy, also spilling over to other vulnerable economies contagiously, in a manner which would have not taken place had the economy and financial system been more robust.

Against this background, we start in section 2 with an overview of the key sources of financial fragility and contagion, highlighting some of the important literature underlying this study. We have identified four key areas of the literature that are directly relevant to this project: identification of a key set of macro-prudential indicators; determining the channels of financial market contagion; assessing the impact of financial crises on the real economy; and reviewing the methodological approaches that have been adopted in early warning system models. Particular focus is given to studies that apply directly (or indirectly) to the NMS. Selected approaches identified in this section are implemented in the rest of the study.

With a view to identifying vulnerabilities to crises and contagion, in section 3 we analyse in a largely descriptive manner the characteristics and structure of the financial sectors in the NMS, covering the banking sector, equity markets, foreign exchange and trade, as well as "Financial Soundness Indicators" for the banking, household and corporate sectors.

Fragility can exist and contagion can take place through the structure of the banking system, and section 3 begins with an overview of the structure of the banking sectors in the NMS and exposure of the banking systems to shocks from abroad. Banking systems are of particular importance in emerging market economics such as the NMS where security markets are typically underdeveloped. However, growth of banking may link not only to financial development but also to credit and asset price bubbles and overlending. Vulnerability to crises often emerges from the effects on the economy of a positive shock such as EU membership that raises growth and investment, which is accompanied by credit and asset price booms. Data show that the NMS banking systems are particularly exposed to problems that may develop in the Austrian and Swedish banking systems, while the banking systems in Austria and

[1] Throughout this report, the term NMS is used to denote the 10 new EU members that were formally centrally-planned economies. This study excludes Malta and Cyprus, which have followed a significantly different path of financial development and integration.

Sweden are themselves vulnerable to shocks that may originate in the NMS. These two countries are also the main potential source of common credit problems. It is possible that defaults in one NMS country, say in the Czech Republic, could spill over into other NMS countries such as Hungary, Slovakia and Romania through its impact on bank margins in Austria. The share of Austrian banking sector assets in the Czech Republic is noticeably larger than in the other countries, but noticeable host to host contagion could also take place from any one of them. Contagion amongst the Swedish banking sector hosts is even more likely, but the problem is contained with in the Baltic States.

Another source of global financial market contagion is through equity markets, which we address in section 3.2. Equity markets in the NMS have deepened significantly over the last 10 years, although even the most developed ones (in Poland, the Czech Republic and Slovenia) remain shallow relative to the more equity intensive economies such as the US and the UK. Equity market volatility seems to be related to the exchange rate regime, with a flexible exchange rate associated with greater equity market volatility. This suggest that ERM2 membership may bring with it the added benefit of more stable equity markets in economies such as Poland. Global equity market correlations have increased significantly in all the NMS over time, and there is some evidence that this reflects deeper integration into global networks as a result of EU membership. Stronger correlations indicate greater scope for contagion, and this was evidenced by a marked rise in global equity return correlations related to the global financial crisis. Equity risk premia give an indication of the perceived risk associated with an equity market. An estimate of this premium can be extracted from data, and we recommend regular monitoring of equity risk premia in the NMS as part of a financial surveillance toolkit. For example, equity risk premia in Hungary appear low relative to the other NMS, which may indicate an underpricing of equity risk in Hungary, leaving Hungarian equity prices exposed to a downward correction.

Financial crises may also spread through foreign exchange markets, and we look at exchange rates and interest rates in the NMS in section 3.3. Shifts in exchange rate risk premia can be effected either through the exchange rate or through the domestic interest rate relative to foreign interest rates. A fixed exchange rate regime in the NMS does not itself eliminate the premium, as interest rates can still come under pressure so long as the currency is not formally integrated into the Euro Area. As part of the financial surveillance toolkit, we recommend monitoring the volatility of interest rates in the NMS with fixed exchange rate regimes, as a rise in volatility may indicate pressure on the exchange rate, which could eventually force a devaluation. Interest rate volatility has been elevated in Latvia since 2007, and rose sharply in 2009, indicating severe pressure on the exchange rate. Regular monitoring of interest rate volatility would have given advance warning of this vulnerability.

Our analysis indicates that exchange rates in Poland and the Czech Republic are more sensitive to financial shocks in emerging markets, while interest rates in Hungary and Romania are relatively more sensitive. It appears that the risk premium in NMS countries with flexible exchange rate regimes is larger than that in the countries with fixed regimes, although the premium is present in both groups, albeit through interest differentials for countries with rigidly fixed exchange rates. The exchange rate risk premia in Hungary and Poland are more sensitive to shocks originating in other NMS economies, while Romania is more sensitive than the other NMS to shocks originating in the rest of Europe. The exchange rate risk premium rose sharply in Poland, Hungary and the Czech Republic in response to the global financial crisis, with the sharpest rise occurring in Poland, reflecting a greater sensitive to shocks in the US. While the Latvian exchange rate risk premium remains low, it has been rising steadily since 2007, and is higher than in the other fixed regime economies. As part of a financial surveillance toolkit, we recommend regular monitoring of exchange rate risk premia in the NMS.

In section 3.4 we describe key data and indicators for the NMS which are relevant to contagion and financial fragility. We then provide a short summary of the potential uses to which such data can be put. There is an immense premium on timely warnings regarding systemic risks as an input to policy decisions as well as to strategies and market behaviour of financial institutions. Accordingly, in the last decade 'macroprudential surveillance' – defined as monitoring of conjunctural and structural trends in financial markets so as to give warning of the approach of financial instability – has become a core activity for many central banks and international organisations. Data needs include macroeconomic and financial data for assessing conjunctural conditions, non-financial sector debt, leverage and asset prices for considering vulnerability of borrowers, and in the light of these, bank balance sheets and income and expenditure for considering robustness of banks. Risk measures derived from financial prices complement leverage and income indicators. Stress tests and forecasts of indicators and derived stability indicators such as defaults and bankruptcies, including risks to the central projection are needed to tell a full story. An appropriate use of the toolkit is to incorporate model findings as in Sections 5-7 with the qualitative and judgemental approach recommended here in arriving at an overall view about the risk to financial stability. We provide a practical guide to undertaking macroprudential surveillance, detailing the wide range of issues that have to be addressed. We also caution that no toolkit can contain prefect predictors, and probably can only highlight serious concerns.

Among the key findings of the examination of macroprudential indicators is some indicators of weakening of banking sector performance, despite quite high profitability; the large exposure of the household sector to foreign currency debt in a number of countries, as well as to possible bubbles in the housing market; and rising default risk in a number of corporate sectors over 2005-7.

In section 4 of this report we provide case studies, outlining the crises that have occurred in recent history that have affected the NMS, both idiosyncratic and global, with a view to detecting generic and idiosyncratic vulnerabilities for the NMS economies. We also undertake a comparative case study to Estonia and Latvia as well as Poland and Hungary. These comparisons apply the toolkit to each of the countries, and bring out the differences in each pair. Such analyses are recommended on a regular basis for NMS countries by country desk officers. We note the divergent predictions from the models as well as from qualitative analysis, which underlines the need for judgement in overall analysis and crisis prediction.

In section 5 we model contagion to the NMS and from the NMS, using a structural macro-model. The modelling procedures described in this section, which is undertaken using NiGEM, can be applied to the Commission's QUEST model or other similar models. Our analysis of risk premium shocks suggest that most contagion comes through trade effects unless there are direct links to banking systems. If there is a financial crisis in the Old Members but not the NMS, then the output effects on NMS are strongly correlated with trade openness. Banking crisis propagate directly through the effects of capital losses on the need for a larger gross operating surplus and hence higher borrowing costs. There is a significant level of banking sector penetration in the Baltic States from Sweden, and hence a banking crisis in Sweden will impact on these countries, and conversely. However, the scale of effects on Sweden does not appear to be great. More importantly for policy makers in Europe, the Austrian banking system is heavily involved in Hungary and the Czech and Slovak Republics. The Austrian economy is vulnerable to shocks to the banking sectors in these economies, and they are vulnerable both to Austria and to each other.

In section 5 we also examine the impacts of devaluations and realignments. A fall in the exchange rate induced by a rise in risk premia in Poland and Hungary would reduce output in the longer term as it would raise the user cost of capital. However, in the shorter term there may be benefits from the depreciation for the more open economy, Hungary. However, foreign currency borrowing by households has been extensive, and this might be a harbinger of problems if the fall in the exchange rate led to an increase in loan defaults. This would add to the contractionary pressures for the rise in the exchange rate risk premium. A simple realignment of the Baltic States might bring large short term benefits as they are very open and competitiveness elasticities are large. High levels of foreign currency borrowing would partly offset these gains, as they would result in a revaluation of wealth and hence a reduction in consumption. Much of this would be absorbed in lower imports, and output would probably only be marginally affected unless the revaluation led to large scale defaults and hence banking sector crises. We analyse the impacts of such a crisis on domestic demand and on risk premia, and suggest that a realignment might well be associated with large scale defaults and a contraction in demand, much along the lines the changes we have seen in the UK and the US. We use these countries recent experience of banking crisis to scale the impact of defaults on domestic demand in the Baltic States. As part of its toolkit the Commission should undertake such joint analyses. We conclude that the use of a large structural model with the banking sector as well as trade and policy embedded in it is a central part of a toolkit, and would encourage the Commission to use one.

Early warning systems for banking crises that have been described extensively in the literature can be applied to the NMS. We discuss the methods of application in section 6. Three different approaches are used to capture different views on the evolution of financial instability in these economies: a univariate approach (signal extraction), a traditional multivariate approach (logit) and a non-traditional, non-linear multivariate approach (the Binary Recursive Tree). In order to parameterise these models, samples of Asian and Latin American data are used with banking crises that could have similarities with banking crises that the NMS may experience in future. We find that different factors drive the probability of banking crises in each region and conclude that it is unwise to pool them into one set of results. Apart from a wave of crises just after the start of transition, there are few banking sector crises in the NMS, and hence we have to use other models to predict risks their. Our analysis suggest that the structural similarities are greater with the East Asian economies than they are with the Latin American ones, and hence we recommend the use of a logit model structure based on these economies when evaluating the risks of crises in the NMS. Some of the models suggest some NMS, in particular Hungary and Poland, face significant financial system instabilities in future if they do not monitor certain macroprudential indicators such as GDP growth, budget deficits and credit expansion. These preliminary results confirm the need for ongoing quantitative macroprudential surveillance in the NMS as a matter of course.

Crises are inseparably related to periods of enhanced macroeconomic and financial uncertainty, with most sectors of the economy witnessing increased volatility and higher risk premia. In section 7, univariate GARCH models are used to analyse volatility of NMS exchange rates and equity prices. We also look at volatility of output and inflation measures. Equity markets show a pattern of declining conditional volatility, which was interrupted by the 2008 crisis. In 2008, there was also a rise in dispersion of volatility, but much less than in 1998, indicating higher integration and hence scope for contagion. Correlations of volatility have also increased, consistent with this conclusion. Univariate effective exchange rate GARCH estimates show that the 2008 crisis is more severe than that of 1998. For most countries, correlation of variance increased after 2002 compared with 1995-2002. Conditional volatility of retail sales is lower and more stable than that of industrial production, which was markedly increased by the crisis of 2008. The correlation of the two series is less marked than for equities and the exchange rate.

Panel estimation for determinants of conditional volatility in equities and exchange rates shows that macroeconomic variables have little consistent impact for equities, while for exchange rates, significant effects of real interest rates and the fiscal balance can be detected, as well as EMU, which raised volatility in NMS currency rates. Multivariate GARCH permits the derivation of conditional covariance as well as variances. Higher covariance is an indicator of contagion risk. The recommended tool is the VECH model estimable in Eviews and it is recommended to re-estimate and assess charts regularly from this model as well as univariate GARCH models as part of the toolkit for macroprudential surveillance.

In order to facilitate the ongoing quantitative macroprudential analysis of the NMS, we provide two practical user guides, which describe the early warning system and GARCH methodologies outlined above. These can be used by individual desk officers to analyse their respective country's financial fragility.

# 2 Overview and literature survey

Financial contagion and fragility have a number of dimensions, and they are all of relevance for the analysis of New Member States. Fragility can exist and contagion can take place through the structure of the banking system, or because of developments in the non-bank private (or public) sectors at home and abroad. Fragility in the face of shocks is a precursor of crises and a cause of the contagion of crises. There is a growing realisation that crises have a generic nature (Davis 2002). Vulnerability to crises often emerges from the effects on the economy of a positive shock that raises growth and investment, which is accompanied by credit and asset price booms. Deregulation or innovation in financial or in production markets may raise growth and the complexity of financial structure, also raising vulnerability. The accession of the New Member States to the EU could be such a shock, with reduced barriers to trade and to capital mobility raising potential growth in the run up to membership as well as after it but also raising vulnerability to crises (Cihak and Fonteyne 2009).

At least in the early stages of an upturn, it is very difficult for policy makers to distinguish sustainable from unsustainable developments as a consequence of deregulation and integration. Consumers may be forward looking and optimally responding to changed circumstances, or they may be acting imprudently. The early stages of an asset price bubble may look like the convergence of asset prices to a sustainable equilibrium in response to changes in underlying factors. Firms should respond when their costs are reduced. Innovation in financial markets can raise sustainable output by reducing the cost of capital, but it can also lead to excessive borrowing, overvalued asset prices and reductions in risk premia to levels that are not sustainable, leaving the economy vulnerable to crises following external or internal shocks. Certainly, we contend that a bubble does become more evident over time, especially if one uses deviations of certain key levels and ratios from past norms as indicators.

The objective of this report is to show how to extract warning signals from data and also to discuss the role of prudence in the setting of economic policy. To that end, a surveillance toolkit is necessary. We discuss the possibility of fragility in the corporate and personal sectors of the New Member States, and assess the extent to which levels of borrowing rose too rapidly in the personal sector, and whether risk was underestimated in the corporate sector. In both cases we point to levels of foreign currency borrowing. These have risen in some countries but not others, and they are a clear harbinger of risks. However, there are a myriad of other factors to look at.

Once fragilities have developed within a Single Market such as that in the European Union, crises may develop in one area and contagion may spread them to other areas. Contagion during crises is the obverse of risk sharing in an upswing, and economists and policy makers have encouraged risk sharing as it raises welfare. However, taking on risk from others has at times led to it being under priced, as it was not understood, and hence there have been severe consequences. Contagion carries an adverse shock from one country to another, either from the Old to New Member States (or from outside both), from one New Member to another or from New to Old Members. Contagion can come through trade effects on firms or through the effects of changes in asset prices in one country on the wealth of consumers in another country. It can also come through linkages in the financial system, and we analyse that at length below. Contagion may also be from one financial market to another, with equity markets being of primary concern. Equity Market contagion can come either through correlated movements in prices or volatility independently of movements in fundamentals or in correlated movements in fundamentals, including risk premia. Given their financial structure, for the CEE countries most contagion, however, will be through the banking system, either through structures of ownership, patterns of cross border lending or through contagion in the movements in interest rates that impact on the cost of borrowing.

Crises are indeed often associated with severe banking sector problems, that lead to failures or nationalisation of part or all of the banking system. Hence the key to most crises comes through an understanding of the behaviour of the banking system and its relationship to regulators. Banks lend on a multiple of their capital base, and they have to evaluate risks and returns to decide on that multiple after they have taken into account regulatory constraints. If the capital base of a bank declines because of losses on unwise lending or poor investments in securities then adjustment has to take place. Banks that have made losses might find it hard to raise capital in the markets, as their losses and resultant need for capital may act as adverse signals. Hence they may either contract their loan book to match their reduced capital base, or they may try and recoup losses from an increased gross operating surplus. In either case the cost of borrowing from banks will rise, and there may be capital rationing.

If a home country bank suffers capital losses at home, it will probably raise charges in all its host country subsidiaries in order to rebuild its capital. Contagion would then flow from an Old to a New Member State. Part of the toolkit must therefore be a detailed knowledge of the ownership structure of banks within the New Members. There could also be contagion during a crisis from a New to an Old Member through a banking or financial subsidiary in a New Member. Substantial losses in one New Member could impinge on the solvency of home country banks and ensure that contagion effects on borrowing costs takes place through this channel. An important part of a toolkit on contagion must be the knowledge of the exposure of home countries to host countries (see also Maechler and Ong 2009).

The European financial architecture is complex, in that over the last few years it has had one market in financial services but 29 regulators, and domain for the impact of risk and the domain for appropriate regulation have sometimes not overlapped. The Single Market in Financial Services has meant that banks in a country such as Austria or Sweden have been able to buy up banks in the New Member States. In general the risk and capital adequacy impacts of activities in host countries have been the concern of home country regulators, even when they have exposed the host to risks. An important part of any toolkit for surveillance must be a knowledge of the currency composition of borrowing from banks along with a knowledge of the nationality of the bank doing the lending. Foreign currency borrowing is a risky activity that may not be fully understood, especially in the personal sector where the reliability and strength of a currency peg may not be fully appreciated. If a currency moves it can leave a borrower exposed to a greater liability in terms of their assets and their income than they had anticipated. If they do not default this is a problem for the host economy. If they do default the exchange rate movement induces contagion to the home country. The regulator in the home country may not have fully appreciated the risks its financial sector was taking in host countries, and hence it target for regulatory capital may have been inadequate.

A toolkit to observe the build up of fragility and the development of contagion is very useful as part of the equipment needed for macro-prudential regulation. However, somebody also has to take responsibility for that regulation. Individual regulators in Europe appear to have been under-informed about the risks both home and host countries were taking. They also appear to have been too sanguine about the development of asset price bubbles, and such bubbles are at the centre of the fragilities that develop into crises. The lack of an overall regulatory framework and the absence of a market wide macro-prudential regulator should itself have been seen as a major fragility in Europe, and understanding regulatory failure and its consequences must also be a tool the Commission needs.

There is a vast body of literature on financial crises and contagion. This brief literature survey and overview is designed to lay the foundations for the descriptive and empirical analysis to follow, in order to develop a toolkit to assess the exposure of the new EU member states (NMS) to risks of financial crises and to assess the likely impact of a financial crisis on the real economies. We have identified four key areas of the literature that are directly relevant to this project: identification of a key set of macro-prudential indicators; determining the channels of financial market contagion; assessing the impact of financial crises on the real economy; and reviewing the methodological approaches that have been adopted in early warning system models.

As a first step, we will review findings in the literature that point to a key set of macro-prudential indicators. These indicators should be monitored closely by policy makers, so that action can be taken when the indicators point to heightened risk of a crisis. This work has been developed largely by the IMF but also reviewed extensively by international bodies such as the BIS, the OECD and the ECB, so rather than reproducing a detailed survey of the underlying theoretical and empirical findings to date, we will review the indicators that these international bodies have selected to monitor in their role of surveillance of the international banking system. Many of these indicators act as inputs into financial market early warning systems.

In the next section we look at the channels of contagion, in order to identify the exposure of the NMS to financial stress in other NMS, in the old EU member states, as well as in other major regions of the world. A review of this literature highlights the fact that international financial linkages are not necessarily straightforward to identify from macro-level data. We will review the literature on the empirical techniques that have been employed to extract information on the co-movement of financial markets in the past, which acts as a guide to financial market exposure. Some of these techniques will be applied in the empirical work that follows, to extract information on the exposure of the NMS to external financial shocks. This in turn will act as an input into the NiGEM scenarios undertaken in the second part of this project.

The third section of the literature survey will review studies that have analysed the impact of financial crises on the real economy. The costs of crises differ across countries, depending on factors such as the depth of financial markets, institutions and policy regimes. This will allow us to assess the exposure of the real economies in the NMS to financial crises, in order to gauge the appropriate degree of risk aversion that should be taken by policy makers in the design of crisis prevention policy. The key points will also act as an input into the NiGEM scenarios undertaken in the second part of this project.

The final section will review the methodological approaches that have been adopted in early warning system models, as a precursor to the empirical work that will be undertaken in the second part of this project. The inputs into the empirical models will rely heavily on the macro-prudential indicators identified in the first section of this survey.

## 2.1 Identifying key macro-prudential indicators

The term macro-prudential indicators is applied to a broad range of variables, that include macro-economic indicators such as GDP growth, real interest rates and inflation, as well as financial variables, such as asset prices, bank liquidity ratios and household indebtedness. A small fraction of these indicators have been widely used as inputs into early warning system models. The choice of indicator used in these models has been driven by data availability and of course empirical significance, while relevance to policy makers has also been important in the selection process. Recent studies have highlighted the importance of a number of additional macro-prudential indicators that may be associated with an increased risk of a financial crisis. While the lack of an adequate time series across a broad range of countries precludes the inclusion of such variables in empirical modelling work, it would be wise for policy makers to monitor these variables closely. The aim of this section is to identify the key indicators that will be used in the early warning system models produced in the second half of this project and to identify a key set of additional variables that should be closely monitored by policy makers.

An essential source for the identification of macro-prudential indicators (MPIs) is work that has been carried out under the Financial Sector Assessment Program, a joint programme launched by the IMF and the World Bank in 1999. Evans *et al* (2000) outlines the IMF's selection of a core set of MPIs, and reviews the existing literature from outside the IMF in support of this selection. This set of indicators can be subdivided into macroeconomic indicators and what they term "aggregated microprudential indicators". The macroeconomic indicators include measures of economic growth, balance of payments indicators, volatility in inflation, interest rates and exchange rates, lending and asset price booms, and contagion effects. The microprudential indicators include measures of banking system wide capital adequacy, asset quality, management soundness, earnings and profitability, liquidity, sensitivity to market risk and market-based indicators.

More recent work has attempted to rank these indicators according to importance and refine the definition of indicators. A refined set of Financial Soundness Indicators (FSI) was agreed by the IMF in 2003, in conjunction with the *Financial Soundness Indicators: Compilation Guide*, which provides a standardised reference on the concepts and definitions. These indicators include (among others): household debt to GDP; debt to equity ratio of nonfinancial corporations; real estate prices; foreign currency denominated loans as a share of total loans; return on equity; non-performing loans as a share of total loans; the liquid asset ratio of the banking system; and the rate of return on bank assets. The macro-economic indicators highlighted by the IMF include GDP growth; the current account deficit; foreign exchange reserve adequacy; the terms of trade; the volatility of interest rates, exchange rates, and the inflation rate; and also the emergence of lending booms.

In general, financial soundness indicators are used for qualitative assessment of the current vulnerability of the economy to a financial crisis, as distinct from the quantitative early warning models discussed below. Judgement about whether combinations of developments are threatening, as well as assessment of deviation from norms are crucial inputs to this "macroprudential surveillance" process. Broadly similar indicators and techniques are used by other international organisations such as the BIS and ECB, as well as many central banks. For example, Davis and Karim (2008b) evaluated the predictive ability of various financial stability reports before the crisis began in mid 2007. They noted that the ECB focused on risks due to Euro area household and corporate leverage, and possible disappearance of market liquidity. The BIS was concerned about cheap credit and volatile liquidity, as well as broader deviation of financial and economic indicators from traditional norms. Neither they nor the IMF fully predicted the crisis, although there was an overtone of concern, especially from the BIS. As an example of the use of FSIs for the NMS, Cihak and Fonteyne (2009) assess the FSIs for Eastern Europe and conclude that the picture is mixed, with evidence of low capitalisation and weak banks expanding most rapidly offsetting high bank profitability and low non performing loan ratios.

Turning to indicators used in econometric and statistical work, Davis and Karim (2008a) provide a thorough overview of the literature supporting the selection of indicators that are commonly used in early warning system models, as well as estimating new equations themselves. They identify rapid real credit growth and increases in private sector credit relative to GDP as indications of credit risk accumulation (Borio *et al*, 2001), while the level of the credit to GDP ratio is an indicator of economic and financial development. Davis and Karim (2008a) argue that the common pattern of procyclicality of financial instability implies that GDP growth should be included as an indicator, while the banking sector liquidity ratio captures the probability that banks will be unable to satisfy the short term claims of depositors, if the ratio of illiquid assets relative to liquid liabilities is too high (Diamond and Dybvig, 1983; Santos, 2000). Barrell, Davis, Karim and Liadze (2009) show that, at least in OECD countries, banking sector liquidity ratios – as well as capital adequacy - are a significant element in the prediction of crises, which strengthens the case for including them in a toolkit for monitoring financial fragility. Davis and Karim (2008a) also suggest that terms of trade shocks can trigger a financial crisis, especially in small open economies, while they argue that the adequacy of foreign exchange reserves should also be monitored, as an inadequate level may impair the ability to defend the currency.

There are other financial market related indicators that should be monitored regularly, but they are in many ways more marginal to the prognosis of a crisis. Real interest rates have been found to have a positive relationship with the probability of a banking crisis (Hardy and Pazarbasioglu, 1998; Kaminsky and Reinhart, 1999; Gourinchas et al 2001), and also act as a proxy for financial liberalisation. Direct use of asset prices for proxying market risk in early warning system models has been limited due to lack of data outside the OECD countries, but many studies have documented the link between commercial real estate prices in particular and banking crises (FDIC, 1997; Herring and Wachter, 1998; Davis and Zhu, 2004). Barrell, Davis, Karim and Liadze (2009) show that in OECD countries house price growth is an important indicator of banking crises. High inflation acts as a signal for policy mismanagement, which causes higher nominal interest rates, and may also reflect risk of asset price booms. Policy mismanagement is also reflected in high fiscal deficits, which may limit the government's ability to introduce financial liberalisation (Demirguc-Kunt and Detragiache, 1998). Increases in interest rate volatility are typically a consequence of financial liberalisation (Honohan, 2000) and may increase the risk premium charged by banks, or increase risk aversion of investors.

There is clearly a high level of overlap between the MPIs identified by the IMF and others and the key indicators that have been used in early warning models, as described by Davis and Karim (2008a). In the next section of this report, we present of an overview of several key macro-prudential indicators in the NMS. Particularly given the importance of banking in the New Member States financial structure, these include many of the key indicators identified in this section that signal the risk of a banking crisis developing. Policy makers should monitor these indicators regularly in order to identify any increase in risks. They will act as inputs into the EWS models and simulations developed in this project.

The assessment of the vulnerability of different sectors of the economy which provides a foundation for the EWS models involves an investigation of various sector-specific indicators. Our study focuses on indicators that contain a large amount of information on the condition of the sector being analysed and may serve as crisis predictors. For households this includes overall indebtedness relative to income, property prices and foreign currency borrowing. Meanwhile, to assess the financial soundness of the corporate sector we will use the Altman index (see e.g. Altman, 1968, Altman, 1993, Altman, 2000). Computing the Altman indicator of financial fragility, involves calculating five ratios normally found in company's financial statements: working capital over total assets, retained earning over total assets, earnings before interest and taxes over total assets, market value equity over book value of total liabilities and sales over total assets. These ratios are then adjusted for predetermined weights enabling assessment of the financial standing of a company and its susceptibility to a bankruptcy. As a relatively powerful and informative tool, the Altman index has been modified and/or used by many authors (see e.g. Ohlson (1980), Grice, Ingram (2001), Altman, Sabato (2006)) not only to assess the financial standing of individual companies, but also particular branches of industry. We apply this methodology to the corporate sector as a whole, following Pomerleano (2000) who analyses the performance of the corporate sector in East Asian economies during the 1997 crisis.

## *2.2 Channels of financial contagion*

Financial crises can develop at home or abroad, and linkages between countries affect the likelihood of a crisis spreading across countries. For the purposes of this report, we adopt the broadest definition of contagion put forward by Pritsker (2000): "contagion occurs when a shock to one or a group of markets, countries, or institutions, spreads to other markets, countries, or institutions". In some strands of the literature, authors distinguish between spillovers, or interdependence, and contagion, which they define, broadly speaking, as the increase in cross-market correlations during periods of turmoil (see for example Forbes and Rigobon, 1999; Pericoli and Sbracia, 2001; Corsetti *et al*, 2002). However, the aim of this project is to develop a toolkit to assess the exposure of the NMS to risks of financial crises, and therefore the broadest definition of contagion is most appropriate for our needs. This is also the definition most commonly used by the IMF and other international bodies.

The main channels of financial contagion are through trade linkages and financial market linkages. Trade linkages are straightforward to identify through bilateral international trade statistics, and financial distress can spread through both export and import volumes as well as income effects, relative prices and competitiveness effects. Financial market linkages are often more nuanced. There may be direct linkages through capital flows and cross-border banking, especially where countries share a large common creditor (George, 1998), while indirect linkages can be observed through co-movements in exchange rates, interest rate spreads, equity markets and capital flows (Dornbusch *et al*., 2000), which may reflect correlations in different types of risk premia. Some of the literature on financial market contagion has also stressed the presence of non-linearities in the cross-market correlation of financial variables, which may increase once a crisis has occurred in one or more markets. De Brandt and Hartmann (2000) and Dungey *et al* (2004) provide thorough reviews of the theoretical and empirical models of contagion.

### 2.2.1 Trade linkages

There is a vast literature on the role of trade linkages in financial market contagion. Financial crises are often associated with sharp exchange rate realignments, and this can have a significant impact on global supply chains, especially in the short-term. Importers in countries with devalued exchange rates suddenly find it much too costly to import goods at previously agreed prices. Exporters, on the other hand, often find they are able to undercut competitor's prices, and may gain market share, at least in the short-term, thus provoking contagion to other countries. Crises are often propagated by a drying up of trade credits, as banks and other financial institution become unwilling to lend short term or offer insurance cover except at penal rates, and this impacts on both imports and exports. Furthermore besides these competitiveness and financial effects, there may be an income effect of trade linkages, whereby a crisis affects income and the demand for imports. Trade is thus disrupted in a number of ways during a crisis and countries are exposed both in the countries they trade with and in the countries with whom they compete for export market share - and crises become contagious.

Eichengreen, Rose and Wyplosz (1996) demonstrate that the existence of trade linkages has a significant impact on the probability of financial crises spreading across countries. Using a probit model covering 20 industrial economies, the authors show that contagion appears to spread more easily to countries that are closely tied by international trade linkages than to countries that exhibit macroeconomic similarities. Similarly, Glick and Rose (1998) find that in five episodes of currency crises, for 161 countries, trade channels contributed to the propagation of the crisis. The authors argue that the impact of contagion tends to be regional rather than global, as trade tends to be intraregional rather than interregional. The regional spread of crises resulting from trade adjustments is also supported by studies by Kaminsky and Reinhardt (1998). The authors show that strong trade linkages increase the probability of the crisis spreading to neighbouring countries.

Cihak and Fonteyne (2009) show that such regional trade linkages between NMS and the old member states have increased sharply since transition, implying an increase in risk of contagion via this channel. Using a gravity model, Bussiere et al (2005) suggest that for most of the NMS the level of trade with the rest of the EU is already at its potential level. They also show that the exposure to other NMS varies significantly from a maximum of 24.8% of Slovak exports being to other NMS to a minimum of 7.3% in Hungary and 4,6% in Bulgaria. And exposure to Western Europe ranges from a high of 63.5% in Slovenia to a low of 33.3% in Latvia. This implies that the scope for trade related contagion is also likely to differ markedly.

Regarding the impact of such contagion, Montalbano et al (2005) examine the impact of trade openness in Eastern Europe on vulnerability of the economy, which they link in turn to volatility of consumption and its potential impact on overall economic growth. The volatility of trade openness and the terms of trade were found to be both significant determinants of the volatility of annual per capita consumption growth. Western European countries were found to be structurally less volatile to trade shocks than those in Eastern Europe. Furthermore, higher consumption volatility was found to impact on overall economic growth. This was particularly the case of what the authors term "extreme and crisis volatility" which exceeds normal cyclical levels, and which was particularly common in the CEE during the 1990s. Bulgaria, the Czech and Slovak Republics and the Baltic States were highlighted as particularly vulnerable to the impact of trade shocks during the 1990s.

Overall, we conclude that the economies of the NMS are relatively open, especially the smaller Baltic countries, suggesting that they may be more exposed than average to financial market contagion through trade linkages. In the next section we will illustrate in more detail the exposure of each of the NMS economies to the other NMS, to the old EU member states, as well as to other major regions of the world through trade linkages and competition for export markets.

### 2.2.2 Capital flow links

Kahler (1998) notes that the rise of capital inflows into many emerging economies could raise the risk of financial crises as occurred during the SE Asian episode of 1997. Whilst capital account liberalisation and the removal of capital controls facilitates foreign direct investment flows (FDI), the same measures also enable the rapid retraction of funds if investor sentiments reverse. Liete (2001) also warns of the link between capital flows and crises and suggests a major challenge of policymakers lies in the need to balance growth enhancing investment flows against increased vulnerabilities to crises. Hence the IMF stresses the need for increased capital flows to be accompanied by macroeconomic and financial stability; to achieve the latter, capital flows should be monitored as part of macroprudential surveillance. Lane and Milesi Ferretti (2006) take an overview of such capital flows to the CEE NMS, highlighting the benefits to growth from major capital inflows, and notably their focus on FDI. But they also noted the risks of capital flow reversal linked to large current account deficits.

### 2.2.3 Cross-border banking exposure

Banking sector exposure to crises abroad can materialise through direct cross-border exposure or indirectly through the 'common lender' channel. Defining the latter, a common lender is typically a key funding source for a number of countries. If a crisis occurs in country A, an international bank that acts as a common lender in both country A and country B may react by reducing its overall risk exposure, which may involve restricting lending in country B, although country B has no direct exposure to the shock in country A. The direct channel can be identified through foreign claims on domestic banks, which in aggregate can be proxied by the IMF's FSI of foreign currency-denominated liabilities to total liabilities or net open position in foreign exchange to capital. Common lender channels can only be identified through a careful analysis of bilateral cross-border claims on banks where data is available. Maechler and Ong (2009) note the shortcomings of these data for CEE countries.

The common lender channel in CEE is investigated inter alia by Aydin (2008). The author utilises a panel model to analyse the role of foreign-owned banks in credit booms in several NMS countries. A high level of foreign-ownership of banks increases the risk of exposure through the common lender channel. The results of this study show banks in the NMS have a relatively high level of foreign ownership. The parent banks are reliant on interbank funding, opening a channel from the NMS banks to international liquidity markets. When providing credit, foreign banks base their decisions on growth in the host economy, interest rate margins, and financial conditions in their home country.

Arvai, Driessen and Oetker-Robe (2009) analyse cross-border banking exposures between the old EU member states and several of the NMS. They use consolidated foreign claims on individual countries from the BIS dataset to capture cross-border banking exposure. Following the approach developed by Sbracia and Zaghini (2001), the authors discuss risks of exposure to regional contagion, focussing on the common lender channel. The paper shows that financial interlinkages within Europe are significant, with most of the NMS being highly dependent on Western European banks (either directly or through the local banking sectors). The analysis also suggests that the larger the dependence of the NMS as a whole on funds from a common lender and the greater the latter's exposure to a trigger country, the higher is its exposure to regional contagion. Difficulties for Austria would hence be a greater problem for the region than would difficulties for Sweden, with its activities focused in the Baltics. The authors caution, however, that overall vulnerability of NMS financial systems depends on a number of other factors including capitalization, liquidity, and general soundness of the individual banking systems and its key institutions, as well as the country's macroeconomic fundamentals. So the conclusions regarding contagion are partial.

Derviz and Podpiera (2007) look at the common lender channel through a study of the interdependence of lending decisions in different country branches of a multinational bank. The paper develops a theoretical model of the common lender channel, and then looks for the presence of lending contagion by panel regression methods in a large sample of multinational banks and their affiliates. The authors found that the majority of multinational banks behave in line with the anticipated contagion effect. Contagion effects were particularly strong in the multinational banks operating in Central and Eastern Europe. They conjecture that this reflects the fact that the foreign banks operating in these economies are more likely to rely on delegated management, and this is supported by the route followed by most foreign investors in Central and East European banks, which involved taking over pre-existing institutions with some business history. Multinational banks operating in the Baltic economies showed less evidence of contagion, which may reflect the close proximity of the home and host country bank loan markets with little space for managerial capture effect, and the small relative size of the controlled foreign units.

While the previous studies are based on a direct analysis of bank exposure, Gropp, Lo Duca and Vesala (2006) adopt a different approach in testing for evidence of bank contagion within the largest EU economies based on previous banking shocks. The authors study the effects of a shock affecting one bank (or a group of banks) on other banks. Defining an indicator measuring whether a bank is experiencing a large shock, based on capital adequacy and equity price volatility (the distance to default), the authors estimate the probability of several banks simultaneously experiencing a large shock in a given country. They use a multinomial logit model and estimate the number of coexceedences (an indicator measuring the number of large returns in a given day) in one country as a function of the number of coexceedences in the other countries lagged for one day (controlling for common shocks). They find evidence of significant cross border contagion. The paper suggests that integrated money markets in Europe may have resulted in an increase in contagion risk. As the Aydin (2008) study has highlighted the exposure of NMS banks to international interbank funding, the findings of this study is also relevant for the NMS banks. Cihak and Fonteyne (2009) also show a high correlation of distance to default between the EU-15 and NMS, and note that the distance to default for both Old and New Member State banks having been high during the boom, were close to zero at end 2008.

Bernard and Bisignano (2001) analyse contagion in the international interbank market during the financial turbulence in Asia in the second half of the 1990, finding a low impact of the crisis on flows to Eastern Europe. The work is nonetheless highly relevant now given the dependence of NMS countries on the international interbank market as we detail below. The authors discuss the role of government guarantees in international interbank credit for the volumes of credit provided in emerging market economies where there exist significant information asymmetries making the analysis of risk difficult. The paper argues that while the guarantees given to risky borrowers can help ensure the liquidity of the market, they can also be a source of instability if inappropriately managed.

Rosenberg and Tirpák (2008) investigate the determinants of foreign currency borrowing by the private sector in the NMS. They find the most important determinants to be the loan-to-deposit ratios, openness, and interest rate differentials. Joining the EU appears to have played an important role, by providing direct access to foreign funding, offering hedging opportunities through greater openness, lending credibility to exchange rate regimes, and raising expectations of imminent euro adoption. The empirical evidence suggests that regulatory policies to slow foreign currency borrowing have had only limited success, although in the Czech Republic, foreign currency exposure is very low.

Offsetting the above concerns to some extent is evidence that foreign owned banks may act differently from domestically owned banks, and there is evidence that they act in a more benign way. De Haas and van Lelyveld (2003) show that in Eastern Europe, foreign banks are less likely to reduce credit in a downturn, although this role was influenced by the health of the parent bank. Mian (2003) shows that foreign banks tend to hold more liquidity than domestic banks and to lend to lower risk borrowers. They also tend to reduce credit by less in response to domestic macro shocks to the local corporate sector. Crystal et al. (2002) focusing on foreign banks in Latin America, found that average loan growth was consistently higher and less volatile, which should reduce pro-cyclicality. Foreign banks were also found to maintain higher risk-adjusted capital ratios and to be more aggressive in provisioning. Detragiache and Gupta (2004) compared the performance of domestic banks and a long-established group of foreign banks during the recent crisis in Malaysia. They found that the sharpest differences are between banks mainly active in Asia (including all domestic and some foreign banks) and foreign banks not specialized in Asia. The latter group performed better than the rest during the crisis, maintaining higher profitability thanks to higher interest margins and lower nonperforming loans. Foreign banks did not abandon the local market during the crisis and received less government support than domestic institutions. On balance, the evidence seems to suggest that foreign banks behave less procyclically than domestic banks.

Later in this report we will review the evidence on banking sector linkages through an analysis of the foreign ownership structure of banks, lending in foreign currency and foreign claims of reporting banks in the NMS. We also undertake model simulations focused on impacts of shocks via the banking system.

### 2.2.4 Risk premia correlations

A risk premium is the additional expected return that an investor requires over the return on a risk-free asset, in order to be willing to take on the risk of default. Risk premia are attached to market interest rates, share prices and exchange rates, as well as investment in real assets. Risk premia may be correlated across countries, reflecting both real linkages between countries of the types described above, or reflecting correlations in investor perceptions, which may be unrelated to real linkages. They may nonetheless have an important impact in crises, for example, Diamond and Dybvig (1983) emphasise the role of confidence in precipitating bank runs, which may be reflected in widening risk premia. As cross-country correlations in the movement of risk premia may depend on factors that cannot be directly observed from macro-level data, statistical techniques are employed to uncover these underlying dependencies.

- <u>Exchange rate and interest rate linkages</u>

Under a standard Uncovered Interest Parity condition, exchange rates adjust to ensure that the risk-adjusted expected rate of return from an investment in one country is equivalent to the risk-adjusted expected rate of return from an investment in another country. In addition to interest rate differentials, this relationship includes an exchange rate risk premium, and it may be possible to uncover correlations in exchange rate risk premia across countries. A number of studies have also looked at the correlation of interest rates across countries, after allowing for interdependence, and we interpret this as a correlation in interest rate risk premia.

These correlations may be non-linear if behaviour changes when the risk premium in one country rises above a certain threshold. In addition to correlations in the levels of interest rates and exchange rates, several studies have analysed correlations in the volatility of financial variables across countries. These volatilities, which reflect risk premia, also affect the real economy, as we will discuss in the section on links between the financial sector and the real economy below. Hence, it is important to understand cross-market correlations.

The main methodology that has been used in the literature to identify correlations in financial variables across countries is through Vector Auto Regression (VAR) analysis. This approach has been used in studies by Favero and Giavazzi (2002), Edwards (2001), and Habib (2002).

Habib (2002) applies a VAR approach to three economies of Central Europe: the Czech Republic, Hungary and Poland. The model is expanded to include bilateral exchange rates against Germany (exchange rates in the previous study were fixed under the ERM, so this was unnecessary) as well as a measure of the risk premium attached to emerging markets. The paper shows that shocks to emerging market risk premia had a significant impact on exchange rates in all three countries and on interest rates in the Czech Republic. This highlights the exposure of the NMS to financial crises in all emerging markets, even those with few direct links to the NMS economies. Our study will apply the same technique developed in this paper to interest rate differentials in the NMS relative to Germany.

The study by Favero and Giavazzi (2000) applies the technique to three month interest rate spreads in ERM members over Germany, which could now be applied to the CEE countries in relation to the Euro. The authors show in a reduced form VAR framework that it is possible to implement a two step approach to examine and test for evidence of contagion, which they define as a change in the way shocks are transmitted across countries during crisis periods. In the first phase, the channels through which shocks are normally propagated across markets are traced by estimating a model of interdependence. The second phase consists in running a test of the hypothesis that such channels change during crises periods. They find evidence of non-linearities in European financial market correlations, and this could be attributed to correlations in interest rate risk premia.

When the analysis focuses on correlations in volatility, General Auto Regressive Conditional Heteroskedasticity (GARCH) models, introduced by Engle (1982) and Bollerslev (1986), are commonly used. One advantage of this approach is the potential to capture shocks which are mean-preserving. For example, Edwards (1998) utilizes a simple GARCH approach to examine contagion in bond markets after the Mexican crisis. While this author finds evidence of volatility spillovers from Mexico to Argentina, the tests presented cannot shed light on whether the size of propagation changed during the crisis period. Habib (2002) undertakes a similar GARCH analysis to assess contagion for Poland, Hungary and the Czech Republic. The paper tests whether the volatility of German interest rates or the measure of emerging market risk premia affect the volatility of interest rates and exchange rates in the analysed NMS. The author shows that the exchange rates were affected by volatility contagion, with the emerging market risk premium having the most impact.

Pramor and Tamirisa (2006) also use a GARCH model to examine the correlation between Central and Eastern European currencies and the euro. While they find evidence of exchange rate volatility correlation, the degree of correlation is weaker than in the major European currencies before the introduction of the euro. Similar results were found by Fidrmuc and Korhonen (2004) and Horváth (2005). Volatility in the Slovak koruna appears to be most closely related to that in the euro. The degree of similarity is smaller for the Czech koruna, the Hungarian forint, and the Slovenian tolar, while volatility in the Polish zloty is least correlated with the euro, possibly reflecting the relatively large size of the Polish economy and the smaller degree of trade openness, compared to the neighbouring countries. Spillovers of volatility across regional markets appear to have diminished over time, with the exception of the Hungarian forint, which was shown to remain a source of volatility shocks to regional currencies.

- <u>Equity market linkages</u>

In addition to the direct international linkages in equity markets, through foreign direct investment and cross-border equity holdings, equity markets may be linked through correlated risk premia.

Jokipii and Lucey (2005) investigate banking and financial sector co-movements in Central European countries. The study analyses the co-movements between banking sector indices of Poland, Hungary and Czech Republic, as well as the US, UK and other EU economies. The authors look at correlation coefficients between daily changes in the banking sector indices, and estimate a VAR model of cross-market correlations. They find linkages in all markets, and find that the US market has the largest consistent impact on the Central European banking sector indices. Cross-country correlations remain large after controlling for own country macro-economic news, and find an increasing dependence on news originating in the EU over the sample period that extends from 1994 to 2004.

Contagious effects of a financial shock for stock markets are analysed by Bekaert *et al.* (2003). The authors analyse stock returns in countries of Europe, South East Asia and Latin America using a two factor model that accommodates various degrees of market integration. The analysis focuses on crisis periods and the authors find evidence of contagion in stock markets. Particularly strong effects of contagion in stock markets materialised in South-East Asia during the Asian crisis. The European and Latin America crises are shown to have been less contagious in terms of asset prices behaviour.

Phylaktis and Lichuan Xia (2007) use the same methodology as Bekaert et al. (2003), but apply it to market indices disaggregated at the sectoral level in the regions of Europe, Asia and Latin America. They find that sectors in Europe and Latin America show a greater degree of regional integration than those in Asia, which are more responsive to the US market than to the regional market. Information Technology stands out as a sector, as it is more globally integrated than regionally integrated. They find evidence of non-linearities in sectoral integration during crisis periods, with a greater response to US developments over regional developments during crisis periods.

Many studies of equity market correlations have also adopted GARCH models to capture correlations in the volatility of share prices across countries. This is the basis of the approach adopted by Edwards and Susmel (2001, 2003), who adopt a nonlinear approach to modelling contagion using the GARCH framework. The authors consider a Markov Switching ARCH model for conditional volatilities for a group of Latin American countries. The states of the world of each economy are identified by a low and high volatility regime. The country that originates the shock is identified, and then the correlation coefficient is made dependent on the originator country's state of nature (and hence under potentially higher variance). Billio and Caporin (2005) adopt a similar approach to analyse correlations between the major Asian stock exchanges with those in the US and Europe. They also identify discontinuities in the volatility propagation mechanisms.

Carvalho (2007) proposes a multivariate GARCH model with non-linear conditional variances, and applies this model to returns in both the bond and equity markets. The conditional variances are allowed to change smoothly between two extreme regimes and the transition is governed by past volatility. The results of the empirical example offer some support to the abrupt regime switching model of Billio and Caporin (2005) over a smooth transition, at least in the return on bonds.

Christiansen and Ranaldo (2008) employ a different methodological approach to analyse contagion in stock markets of the European Union. The authors apply a multinomial logit model to investigate how persistence, asset classes, and volatility are related to the coexceedance. The results show that the effects of a shock differ depending on the sign of the shock. They differ also depending on the country group (old member states react differently from new member states) and on the period when the shock occurs – before and after the EU enlargement. This suggests that stock markets in the NMS have become more closely connected to those in the old members.

We undertake an analysis of correlations in equity price volatility for the NMS using univariate and multivariate GARCH models for the NMS as part of this study. We also assess risk premia using a VAR approach.

## 2.3 Links between the financial sector and the real economy

A financial crisis is manifested through a rise is risk premia or a rise in financial market volatility, and both can spill over into the real economy. A rise in equity market risk premia is generally associated with a drop in share prices, and a decline in shareholders' financial wealth. This will have a negative effect on household spending. It may also make it more difficult or costly for firms to obtain finance for investment, thus curtailing such expenditures. A rise in exchange rate risk premia is associated with a depreciation of the exchange rate. The impact on output is generally negative, as a rise is exchange rate risk premia is generally associated with a rise in real interest rates in the country affected, as Barrell, Holland and Hurst (2008) discuss. A sharp depreciation may initially boost trade and output in the country affected, but it will generally have a short term negative effect on countries that are linked to the affected currency through trade channels, as exports to the affected country deteriorate, while the shift in relative prices may lead to a loss of market share through competitiveness channels.

A rise in the risk (or term) premium on long term interest rates alone has a direct impact on the cost of borrowing. This will constrain both consumption spending and investment. In some cases a rise in risk premia is effected through tighter lending conditions rather than simply a rise in the interest rate, and higher-risk borrowers may find it difficult to obtain finance at any price. A number of studies have also shown that increased volatility in financial market variables has a negative impact on investment. This may feed through either the supply channel, if banks tighten lending conditions when uncertainty is higher, or through the demand channel, if individuals are unwilling to take on investment projects when their expected return is less certain.

The international propagation of equity market shocks and their impact on the real economy is studied by Barrell and Davis (2005). The authors analyse the macroeconomic impact of equity market falls in the context of the high degree of cross-market equity price correlations. The study estimates a VECM model of the relationship between equity prices and economic activity for major economies of the EU and the US. The results are then compared with those obtained using the NiGEM model. The analysis assesses the impact of a shock occurring in one country on other economies, with a focus on international propagation through trade, the impact of equity prices on wealth, and contagion of equity prices falls to other markets. The results suggest that the contribution of equity prices to a variance decomposition of output is about three times greater in the US than in the larger countries of the Euro Area. The simulations also show that the scale of the impact can be mitigated by appropriate macroeconomic policy adjustments to either interest rates or the fiscal position. In many NMS countries monetary policy is effectively in the hands of the monetary authorities in the rest of Europe, and fiscal policy is constrained by a desire for EMU membership

Arratibel *et al* (2008) look at the impact of exchange rate volatility and several macroeconomic variables in the NMS. Using panel estimations for the period between 1995 and 2006, they find that lower exchange rate volatility is associated with higher growth for relatively less financially developed economies. However, this positive impact on growth dissipates once countries have moved to a higher level of financial development. They find the threshold level of financial deepening to be a credit to GDP ratio of 67 per cent, a level most CEE countries still fall below. They also find that lower exchange rate volatility is associated with higher stocks of FDI, especially in more open economies, higher current account deficits, and a more volatile development of the credit to GDP ratio. This study highlights key interactions between the exchange rate regime and the depth of financial markets, and we will review the exchange rate regimes in the next section of this report.

Darvas and Szapáry1 (2008) also look at exchange rate regimes in the NMS, and argue that the initial level of economic development as measured by per capita income and the speed of real convergence affect the appropriate timing of entry into the Euro Area. This is because the lower the initial level of per capita income, the larger is the price level gap to close and the greater is the danger of credit booms and overheating. They argue that inflation targeting with floating exchange rates is better suited than hard pegs to manage the price level catching-up process, and may reduce the risk of a financial crisis.

Agenor, Aizenman, Hoffmeister (1998), looking at Argentina, estimate a VAR model including domestic and external lending spreads, the real interest rate and the cyclical component of output. The structure links to two stage intermediation, with foreign banks giving credit to domestic ones, and domestic banks providing intermediation services. A shock to the external spread raises the domestic spread and hence expected output.

Caramazza, Ricci and Salagado (2000) look at factors making a country vulnerable to contagion, covering the relevance of external, domestic and financial weaknesses, as well as trade and financial linkages in provoking crises in a sample of 61 countries during the 1990s, using panel probit estimation. Macroeconomic imbalances matter when they are combined with recent exchange rate appreciation, while trade spillovers from the devaluation and output contractions of other crisis countries is particularly relevant for countries with weak current account balances. On the financial side, they find vulnerability to international financial spillovers (the common creditor) and financial fragility (reserve adequacy) are significant in explaining crises and their regional concentration. Exchange rate regimes and capital controls were less relevant.

Borio *et al* (2001) stress that financial systems are strongly pro-cyclical, and the "financial accelerator" may exacerbate swings in the business cycle. They also argue that risk tends to be underestimated during booms, leading to excessive credit growth, while it is overestimated in recessions, leading to a collapse in credit issue, and possible banking crises.

Such banking crises are likely to aggravate the effects identified above (Barrell, Davis and Pomerantz 2006). The components of economic losses following such crises include the following: First there are losses by stakeholders in the banks which have failed, including shareholders, depositors and other creditors. Taxpayers may also face costs as the public sector seeks to resolve the crisis. Losses may also be incurred by borrowers who lose access to funds and may find difficulty accessing other sources due to asymmetric information on their creditworthiness. More generally, a banking crisis in the monetarist tradition induces a shrinkage of the money supply that may lead to a recession. Rationing of credit by price or quantity, due to bank failures or bank capital constraints, may impact on expenditure by consumers and business, leading to output contractions. Reduced investment may hit economic growth over the longer term. Deposit rates are likely to fall as banks seek to widen spreads in order to recoup loan losses, reducing the incomes of depositors. Finally, if the payments system is impaired because consumers are unwilling to deposit cash in banks, there may be yet more severe impacts on overall economic activity.

Most work on costs of banking crises has focussed on fiscal costs and GDP. For example, concerning fiscal costs, Caprio and Klingelbiel (1999) and Barth et al (2000) reported estimates of 12% of GDP for developed countries, 4.5% with a banking crisis only and 16% when there is a currency crisis as well as a banking crisis (defined as at least a 25% depreciation which accelerates by 10% in the crisis year). Such fiscal costs include recapitalisation of banks and reimbursement of insured depositors. The resolution costs are greater in Emerging Market Economies, possibly due to larger overall shocks, weaker capital adequacy and regulation generally, as well as the role of state banks that are most likely to be bailed out. Costs are also higher where banking intermediation is dominant, as is the case in the NMS.

Hoggarth and Sapporta (2001) measure output losses relative to the growth rate in the previous 10 years, and measure in terms of the cumulated levels of GDP relative to that trend in the wake of the crisis. Using this measure, on average banking crises alone cost 5.6% of GDP and twin crises (including currency crises) 29.9%. They found that crises lasted a 4.6 years in OECD countries but less in emerging market economies (3.3 years). They also found that cumulative output losses were much greater in OECD countries (23.8%) than in emerging market economies (13.9%). This pattern has implications for the NMS as they transition from EME to advanced country status. In terms of why crises are historically more severe in advanced countries, one aspect could be that shocks needed to destabilise the financial system are larger in OECD countries and hence so are output losses. Higher losses could also link to less flexible real wages in developed countries. The authorities may be misled by the initial small effect of a crisis, due to seeming robustness of the financial sector, into taking less radical action. The length of the crisis will also depend upon the inertia in behaviour in the economy. And finally the time to recovery will depend on institutions such as the effectiveness of bankruptcy laws in clearing out broken contracts, as these may prevent new relationships being developed.

Some studies have focused on the effects of crises on subcomponents of GDP. Barrell, Davis and Pomerantz (2006) show that crises impact directly on consumption through credit rationing. They undertake a 19 country panel study of the macro-economic determinants of consumption. They look at the role of income, financial wealth and house prices in determining consumption, and show that crises have an additional negative effect n consumption even given their major impact on income and wealth. The negative additional impact of a crisis on consumption increases as the debt to income ratio increases, suggesting that monitoring the level of personal sector indebtedness is an important part of a fragility and contagion toolkit. We return to this issue below.

Davis and Stone (2004) evaluated the impact of financial crises on investment, inventories and financial variables using regression techniques, in effect capturing the excess decline in expenditure or financing in a recession following a banking crisis with a comparable event without one. Their approach was to introduce dummy variables into equations for the relevant variables, thus seeking to capture effects of the banking or currency crisis which go beyond the normal cyclical patterns that would be captured by the standard right hand side variables for the item in question. In general investment was more affected in developing than advanced countries. So for example in a "Jorgensen" investment function they included variables in GDP, interest rates and lagged investment but still found a further fall of 2% shown by the crisis dummies in the first year (6.5% after 4 years) for OECD countries and 7.3% in the first year (24% after 4 years) for EMEs.

Angkinand (2007) offers evidence on policies that authorities can use to limit the probability of a crisis and also to limit the impact of a crisis should it happen. The author analyses the relationship between banking regulation and supervision, and the severity of banking crises measured in terms of the magnitude of output loss. The empirical results show a smaller impact on the real economy in countries that provide comprehensive deposit insurance coverage and enforce strict bank capital adequacy requirements. While restrictions on bank activities are found to influence the severity of crises, the author finds no significant impact of bank supervision or the extent of banks' financial intermediation.

The literature on the impact of financial crises on the real economy will act as a context for interpreting model simulation results in the second half of this project.

## 2.4 Early warning system models

The FSI and other macroeconomic indicators act as inputs into models of Early Warning Systems (EWS), and developments in this area of research have helped to rank the indicators of financial stability according to importance. Davis and Karim (2008b) provide an overview of the literature on EWS. Below we present a summary of the key literature and an outline of the three main methodological approaches that have been adopted in previous studies. These approaches have generally been applied to global samples of banking crises given the relatively small number of such events. Such samples are in turn typically dominated by middle income countries and are hence of direct relevance to the NMS.

The first methodology, the non-parametric signal extraction approach of Kaminsky and Reinhart (1999), tracks individual time series prior to and during crisis episodes to answer the question "is there a signal of future crisis or not?" The logic is that if an input variable's aberrant behaviour can be quantitatively defined whenever that variable moves from tranquil to abnormal activity, a crisis is forewarned. Aberrance occurs when the variable crosses a threshold which the policy maker sets; the model then issues the output as a crisis signal, allowing preventative action to be taken. The higher the threshold the more likely a signal is correct, so policy makers can manipulate thresholds depending on their degree of risk aversion to crisis. This study included output and stock prices as key indicators to signal a banking crisis. Borio and Lowe (2002) and Borio and Drehmann (2009) used a similar signal extraction framework, and found credit growth and asset price deviations from trend, to be useful predictors of banking crises. Davis and Karim (2008a) improve signal extraction for banking crisis prediction by creating composites of indicators weighted by their signalling quality, and found GDP growth and equity prices to be the most important macroeconomic indicators to monitor.

The second methodology is the multivariate logit model, which uses macroeconomic, institutional and financial variables as inputs to calculate the probability of a banking crisis as the output via the logistic function estimator. It is suitable for answering the question "what is the likelihood of a banking crisis occurring in the next t years?" Demirguc-Kunt and Detragiache (1998) developed a parametric EWS for banking crises using this methodology using a global sample as noted above. Davis and Karim (2008a) used a similar approach, but improved prediction by introducing more countries, crises[2] and dynamics in the macro variables; over 90% of in-sample crises were correctly identified. Some of the key indicators identified in these studies as signalling the risk of a banking crisis include GDP growth, real interest rates, terms of trade, credit relative to GDP, credit growth and the fiscal balance relative to GDP. Barrell, Davis, Karim and Liadze (2009) utilised this approach solely for OECD countries, contrary to other papers and found a different set of banking crisis determinants. These are, bank liquidity, bank capital adequacy and lagged house price growth. Unfortunately one cannot conclude wholly different behaviour since these variables are generally not available for Emerging Market Economies.

Binary Recursive Tree (BRT) partitioning is the third methodology, and it can be used to answer the question "which non-linear variable interactions make an economy more vulnerable to crisis than others?" It can be argued that liquidity, credit and market risks are all potentially non-linear (e.g. once a threshold level of credit risk is surpassed, a decline in GDP may have a heightened impact on the probability of a crisis). The estimator identifies the single most important discriminator between crisis and non-crisis episodes across the entire sample, thereby creating two nodes. These nodes are further split into sub-nodes based on the behaviour of splitter variables' non-linear interactions with previous splitter variables. This generates nodal crisis probabilities and the associated splitter threshold values. This is an innovative approach used mainly in medical research to date. The technique has been applied to systemic banking crises by Duttagupta and Cashin (2008) and Davis and Karim (2008b). The key indicators used in these studies include real interest rates, GDP growth, inflation and credit variables.

The three methodological approaches each have distinct benefits and disadvantages, suggesting that a multi-model approach may be more appropriate than working with a single model. Logistic models are ideally suited to predicting a binary outcome (1 = banking crisis, 0 = no banking crisis) using multiple explanatory variables selected on the basis of their theoretical or observed associations with banking crises. The logistic approach is also parametric, generating confidence intervals attached to coefficient values and their significance. On the other hand the logit coefficients are not intuitive to interpret and they do not reflect the threshold effects that may be simultaneously exerted by other variables. Davis and Karim (2008a) conclude that the logit approach is the most appropriate for use as a global EWS, while signal extraction methods are more appropriate for a country-specific EWS. Signal extraction could easily be applied to NMSs since the use of individual indicators means data requirements are less intensive than logit models.

The logit and BRT approaches were evaluated in predicting the subprime crisis in Davis and Karim (2008b). BRT is able to discover non-linear variable interactions, making it especially applicable to large banking crises datasets where many cross-sections are necessary to generate enough banking crisis observations and numerous factors determine the occurrence of systemic failure. An important feature of this non-parametric technique is that no specific statistical distribution needs be imposed on

[2] 105 countries are covered by data spanning 1979-2003 which yields 72 or 102 systemic banking crises depending on the crisis definition used.

the explanatory variables (Katz, 2006). It is also not necessary to assume all variables follow identical distributions or that each variable adopts the same distribution across cross-sections. Clearly, this is an advantage when analysing banking crises since we cannot assume macro variables (such as real interest rates) and institutional variables (such as deposit insurance) follow identical distributions across time or across countries. Although logistic regression does not require variables to follow any specific distribution, in Davis and Karim (2008a) it was shown that standardising variables displaying heterogeneity across countries improved the predictive performance of logit models.

Logistic regressions are also sensitive to outlier effects (Congdon, 2003), yet it is precisely the non-linear threshold effects exerted by some variables that could generate anomalous values in the data. In low risk, stable regimes, variables may conform to a particular distribution which subsequently jumps to a regime of financial instability. Non-parametric BRTs should handle such data patterns better than logistic regressions. Finally, the BRT is extremely intuitive to interpret. The model output is represented as a tree which is successively split at the threshold values of variables that are deemed as important contributors to banking crises. As many of the studies have identified non-linearities and discontinuities in behaviour, the BRT modelling work in the second half of this project may be particularly instructive as an EWS for the NMS.

# 3 Characteristics and structure of the financial sectors in the NMS

## 3.1 Banking sector

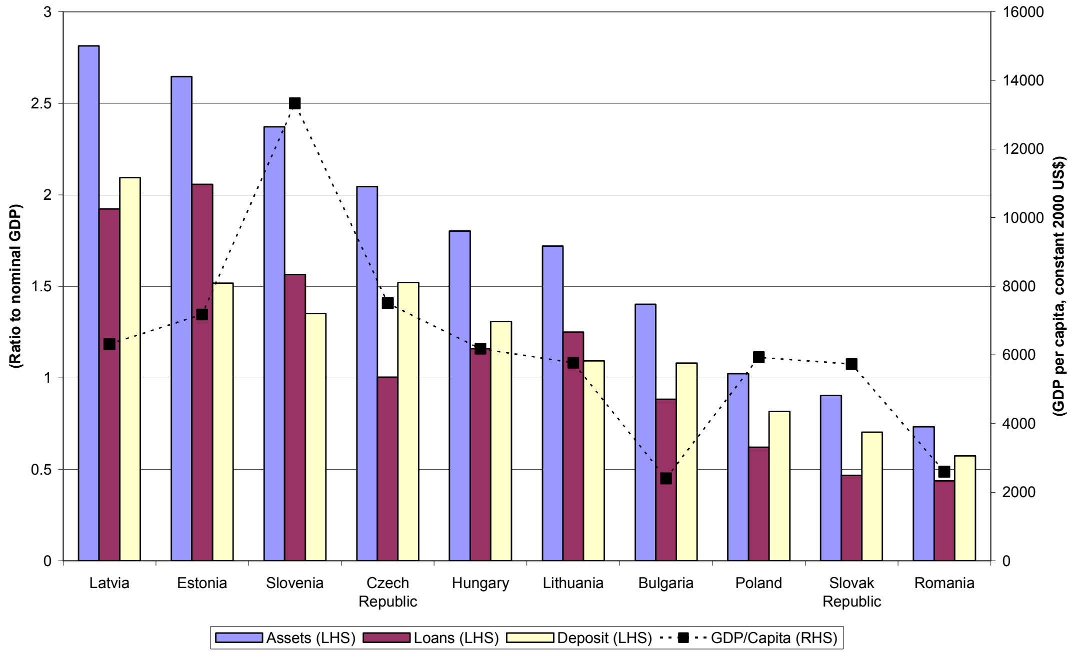
### 3.1.1 Vulnerability of the banking system to financial crises

Banking systems, while essential for economic development, are nonetheless a source of problems in the economy when there are risks of banking crises. They are of particular importance in emerging market economics such as the NMS where security markets are typically underdeveloped. Growth of banking may, however, link not only to financial development but also to credit and asset price bubbles and over lending. Certainly, the larger the banking sector as a share of GDP, the greater the potential effects of a banking crisis as the more dependent normal economic activity is on banking sector transactions. To illustrate the size of the banking system in new member states, we plot the ratio of total assets, loans and deposits to GDP in individual countries in 2007 in figure 3.1.1. Data are derived from Bankscope, summing all assets, loans and deposits of all banks (domestic and foreign owned) in the country concerned.

Following the discussion above, the ratio of banking system assets to GDP can be interpreted as an indicator of the development of the banking sector, but if the ratio is larger than is normal for the level of GDP per capita, perhaps due to an asset and credit bubble, then this may indicate that there are potential problems for the economy if a banking crisis develops. The assets of the banking system exceed GDP in seven out of ten countries considered here. Latvia and Estonia recorded the highest ratio of bank assets to GDP in 2007 despite their relatively low levels of GDP per capita as compared to Slovenia, Hungary and the Czech Republic, while the lowest indicator was recorded in Romania. This could indicate either that firms were much more reliant of bank finance in these economies than in other New Members, which does not appear to be the case, or that they are subject to higher risks because of an over-expanded banking system. The scale of the Slovenian banking system is more commensurate with it relative to GDP per capita and hence can be seen as less of an indicator of potential problems.

In Estonia, Slovenia and Lithuania, total loans exceed deposits, whilst in the other economies considered here they do not. These ratios allow us to assess some of the risks associated with the banking sector. The recent financial crisis started with problems in relation to exposure to the interbank market. If loans exceed deposits then access to the wholesale market, either domestically or internationally, is inevitable. The increase in the interbank spread was the first indicator of the developing crisis in 2007 and 2008, and these three countries would have been the most exposed with their gross operating margins being squeezed by the increase in the cost of funding loans relative to the return on loans. The least exposed to this source of contagion would have been the Czech and Slovak banking systems where deposits were 50 per cent larger than the loan book. This crude indicator based on comparable figures from Bankscope has to be augmented with a detailed analysis of the source of interbank funding from national central bank sources, which may not be comparable across countries.

**Figure 3.1.1. Banking sector assets, loans and deposits to GDP (LHS) and GDP per capita (RHS)**




Source: Eurostat, Bankscope and NiGEM

The severe turbulence on global financial markets has increased risks faced by banks in the old and the new members of the EU. The financial crisis has involved a liquidity problem, which has reduced gross operating surpluses in all banks, and a solvency problem has faced many banks. Capital losses have to be made good from somewhere, and raising gross operating margins is an obvious source of extra funding as rights issues may be difficult in a crisis. Raising gross operating margins to recoup losses means that borrowing rates rise relative to deposit rates, and a bank suffering from capital losses will do this in all areas where they operate, including in their subsidiaries as well as their branches in other countries.

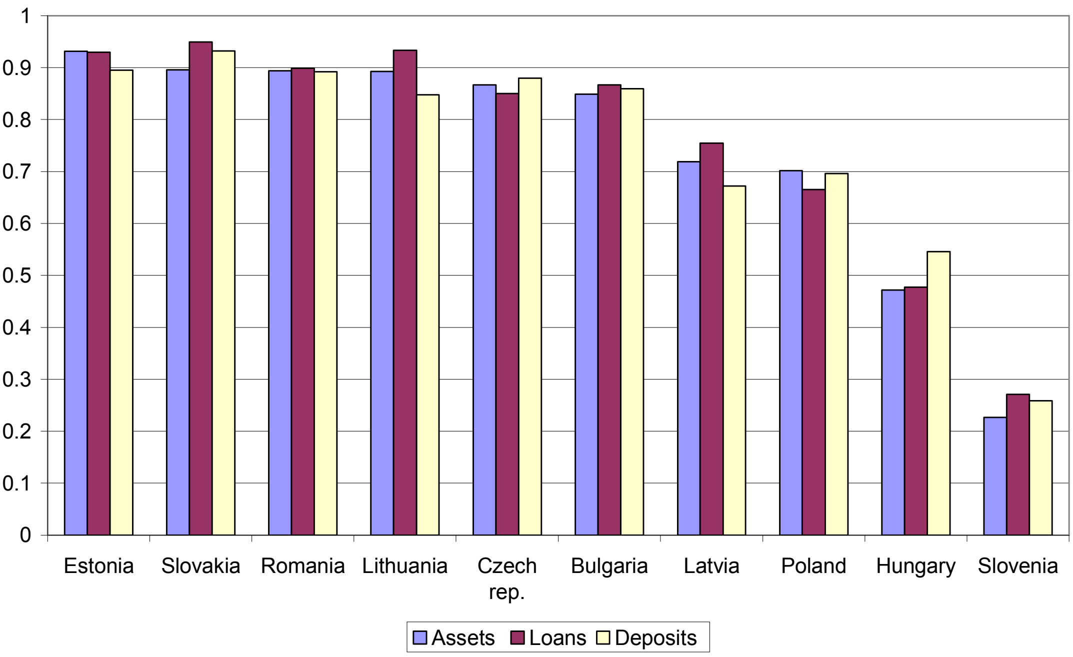
Foreign ownership of banks is common in emerging markets, and it has grown rapidly in the last decade. Foreign owned banks could be a source of propagation of shocks to NMS countries and from NMS countries to each other and to the home countries of the banks in question. If a foreign bank faces liquidity or capital asset problems at home, it may raise margins and reduce lending in host countries as well as at home. This would mean that shocks would propagate from home to host, even when host countries did not face problems. It could also be the case that host country losses could feed back to the home country as they may be so large as to require an increase in margins in all bank activities even if there are no fundamental problems at home. These reactions could spill over to other NMS hosts as well. The major channels of such vulnerability of contagion within the NMS are considered to be through the large Austrian owned banking system in Central Europe, but there are also vulnerabilities in Sweden (which we will discus in  more details in appendix A 4) and to a lesser extent in Greece.

Foreign ownership will propagate the impacts of the financial crises across borders. We discuss these risks from the perspective of host countries (new member states) and from the perspective of home countries (old member states). In Chapter 5 below we undertake simulations on NiGEM to illustrate the propagation of shocks through the banking system from Old to New Member States and the reverse. But we also bear in mind the results of research quoted in the literature survey, that foreign owned banks may act differently from domestically owned banks, and indeed the evidence seems to suggest that foreign banks behave less procyclically than domestic banks.

### 3.1.2 Host country perspectives

There are benefits as well as potential risks from foreign ownership of banks in the NMS. Foreign involvement in the domestic banking system may improve access to credit and reduce margins between borrowing and lending rates. This would reduce the user cost of capital, increase investment and hence help speed convergence toward levels of output per capita seen in the Old member States. On the other hand, foreign banking may involve lending in foreign currencies and hence it may expose the domestic economy to higher levels of exchange rate risk. In order to evaluate the relative importance of foreign banks across countries it is important that we use a data source where definitions are consistent. To that end the underlying data we use in the following charts are for large banks with assets of over $1 billion from the Bankscope database using data for the foreign owned banks in these countries with in excess of 25% foreign ownership. This dataset for the NMS includes 99 banks, all of which are seen as foreign owned in this sense in 2007.

**Figure 3.1.2: Foreign ownership of banking assets, loans and deposits as a proportion of the total**

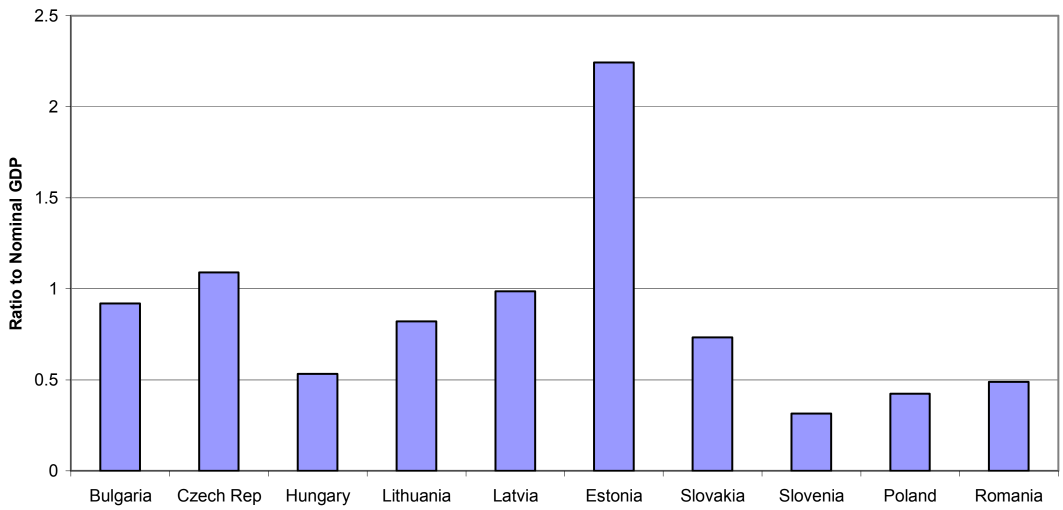



Source: Bankscope

For each country, we divide the banks into two groups: all large banks (domestic and foreign), and banks which have direct foreign shareholdings of more than 25 per cent. We then sum loans, assets and deposit in all the large banks (large foreign-owned banks) within a country. This approximates the total loans, assets and deposits of the banking system. Figure 3.1.2 shows the share of banking activity conducted by banks with foreign ownership in the new member states. More than 80 per cent of banking activity is conducted by banks with foreign ownership in Estonia, Slovakia, Romania, Lithuania, the Czech Republic and Bulgaria. Latvia and Poland have about 70 per cent of their banking system in foreign ownership, at least in part. Hungary and especially Slovenia have a more limited involvement by foreign banks, with only around a quarter of the banking system in the latter country being under foreign control.

Figure 3.1.3 shows the ratio of assets of foreign owned banks to individual new member states' GDP. The share of foreign assets to GDP is the largest in Estonia. This results from the very well developed Estonian banking system (compare figure 11) and the fact that Estonia is a relatively small country. Latvia and Lithuania (in both cases in part through Swedish subsidiaries in Estonia), the Czech Republic, Slovakia and Bulgaria are also relatively exposed to risks channelled through foreign banks. Slovenia is least exposed.

**Figure 3.1.3. Assets of foreign owned banks as a ratio to GDP**




Source: Bankscope, Eurostat and NiGEM

Banking sectors can be a source of risk if they take on foreign currency borrowing to finance loans in domestic currencies, or where collateral is in domestic currency. Table 3.1.1 shows foreign currency lending to NMS banks from banks in the rest of the BIS domain. It is not possible to break this lending down by currency, but much of it is believed to be in euros. The level of borrowing is expressed as a percentage of individual new member states' GDP. Whereas for Slovakia and Slovenia this is less of an issue owing to EMU membership, there are clearly risks to other host banking systems that stem from the level of foreign borrowing through banks, as there is always a risk of realignment even in the run up to EMU membership. Estonia has more foreign currency borrowing than the other Baltic States but this may not be as risk enhancing as it seems as it may be further down a path to EMU membership in the near future. However, there is widely seen to be a strong case for these three countries to realign rather than stay fixed against the Euro, and the scale of foreign currency borrowing could then become serious problem as balance sheets would by significantly altered in an adverse way. The scale of banking sector exposure to foreign loans in Hungary should also be noted.

**Table 3.1.1. Foreign lending to banks as a ratio to GDP**

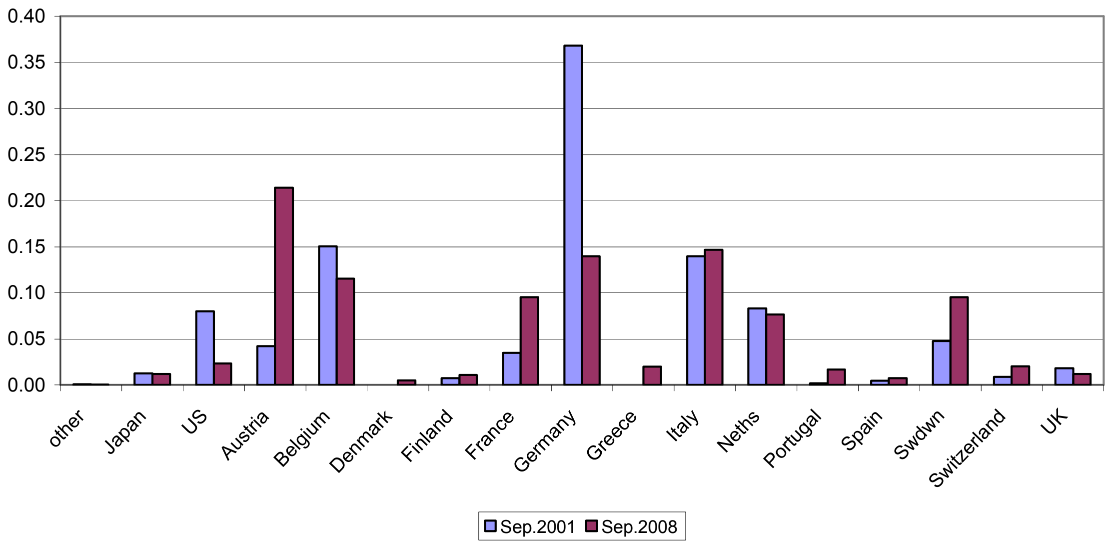
| | Bulgaria | Czech Rep | Estonia | Hungary | Lithuania | Latvia | Poland | Romania | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 0.05 | 0.05 | 0.31 | 0.13 | 0.09 | 0.19 | 0.03 | 0.04 | 0.11 | 0.08 |
| 2005 | 0.07 | 0.05 | 0.47 | 0.12 | 0.14 | 0.33 | 0.02 | 0.06 | 0.16 | 0.08 |
| 2006 | 0.07 | 0.06 | 0.45 | 0.14 | 0.17 | 0.47 | 0.02 | 0.14 | 0.2 | 0.06 |
| 2007 | 0.08 | 0.05 | 0.38 | 0.14 | 0.18 | 0.27 | 0.03 | 0.1 | 0.23 | 0.1 |
| 2008 | 0.09 | 0.04 | 0.34 | 0.12 | 0.15 | 0.24 | 0.03 | 0.07 | 0.2 | 0.07 |

Source: BIS International banking statistics , Eurostat and NiGEM

### 3.1.3 Home country perspectives

The relative involvement of home countries in NMS banking systems has changed over time, as we can see from Figure 3.1.4 which summarises BIS data on consolidated foreign claims of reporting banks (on immediate borrower basis) on all new member states as of September 2001 and September 2008. Austria, Germany, Italy and Belgium account for the largest share of foreign claims for the new members states as a whole. Austrian banks hold over 20 per cent of total foreign claims from the region, Italian and German banks' involvement amounts to about 15 per cent, for both Italy and Germany, and the claims owed to Belgian banks account for about 10 per cent. French and Swedish banks hold about 10 per cent (each) of the total claims on the new EU members. The pattern of ownership has changed over time. The relatively large scale involvement of German banks in the region decreased significantly from over 35 per cent in 2001 to about 15 per cent in 2008. Over the same period the Austrian banks increased their share of claims on the new member states from under 5 per cent in 2001 to over 20 per cent in 2008.

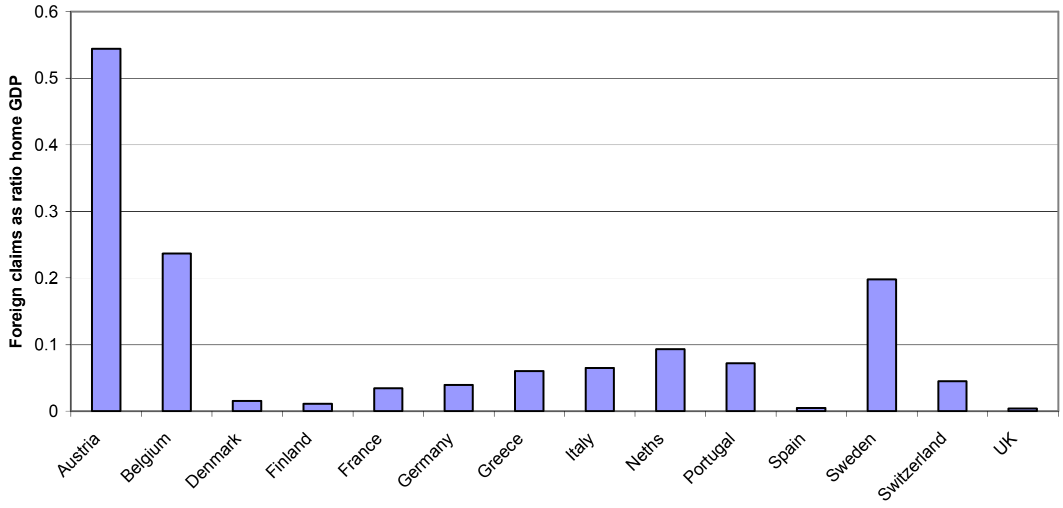
**Figure 3.1.4. Consolidated foreign claims of reporting banks as a proportion of all claims by foreign banks on NMS banking systems**




Source: BIS

Given the relative size of these countries home country exposure can only be evaluated in relation to home country output or the scale of the banking sector. Figure 3.1.5 shows consolidated foreign claims of reporting banks in home countries as percent of their GDP. It is clear from the figure that Austria, Sweden and Belgium are most exposed to potential turbulence in the region of Central and Eastern Europe, and that the Netherlands may also face some risks. Risk to the UK, at lest going forward, may be larger as RBS took a share of eth troubled Low Countries bank, ABN AMRO.

**Figure 3.1.5. 2007 Claims of domestic banks on NMS as a ratio to home GDP**




Source: BIS ,Eurostat and NiGEM

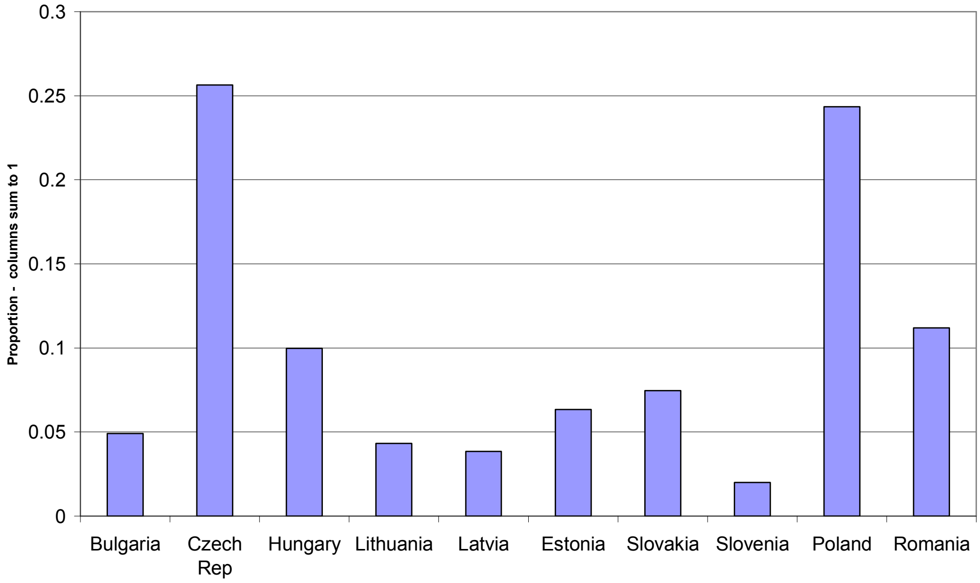
The effects of the turbulence amongst borrowers would be most acute for the home countries if the shock originated in the Czech Republic or Poland, as these economies account for around half of the bank claims from outside the NMS. Significant levels of default in the Baltic countries would have much less impact on the home countries in general as they are small in size. Figure 3.1.6 shows exposure of all home countries to risks originating in individual host countries. Besides Poland and the Czech Republic, only Hungary and Romania present a noticeable threat to home countries in general, but specific links between home and host may also be important, and we turn to that issue in the next section.

We can also scale the risks by looking at the relationship between assets in the NMS as a proportion of home country banking sector assets, and this may be more relevant as part of a risk assessment, as they scale the risk of banking sector contagion. Figure 3.1.7 plots foreign owned assets in NMS banking system as a proportion of domestic (50% or more domestically owned) banks in each country. We choose this cut off as banks with lower levels of domestic ownership become the responsibility of another host, but the proportions for all banks is relevant[3]. The most exposed countries are

[3] We do not plot the proportion of coverage for Greece, as Bankscope contains very little information on the Greek domestic banking system, with only 5 of the 100 or more banks filing reports as domestically owned. In our modelling analysis below, we have assumed coverage of 12 per cent for Greece, a similar level of exposure to that seen in Belgium. However, we have a more complete set of data for all banks which suggests that this may be a high estimate for exposure. If one takes all banks from Bankscope Austria has the largest exposure at 14.4 percent of total assets, Belgium comes next with around 5 percent of total assets, whilst Sweden and Greece have exposure of around 3 to 3 ½ percent of total bank assets.

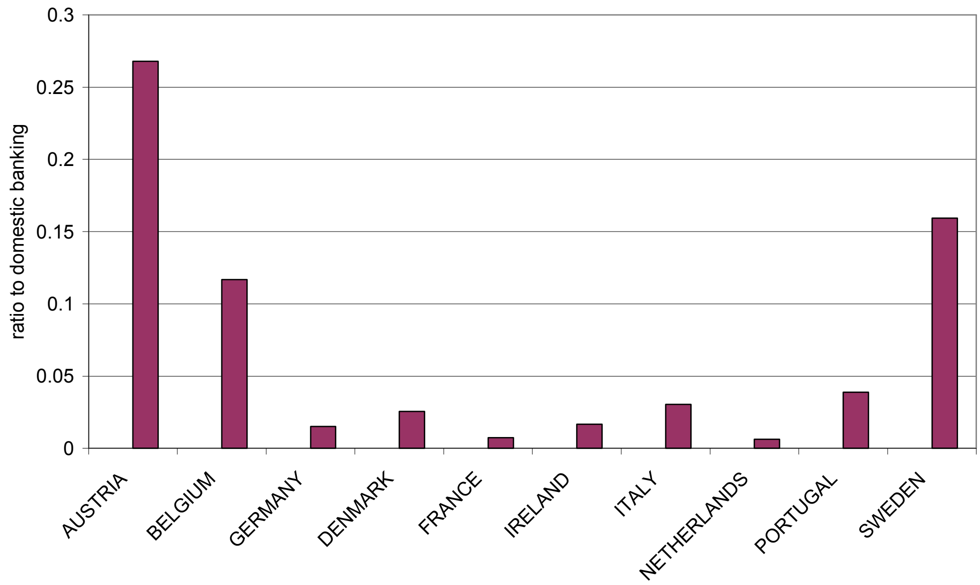
Austria, Belgium and Sweden, where systematic bank failure in the NMS could lead to serious solvency problems in the home country banking system.

**Figure 3.1.6. Exposure of all home countries to NMS banks**




Source: Bankscope

**Figure 3.1.7 NMS assets as a share of domestic bank assets**




Source Bankscope

## 3.1.4 Cross border bank interlinkages

In order to undertake a systematic evaluation of the pattern of risk that the NMS economies present us with, we must look in detail at the foreign ownership structure of banks in individual new member states. We can do this using Bankscope data to produce matrices of ownership patterns. The first dimension involves the ownership pattern for host countries, and we present that in Table 3.1.2. The second pattern involves the ownership pattern for each home country and we present that in Table 3.1.3.

The structure of foreign ownership varies by country, as we can see from table 3.1.2. Austrian banks, for instance, hold major shares in the banking systems of the Czech Republic, the Slovak Republic, Hungary, Romania and Bulgaria, but are barely exposed to risks from Poland or the Baltic states. On the other hand Swedish banks are heavily involved in Estonia where they own 93 per cent of the banking system, and to a lesser extent in Lithuania and Latvia even when we take into account ownership through subsidiaries in Estonia.

If we do consolidate the Estonian ownership of banks in Lithuania and Latvia into their ultimate Swedish parents then the percentage share of the Swedish bank in this table and subsequent table will increases for these two countries. For example in the table 3.1.2 the share of Swedish banks in Lithuania and Latvia will be 63 and 44 per cent respectively and in table 3.1.3 the share of Swedish bank involvement increases in these in Lithuania to 24.3 percent and in Latvia to 18.8 percent, whilst it falls to 50.4 percent in Estonia. We provide more details about the role of Swedish banks in consolidated versions of these tables in appendix A 4. In simulation part in section five we consolidate the Estonian ownership of banks in the Lithuania and Latvia into their ultimate Swedish parents either directly or indirectly by substitution.

**Table 3.1.2. Foreign ownership – country breakdown**

| | Bulgaria | Czech Rep | Hungary | Lithuania | Latvia | Estonia | Slovakia | Slovenia | Poland | Romania |
|---|---|---|---|---|---|---|---|---|---|---|
| AUSTRIA | 0.302 | 0.341 | 0.225 | | 0.038 | | 0.636 | 0.119 | 0.034 | 0.463 |
| BELGIUM | 0.039 | 0.234 | 0.090 | | | | | | 0.066 | |
| GERMANY | 0.029 | 0.015 | 0.018 | 0.052 | | | | | 0.032 | |
| DENMARK | | | | 0.208 | 0.107 | | | | 0.009 | |
| ESTONIA | | | | 0.299 | 0.264 | | | | | |
| FRANCE | 0.038 | 0.179 | | | | | | 0.056 | 0.020 | 0.176 |
| GREECE | 0.283 | | | | | | | | | 0.172 |
| HUNGARY | 0.157 | | | | | | 0.035 | | | 0.016 |
| IRELAND | | | | | | | | | 0.066 | |
| ICELAND | | | | | 0.032 | | | | | |
| ITALY | | 0.005 | | | | | | 0.051 | 0.198 | |
| LITHUANIA | | | | | 0.035 | | | | | |
| LUXEMBOURG | | | 0.084 | | | | 0.202 | | | |
| MALTA | | | | | 0.063 | | | | | |
| NETHERLANDS | | 0.031 | | | | | | | 0.096 | 0.030 |
| PORTUGAL | | | | | | | | | 0.049 | |
| SWEDEN | | 0.008 | | 0.334 | 0.179 | 0.931 | | | 0.016 | |
| TURKEY | | | | | | | | | | 0.019 |
| UNITED STATES | | 0.054 | 0.055 | | | | 0.024 | | 0.115 | 0.018 |
| Total | 0.849 | 0.866 | 0.472 | 0.893 | 0.719 | 0.931 | 0.896 | 0.227 | 0.702 | 0.894 |

Source: Bankscope

The Italians, Belgians and French are heavily involved in Poland, whilst the Greeks appear to have large holding in Romania and Bulgaria. The major exposures the Austrians face are in Czech Republic, Hungary, Romania and Slovakia. We can use this table to judge the implications for the New Member States from problems in the banking sectors in each of the old member states. If for instance the Austrian Banking system were to have a solvency problem and needed to raise its gross operating surplus by raising margins everywhere, the impacts would be quite widespread in the central and southern NMS, but would have little impact on the Baltics or Poland. Conversely Swedish problems would be reflected in the Baltic countries.

The UK is absent from this table and the subsequent one, as no bank ownership structure involved a 25 per cent stake or greater in the period reported in the 2007 version of Banskscope. Obviously there were some changes with takeover of parts of ABN AMRO by RBS. The subsequent nationalisation of RBS left the UK Treasury as the ultimate owner of some banking assets in the NMS. In our tables these were allocated to the Netherlands, their initial source because the Netherlands is the location of the immediate shareholder and the global ultimate owner according to the Bankscope database[4]. We contend that it is more relevant to allocate ownership in this case to the country that the immediate shareholder is located in order to judge the effects of banking sector shocks on home countries, as the fiscal authorities in the home country will have to bear the costs of any failure in home country banks generated by losses in host countries. The fiscal cost of bank failures in the New Members would not in general be borne by the host countries, and this possibility is one path for contagion from new to old member states as we noted earlier. Regulators in home countries have probably underestimated risks being taken by their banks in the NMS, which is perhaps why foreign ownership is so common.

**Table 3.1.3. Foreign ownership – shares of home country bank ownership by host**

| | Bulgaria | Czech Rep | Hungary | Lithuania | Latvia | Estonia | Slovakia | Slovenia | Poland | Romania |
|---|---|---|---|---|---|---|---|---|---|---|
| AUSTRIA | 0.051 | 0.337 | 0.159 | | 0.007 | | 0.177 | 0.035 | 0.040 | 0.194 |
| BELGIUM | 0.068 | 0.581 | 0.159 | | | | | | 0.193 | |
| GERMANY | 0.137 | 0.174 | 0.151 | 0.098 | | | | | 0.440 | |
| DENMARK | | | | 0.531 | 0.304 | | | | 0.165 | |
| ESTONIA | | | | 0.506 | 0.494 | | | | | |
| FRANCE | 0.038 | 0.587 | | | | | | 0.055 | 0.077 | 0.244 |
| GREECE | 0.274 | | | | | | | | | 0.726 |
| HUNGARY | 0.687 | | | | | | 0.188 | | | 0.125 |
| IRELAND | | | | | | | | | 1.000 | |
| ICELAND | | | | | 1.000 | | | | | |
| ITALY | | 0.019 | | | | | | 0.060 | 0.921 | |
| LITHUANIA | | | | | 1.000 | | | | | |
| LUXEMBOURG | | | 0.515 | | | | 0.485 | | | |
| MALTA | | | | | 1.000 | | | | | |
| NETHERLANDS | | 0.198 | | | | | | | 0.721 | 0.081 |
| PORTUGAL | | | | | | | | | 1.000 | |
| SWEDEN | | 0.026 | 0.000 | 0.166 | 0.098 | 0.652 | 0.000 | 0.000 | 0.058 | 0.000 |
| TURKEY | | | | | | | | | | 1.000 |
| UNITED STATES | | 0.224 | 0.162 | | | | 0.027 | | 0.555 | 0.031 |
| | | | | | | | | | | |

Rows add to one
Source: Bankscope

There are other dimensions of risk we can inspect from the data underlying the table. As we can see from table 3.1.3, countries in the old member states differ in terms of their exposure to risk in the NMS. Given the scale of bank ownership in the NMS,

[4] RBS has 50 per cent share via the consortium 'RFS Holdings B.V', the company incorporated by RBS, Fortis and Santander.

given by Figure 3.1.7 above, Table 3.1.3 decomposes the country composition. Around a third of Austrian assets are in the Czech Republic whilst around one sixth or a little more is in each of Romania, Slovakia and Hungary. The Belgian Banking system is heavily exposed in the Czech Republic, Hungary and Poland, whilst the Swedish system is exposed in the Baltic States. The Greek banking system has exposure to Romania, and to a lesser extent Bulgaria.

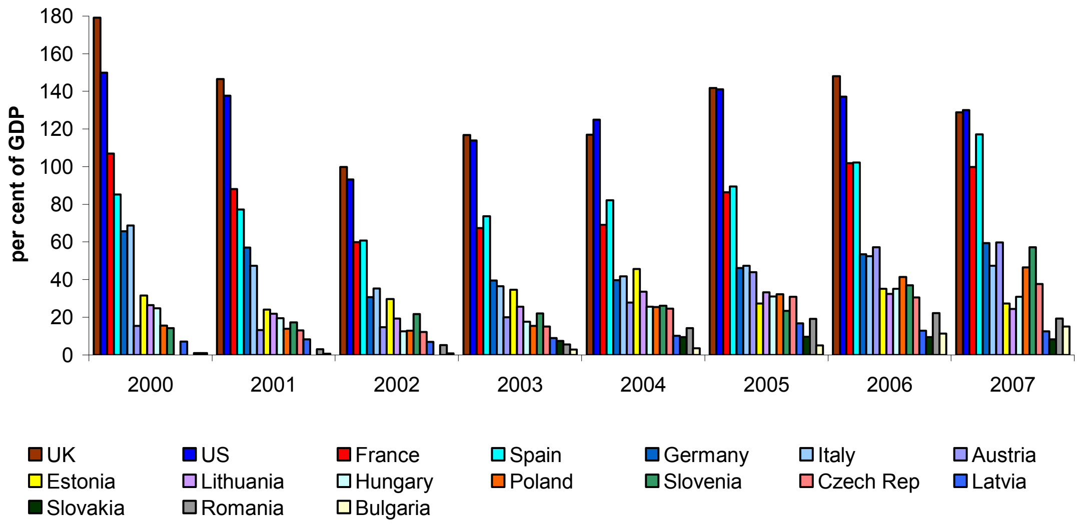
In addition from both tables we should consider the role of common creditor as a possible source of contagion. Austria, Germany and Sweden are probably the largest common creditors and hence could have the largest effect in propagating shocks across NMS countries. However, as we can see from Figure 3.1.7 the coverage of German banking sector assets by exposure to the NMS is less than 2 percent, and hence losses should be easy to avoid and pass through from host to home and hence to other host should be minimal in this case. The same cannot be said of Austria, and Sweden, and to a lesser extent Belgium. Around a third of Austrian assets are in the Czech Republic and banking sector failure in that country could impact noticeably on banking sector margins in Austria itself. There would also be an impact in Slovakia, where the Austrians own almost two thirds of the banks, and in Romania, Hungary and to a lesser extent in Slovenia. Contagion from host t host might also be important if there were defaults in Romania, Slovakia or Hungary, as each of these represents a fifth to a sixth of Austrian assets in the NMS. Although the coverage of Belgian banking sector assets by exposure to the NMS exceeds 10 percent, it is clear from Table 3.1.2 and 3.1.3 that this is largely in the Czech Republic, which takes 58 percent of Belgian exposure and where almost a quarter of the banking system is Belgian owned. In this case host to host contagion is unlikely. Swedish banks are exposed in the three Baltic countries, with a fifth of their assets (directly and indirectly) in Latvia, a quarter in Lithuania and a half in Estonia. In turn these assets cover a sixth of the assets of the Swedish banking system, and hence failure in one of these countries will have a noticeable effect on Swedish banking costs. As the Swedes (directly or indirectly) own 44 percent of Latvian banks, 63 percent of Lithuanian banks and 93 percent of Estonian banks we could expect significant host to host contagion in this region, with problems in Estonia being significant for Lithuania as the most prominent linking. Spillovers outside the Baltics would be very limited. Tables 3.1.2 and 3.1.3 and the adjustments made in Appendix 4 are central to our analysis of banking sector spillovers in our simulation analysis in Chapter 5 below.

## 3.2 *Equity markets*

### 3.2.1 Depth of equity markets

One of the main sources of global financial market contagion is through equity markets. Equity markets in the NMS were essentially nonexistent in the early 1990s, and remained relatively underdeveloped compared to the OMS in 2000, as illustrated in figure 3.2.1, which shows stock market capitalization as a share of GDP in the NMS compared to several of the OMS and the US[5]. Equity markets in the NMS have developed rapidly over the last ten years, and by 2007 equity markets in Poland, Slovenia and the Czech Republic were similar in size (relative to GDP) to the less equity intensive economies of the OMS, Germany, Italy and Austria. They remained, however, small relative to more equity intensive economies, such as the US, UK, France and Spain. Equity markets in Hungary, Lithuania and Estonia remained somewhat smaller than those in Poland, Slovenia and the Czech Republic, while those in Slovakia, Latvia, Romania and Bulgaria remained in a relatively nascent stage.

**Figure 3.2.1 Stock Market Capitalisation**




Source: Eurostat, NASDAQ OMX. Time period: 2000-2007.

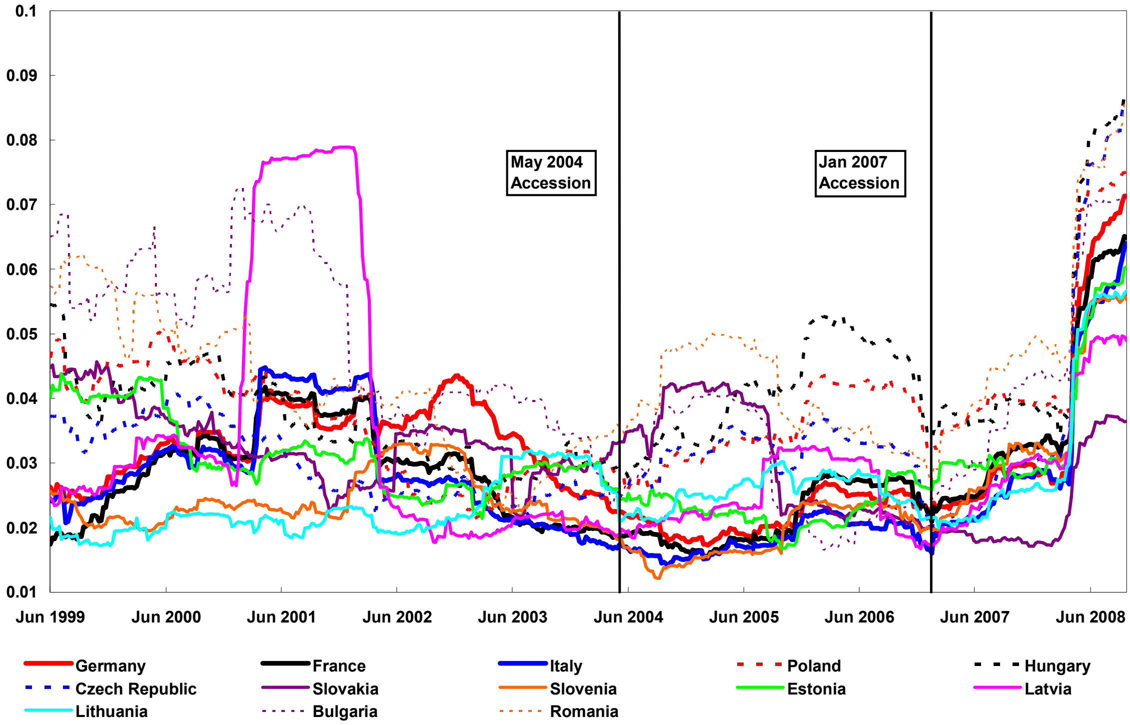
The size of the equity market has implications for the impact that a shock to equity prices has on the real economy. Where equity holdings are small, even a sharp drop in share prices would have a limited impact on the wealth holdings of consumers and the direct borrowing costs of firms. Clearly the NMS are not as sensitive to equity markets as the US or the UK. Nonetheless, markets have now developed to a degree in countries such as Poland that the impact of equity market shocks on the real economy can be significant, for example via the cost of equity capital and the "financial accelerator" (which suggests that corporate net worth is a key determinant of creditworthiness). The depth of equity markets has an important role to play in the simulation studies discussed in chapter 5.

[5] While these series are not strictly comparable across countries, the relative developments over time are comparable, clearly indicating a convergence in equity market depth in Poland, Slovenia and the Czech Republic.

### 3.2.2 Volatility of equity markets

In order to assess the stability of equity markets in the NMS, we look at the unconditional volatility of the weekly change in share prices, adjusted by the exchange rate so that all equity prices are considered in a common currency. This is compared to volatility in the three biggest Euro Area members, Germany, France and Italy, in Figure 3.2.2. Note that conditional volatility is assessed in Section 7.

**Figure 3.2.2 Equity market volatility**




Note: Standard deviation of weekly equity price growth in US$, +/- 6 month
Source: derived from Datastream series. Time period: June 1999-Sept 2008

Equity markets in the countries with fixed exchange rate regimes seem to have been less volatile than in those with flexible exchange rates. Exchange rates in Estonia and Lithuania have been fixed to the euro, DM or US$ since 1992 and 1994 respectively, and equity market volatility in these countries has closely followed that in the large Euro Area countries since 2000. The Slovenian exchange rate has been fixed to the euro since 2004, and although prior to this it officially operating as a managed float, in practice exchange rate movements since 1999 followed what appeared to be a predictable crawling peg. There too, equity market volatility has been closely in line with the larger Euro Area economies. Bulgaria, on the other hand, despite a fixed exchange rate regime since 1997, had more volatile equity markets until 2005-2006, when it become clear that they would join the European Union. The Latvian equity market exhibited high volatility 2000-2002, but has been more closely in line with the large Euro Area countries since then. Volatility in Hungary, Poland and Romania, which all have flexible exchange rate regimes, has remained higher than in the large Euro Area economies. Since the onset of the global financial crisis, volatility in Poland, Hungary, Romania, the Czech Republic and Bulgaria has been somewhat higher than in the three large Euro Area members, while equity markets in Estonia, Lithuania and Slovenia have been more or less in line with the large Euro Area members and Latvia and Slovakia have been less volatile - perhaps reflecting the relatively modest size of equity markets in these economies, and so little scope for contagion.

This brief analysis suggests that pegged exchange rates may bring additional benefits in terms of more stable equity markets, which has implications for the appropriate timing of membership in countries with developed and relatively volatile equity markets such as Poland. Equity market volatility is addressed in more detail through ARCH and GARCH analysis in chapter 7 of this report.

### 3.2.3 Cross-market equity return correlations

Many studies have identified the interdependence of global equity markets (see for example Forbes and Rigobon, 2002), through strong correlation in equity market returns across countries. This suggests a high level of scope for contagion, as equity markets, especially in smaller economies, are at least as dependent on external conditions as they are on domestic conditions. In order to determine the extent to which this holds for the NMS, we first look at the unconditional correlation of real equity returns in each country with a selection of major economies across the world (Australia, Belgium, China, Canada, Denmark, Finland, France, Germany, Greece, India, Italy, Japan, Netherlands, Norway, Austria, Portugal, Russia, Sweden, South Korea, Spain, UK and US). Correlations in equity market returns can help us to identify channels of equity market contagion, and may also point to more general financial market sensitivities, which are relevant even for economies such as Slovakia, where equity markets remain extremely shallow.

Most studies tend to proxy equity market returns as the change in the equity price in domestic currency, deflated by the consumer price index. Table 3.2.1 shows the cross-country correlations of this measure of real equity returns, over the sample period from 5 December 1997 – 27 March 2009. We use weekly data for equity prices, and convert monthly (annual) consumer price inflation to weekly by assuming the weekly inflation rate is constant within the month. For each country, we highlight in red the strongest correlation, and highlight in blue the weakest correlation. Poland, Hungary and the Czech Republic are all closely correlated with each other, while they are not closely correlated with Slovakia. The lack or correlation between the Czech Republic and Slovakia is particularly unexpected. Slovakia exhibits very little correlation with any of the countries in our sample. Slovenia is closely correlated with Austria, while Estonia and Lithuania are closely correlated with each other, with a much weaker correlation with Latvia. Bulgaria shows a relatively strong correlation with Lithuania, while Romania is more closely tied to the Czech Republic. While the cross-market correlations tend to be strongest within the NMS economies, correlations with other EU members are also strong in many cases, notably with Austria, Germany and France. Correlations with equity markets in Asia tend to be relatively weak, suggesting a different pool of investors or different investment motives between the two regions.

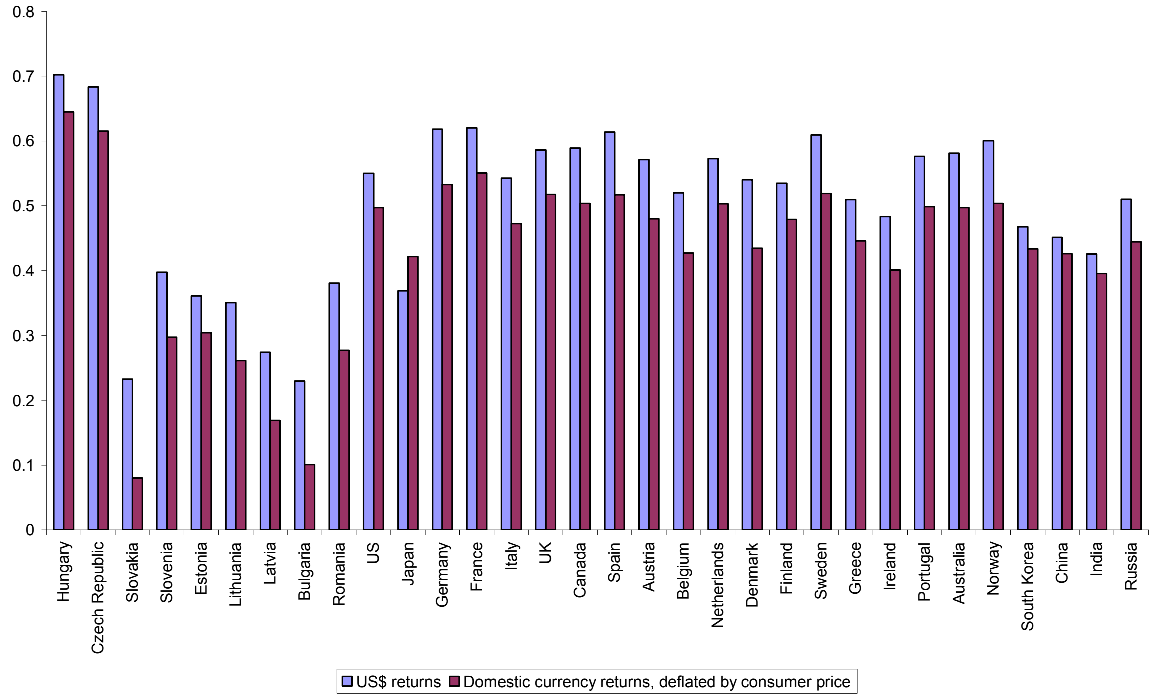
**Table 3.2.1 Real equity market returns in domestic currency, cross-market correlations, weekly data, 5 December 1997-27 March 2009**

| | | Poland | Hungary | Czech Republic | Slovakia | Slovenia | Estonia | Lithuania | Latvia | Bulgaria | Romania |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Other NMS | Poland | | **0.64** | 0.62 | 0.08 | 0.30 | 0.30 | 0.26 | 0.17 | 0.10 | 0.28 |
| | Hungary | **0.64** | | **0.64** | 0.14 | 0.36 | 0.26 | 0.26 | 0.14 | 0.17 | 0.25 |
| | Czech Republic | 0.62 | 0.64 | | 0.10 | 0.37 | 0.31 | 0.34 | 0.20 | 0.23 | **0.39** |
| | Slovakia | **0.08** | **0.14** | **0.10** | | **0.09** | **0.08** | **0.12** | 0.04 | 0.14 | **0.07** |
| | Slovenia | 0.30 | 0.36 | 0.37 | 0.09 | | 0.27 | 0.27 | 0.13 | 0.27 | 0.34 |
| | Estonia | 0.30 | 0.26 | 0.31 | 0.08 | 0.27 | | 0.38 | **0.27** | 0.24 | 0.23 |
| | Lithuania | 0.26 | 0.26 | 0.34 | 0.12 | 0.27 | **0.38** | | 0.24 | **0.29** | 0.27 |
| | Latvia | 0.17 | 0.14 | 0.20 | **0.04** | 0.13 | 0.27 | 0.24 | | 0.19 | 0.21 |
| | Bulgaria | 0.10 | 0.17 | 0.23 | **0.14** | 0.27 | 0.24 | 0.29 | 0.19 | | 0.19 |
| | Romania | 0.28 | 0.25 | 0.39 | 0.07 | 0.34 | 0.23 | 0.27 | 0.21 | 0.19 | |
| G7 | US | 0.50 | 0.50 | 0.53 | 0.07 | 0.32 | 0.23 | 0.28 | 0.16 | 0.13 | 0.24 |
| | Japan | 0.42 | 0.41 | 0.46 | 0.05 | 0.28 | 0.21 | 0.24 | 0.16 | 0.11 | 0.21 |
| | Germany | 0.53 | 0.56 | 0.55 | 0.05 | 0.32 | 0.31 | 0.29 | 0.13 | 0.13 | 0.21 |
| | France | 0.55 | 0.56 | 0.57 | 0.06 | 0.36 | 0.33 | 0.31 | 0.15 | 0.12 | 0.22 |
| | Italy | 0.47 | 0.55 | 0.52 | 0.06 | 0.36 | 0.35 | 0.33 | 0.15 | 0.15 | 0.22 |
| | UK | 0.52 | 0.55 | 0.56 | 0.10 | 0.34 | 0.29 | 0.30 | 0.16 | 0.14 | 0.20 |
| | Canada | 0.50 | 0.48 | 0.55 | 0.09 | 0.35 | 0.25 | 0.26 | 0.17 | 0.09 | 0.21 |
| Other EU | Spain | 0.52 | 0.58 | 0.56 | 0.08 | 0.34 | 0.29 | 0.28 | 0.12 | 0.13 | 0.25 |
| | Austria | 0.48 | 0.53 | 0.61 | 0.09 | **0.45** | 0.29 | **0.39** | 0.21 | 0.26 | 0.38 |
| | Belgium | 0.43 | 0.46 | 0.48 | 0.12 | 0.34 | 0.26 | 0.29 | 0.15 | 0.16 | 0.23 |
| | Netherlands | 0.50 | 0.53 | 0.52 | 0.09 | 0.34 | 0.31 | 0.29 | 0.12 | 0.11 | 0.20 |
| | Denmark | 0.43 | 0.47 | 0.50 | 0.09 | 0.39 | 0.31 | 0.29 | 0.08 | 0.16 | 0.18 |
| | Finland | 0.48 | 0.46 | 0.44 | 0.07 | 0.23 | 0.24 | 0.20 | 0.13 | 0.08 | 0.11 |
| | Sweden | 0.52 | 0.55 | 0.56 | 0.05 | 0.34 | 0.29 | 0.26 | 0.13 | 0.15 | 0.20 |
| | Greece | 0.45 | 0.46 | 0.51 | 0.07 | 0.29 | 0.20 | 0.23 | 0.12 | 0.11 | 0.22 |
| | Ireland | 0.40 | 0.43 | 0.41 | 0.04 | 0.27 | 0.26 | 0.26 | 0.12 | 0.15 | 0.16 |
| | Portugal | 0.50 | 0.50 | 0.50 | 0.05 | 0.38 | 0.33 | 0.30 | 0.13 | 0.19 | 0.25 |
| Other Advanced Economies | Australia | 0.50 | 0.49 | 0.55 | 0.11 | 0.38 | 0.25 | 0.27 | 0.20 | 0.18 | 0.25 |
| | Norway | 0.50 | 0.54 | 0.57 | 0.08 | 0.35 | 0.30 | 0.30 | 0.14 | 0.16 | 0.21 |
| | South Korea | 0.43 | 0.42 | 0.36 | 0.10 | 0.21 | 0.21 | 0.18 | **0.02** | **0.05** | 0.14 |
| Emerging Markets | China | 0.43 | 0.34 | 0.36 | 0.08 | 0.19 | 0.17 | 0.12 | 0.13 | 0.13 | 0.24 |
| | India | 0.40 | 0.36 | 0.41 | 0.09 | 0.23 | 0.27 | 0.22 | 0.12 | 0.20 | 0.20 |
| | Russia | 0.44 | 0.50 | 0.44 | 0.07 | 0.23 | 0.30 | 0.14 | 0.15 | 0.11 | 0.19 |

Note: Figures highlighted in red show strongest correlations and those in blue show weakest correlations.
Source: Derived from Datastream series

While the majority of previous studies have looked at equity market returns in domestic currency, there is a strong argument for comparing equity market returns in a common currency. Cross-market correlation in equity markets largely reflects the behaviour of international investors, who are looking for a high rate of return in their home currency. If they anticipate a downturn or depreciation in one country, they will withdraw their investments from that country and place them in a location where they anticipate a higher rate of return. In table 3.2.2, we look at the cross market nominal equity return correlations in US dollars. What initially stands out in this table is that virtually all cross-market correlations are stronger in US$ than they are in domestic currency, suggesting a key role for international investors. Figure 3.2.3 illustrates this rise in correlations for the case of Poland. This offers evidence of exchange rate arbitrage and highlights the international approach of investors. The domestic currency series omit this important role for exchange rate arbitrage in smoothing the rates of return across markets, and for the remainder of this section we will focus on returns in US$.

**Figure 3.2.3 Cross market equity return correlations for Poland**




Source: Tables 3.2.1 and 3.2.2

The rise in cross-market correlations is particularly marked in Slovakia, and is also very strong in Bulgaria and Slovenia. Correlations with equity market returns in Japan decline in most of the NMS when calculated in US$ compared to correlations in domestic currency. This suggests that investors do not view Japan and the NMS as interchangeable investment locations, distinguished predominantly by exchange rate arbitrage opportunities. Overall, the three largest economies seem to be most integrated into global markets, as equity markets in Poland, Hungary and the Czech Republic are more closely correlated with external markets. This suggests a higher degree of exposure to equity market contagion. Slovakia, Latvia and Bulgaria, on the other hand, show little correlation in equity market returns with the other economies in this sample. This may reflect the relatively undeveloped state of equity markets in these economies.

**Table 3.2.2 Nominal equity market returns in US$, cross-market correlations, weekly data, 5 December 1997-27 March 2009**

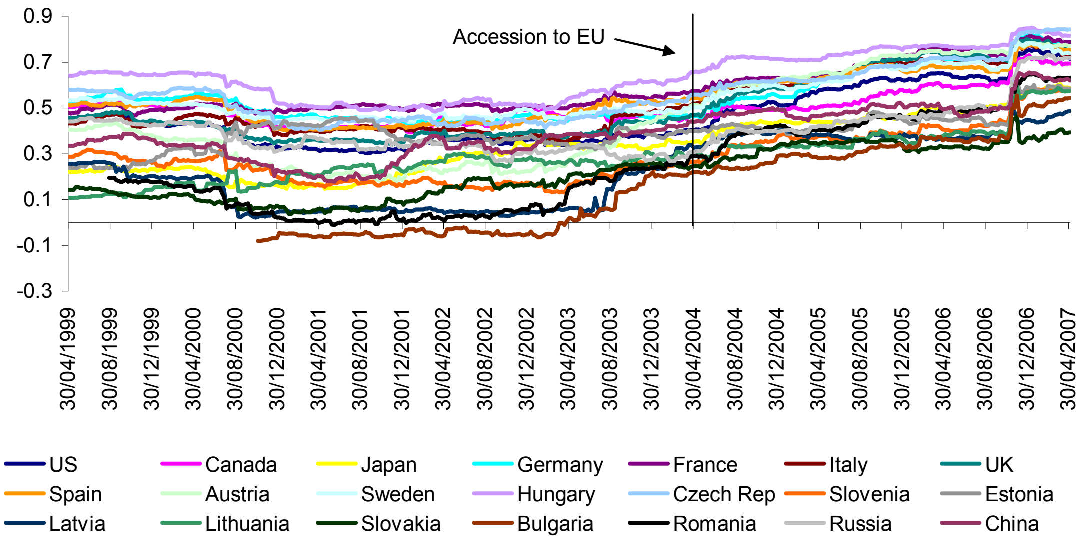
| | | Poland | Hungary | Czech Republic | Slovakia | Slovenia | Estonia | Lithuania | Latvia | Bulgaria | Romania |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Other NMS | Poland | | **0.70** | **0.68** | 0.23 | 0.40 | 0.36 | 0.35 | 0.27 | 0.23 | 0.38 |
| | Hungary | **0.70** | | 0.68 | 0.29 | 0.43 | 0.33 | 0.34 | 0.25 | 0.29 | 0.35 |
| | Czech Republic | 0.68 | 0.68 | | 0.26 | 0.46 | 0.36 | 0.39 | 0.30 | 0.34 | 0.45 |
| | Slovakia | 0.23 | 0.29 | **0.26** | | 0.29 | 0.24 | 0.26 | 0.17 | 0.31 | 0.20 |
| | Slovenia | 0.40 | 0.43 | 0.46 | 0.29 | | 0.38 | 0.35 | 0.24 | **0.42** | 0.40 |
| | Estonia | 0.36 | 0.33 | 0.36 | 0.24 | 0.38 | | 0.43 | **0.34** | 0.37 | 0.28 |
| | Lithuania | 0.35 | 0.34 | 0.39 | 0.26 | 0.35 | **0.43** | | 0.30 | 0.37 | 0.35 |
| | Latvia | 0.27 | **0.25** | 0.30 | 0.17 | **0.24** | 0.34 | 0.30 | | 0.28 | 0.26 |
| | Bulgaria | **0.23** | 0.29 | 0.34 | **0.31** | 0.42 | 0.37 | 0.37 | 0.28 | | 0.29 |
| | Romania | 0.38 | 0.35 | 0.45 | 0.20 | 0.40 | 0.28 | 0.35 | 0.26 | 0.29 | |
| G7 | US | 0.55 | 0.53 | 0.51 | **0.14** | 0.31 | 0.24 | 0.32 | 0.19 | 0.16 | 0.29 |
| | Japan | 0.37 | 0.37 | 0.37 | 0.14 | 0.26 | 0.24 | 0.22 | 0.20 | **0.11** | **0.16** |
| | Germany | 0.62 | 0.62 | 0.60 | 0.21 | 0.40 | 0.36 | 0.36 | 0.21 | 0.26 | 0.30 |
| | France | 0.62 | 0.62 | 0.62 | 0.23 | 0.46 | 0.39 | 0.39 | 0.23 | 0.27 | 0.32 |
| | Italy | 0.54 | 0.60 | 0.56 | 0.22 | 0.44 | 0.40 | 0.40 | 0.23 | 0.29 | 0.32 |
| | UK | 0.59 | 0.59 | 0.60 | 0.23 | 0.43 | 0.35 | 0.39 | 0.23 | 0.25 | 0.30 |
| | Canada | 0.59 | 0.56 | 0.59 | 0.21 | 0.43 | 0.32 | 0.37 | 0.25 | 0.19 | 0.29 |
| Other EU | Spain | 0.61 | 0.64 | 0.62 | 0.26 | 0.44 | 0.36 | 0.37 | 0.22 | 0.28 | 0.35 |
| | Austria | 0.57 | 0.60 | 0.66 | 0.30 | **0.56** | 0.38 | **0.48** | 0.31 | 0.40 | **0.46** |
| | Belgium | 0.52 | 0.54 | 0.55 | 0.29 | 0.45 | 0.33 | 0.36 | 0.23 | 0.31 | 0.33 |
| | Netherlands | 0.57 | 0.58 | 0.56 | 0.21 | 0.40 | 0.34 | 0.35 | 0.19 | 0.23 | 0.28 |
| | Denmark | 0.54 | 0.55 | 0.55 | 0.28 | 0.50 | 0.40 | 0.40 | 0.19 | 0.30 | 0.29 |
| | Finland | 0.53 | 0.49 | 0.48 | 0.16 | 0.29 | 0.27 | 0.26 | 0.18 | 0.17 | 0.20 |
| | Sweden | 0.61 | 0.61 | 0.60 | 0.22 | 0.45 | 0.37 | 0.37 | 0.23 | 0.26 | 0.28 |
| | Greece | 0.51 | 0.50 | 0.56 | 0.18 | 0.37 | 0.24 | 0.29 | 0.17 | 0.21 | 0.28 |
| | Ireland | 0.48 | 0.50 | 0.47 | 0.18 | 0.36 | 0.31 | 0.34 | 0.19 | 0.27 | 0.25 |
| | Portugal | 0.58 | 0.56 | 0.57 | 0.27 | 0.49 | 0.40 | 0.39 | 0.23 | 0.36 | 0.35 |
| Other Advanced Economies | Australia | 0.58 | 0.57 | 0.60 | 0.26 | 0.49 | 0.37 | 0.37 | 0.30 | 0.33 | 0.38 |
| | Norway | 0.60 | 0.61 | 0.63 | 0.23 | 0.47 | 0.35 | 0.37 | 0.25 | 0.25 | 0.28 |
| | South Korea | 0.47 | 0.41 | 0.40 | 0.18 | 0.25 | 0.24 | 0.22 | **0.11** | 0.15 | 0.20 |
| Emerging Markets | China | 0.45 | 0.38 | 0.40 | 0.16 | 0.24 | **0.21** | **0.18** | 0.18 | 0.16 | 0.28 |
| | India | 0.43 | 0.39 | 0.44 | 0.17 | 0.29 | 0.32 | 0.29 | 0.16 | 0.24 | 0.25 |
| | Russia | 0.51 | 0.55 | 0.49 | 0.14 | 0.25 | 0.34 | 0.26 | 0.22 | 0.15 | 0.25 |

Note: Figures highlighted in red show strongest correlations and those in blue show weakest correlations.
Source: Derived from Datastream series

While cross-market correlations between Slovakia, Latvia and Bulgaria are weak over the sample period, this may reflect outlying observations in the earlier years of our sample. In order to assess the stability of correlations coefficients over time, we plot the rolling correlations over time, using a 200 week rolling window in figures 3.2.4a-4j.

There is a clear strengthening of global correlations over time, as financial markets have become deeper and more closely intertwined in the international financial system. There also appears to be some evidence of increased international integration associated with EU membership. The dates on the x-axis indicate the centrepoint of the 200 week moving window, and in each figure we indicate the point of accession to the European Union[6]. There is a tendency for correlations with all countries to rise in the period leading up to and after accession, although this is less clear in the cases of Estonia and Slovakia. There is a sharp rise in equity market correlations in October 2008, related to the global financial crisis. In our centred dataset, this enters the rolling figures starting in November 2006. This rise is particularly marked in Slovenia, Lithuania, Romania and Bulgaria, although for the latter two this may also reflect the timing of EU membership. This is consistent with the definition of contagion adopted, for example by Forbes and Rigobon (1999), Pericoli and Sbracia (2001) and Corsetti *et al* (2002), as an increase in cross-market correlations during periods of turmoil.

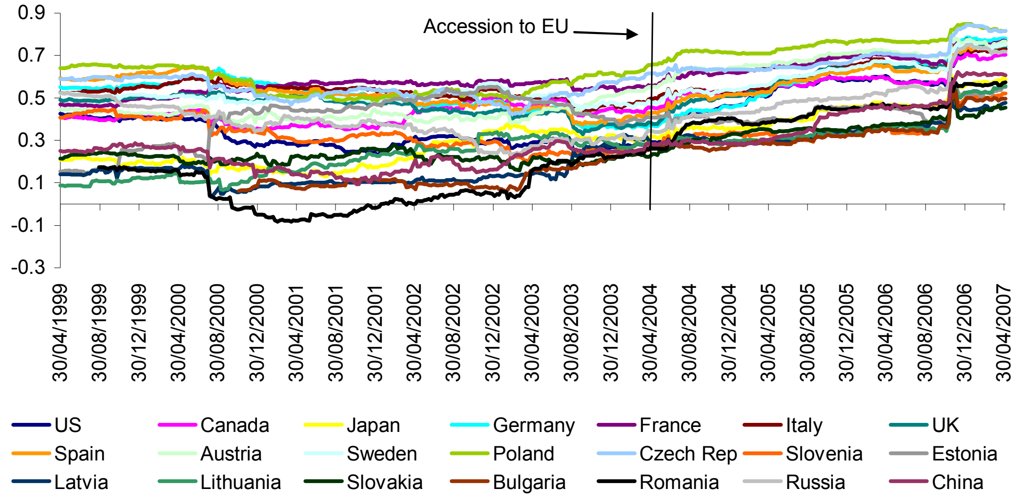
**Figure 3.2.4a Poland: Equity market rolling correlations**




Source: Derived from Datastream series

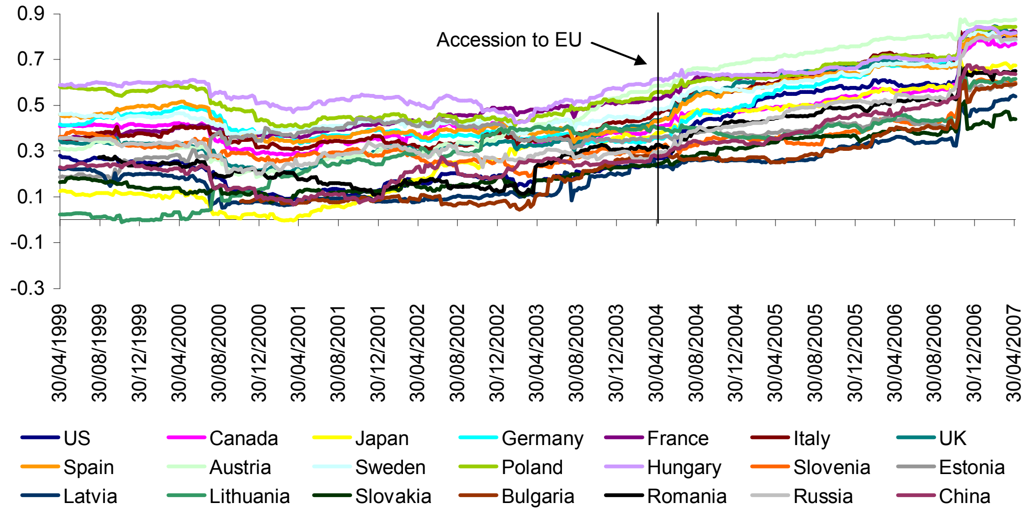
[6] As such, for the 100 periods, or approximately two years, prior to this point, a fraction of the correlation relates to post-accession.

## Figure 3.2.4b Hungary: Equity market rolling correlations



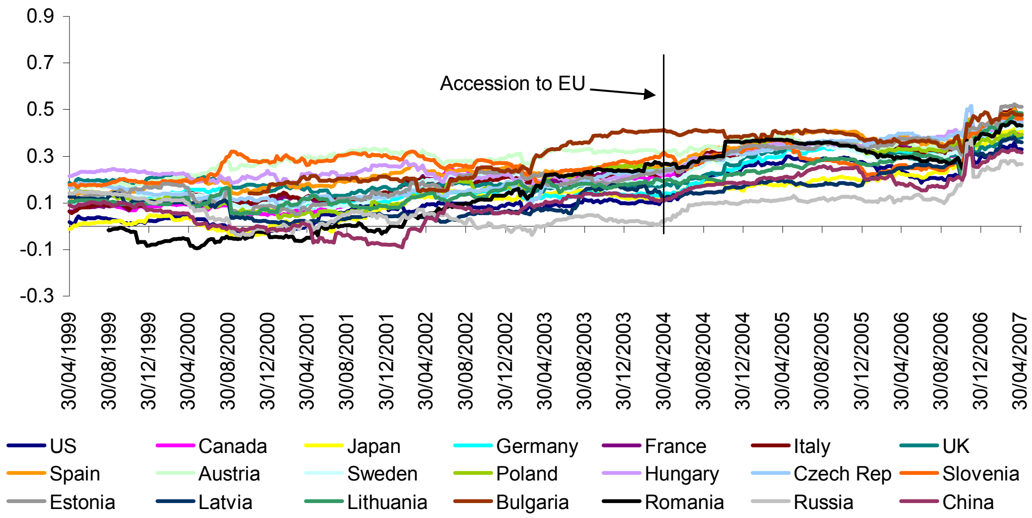

Source: Derived from Datastream series

## Figure 3.2.4c Czech Republic: Equity market rolling correlations



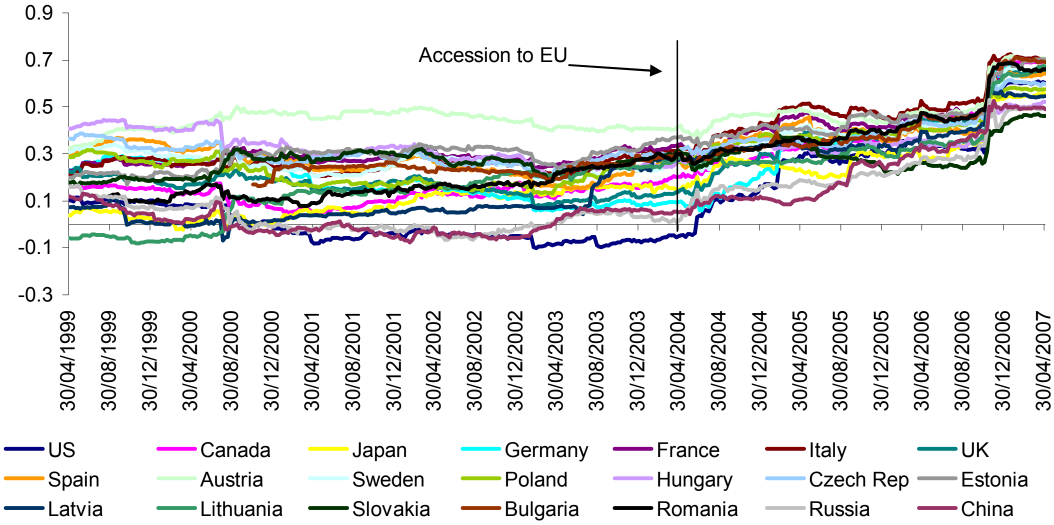

Source: Derived from Datastream series

## Figure 3.2.4d Slovakia: Equity market rolling correlations



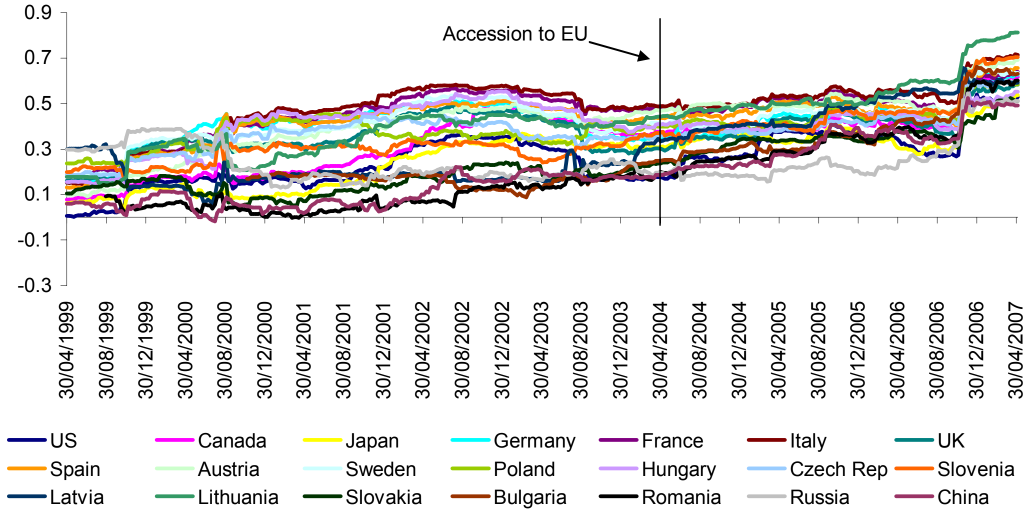

Source: Derived from Datastream series

**Figure 3.2.4e Slovenia: Equity market rolling correlations**



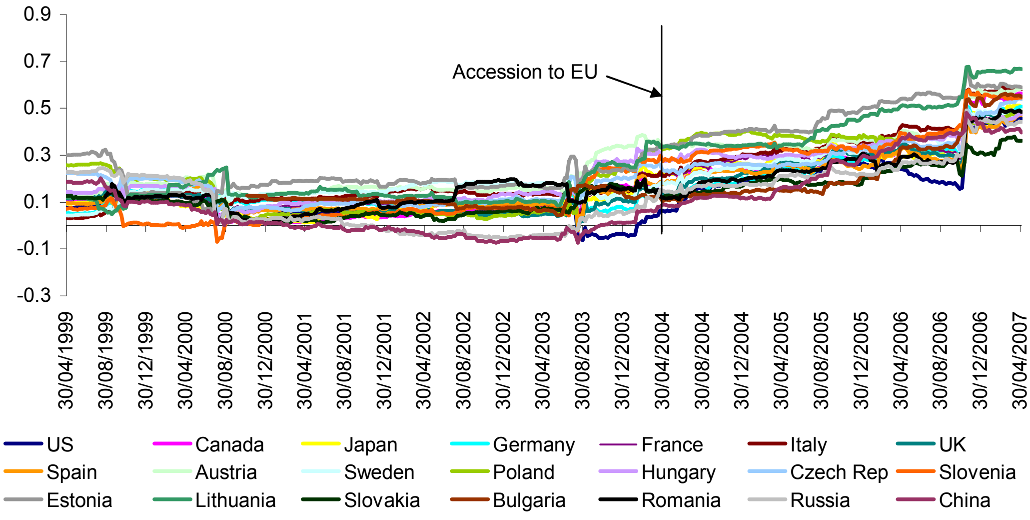

Source: Derived from Datastream series

**Figure 3.2.4f Estonia: Equity market rolling correlations**



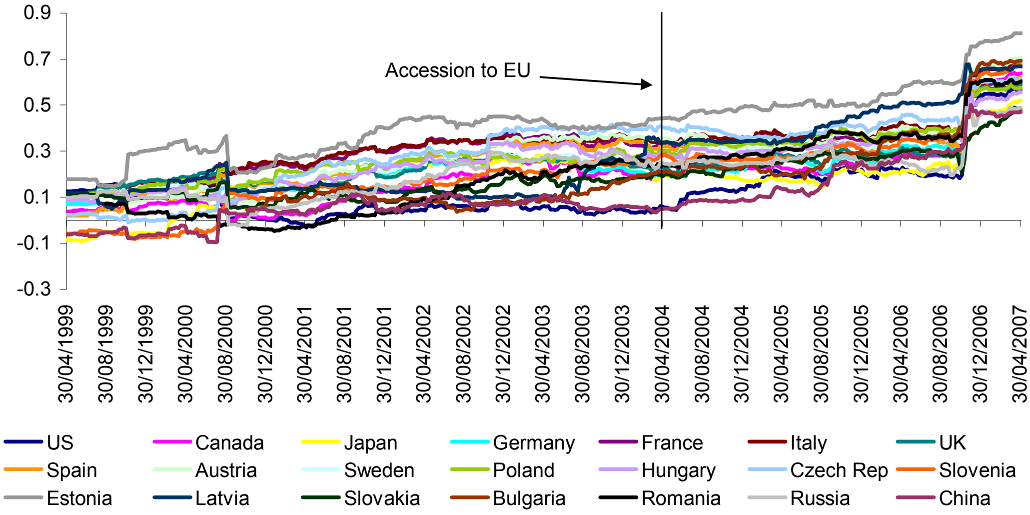

Source: Derived from Datastream series

**Figure 3.2.4g Latvia: Equity market rolling correlations**



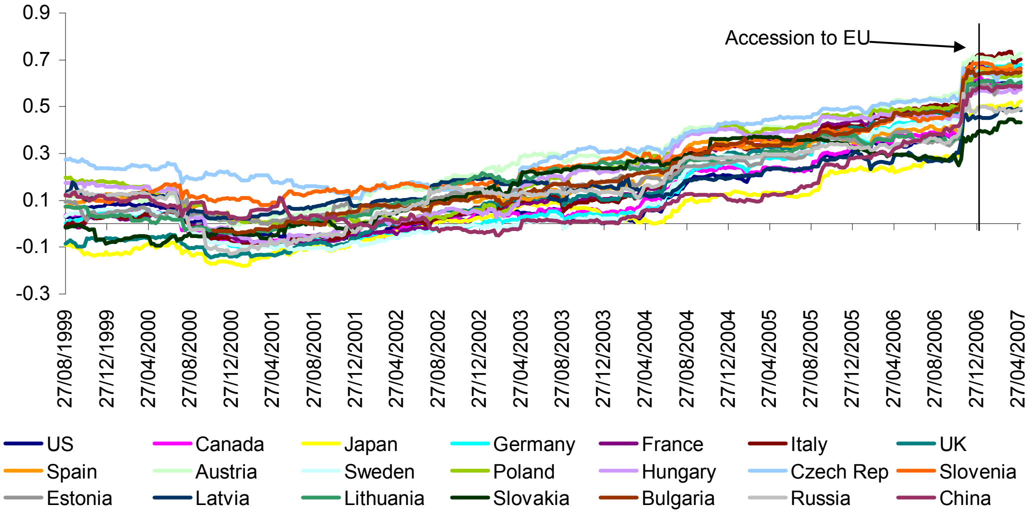

Source: Derived from Datastream series

**Figure 3.2.4h Lithuania: Equity market rolling correlations**



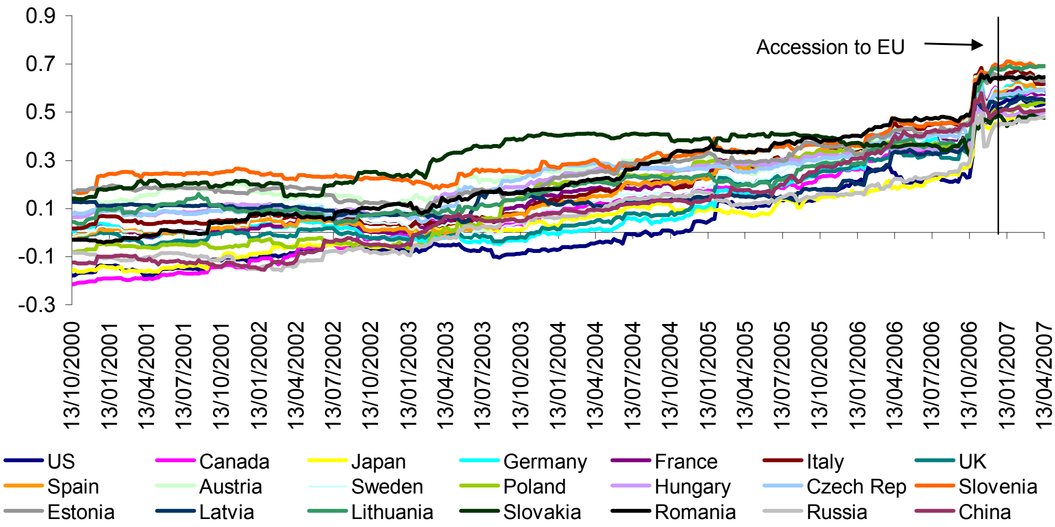

Source: Derived from Datastream series

**Figure 3.2.4i Romania: Equity market rolling correlations**




Source: Derived from Datastream series

**Figure 3.2.4j Bulgaria: Equity market rolling correlations**



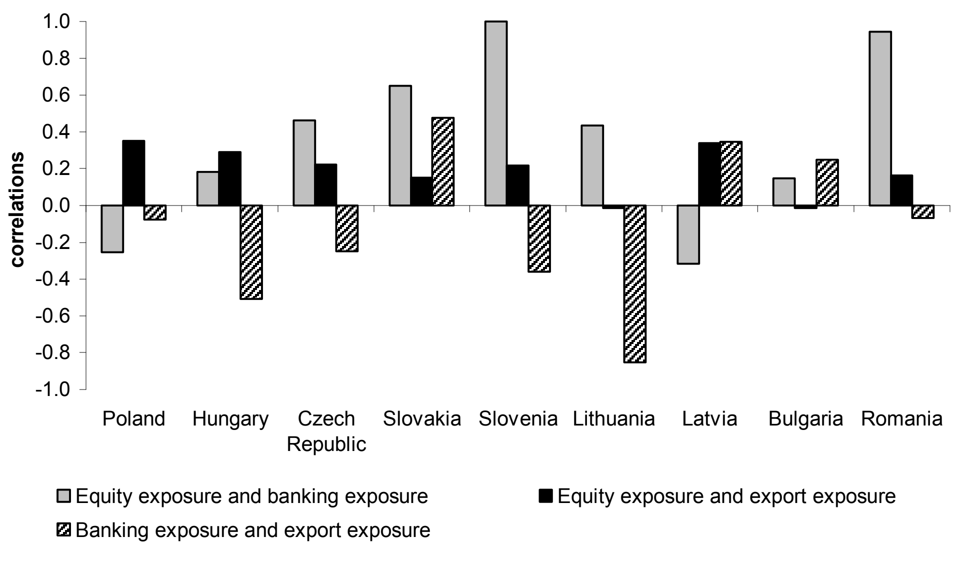

Source: Derived from Datastream series

The rise in correlations over time suggests that using the full sample period in order to assess sensitivity to shocks that originate abroad may be misleading. This is particularly important for the VAR analysis we conduct below. While stronger correlation does not necessarily affect parameter estimates in VAR estimation, it will affect the significance level of these parameters. The sample period will matter particularly for Romania, Bulgaria, Latvia, Lithuania and Slovenia, where equity markets exhibited negative correlations with several markets in the earlier period of our sample, necessarily pointing to a change in parameter estimate as well as significance level. A sample period that starts in 2003 avoids most of the negative correlations observed in the figures.

### 3.2.4 Equity exposure, export exposure and banking exposure

Cross-market linkages in equity markets are largely driven by investor perceptions, and it may be interesting to determine if these perceptions are closely related to economic linkages, such as the trade linkages discussed in chapter 2 and the banking sector linkages discussed in chapter 3.1. In figure 3.2.5 we plot the correlations between equity exposure, banking exposure and export exposure[7]. We capture equity exposure with the cross-market equity return correlations discussed above, using the sample period from 2003-2009. Banking exposure is captured by the country breakdown of the foreign ownership of banks from Table 3.1.2, and export exposure is given by the share of exports from the NMS directed towards each trading partner, derived from the data illustrated in Figures 3.4.10 and 11. With the exceptions of Poland, Hungary and Latvia, equity exposure is generally more closely tied to banking exposure than it is to export exposure. In Slovenia and Romania, in particular, equity exposure and banking exposure appear very closely linked. It is also interesting to note that banking exposure is not generally very closely linked to trade exposure, except in Slovakia and to a lesser extent Latvia.

**Figure 3.2.5 Correlations between equity, banking and export exposure**




Derived from tables 3.1.2 and 3.2.2 and figures 3.4.10 and 3.4.11

[7] Estonia is omitted from this figure as Table 3.1.2 indicates that foreign ownership of the banking sector is dominated by a single country.

### 3.2.5 VAR analysis

In order to gain a better understanding of the dynamics of equity market linkages, we use a Vector Auto-regression (VAR) model to analyse the interactions between equity market returns. This allows us to incorporate lagged values of the variables and to move away from contemporaneous correlations. We run an unrestricted VAR analysis of order 4[8], following the approach used by Jokipii and Lucey (2005) to capture cross-market equity return correlations. In order to make the model more tractable, we limit the analysis to seven endogenous variables: the three largest NMS, which are clearly more closely tied to external markets, and the US, Germany, the UK and Austria, which appear to be among the most relevant external markets[9]. We include year dummies as exogenous variables to capture common global shocks to equity markets. We omit the full details of parameter estimates, but report the key estimation statistics in table 3.2.3 below.

**Table 3.2.3 VAR estimation of equity returns – key statistics**

Sample: 12/27/2002 3/27/2009
Included observations: 327

| | US | Germany | UK | Austria | Poland | Czech Republic | Hungary |
|---|---|---|---|---|---|---|---|
| R-squared | 0.28 | 0.25 | 0.30 | 0.31 | 0.19 | 0.24 | 0.23 |
| Adj. R-squared | 0.20 | 0.17 | 0.22 | 0.23 | 0.10 | 0.15 | 0.14 |
| Sum sq. resids | 0.19 | 0.34 | 0.25 | 0.34 | 0.53 | 0.49 | 0.62 |
| S.E. equation | 0.025 | 0.034 | 0.029 | 0.034 | 0.042 | 0.041 | 0.046 |
| F-statistic | 3.42 | 3.01 | 3.84 | 3.96 | 2.14 | 2.80 | 2.64 |
| Log likelihood | 757.51 | 657.10 | 709.92 | 656.68 | 587.87 | 600.54 | 559.55 |
| Akaike AIC | -4.43 | -3.81 | -4.13 | -3.81 | -3.39 | -3.47 | -3.21 |
| Schwarz SC | -4.03 | -3.42 | -3.74 | -3.41 | -2.99 | -3.07 | -2.82 |
| Mean dependent | 0.000018 | 0.001760 | -0.000184 | 0.001643 | 0.002020 | 0.002913 | 0.001115 |
| S.D. dependent | 0.0281 | 0.0376 | 0.0331 | 0.0391 | 0.0447 | 0.0443 | 0.0499 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 2.27E-24 |
| Determinant resid covariance | 1.05E-24 |
| Log likelihood | 5779.369 |
| Akaike information criterion | -33.89217 |
| Schwarz criterion | -31.13373 |

The variance decomposition of this estimation is reported in table 3.2.4. Variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. This provides information about the relative importance of each random innovation in affecting the variables in the VAR, or the importance of equity market shocks in one country to equity market returns in another. Table 3.2.4 reports the percentage of the forecast variance due to innovation in each country in our sample after 10 periods. The Cholesky ordering was determined by the size of the country. There is clearly a high level of correlation among equity markets, and a change in the ordering will alter the results, as the first period decomposition for the first variable in the VAR ordering is completely due to its own innovation. Therefore, the relationship to US equity markets should be viewed as the relationship to 'global' equity markets, which factors out shocks that are common to the other economies in

8 Two of the lag-length criteria tests point to 4 lags, one of the criteria points to 8 lags and two of the criteria points to 0 lags (ie no relationship).

9 If the Commission wishes to expand this study to include additional countries or a different subset of countries, the relevant Eview files would be made available.

our sample[10]. This indicates that 40-50 per cent of the error variance in forecasting 10 week ahead equity returns in the three large NMS is due to innovations to global returns. Innovations in German returns are responsible for about 5 per cent of the error variance in forecasting Czech and Hungarian returns, and close to 8 per cent in Poland. Austrian innovations are slightly more important than German ones in the Czech Republic and Hungary, while they are slightly less important in Poland. Of the NMS, Poland appears to dominate, accounting for 6 and 10 per cent of error variance in forecasting Czech and Hungarian returns, respectively.

**Table 3.2.4 Variance decomposition and equity market spillovers[11]**

| | | From | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | US | Germany | UK | Austria | Poland | Czech Republic | Hungary | Contribution from others |
| To | US | 79.4 | 1.1 | 3.0 | 3.6 | 4.2 | 7.3 | 1.4 | 20.6 |
| | Germany | 65.1 | 18.1 | 4.8 | 2.8 | 4.0 | 4.1 | 1.0 | 81.9 |
| | UK | 58.8 | 5.7 | 21.6 | 3.3 | 5.3 | 4.3 | 1.1 | 78.4 |
| | Austria | 42.8 | 6.4 | 13.4 | 26.4 | 4.8 | 5.0 | 1.2 | 73.6 |
| | Poland | 39.1 | 7.5 | 6.8 | 5.4 | 37.5 | 2.5 | 1.2 | 62.5 |
| | Czech Republic | 40.2 | 4.5 | 9.9 | 14.1 | 6.3 | 24.1 | 1.0 | 75.9 |
| | Hungary | 34.2 | 5.6 | 6.2 | 7.9 | 10.7 | 5.5 | 30.0 | 70.0 |
| Contribution to others | | 280.3 | 30.8 | 44.0 | 37.2 | 35.2 | 28.6 | 6.9 | 463.0 |
| Total contribution | | 359.7 | 48.9 | 65.6 | 63.6 | 72.7 | 52.7 | 36.9 | Spillover index - 66.1% |

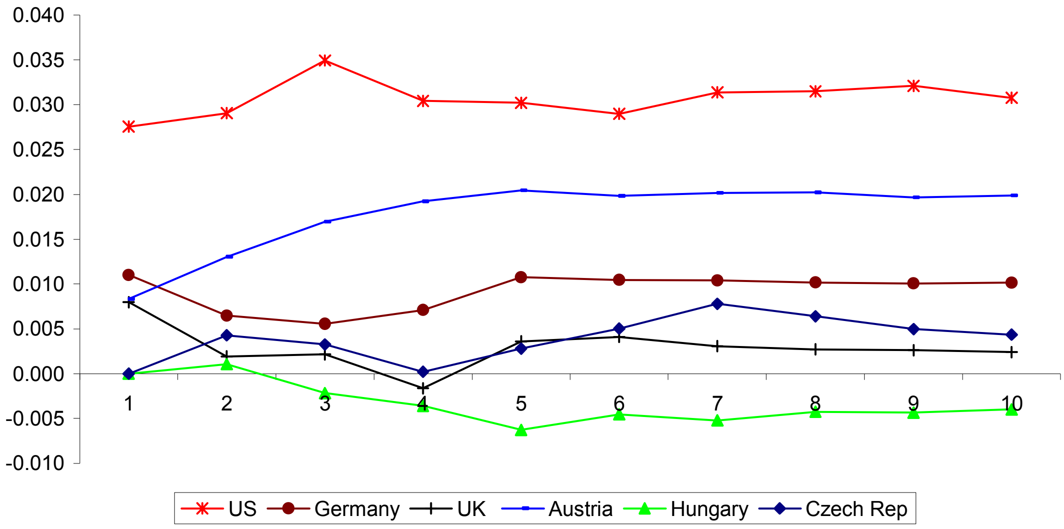
Following the approach developed by Diebold and Yilmaz (2007), we calculate a spillovers index for our sample, which is reported at the bottom of table 3.2.4. This gives the share of variation in real equity market returns that can be explained by innovations in other countries in our sample after 10 weeks. This is a simple and intuitive measure of interdependence of equity returns in the full sample of countries. In table 3.2.5 below, we will calibrate country-specific interdependencies, using an alternative approach. To calculate the spillover index in table 3.2.4, we add the shares of forecast variance in each market of our sample coming from shocks to other markets in our sample (final column in the table). This is summed across all countries, and divided by the total contribution including own market shocks (bottom row in the table) to calculate the aggregate spillovers index. The spillover index is estimated at 66 per cent. This is significantly higher than that calculated by Diebold and Yilmaz (2007), reflecting much stronger correlation in the markets we study, compared to the primarily American and Asian economies covered by Diebold and Yilmaz, and also the stronger correlations associated with returns calculated in a common currency. There is clearly significant scope for equity market contagion within our sample set of countries.

We next obtain the cumulative impulse response functions for a one standard deviation[12] shock originating in each of the countries in our sample. We plot the responses of Poland, Hungary and the Czech Republic in figures 3.2.6a-6c. Own

[10] Further experimentation with ordering, including Pesaran and Shin style generalised ordering, could be undertaken, although this imposes a restrictive assumption of a triangular covariance matrix on the residuals.
[11] The “spillover index” reported in this table merely illustrates the strong cross-market equity correlations in the selected group of countries, and does not identify spillovers from one country to another.
[12] These are Cholesky degrees of freedom adjusted one standard deviation innovations.

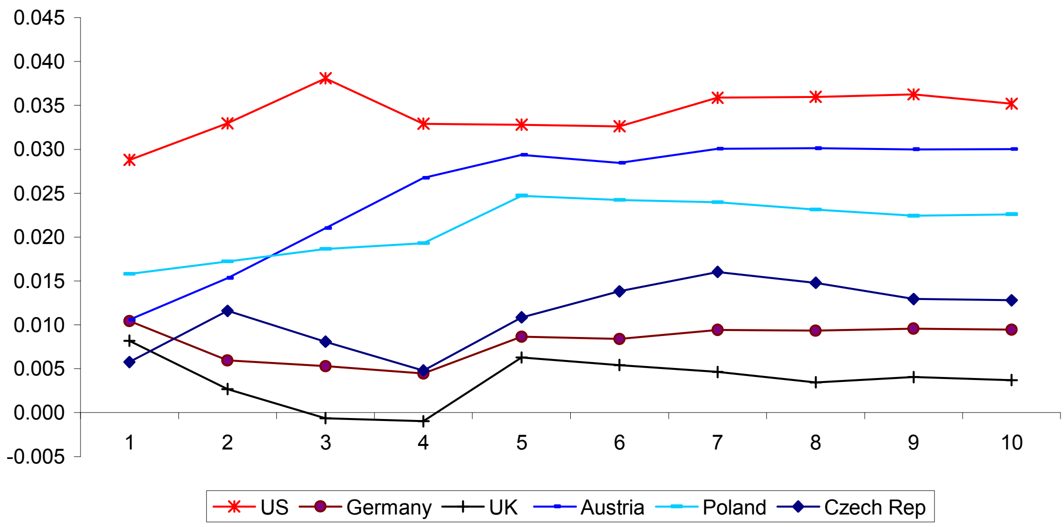
country responses are omitted, in order to concentrate on external linkages. We then run a series of 8 endogenous variable VAR analyses, adding each of the other seven NMS to the sample in turn. This allows us to extract the impulse response functions for all 10 NMS, without increasing the number of endogenous variables beyond a tractable level. These impulse response functions are illustrated in figures 3.2.6d-6j. We exclude error bands from the figures for clarity. As an annex to this section we show the same charts with error bands included.

**Figure 3.2.6a Cumulative impulse response functions: Poland**



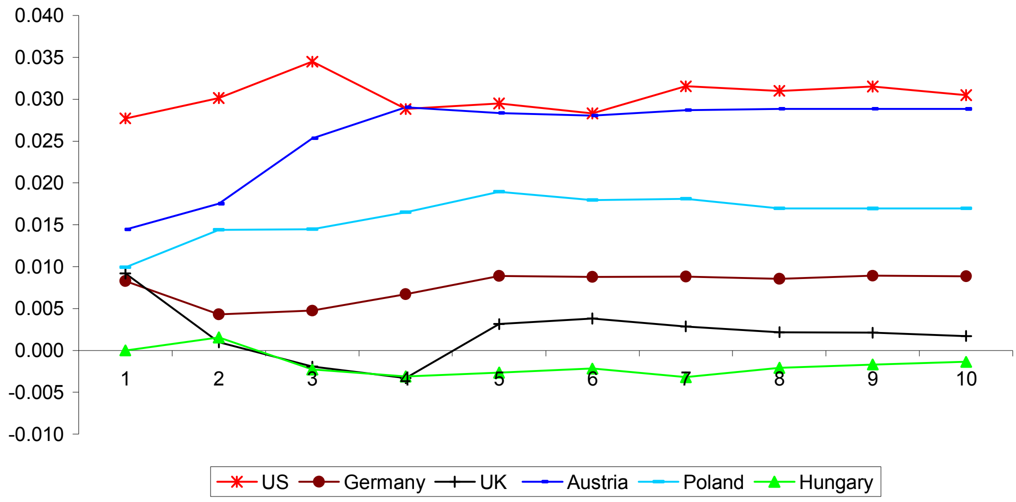

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6b Cumulative impulse response functions: Hungary**



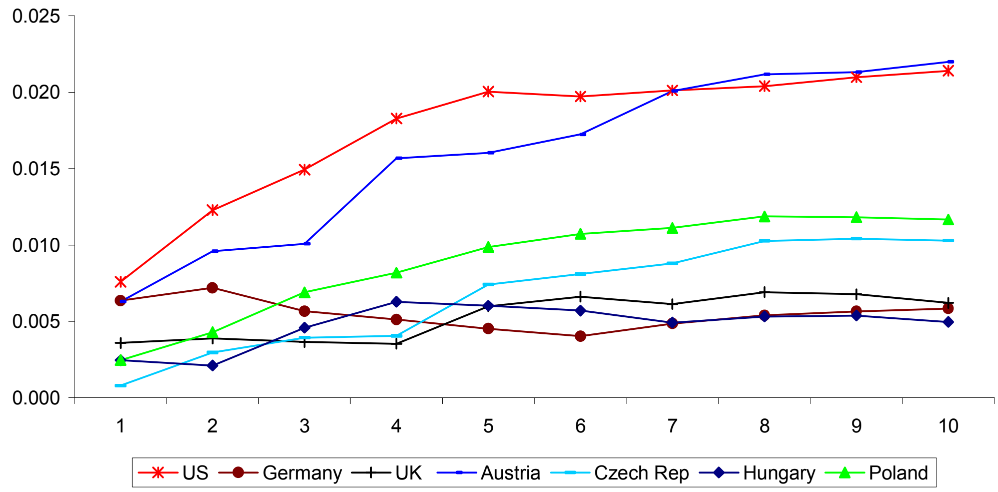

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6c Cumulative impulse response functions: Czech Republic**



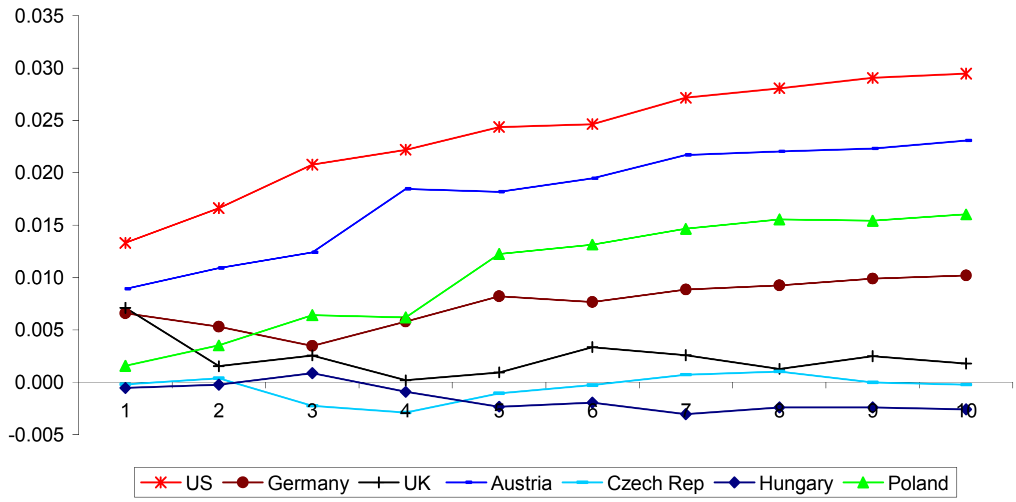

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6d Cumulative impulse response functions: Slovakia**



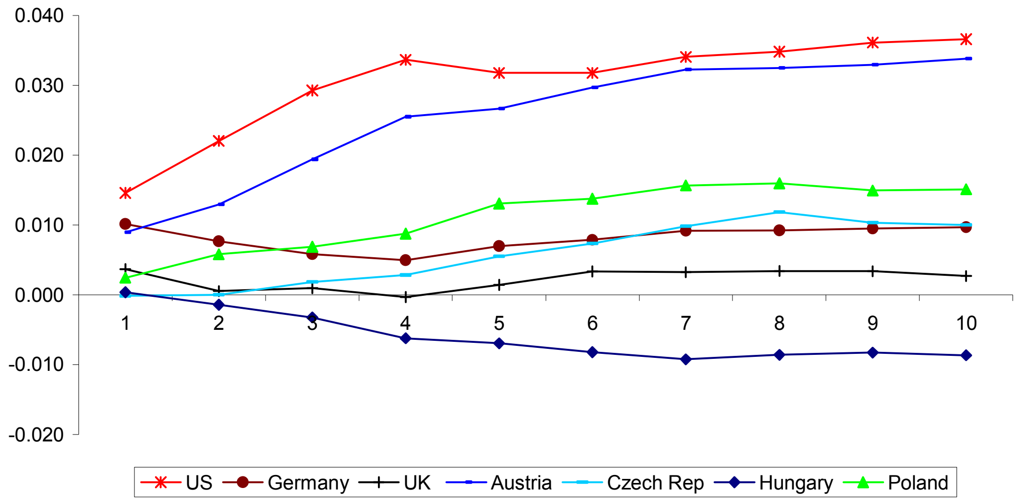

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6e Cumulative impulse response functions: Slovenia**



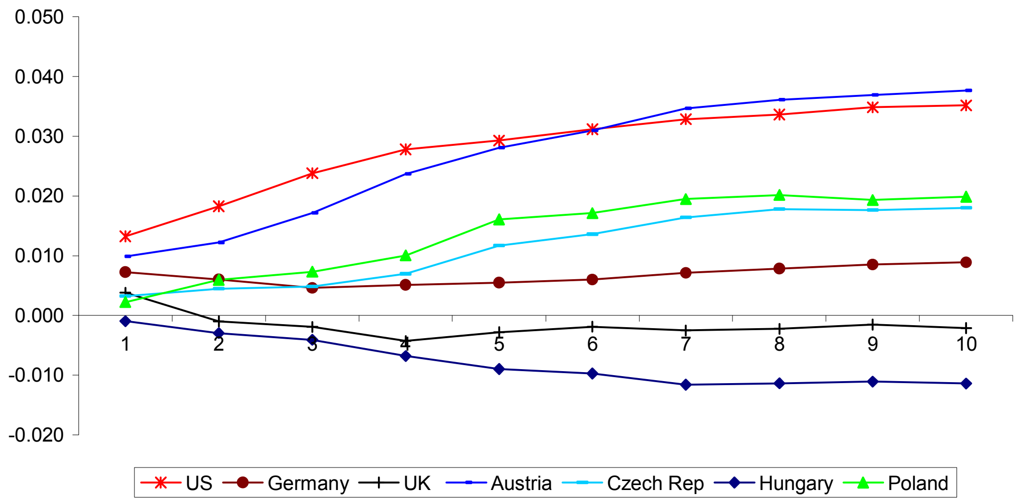

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6f Cumulative impulse response functions: Estonia**



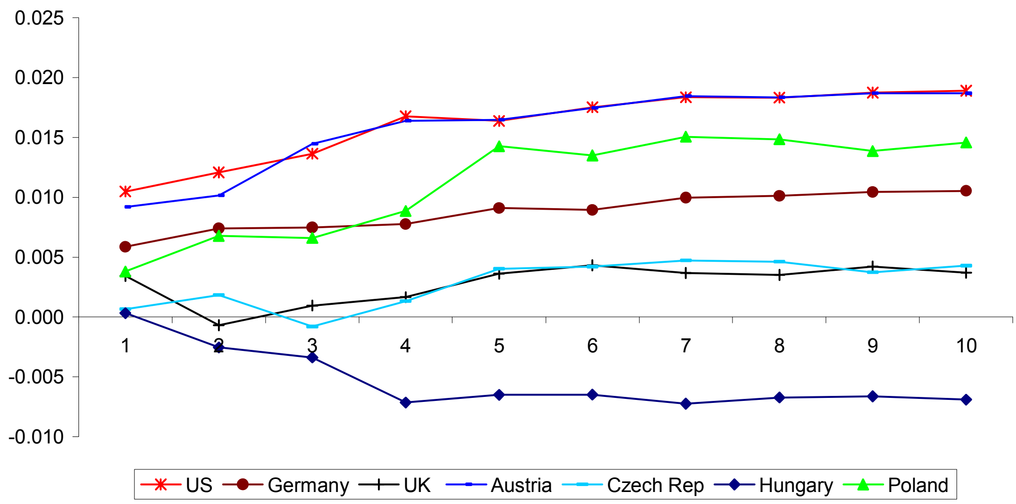

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6g Cumulative impulse response functions: Lithuania**



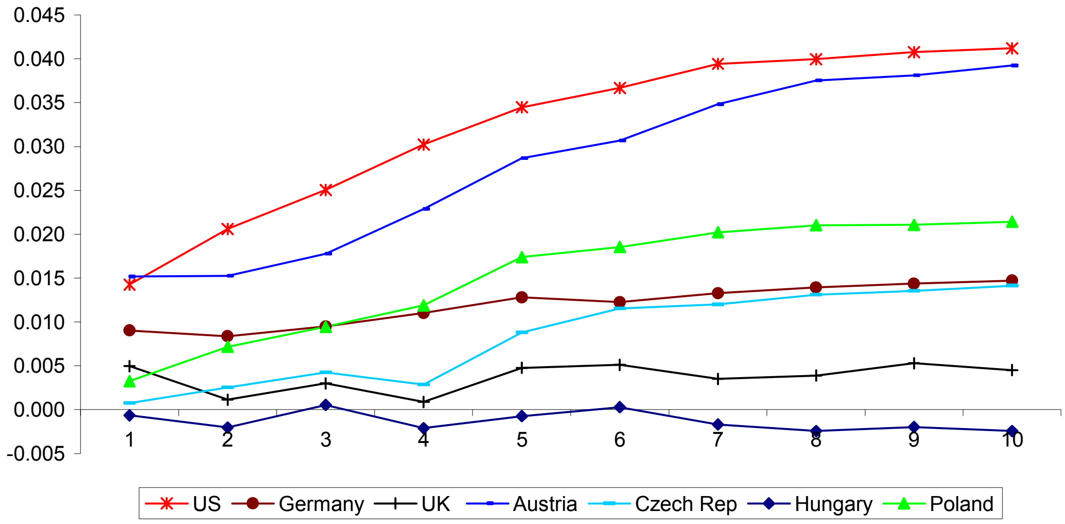

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6h Cumulative impulse response functions: Latvia**



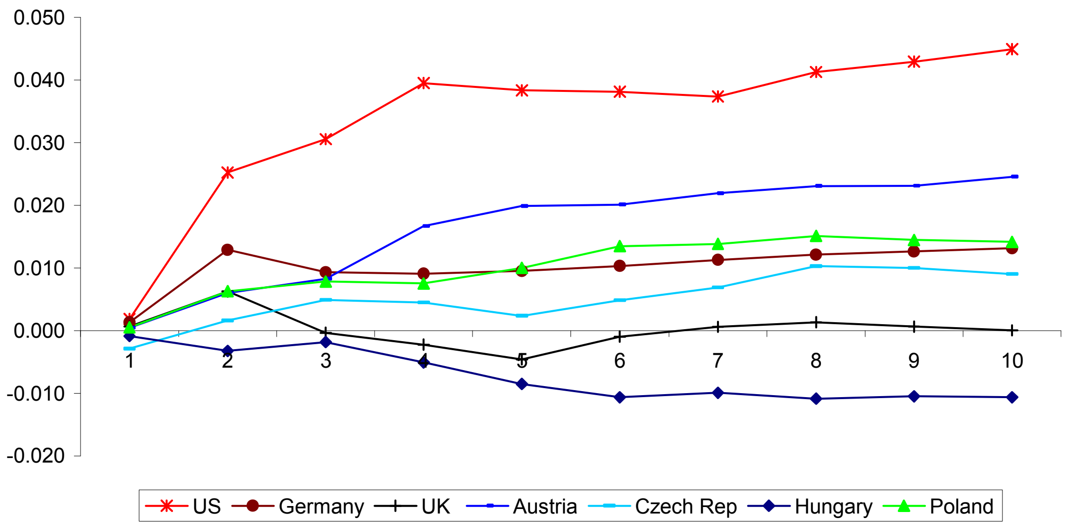

Note: Response to a 1 SD innovation in each country

**Figure 3.2.6i Cumulative impulse response functions: Bulgaria**




Note: Response to a 1 SD innovation in each country

**Figure 3.2.6j Cumulative impulse response functions: Romania**




Note: Response to a 1 SD innovation in each country

The response to a global equity market shock is stronger in Poland, Hungary and the Czech Republic than in the other NMS. Austria seems to have a bigger impact on the NMS equity markets than either Germany or the UK. This may reflect the high level of Austrian banking exposure to the region, as discussed in section 3.1, if Austrian-owned banks are listed in the NMS equity markets. Looking at within region shocks, responses to shocks originating in Poland seem to have a bigger impact than those originating in the Czech Republic, while Hungarian shocks have little spillover effect to the other NMS economies, except in the case of Slovakia. In Romania, impulses are lagged, which may distort the unconditional correlations discussed above.

We use the results of the impulse response analysis illustrated in figures 3.2.6a-j to calibrate the degree of cross-market linkages in equity market shocks. These results can be used to parameterise equity market shocks for simulation studies, such as those reported in chapter 5. The calibrated parameters are reported in table 3.2.5. The figures are derived from the ratio of the impact of a shock to country i on country j after 10 periods, to the impact in country i itself in the same period. For example, a 1 per cent shock to US equity prices would be associated with a 1.45 per cent shock to Polish equity prices and a 50 per cent shock to Latvian equity prices. A parameter of more than one can be associated with more volatile equity markets[13].

**Table 3.2.5 Equity market linkages**[14]

| | Shock originating in | | | | | | |
|---|---|---|---|---|---|---|---|
| | **US** | **Germany** | **UK** | **Austria** | **Poland** | **Czech Rep** | **Hungary** |
| **Poland** | 1.45 | 0.87 | 0.75 | 0.64 | 1.00 | 0.19 | -0.24 |
| **Hungary** | 1.66 | 0.82 | 1.16 | 0.97 | 0.79 | 0.56 | 1.00 |
| **Czech Rep** | 1.43 | 0.76 | 0.53 | 0.93 | 0.59 | 1.00 | -0.08 |
| **Slovakia** | 1.01 | 0.50 | 1.94 | 0.71 | 0.41 | 0.45 | 0.30 |
| **Slovenia** | 1.39 | 0.88 | 0.56 | 0.75 | 0.56 | -0.01 | -0.16 |
| **Estonia** | 1.72 | 0.83 | 0.84 | 1.09 | 0.52 | 0.44 | -0.52 |
| **Lithuania** | 1.65 | 0.77 | -0.66 | 1.21 | 0.69 | 0.79 | -0.69 |
| **Latvia** | 0.89 | 0.91 | 1.16 | 0.60 | 0.51 | 0.19 | -0.42 |
| **Bulgaria** | 1.94 | 1.27 | 1.41 | 1.27 | 0.74 | 0.62 | -0.15 |
| **Romania** | 2.11 | 1.13 | 0.01 | 0.79 | 0.49 | 0.40 | -0.65 |

Note: Calibrated from impulse response functions illustrated in figures 3.2.6a-j.

## 3.2.6 Equity risk premia

A number of studies have attempted to distinguish between equity market correlation and equity market "contagion", where contagion is defined as the co-movement of asset markets not traceable to a common co-movement of fundamentals (see for example Forbes and Rigobon, 2002 and Wolf, 1996). This can be thought of as the ex-ante equity risk premium, or the additional return that investors demand, given their expectations regarding asset growth and dividend yields. Equity prices reflect the discounted future value of profits, where the discount factor includes the equity risk premium mark-up over risk free rates. Profits vary for many reasons, both national and international, but these are not particularly forward looking estimates of risk and the probability of crises. If a group of countries are considered to be similar with similar risks then we would expect their equity risk premia to move together, independently of the exchange rate and other factors. When they move apart this can be seen as an advance warning of country specific problems.

The equity price (Eqp) can be written as dependent on profit per unit of capital (Prof) and the discounted value of next period's equity price, where the discount factor is made up of a real risk free interest rate (rr) and an equity premium (eprem):

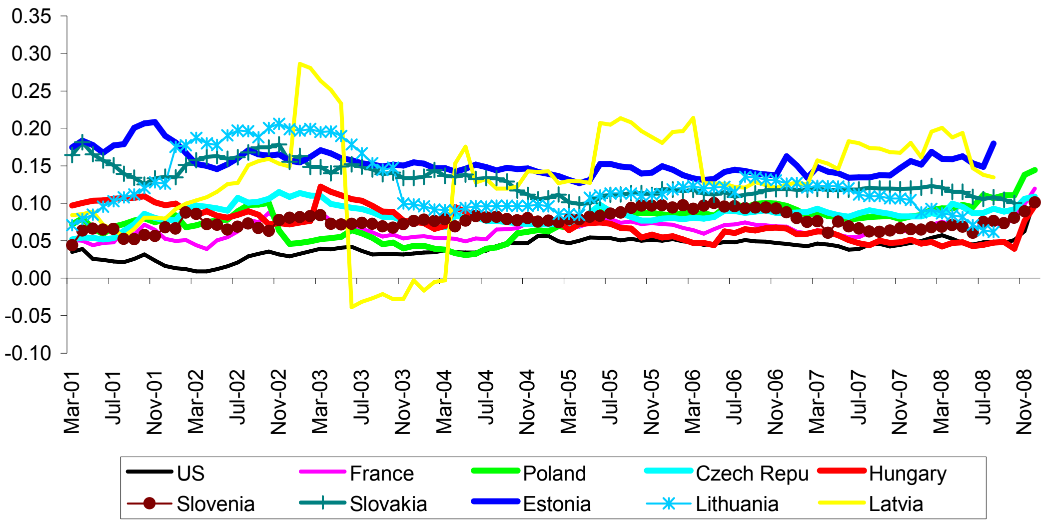
$$Eqp_t = Prof_t + Eqp_{t+1}/((1+rr_t)(1+eprem_t)) \qquad (3.2.1)$$

This equation can be inverted to solve for the equity risk premium, and Jagannathan *et al* (2000) show that this can be proxied by the dividend yield plus expected dividend growth less the real bond yield. IMF (2001) argues that at the economy-wide level the

[13] The estimates reported in table 3.2.5 should be viewed with some caution. While they are useful benchmarks, strong negative spillovers from the UK are not intuitive and the spillovers from global shocks to Poland, Hungary and the Czech Rep. seem exceptionally large. Further testing is advised.
[14] The parameters reported here are not directly related to the aggregate "spillover index" reported in table 3.2.4, which shows the correlation of equity markets in the sample as a whole.

growth in potential output can be used to proxy expected dividend growth. We proxy the dividend yield with the inverse of a market-wide price-earnings ratio, and estimate the ex-post equity risk premium by subtracting the medium term real risk free interest rate from this earnings-price ratio and an estimate of the growth rate of potential output. These are crude estimates of premia, but they move in sensible ways. Appendix 3a gives details on the calculation of these series, which should be monitored regularly as part of the financial surveillance toolkit. Figure 3.2.7 compares these estimates of equity risk premia in the NMS to those in the US and France. While Latvia is more volatile, risk premia in the other NMS appear broadly in line with, albeit somewhat higher than, the comparator economies. The equity risk premium in Hungary may be viewed as exceptionally low, as it is in line with the US and below that in France. This may indicate an underpricing of equity risk in Hungary, which suggests that equity prices were overvalued in 2007-2008, and a correction to the equity price should be anticipated.

**Figure 3.2.7 Equity risk premia**[15]




Source: See Appendix 3a for details

We looked at the correlations of equity premia across 27 countries using monthly data and noted the strongest correlations. These were then recalculated as 5 year rolling correlations, to capture the co-movements of equity premia and their variation over time. In general, correlations of equity risk premia are weaker than correlations of equity market returns, which also capture cyclical co-movements. Some exceptions to this generalization are US correlations with equity risk premia in Poland and Slovenia; UK and Japanese correlations with Poland and Latvia; and India's correlations with Hungary, Slovakia and Estonia. It is particularly interesting to note the shift in correlations with the Asian markets, indicating that the weak correlation in equity returns is partly attributable to different cyclical dynamics between the regions.

Figures 3.2.8a-8h plot rolling correlations of equity premia in the NMS with the US, Germany, France, Poland, Hungary, the Czech Republic and any other strong relationships. The UK, France and Sweden exhibit the strongest correlations with

[15] We omit Bulgaria and Romania from this analysis, due to the lack of adequate price-earnings data. The data for Latvia and Slovakia is also questionable, due to the small size of equity markets in these economies.

Poland. The Czech Republic is also closely tied to France and Sweden, while India and Portugal are more closely related to Hungarian equity risk premia. India and Portugal are also important correlates for Slovakia and Estonia. The US and Poland are among the strongest correlates in Slovenia, while Lithuania is more closely tied to the Czech Republic. In general, the NMS exhibit closer correlations with France than they do with Germany, although Estonia and perhaps Hungary are exceptions to this generalization. Correlations with global equity risk premia are weaker in Slovenia and Latvia than in the other NMS. This suggests that although equity markets in Slovenia are relatively well developed, they are less exposed to contagion from abroad than are their counterparts in Poland and the Czech Republic. This is consistent with the results of the VAR analysis reported above.

**Figure 3.2.8a Rolling correlations of equity risk premia: Poland**

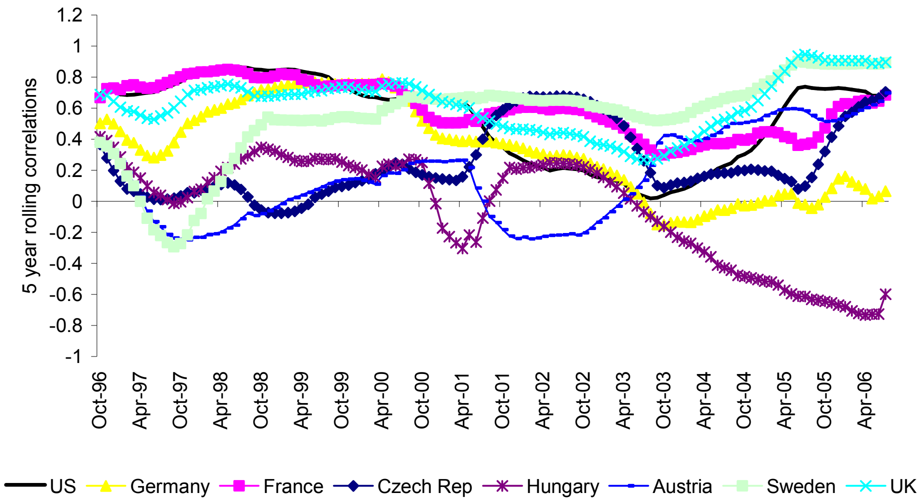



**Figure 3.2.8b Rolling correlations of equity risk premia: Hungary**

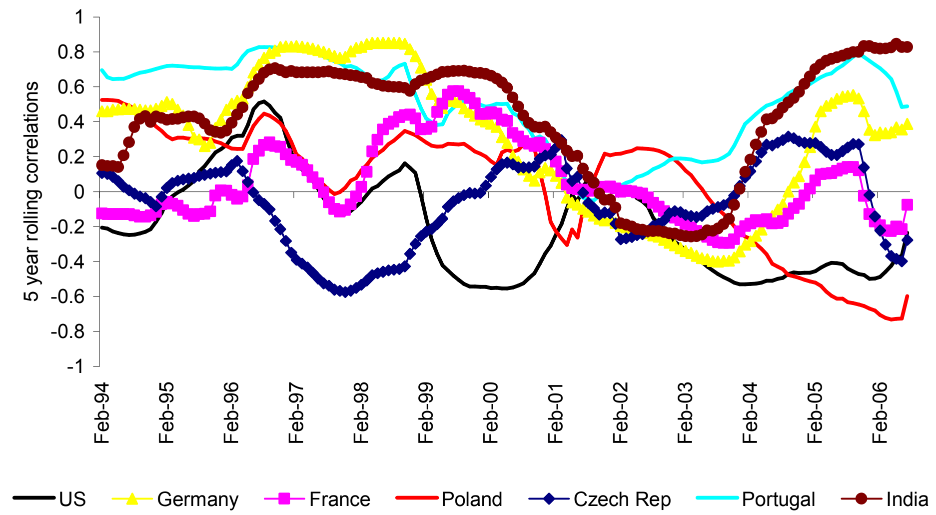


**Figure 3.2.8c Rolling correlations of equity risk premia: Czech Republic**

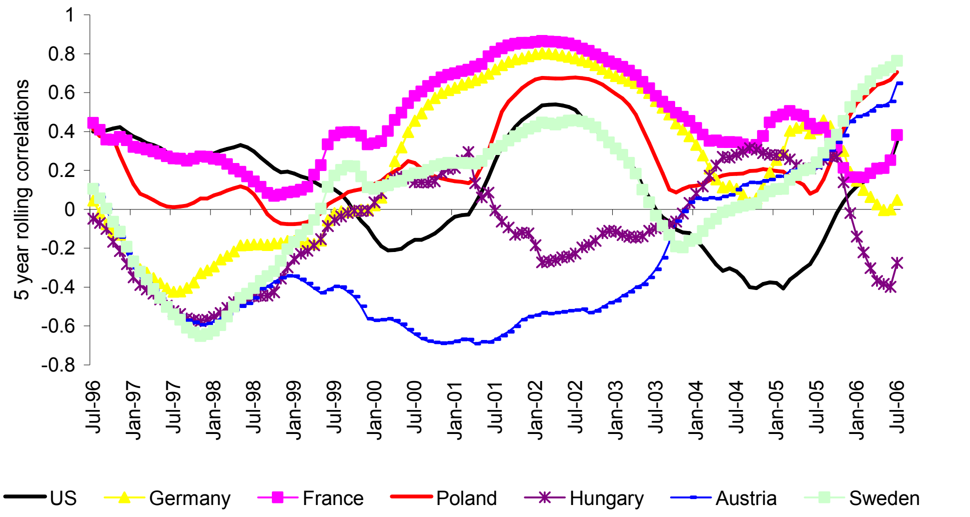



**Figure 3.2.8d Rolling correlations of equity risk premia: Slovakia**

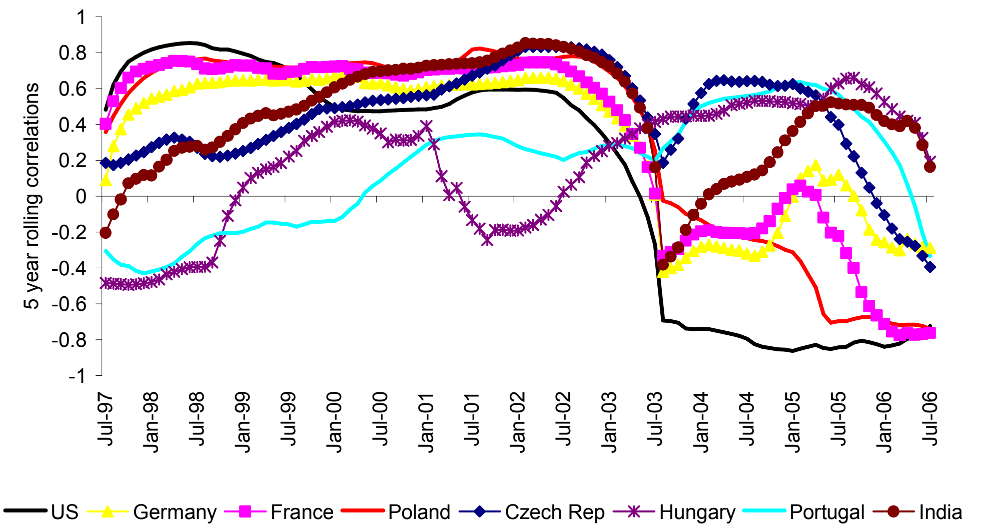
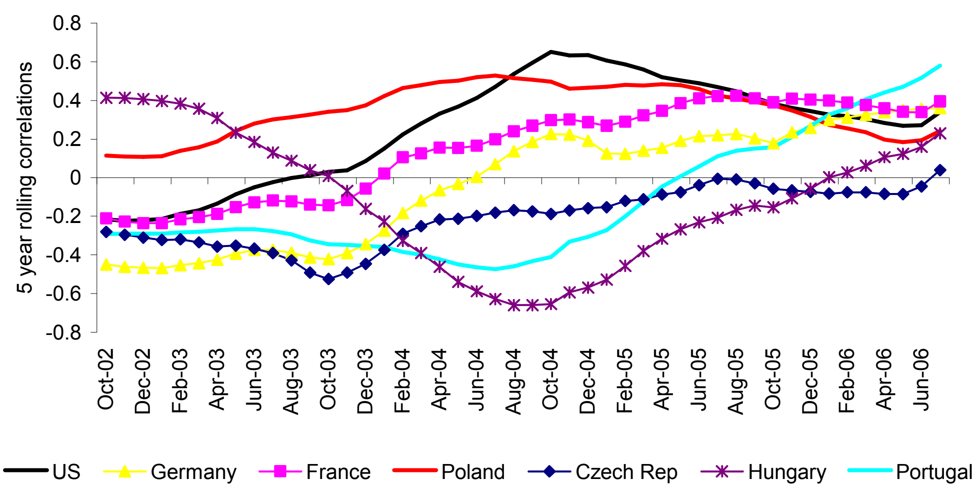
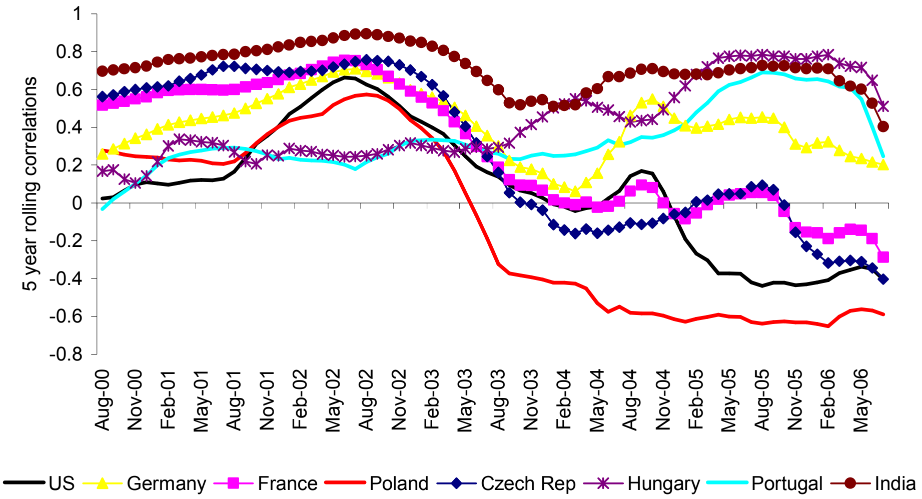


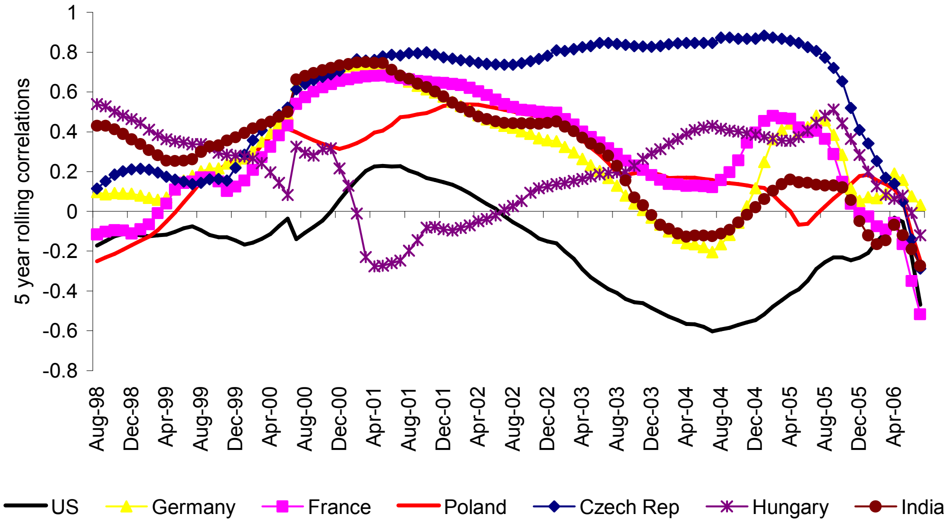

**Figure 3.2.8e Rolling correlations of equity risk premia: Slovenia**



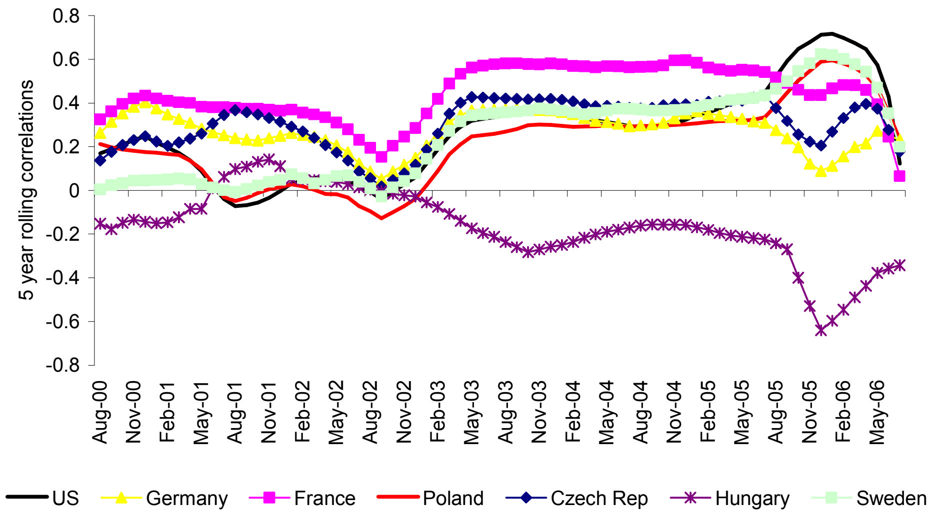
## Figure 3.2.8f Rolling correlations of equity risk premia: Estonia




## Figure 3.2.8g Rolling correlations of equity risk premia: Lithuania




## Figure 3.2.8h Rolling correlations of equity risk premia: Latvia



### 3.2.7 Summary

Equity markets in the NMS have deepened significantly over the last 10 years. Market capitalization in Poland, the Czech Republic and Slovenia is now of a similar size relative to GDP to equity markets in Germany, Italy and Austria, although they remain shallow relative to the more equity intensive economies such as the US and the UK. Equity markets in Hungary, Estonia and Lithuania remain smaller, while those in Slovakia, Latvia, Romania and Bulgaria remain relatively undeveloped.

Equity market volatility seems to be related to the exchange rate regime, with a flexible exchange rate associated with greater equity market volatility. This suggest that pegging related to ERMII membership may bring with it the added benefit of more stable equity markets in economies such as Poland.

Equity market returns in Poland, Hungary and the Czech Republic are closely correlated with each other, and are also closely correlated with the US and other European markets. Slovenian equity markets are also relatively well integrated into European markets, although they are less exposed to contagion from abroad than markets in Poland and the Czech Republic. Within the Baltic States, Estonia and Lithuania are more closely correlated with each other than with Latvia, where equity markets remain smaller. In general, the NMS exhibit relatively strong correlations in equity returns with Austria, Germany and France, and weak correlations with Asian markets.

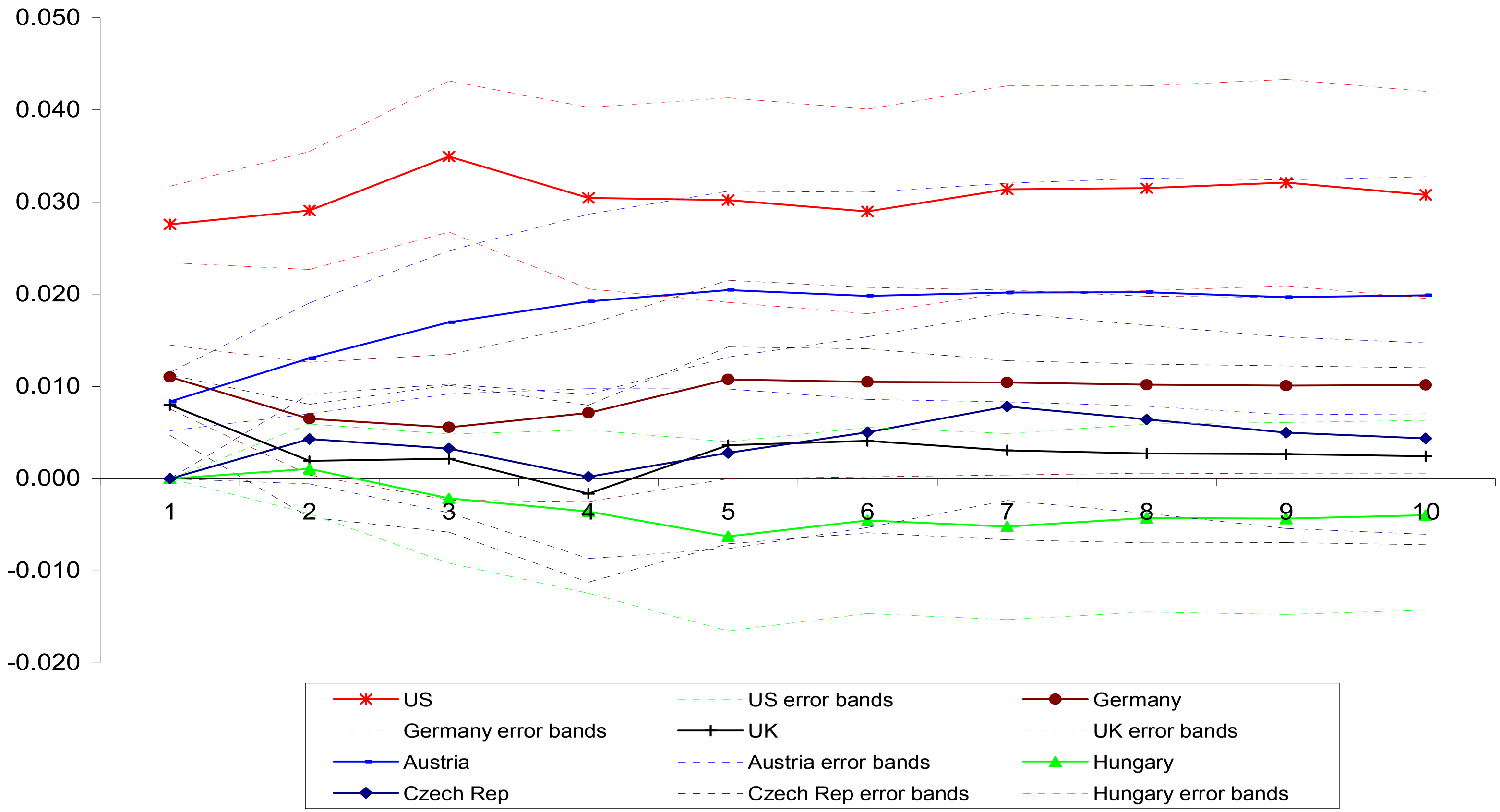
Global equity market correlations have increased significantly in all the NMS over time, and there is some evidence that this reflects deeper integration into global networks as a result of EU membership. There is also a marked rise in global correlations related to the global financial crisis, which is consistent with the definition of contagion adopted, for example, by Forbes and Rigobon (1999), Pericoli and Sbracia (2001) and Corsetti *et al* (2002), as an increase in cross-market correlations during periods of turmoil.

We calibrate a series of equity market linkages parameters, which indicate more than 100 per cent spillovers from global shocks to Poland, Hungary, the Czech Republic, Estonia, Lithuania, Bulgaria and Romania, suggesting that these markets exhibit greater volatility than those in the US. Shocks originating in Germany and Austria have spillovers of 50-100 per cent in the NMS, while those originating in Poland spillover at least 30 per cent in the other NMS.

We recommend regular monitoring of equity risk premia in the NMS as part of a financial surveillance toolkit. Appendix 3a gives details on the calculation of these series. Equity risk premia in Hungary appear low relative to the other NMS, which may indicate an underpricing of equity risk in Hungary, leaving Hungarian equity prices exposed to a downward correction.

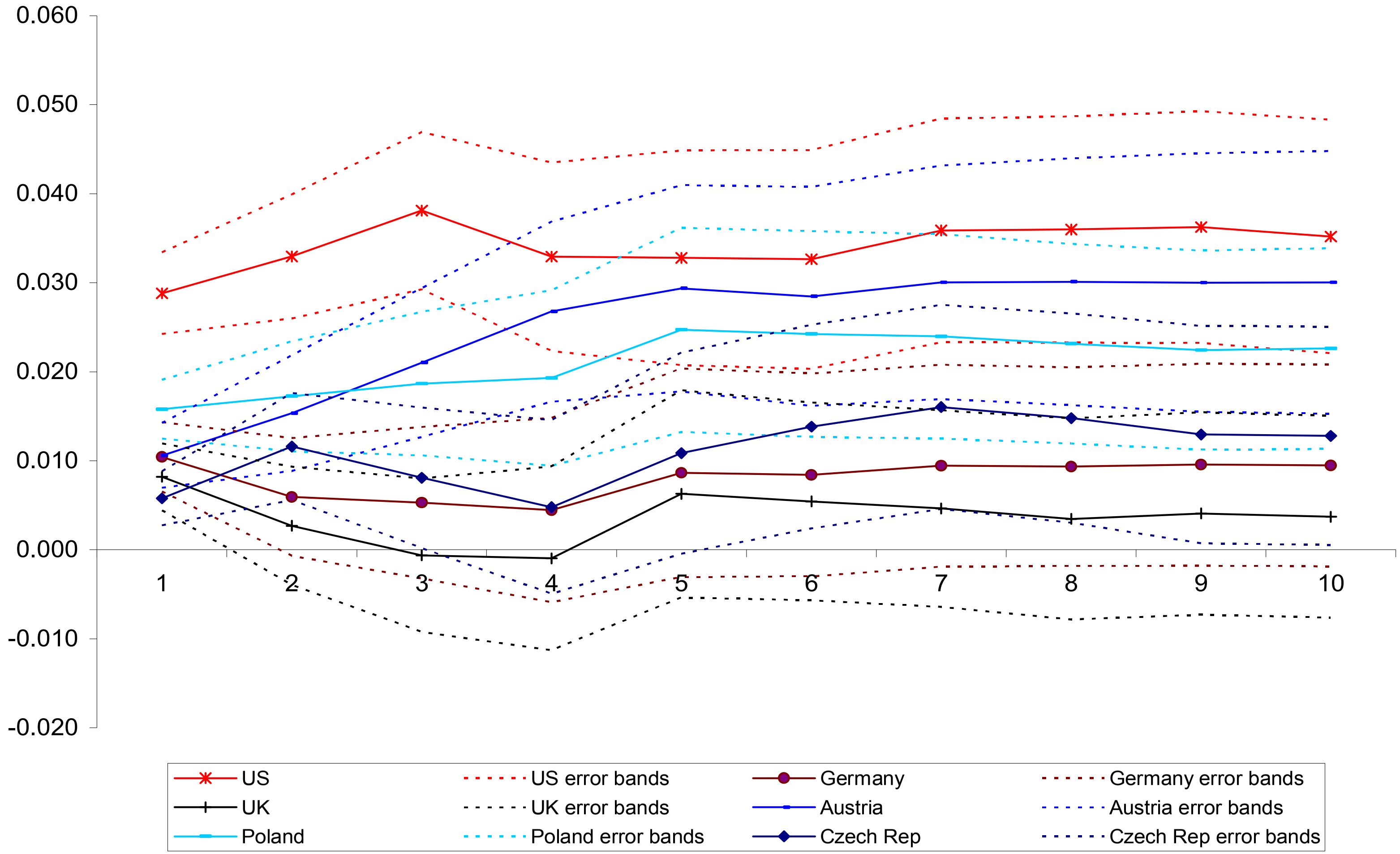
### 3.2.8 Annex: Figures 3.2.6a-j with error bands included

**Figure 3.2.6a2 Cumulative impulse response functions: Poland**



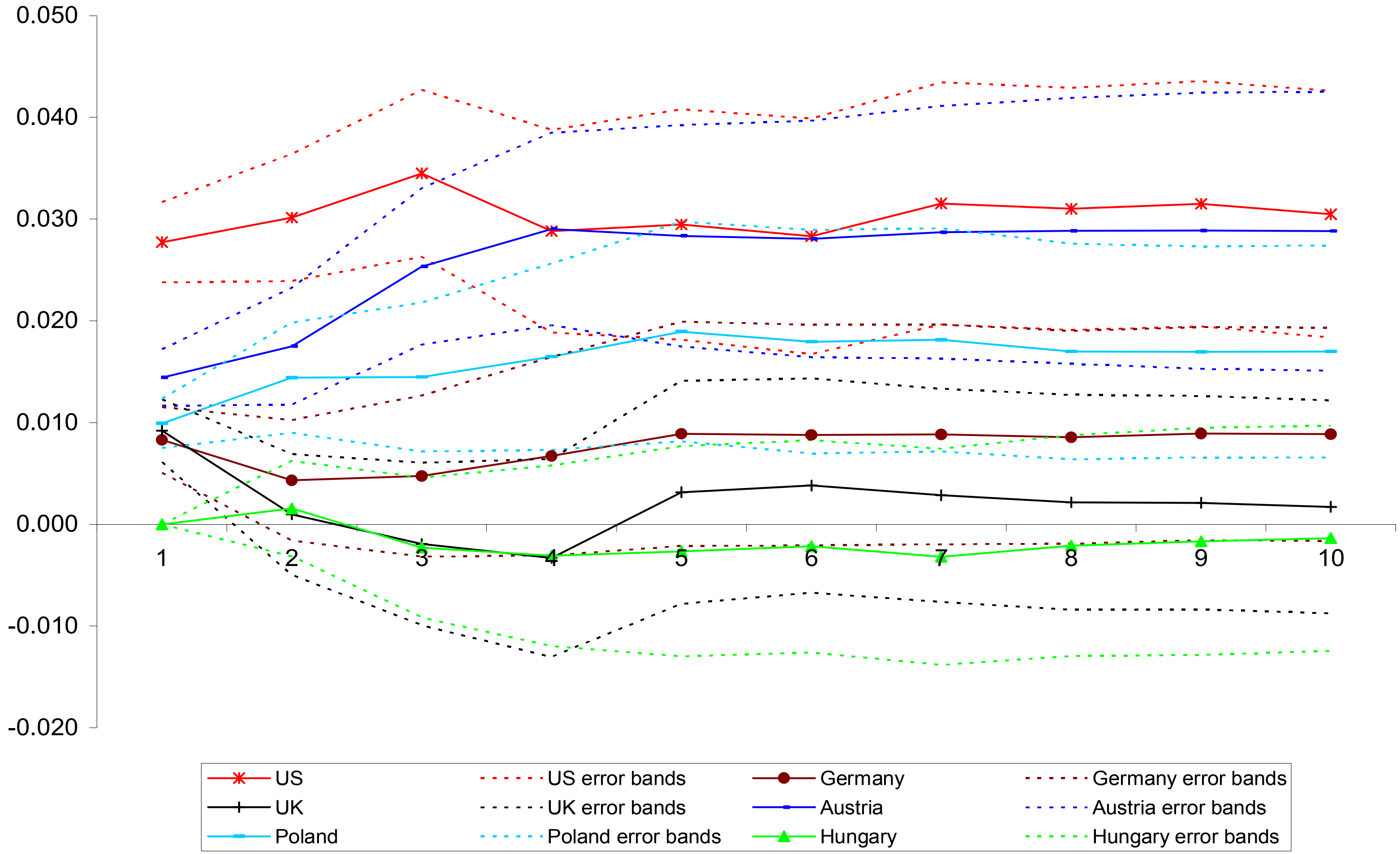

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6b2 Cumulative impulse response functions: Hungary**



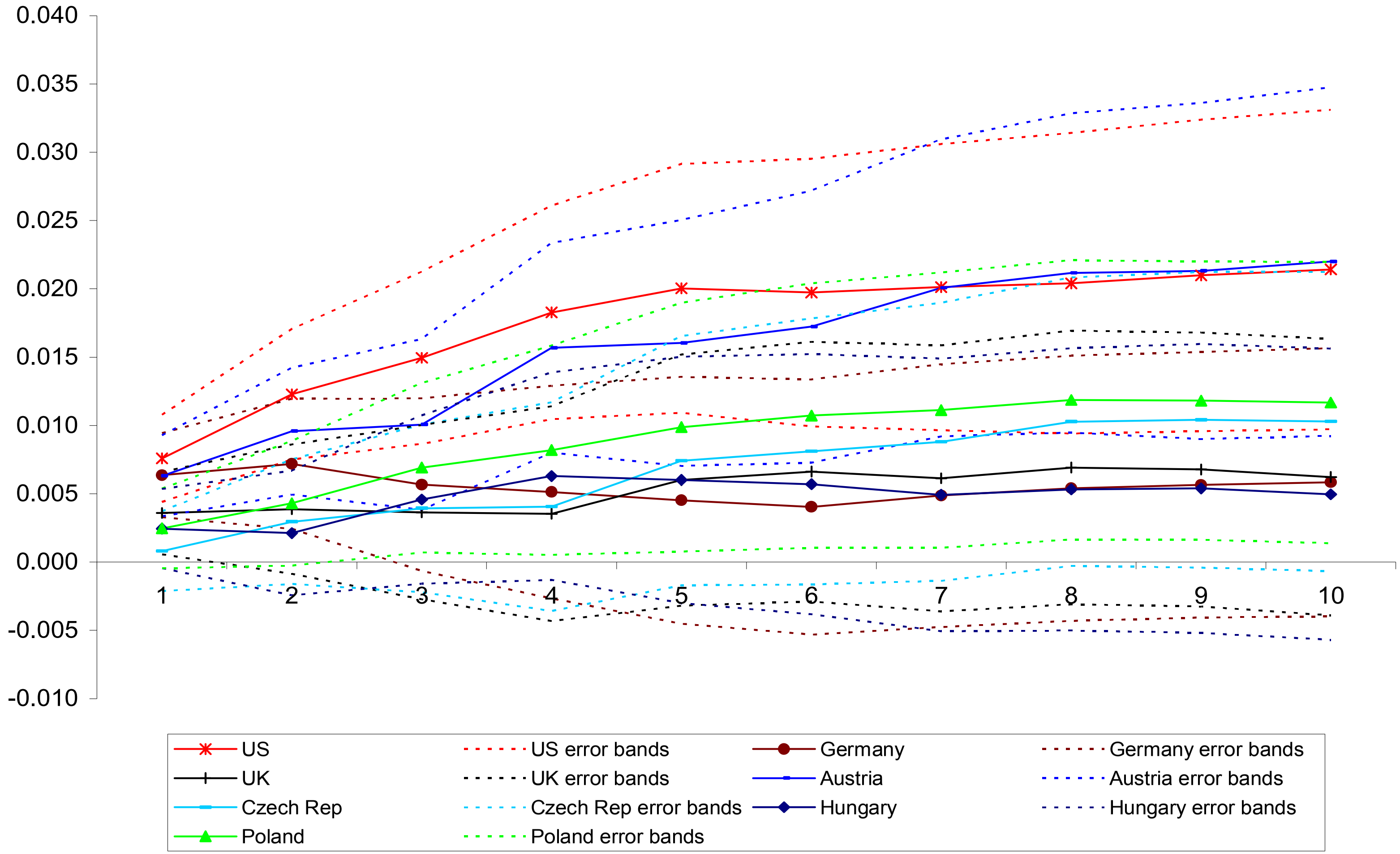

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6c2 Cumulative impulse response functions: Czech Republic**



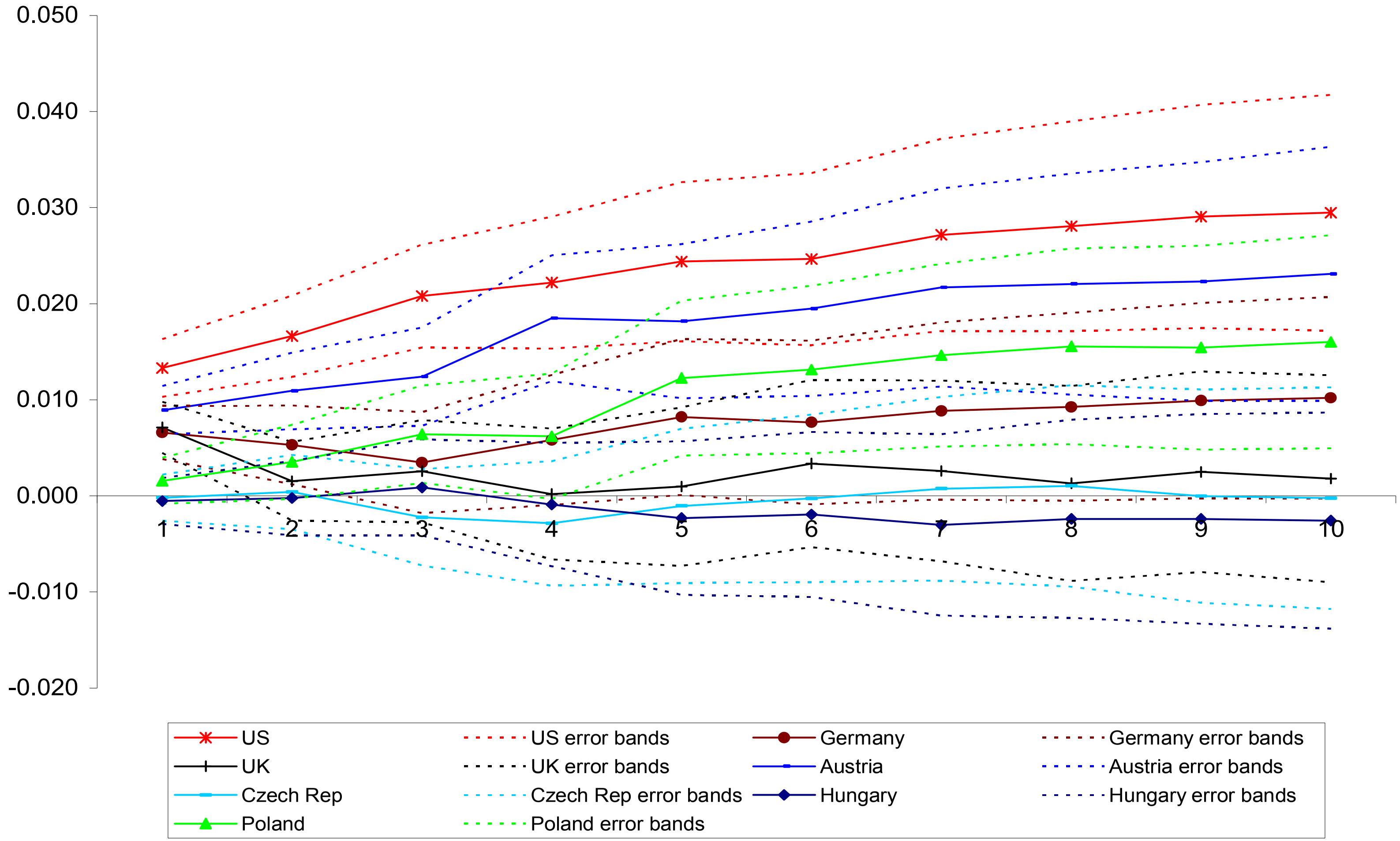

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6d2 Cumulative impulse response functions: Slovakia**



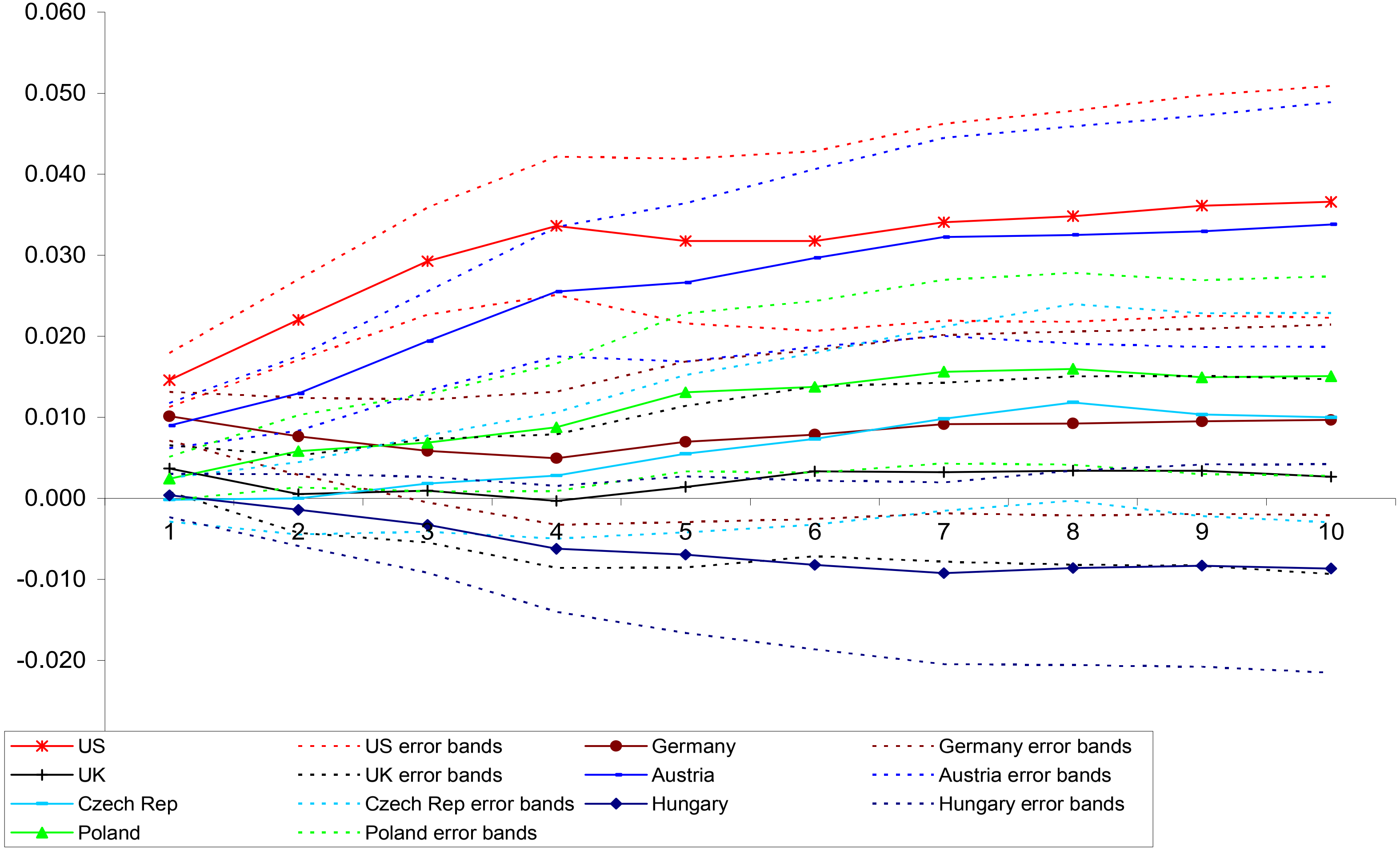

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6e2 Cumulative impulse response functions: Slovenia**



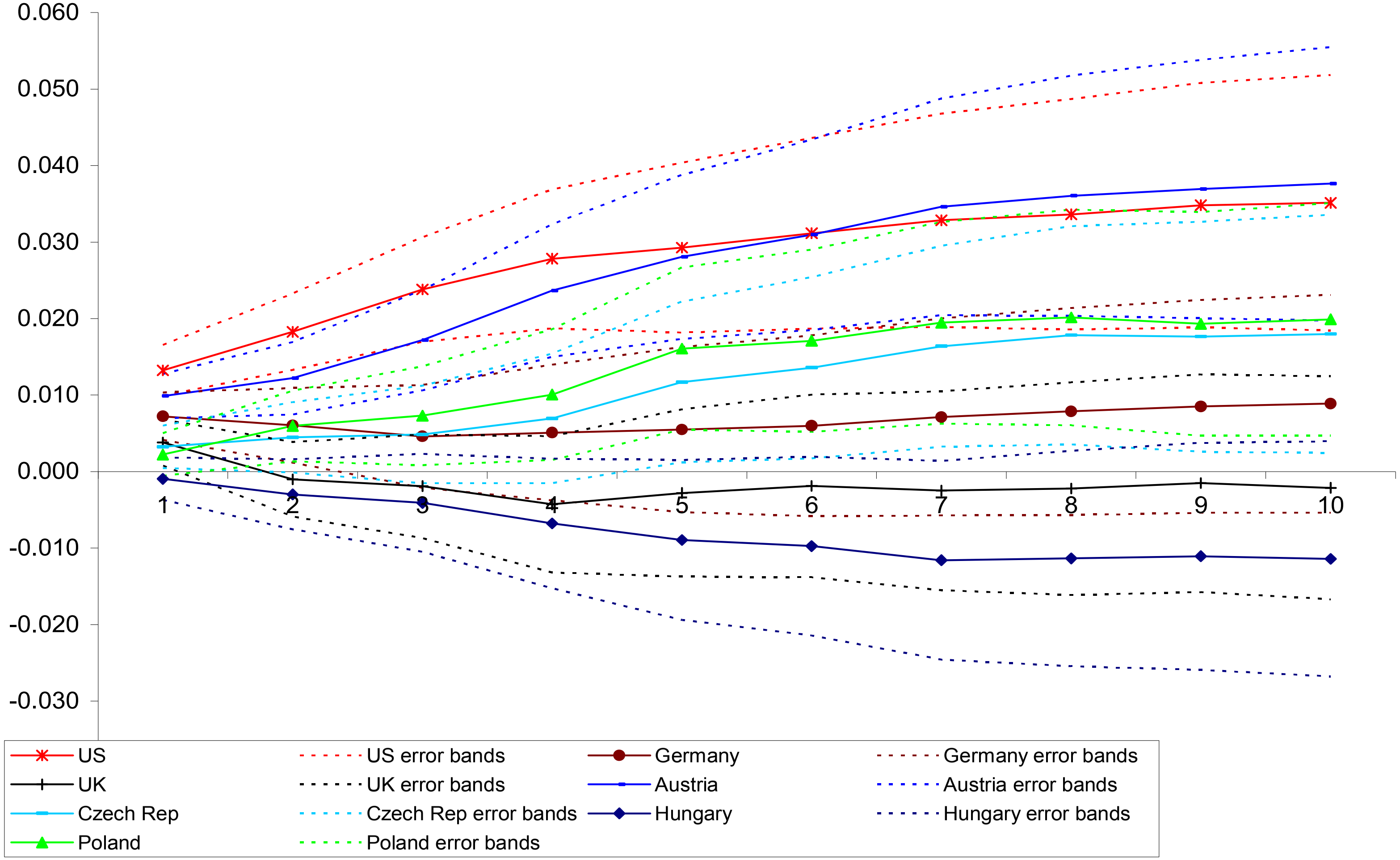

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6f2 Cumulative impulse response functions: Estonia**



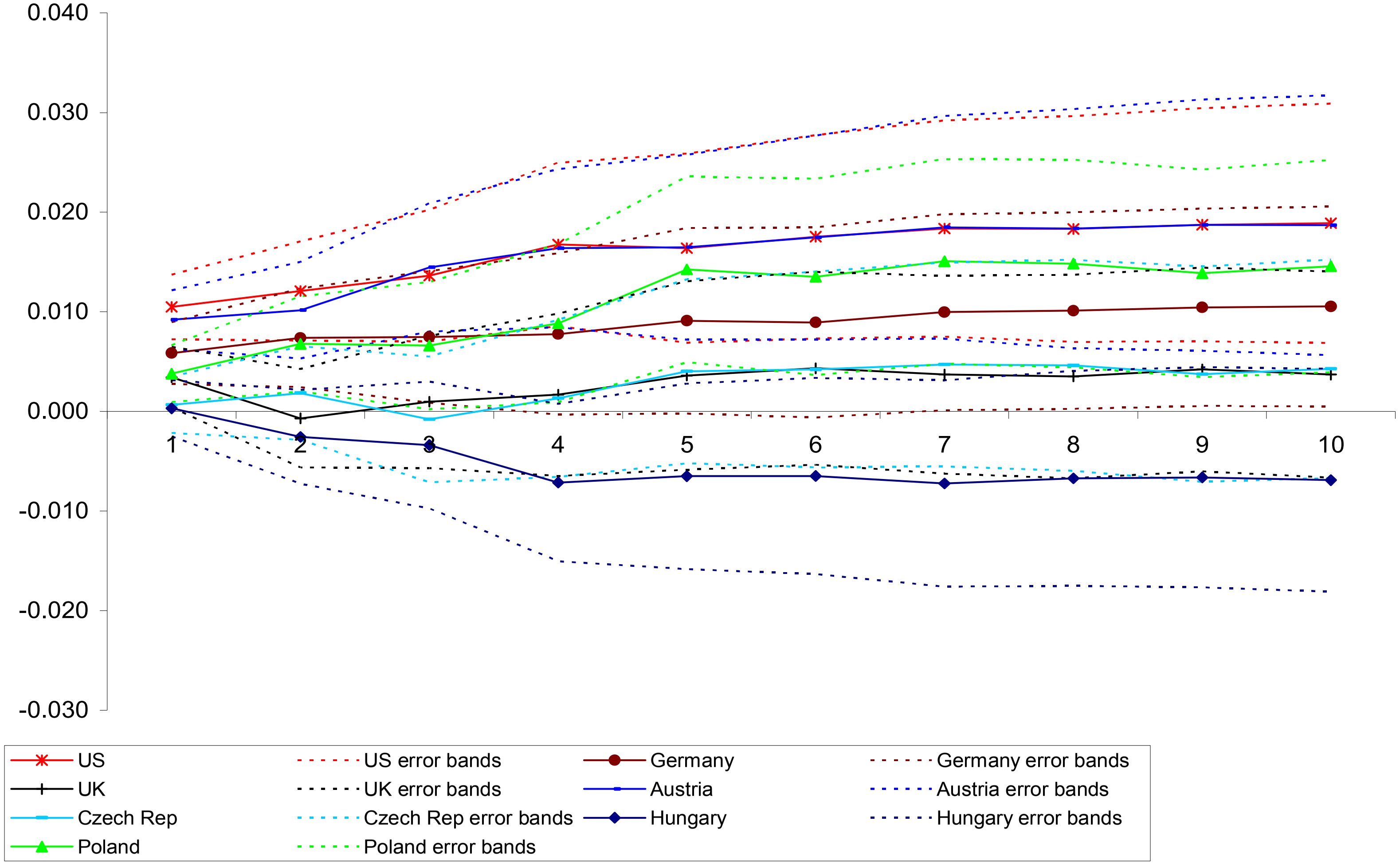

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6g2 Cumulative impulse response functions: Lithuania**



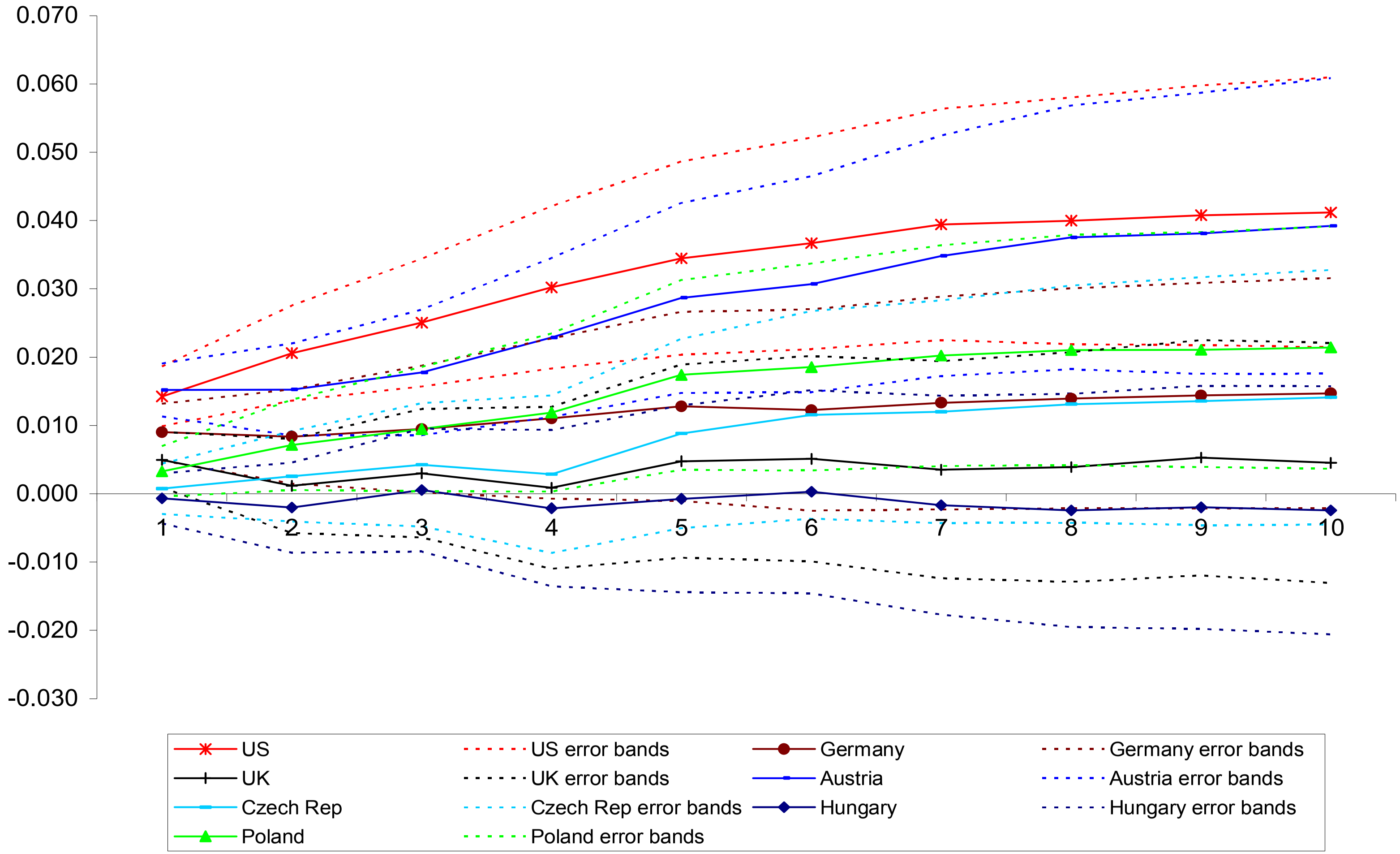

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6h2 Cumulative impulse response functions: Latvia**



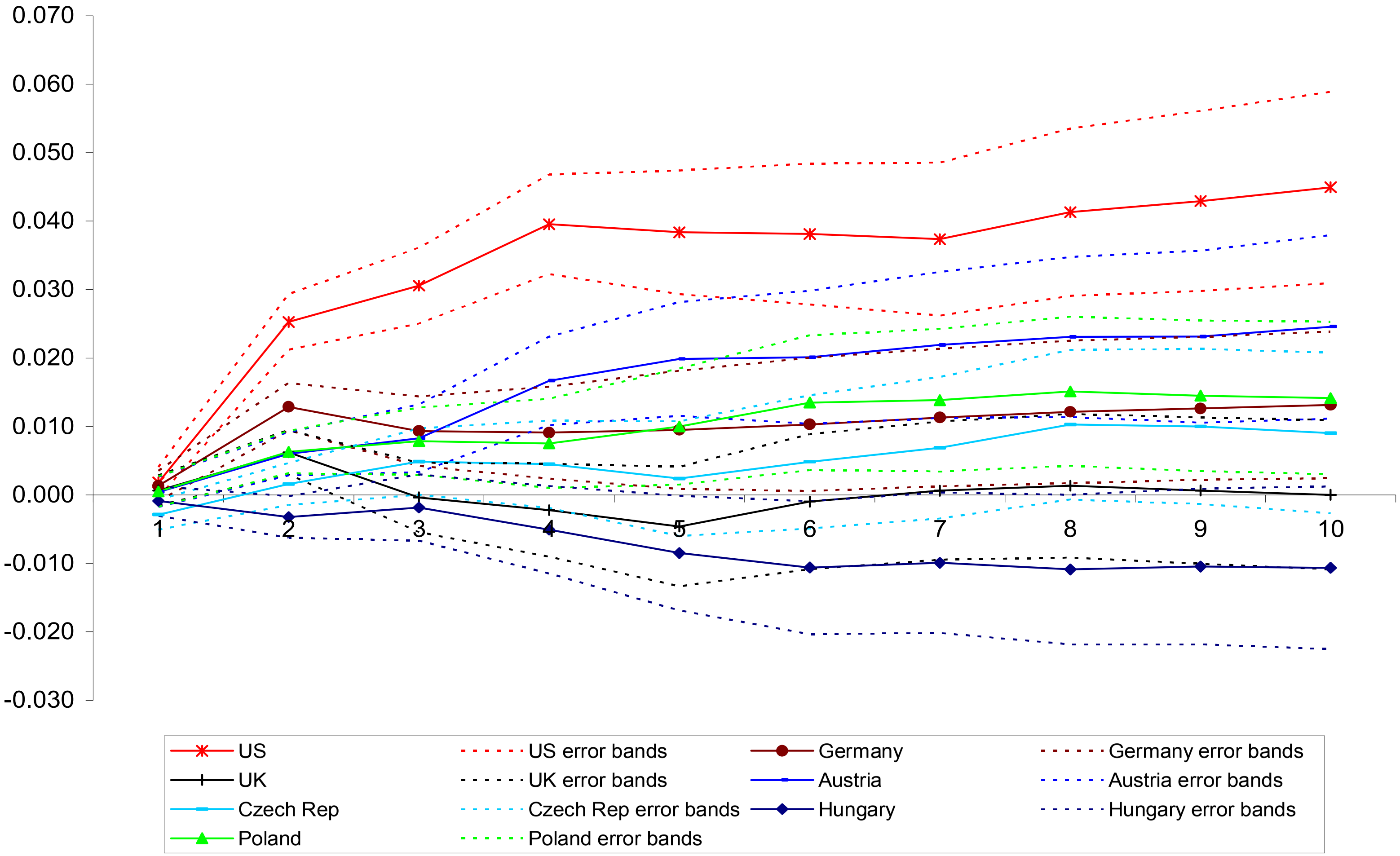

Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6i2 Cumulative impulse response functions: Bulgaria**




Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

**Figure 3.2.6j2 Cumulative impulse response functions: Romania**




Note: Response to a 1 SD innovation in each country. Error bands illustrate +/- 2 standard errors.

## 3.3 Exchange rates and interest rates

In this section we look at both interest rates and exchange rates in the NMS, as we view these instruments of monetary policy as intrinsically linked. While all the NMS are ultimately committed to joining ERM II and EMU, Poland, Hungary the Czech Republic and Romania have so far maintained flexible exchange rate regimes, while the other economies in our sample have all linked their exchange rates to the euro. As long as a currency remains outside of EMU, it will retain a country-specific exchange rate risk premium. In countries with fixed exchange rate regimes, a rise in the risk premium is associated with a rise in domestic interest rates relative to foreign interest rates. Under floating regimes this can be effected either through a depreciation of the exchange rate or a relative rise in interest rates, or some combination of the two. After reviewing exchange rate regimes and volatility of interest rates and exchange rates, we will develop a model that allows us to look at the impact of external shocks on exchange rate risk premia, and determine whether this tends to feed through the exchange rate or the interest rate differential.

### 3.3.1 Exchange rate regimes

We first give a brief overview of exchange rate regimes in the NMS since 1992 in order to identify key turning points which may affect the analysis in this section and elsewhere in the report. Table 3.3.1 shows exchange rate regimes in each economy, as defined by IMF exchange rate regime classification.

Prior to EU accession, there was a noticeable tendency among the NMS to move toward exchange rate regimes that were either relatively flexible or very rigid. The Czech Republic, Poland, Slovakia and Romania abandoned intermediate regimes of crawling pegs or bands to apply loosely managed floats or free floating regimes. In contrast, the Baltic States and Bulgaria have operated very rigid pegs – Estonia, Lithuania and Bulgaria maintained currency board arrangements, while Latvia maintained a conventional peg with a narrow fluctuation band. Hungary maintained an intermediate regime of shadowing the ERM-II, but widened the fluctuation band to +/- 15% in 2003. Finally, Slovenia officially kept a managed float, although in practice, it had very limited exchange rate movements.

Hungary moved to a free floating regime in 2008, while Romania retains more control over its exchange rate than the three largest NMS economies. While the Czech Republic officially maintains a managed float, the IMF changed the classification of the Czech Republic towards a free float in 2007 to reflect *de facto* policy.

Estonia, Lithuania and Slovenia joined ERM II on accession to the EU in 2004, while Latvia and Slovakia joined ERM II in 2005. The other currencies remain outside of ERM II, and the global financial crisis is expected to delay their entry, as exchange rate realignments have increased uncertainty regarding the equilibrium parity rate.

Slovenia joined EMU in 2007, and Slovakia joined EMU in 2009. As such, neither country retains a country-specific exchange rate risk premium, but are exposed to the Euro Area-wide exchange rate risk premium.

**Table 3.3.1 Exchange rate regimes in accession countries**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Czech Republic** | **1992-1995**<br>3 | **1996**<br>4 | **1997-2000**<br>7 | **2001-2002**<br>8 | **2003-2006**<br>7 | **2007-**<br>8 |
| **Poland** | **1992-1994**<br>5 | **1995-1999**<br>6 | **2000-**<br>8 | | | |
| **Slovak Republic** | **1992-1995**<br>3 | **1996-1997**<br>6 | **1998-2001**<br>7 | **2005-2008**<br>4 (ERMII) | **2009**<br>1 (EMU) | |
| **Estonia** | **1992-2003**<br>2 | **2004-**<br>2 (ERMII) | | | | |
| **Latvia** | **1992-1993**<br>8 | **1994-2003**<br>3 | **2005-**<br>3 (ERMII) | | | |
| **Lithuania** | **1992-1993**<br>8 | **1994-2003**<br>2 | **2004-**<br>2 (ERMII) | | | |
| **Hungary** | **1992-1994**<br>3 | **1995-2001**<br>6 | **2002-2007**<br>4 | **2008-**<br>8 | | |
| **Bulgaria** | **1992-1996**<br>8 | **1997-**<br>2 | | | | |
| **Romania** | **1994-1996**<br>8 | **1997-2000**<br>7 | **2001-2003**<br>6 | **2004-**<br>7 | | |
| **Slovenia** | **1992-2001**<br>7 | **2002**<br>5 | **2004-2006**<br>4 (ERMII) | **2007**<br>1 (EMU) | | |

Source: Barrell et al (2004), IMF

Note: IMF Exchange Rate Regime Classification:

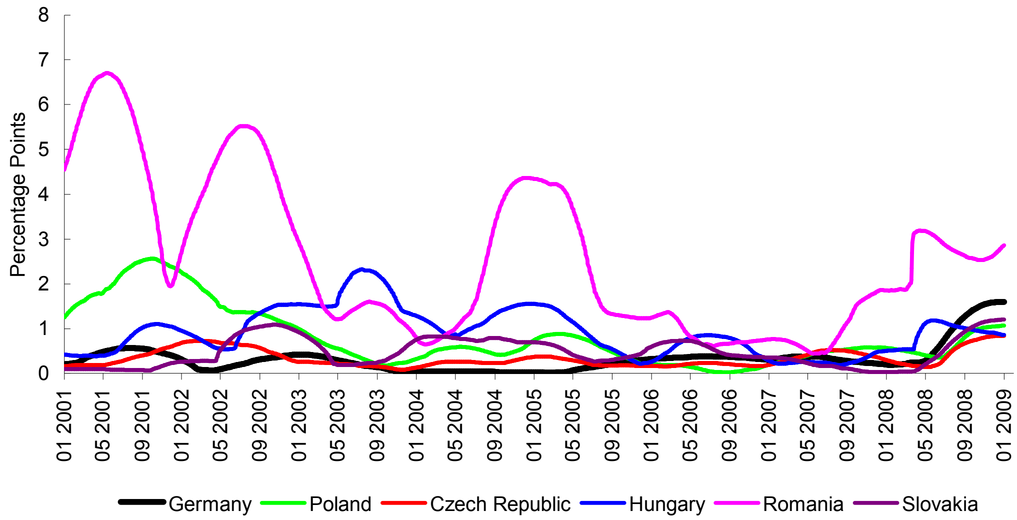
(1) Euroisation — No separate legal tender
(2) Currency board — Currency fully backed by foreign exchange reserves
(3) Conventional fixed peg — Peg to another currency or currency basket within a band of at most +/- 1%
(4) Horizontal bands — Pegs with bands larger than +/- 1%
(5) Crawling Pegs — Pegs with central parity periodically adjusted in fixed amounts at a fixed, pre-announced rate or in response to changes in selected quantitative indicators
(6) Crawling Bands — Crawling pegs combined with bands of more than +/- 1%
(7) Managed float — Active intervention without pre-commitment to a pre-announced target or path for the exchange rate
(8) Independent float — Market-determined exchange rate and monetary policy independent of exchange rate policy

## 3.3.2 Volatility of interest rates

We next look at the unconditional volatility of interest rates in the NMS. We use daily data for 3-month interbank rates and plot a rolling window (+/-6 months) of the standard deviation of this series in figures 3.3.1-3.3.2. We plot countries with floating and fixed exchange rate regimes separately, and compare both to volatility in Euro Area interest rates. Romania stands out as having had significantly more volatile interest rates over most of the sample period. Another feature that stands out in figure 3.3.1 is that since 2006, interest rate volatility in Poland, Hungary, the Czech Republic and Slovakia has essentially converged on the level of volatility in the Euro Area, while volatility in the Czech Republic has been in line with the Euro Area since 2000. Interest rates under the fixed exchange rate regimes have generally been less volatile than under flexible regimes, indicating that the peg has acted as an efficient anchor to inflation expectations and is not simply offset by volatile interest rates. This may also reflect a tendency to target euro area interest rates rather than domestic inflation in certain economies.

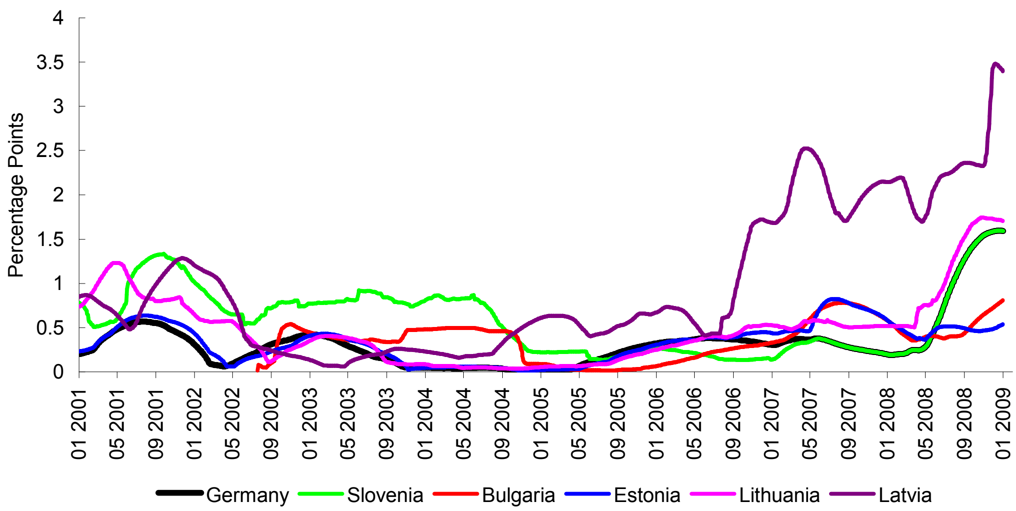
Among the fixed regime economies, Latvia has been the most volatile in recent years. Since the end of 2006 interest rates in Latvia have been far more volatile than in the other economies, pointing to some pressure on the exchange rate and suggesting that the fixed exchange rate regime has ceased to act as an effective nominal anchor to domestic prices and wages.

**Figure 3.3.1 Nominal interest rate volatility: Flexible exchange rate regimes**




Note: Standard deviation of daily 3-month interbank rates, +/- 6 month

**Figure 3.3.2 Nominal interest rate volatility: Fixed exchange rate regimes**

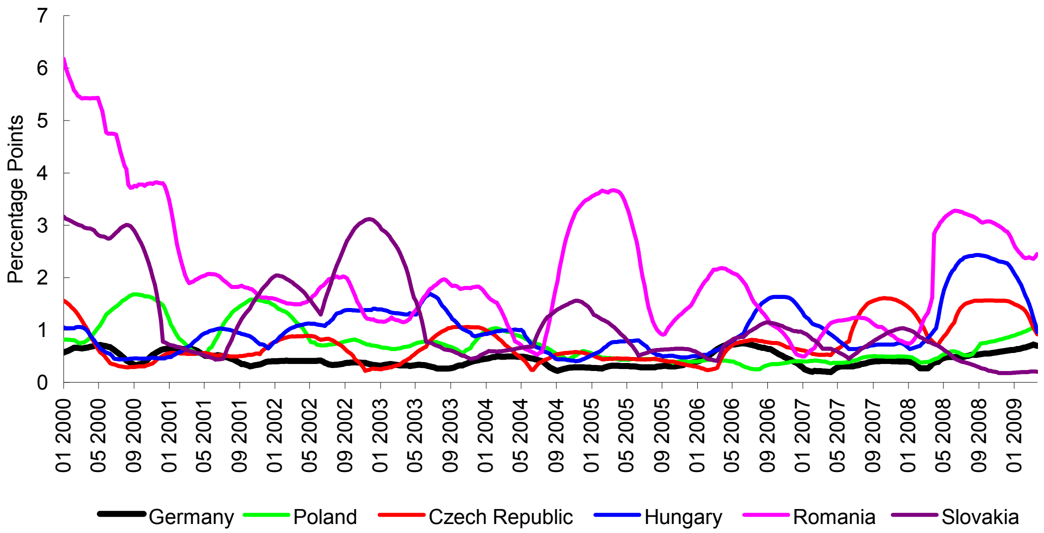



Note: Standard deviation of daily 3-month interbank rates, +/- 6 month

High interest rate volatility in economies with fixed exchange rate regimes can point to pressure on the exchange rate, as seen in Latvia recently. It would be wise to monitor interest rate volatility in these economies as part of a financial surveillance toolkit. This data is available in Appendix 3b for Estonia, Latvia, Lithuania and Bulgaria, and should be regularly monitored.

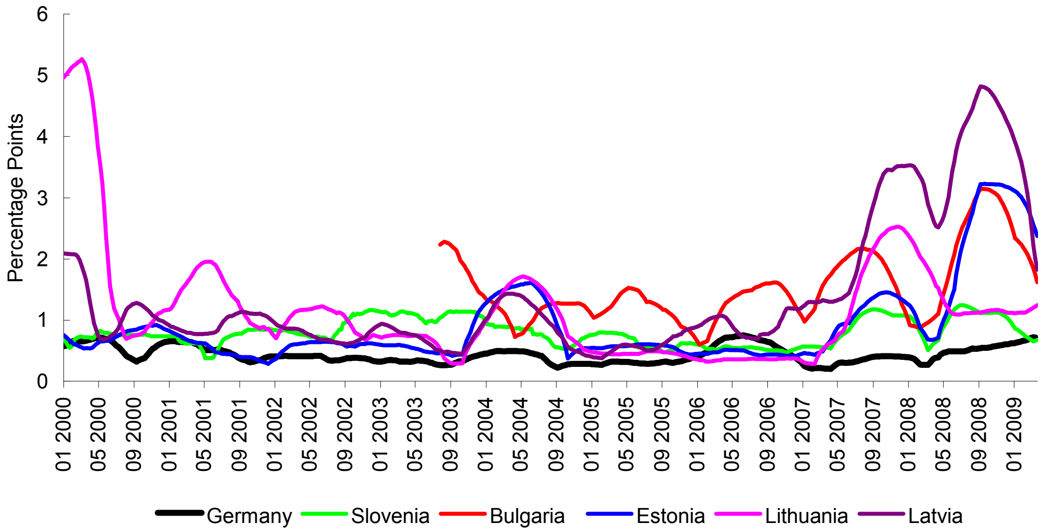
Figures 3.3.3-3.3.4 illustrate unconditional real interest rate volatility, using weekly 3-month interest rates, adjusted for harmonised consumer price inflation. We use monthly inflation, and assume a constant inflation rate in each week of the month. In the earlier part of our sample, allowing for inflation offsets much of the volatility in Romania. In the latter part of our sample, however, real interest rates in most of the NMS tend to be more volatile than nominal interest rates, suggesting that monetary policy has been equally concerned with maintaining interest parity with the Euro Area as in maintaining stable inflation. Real interest rate volatility in Poland, however, has very closely tracked that in the Germany since 2004.

**Figure 3.3.3 Real interest rate volatility: Flexible exchange rate regimes**




Note: Standard deviation of weekly 3-month interbank rates adjusted by harmonised consumer price inflation, where monthly inflation is assumed constant over the weeks within a month, +/- 6 month

**Figure 3.3.4 Real interest rate volatility: Fixed exchange rate regimes**




Note: Standard deviation of weekly 3-month interbank rates adjusted by harmonised consumer price inflation, where monthly inflation is assumed constant over the weeks within a month, +/- 6 month

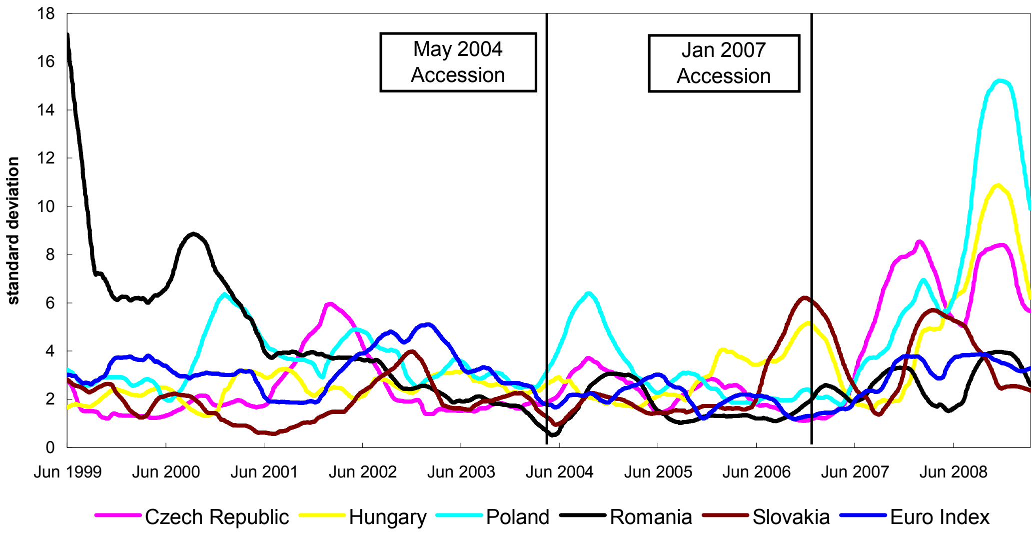
Interest rate volatility is discussed further through ARCH and GARCH analysis in chapter 7.

### 3.3.3 Volatility of exchange rates

We next look at unconditional exchange rate volatility, concentrating on the economies with floating exchange rates. Figure 3.3.5 plots effective exchange rate volatility in Poland, Hungary, the Czech Republic, Romania and Slovakia (which maintained a large degree of exchange rate flexibility until joining EMU). We also include the Euro Area effective exchange rate as a comparator.

Since 2002, exchange rate volatility in the NMS has not been consistently higher than in the Euro Area. Romania has had the most stable exchange rate over this period, following high volatility prior to 2001. Exchange rate volatility in Poland jumped in 2004 after acceding to the EU, and rose sharply in response to the 2008 financial crisis. Volatility in Hungary rose in 2006 and this may be related to the government's fiscal consolidation programme, which severely cut banking sector profit growth. Hungary also responded sharply to the financial crisis. The Czech exchange rate remained very stable until 2007, but has risen significantly above volatility in the Euro Area since then.

**Figure 3.3.5 Effective exchange rate volatility**




Note: Standard deviation of daily effective exchange rates, +/- 6 month, calculated using JP Morgan broad indices

A volatile exchange rate can be detrimental to growth, especially in open economies, as it increases uncertainty in forward contracts.

### 3.3.4 Uncovered interest parity and the exchange rate risk premium

Standard models link interest rates and exchange rates across countries by the familiar uncovered interest parity (UIP) relationship, whereby the expected change in the exchange rate is given by the difference in the interest earned on assets held in local and foreign currencies. Following accepted convention (e.g. see Wadhwani, 1999) we augment the UIP relation with a risk premium ($rp_t$) and a random component ($w_t$)

$$e_t = e_{t+1}\left(\frac{1+r_t^*}{1+r_t}\right)(1+rp_t)+w_t \tag{3.3.1}$$

where $e_t$ is the bilateral exchange rate at time t (defined as domestic currency per unit of foreign currency), $r_t$ is the short-term nominal interest rate at home and $r_t$* is the interest rate abroad.

Due to the high level of short-term noise in exchange rates, many studies have found only weak empirical links between economic fundamentals and exchange rate movements, and several previous studies reject the standard UIP condition or show that a random walk forecast typically outperforms a perfect foresight fundamentals-based forecast (see for example Meese and Rogoff, 1983; and Froot and Thaler, 1990). However, studies such as Al-Eyd *et al* (2006) and Brigden *et al* (1997) have sought to improve on the random walk, by incorporating measures that capture the exchange rate risk premium or economic "news" that affects the random component. Studies that have treated interest rates and exchange rates as both endogenous variables, rather than attempting to forecast the exchange rate from interest rate behaviour, have tended to obtain more robust results (see Edwards, 2000; Borensztein *et al*, 2001; Habib, 2002). This is the approach that we adopt in this study.

We are interested in both the factors that drive the risk premium and the channel of transmission – i.e. through the exchange rate or through interest rates. In a world with perfect foresight, the risk premium would of course be a constant over time with associated random fluctuations around that constant, as there would be no systematic deviation from the UIP relation. However, in the real world risk perceptions change over time. To some extent these perceptions may be related to observables. For example financial contagion may affect exchange rate risk premia in the NMS if financial stability is threatened in a region with either real links to the NMS or perceived links.

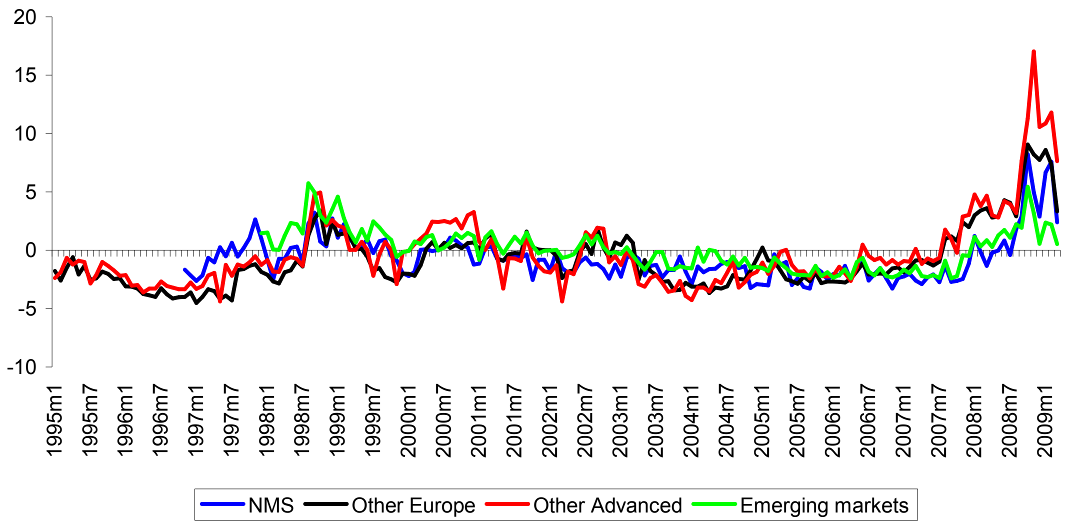
In order to test sensitivity to financial stability in the rest of the world, we will augment the standard exchange rate-interest rate nexus with measures of risk premia in advanced and emerging economies. The risk measures that we adopt are the IMF's Financial Stress Indices, developed by Balakrishnan *et al* (2009) for emerging markets and Cardarelli *et al* (2009) for advanced economies. The objective of the index is to identify episodes of financial stress, defined as periods when the financial system is under strain and its ability to intermediate is impaired. In an effort to remain agnostic on the causes of financial stress, the index measures the responses of securities and exchange markets, as well as the banking sector to capture instead a broad part of each country's financial system.

There are five components to the emerging market index: (i) the standard capital asset pricing model (CAPM) beta for the banking sector; (ii) stock market returns; (iii) GARCH(1,1) measure of time varying stock market return volatility; (iv) sovereign debt spreads as reported in JPMorgan's EMBI Global Database16 and; (v) an index of exchange market pressure (EMPI) that captures both exchange rate depreciations and declines in international reserves. For each country, the components are re-calculated as deviations from their mean, and weighted by the inverse of their variance before being added together to yield the final measure of financial market stress.

The advanced economy index is slightly broader, and includes three measures of interest rate spreads instead of the sovereign debt spreads used in the emerging market index: the interbank spread, the corporate bond yield spread, and the inverted term spread. Instead of the exchange market pressure index described above, the advanced economy index uses a GARCH volatility measure of movement in the real effective exchange rate[17].

In order to construct regional aggregates, we weight together the indices for individual countries, using time-varying GDP weights, calculated at PPPs. Four separate indices are constructed for: NMS, the rest of Europe, other advanced economies and other emerging markets.

**Figure 3.3.6 Financial Stress Indices**




Source: derived from http://www.imf.org/external/pubs/cat/longres.cfm?sk=23039.0

Figure 3.3.6 illustrates our regional indices. Clearly the dominant feature of the figures is the most recent period of financial stress, with the deepest stress indicated in advanced economies outside Europe. While the NMS have fared better than the advanced economies, financial stress has risen more than in the other emerging market economies. This suggests the financial stability in the NMS is more dependent on the global economy than their emerging market counterparts in other regions of the world.

[16] Where EMBI Global Data are not available, sovereign spreads are measured using five-year credit default swaps.
[17] These databases are available to download at http://www.imf.org/external/pubs/cat/longres.cfm?sk=23039.0

### 3.3.5 VAR analysis

In order to assess the impact of external financial stability on NMS exchange rate risk premia, we follow the approach used by Edwards (2000), Borensztein et al (2001) and Habib (2002). We specify for each country a Vector Auto Regression (VAR) model based on equation 3.3.1 above. We are primarily interested in the response of the exchange rate and the response of relative interest rates to external shocks. In order to allow domestic interest rates to adjust at a different rate to German interest rates, we include both the interest rate differential and the level of German interest rates in the model. The basic model therefore includes seven endogenous variables: the log of the domestic 3-month interbank rate relative to the German 3-month interbank rate; the log of the German short-term interest rate; the log of the bilateral exchange rate against the German/euro exchange rate; and the four regional financial stress indices discussed above. For each of the NMS we recalculate the NMS financial stress index to exclude home country effects.

We run 9 separate VAR studies, in order to model each country individually. Slovenia is excluded from this study, as it has been a member of EMU since 2007, and so no longer retains a country-specific exchange rate risk premium. We include Slovakia as a comparator, although it also no longer retains a country-specific exchange rate risk premium. The models are estimated using a monthly dataset that extends from January 1998-March 2009[18], allowing a total of 135 observations.

The models were estimated with 1 or 2 lags, depending on the information provided by five different lag-length criteria. In the selection criteria we allowed for a maximum of 8 lags. Where the selection criteria were indifferent between two lag lengths, the lower order was selected in order to increase the available degrees of freedom in the model. Figures 3.3.7a-i show the impulse response functions with respect to a Cholesky one standard deviation shock to the residual of the financial stress indicators for interest rate differentials and exchange rates in each country. The responses are not invariant to the ordering of variables. The results illustrated here are based on a Cholesky decomposition assuming the following order of variables: interest rate differential, German interest rates, exchange rate, advanced economy index, emerging market index, European index, NMS index. Experimentation with the ordering suggests that the response to the advanced economy index is most sensitive to the ordering process, while the responses of innovations originating in the other indices are relatively stable, at least in relation to each other if not in absolute magnitude. This suggests some care should be taken in interpreting the responses to innovations in the advanced economy financial stress index. Experimentation with applying Pesaran and Shin style generalised impulses instead of Cholesky impulses also highlights the sensitivity of the impulse responses to the advanced economy financial stress index to model specification.

If contagion is present, a rise in the financial stress index in each region would be associated with a rise in the exchange rate risk premium. If contagion is not present, the exchange rate risk premium may remain unchanged, or may even decline, as risk

[18] The sample period available for some countries is slightly shorter: Latvia starts in February 1998; Estonia starts in May 1999; Bulgaria starts in April 2003; Lithuania runs from March 1999-October 2007; and Slovakia ends in December 2008 when it joined EMU.

premia are assessed relative to the rest of the world. For example, a rise in financial strain in Europe that does not spillover into the NMS may be associated with an appreciation of the NMS currencies against other European currencies, or a decline in the exchange rate risk premium relative to the rest of Europe.

As we discuss above, a rise in the exchange rate risk premium can be affected either through a depreciation of the exchange rate or a rise in interest rates relative to the rest of the world. We define the exchange rate as the spot rate of the domestic currency against the DM/euro, so a rise in the exchange rate indicates a depreciation. Figures 3.3.7a-i allow us to identify both regional sensitivity and the relative sensitivity of interest rates versus exchange rates.

**Figure 3.3.7a Impulse responses in Poland**

*Interest rates relative to Germany* *Exchange rate*

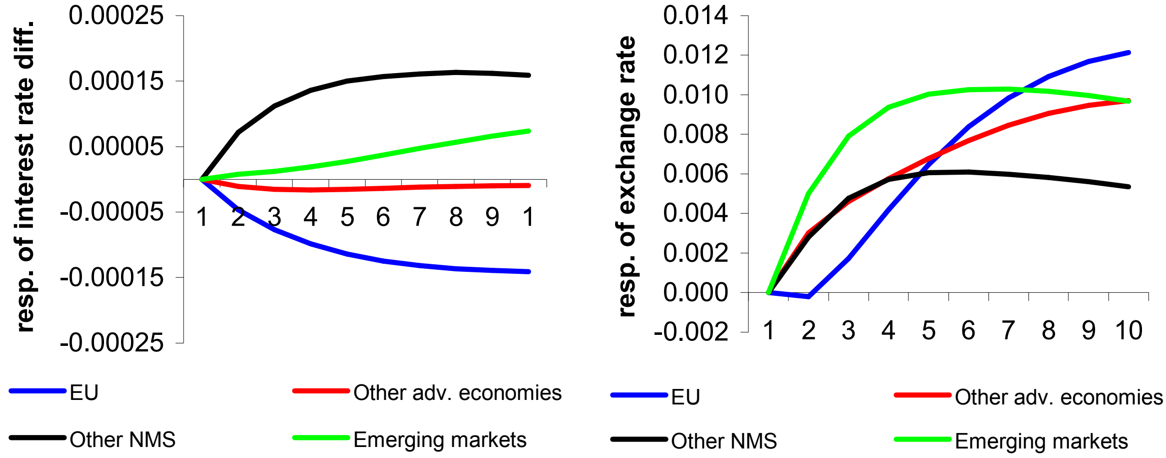



**Figure 3.3.7b Impulse responses in Hungary**

*Interest rates relative to Germany* *Exchange rate*

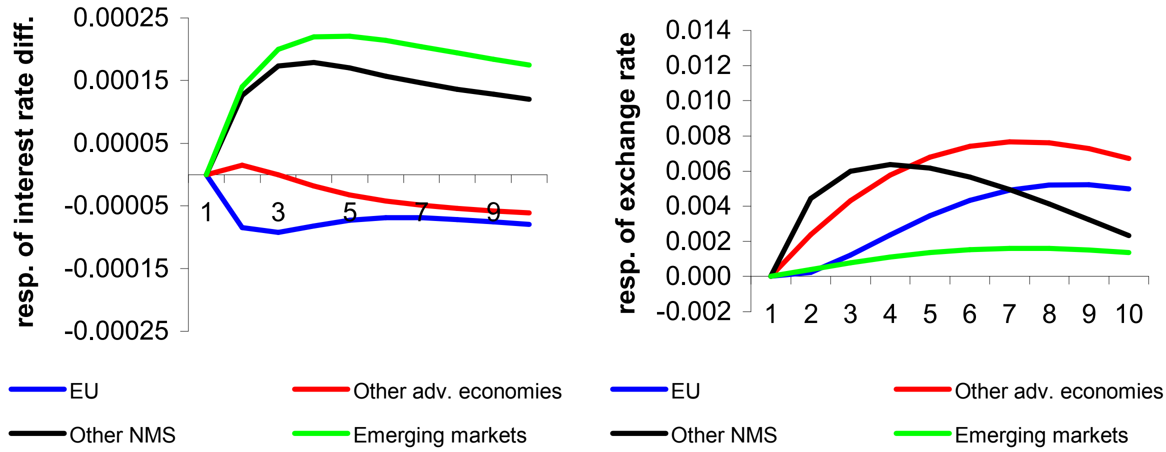


**Figure 3.3.7c Impulse responses in Czech Republic**

*Interest rates relative to Germany* *Exchange rate*

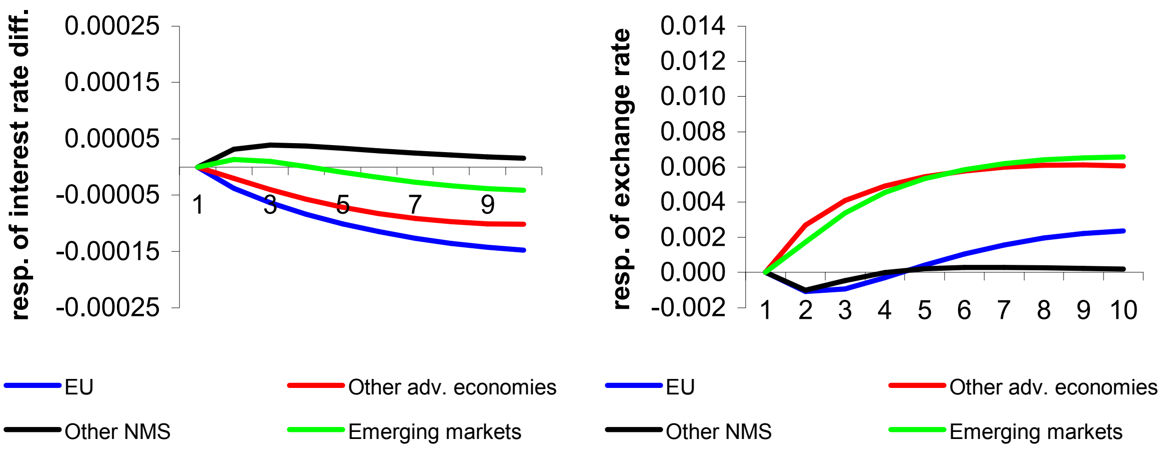



**Figure 3.3.7d Impulse responses in Romania**

*Interest rates relative to Germany* *Exchange rate*

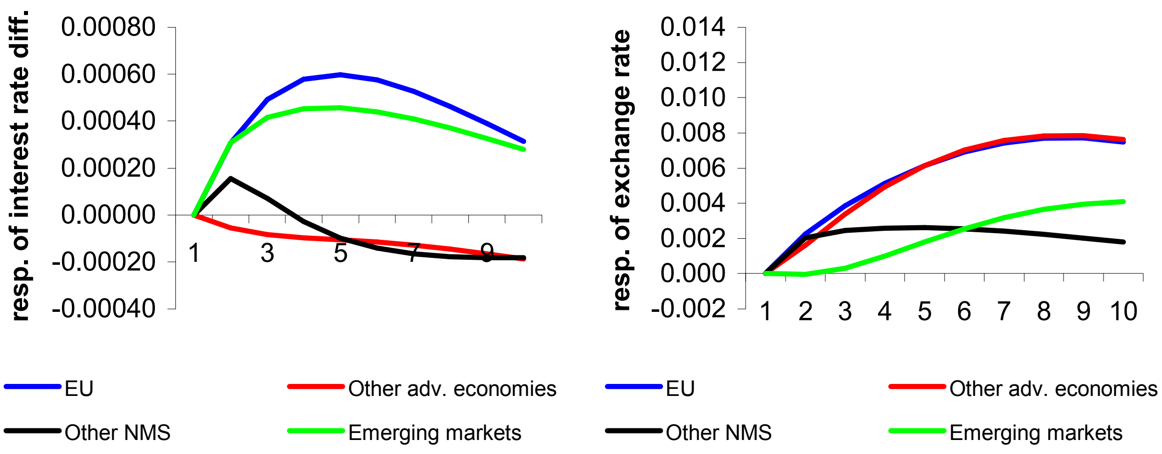



**Figure 3.3.7e Impulse responses in Slovakia**

*Interest rates relative to Germany* *Exchange rate*

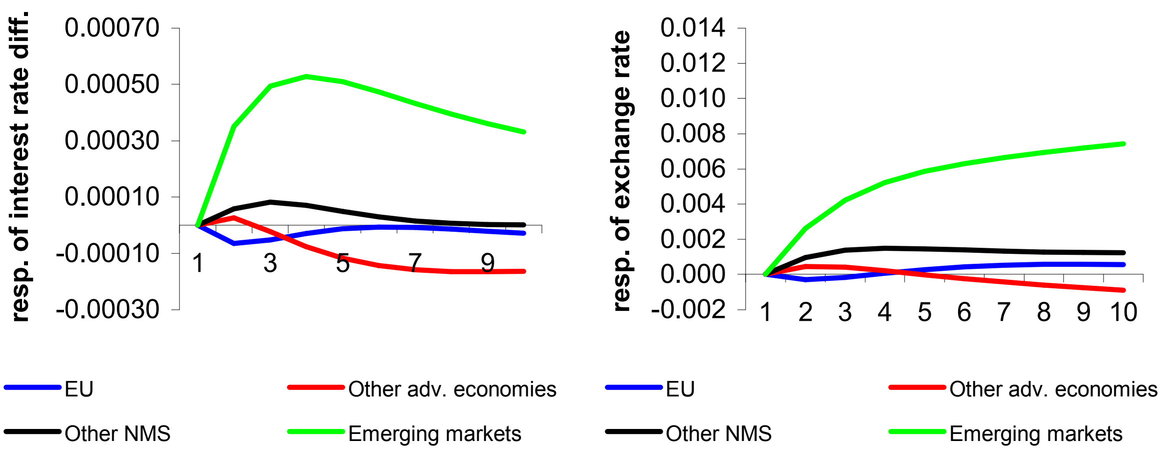


**Figure 3.3.7f Impulse responses in Lithuania**

*Interest rates relative to Germany* *Exchange rate*

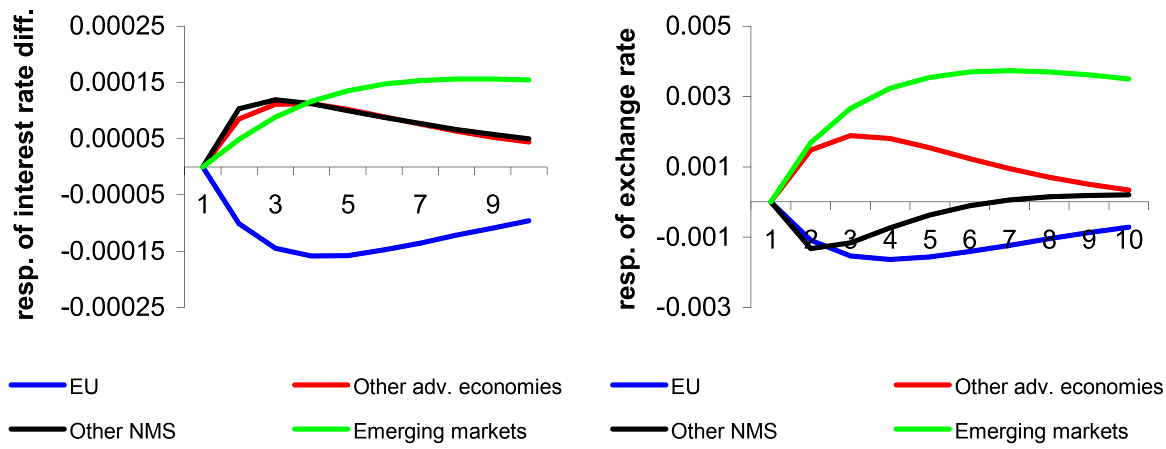



**Figure 3.3.7g Impulse responses in Latvia**

*Interest rates relative to Germany* *Exchange rate*

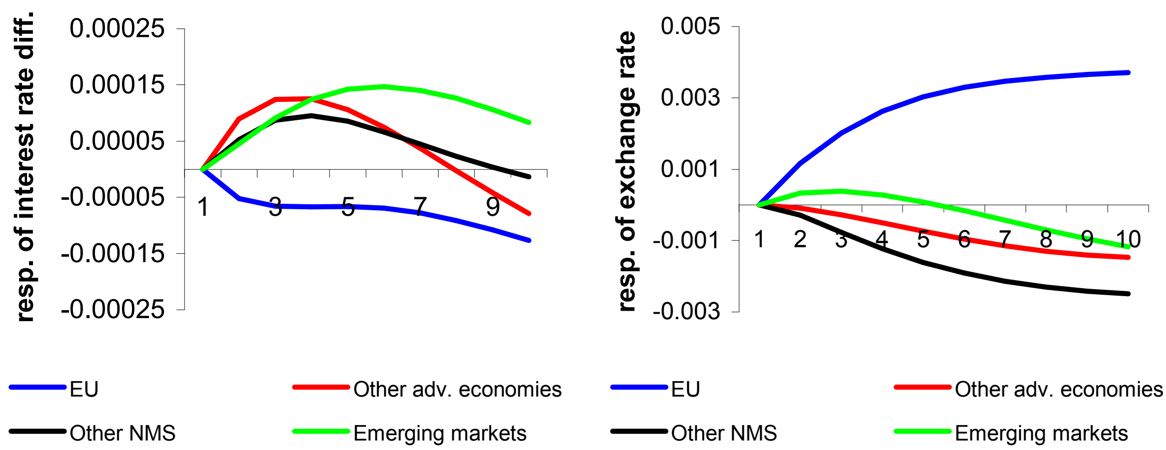



**Figure 3.3.7h Impulse responses in Bulgaria**

*Interest rates relative to Germany* *Exchange rate*

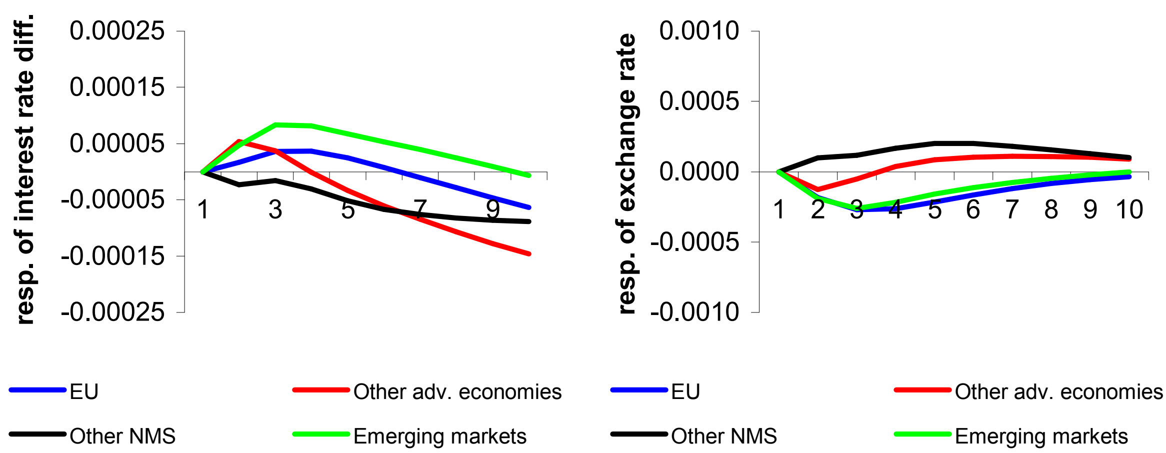
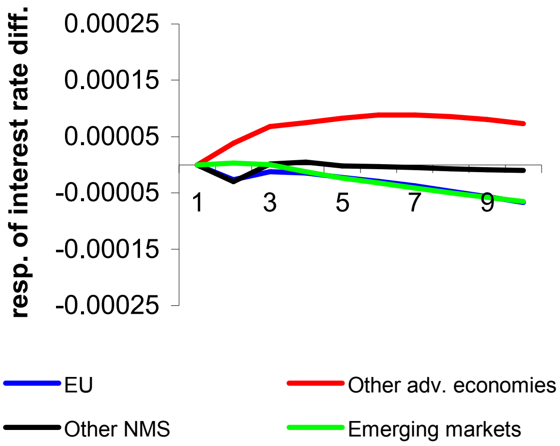


**Figure 3.3.7i Impulse responses in Estonia**

*Interest rates relative to Germany*




The magnitude of the exchange rate response to shocks originating in non-European advanced economies is broadly the same in the four economies that maintain flexible exchange rate regimes, with little response or a decline in relative interest rates. The Hungarian and Romania exchange rates seem less responsive to emerging market shocks, however, the interest rate differentials are relatively more sensitive, suggesting a similar sensitivity of the exchange rate risk premia themselves. Poland and Hungary are both relatively sensitive to shocks originating in the other NMS, while Romania and especially the Czech Republic are relatively insensitive to local shocks. The Czech Republic is also relatively insensitive in response to European shocks, or may even exhibit a decline in the exchange rate risk premium. Romania is highly sensitive to the EU shocks, while it is unclear whether the depreciation of the exchange rate offsets the decline in relative interest rates in Poland the Hungary. In general, interest rates in Romania are more sensitive than those in the other economies, as might be expected given the volatility of nominal exchange rates discussed above.

We include the exchange rate in this analysis even for those countries with fixed exchange rate regimes, as the fluctuation bands in most countries do allow some volatility. The exception is Estonia, where exchange rate variation is so minimal that it is essentially a constant, and we received a singular matrix error when it was included. However, the magnitude of exchange rate response is small, especially in Bulgaria. Slovakia was relatively sensitive to developments in emerging markets, with little response to developments in other regions. Interest rates in Bulgaria, Latvia and Lithuania are also more sensitive to shocks in emerging markets than in other regions. Estonian interest rates show very little response to shocks originating in any region except non-European advanced economies, suggesting a relatively stable exchange rate risk premium. Bulgaria also appears to have a relatively stable exchange rate risk premium, while the Latvian exchange rate exhibited some response to European shocks and the Lithuanian exchange rate risk premium is affected by shocks to other advanced economies.

While the figures omit the standard error bands for reasons of space, in table 3.3.2 below we give the impulse response after 10 periods divided by its analytic standard error to give an indication of the confidence intervals around each estimate. The exchange rate responses tend to be relatively better defined than interest rate differentials in the economies with floating exchange rates.

**Table 3.3.2 Impulse response adjusted by standard error**

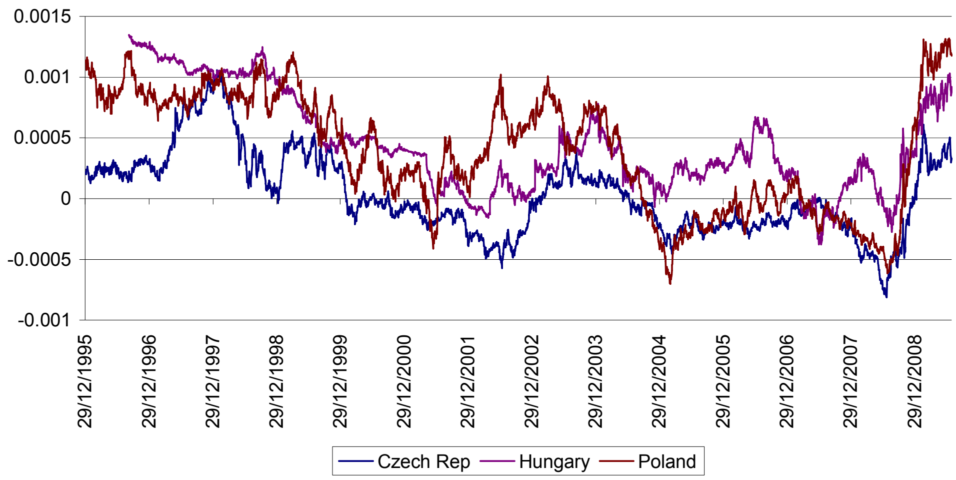
| | Interest differential | | | | Exchange rate | | | |
|---|---|---|---|---|---|---|---|---|
| | Advanced | Emerging | European | NMS | Advanced | Emerging | European | NMS |
| **Poland** | 0.12 | -0.99 | 1.74 | -2.01 | -2.06 | -2.15 | -2.45 | -1.13 |
| **Hungary** | 0.66 | -2.92 | 0.90 | -1.69 | -2.32 | -0.76 | -1.82 | -1.07 |
| **Czech Republic** | 2.13 | 1.07 | 3.22 | -0.43 | -1.83 | -2.50 | -0.73 | -0.07 |
| **Romania** | 0.52 | -1.22 | -0.98 | 1.01 | -1.22 | -0.90 | -1.38 | -0.47 |
| **Slovakia** | 1.17 | -2.37 | 0.18 | -0.01 | 0.31 | -2.60 | -0.18 | -0.58 |
| **Lithuania** | -0.54 | -1.71 | 1.07 | -0.89 | -0.20 | -1.86 | 0.38 | -0.17 |
| **Latvia** | 1.05 | -1.23 | 1.79 | 0.28 | 0.51 | 0.42 | -1.31 | 1.15 |
| **Bulgaria** | 2.98 | 0.15 | 1.35 | 1.74 | -0.83 | 0.01 | 0.47 | -1.17 |
| **Estonia** | -1.14 | 1.41 | 1.37 | 0.23 | -0.84 | 0.88 | 0.86 | 0.56 |

### 3.3.6 Exchange rate risk premia

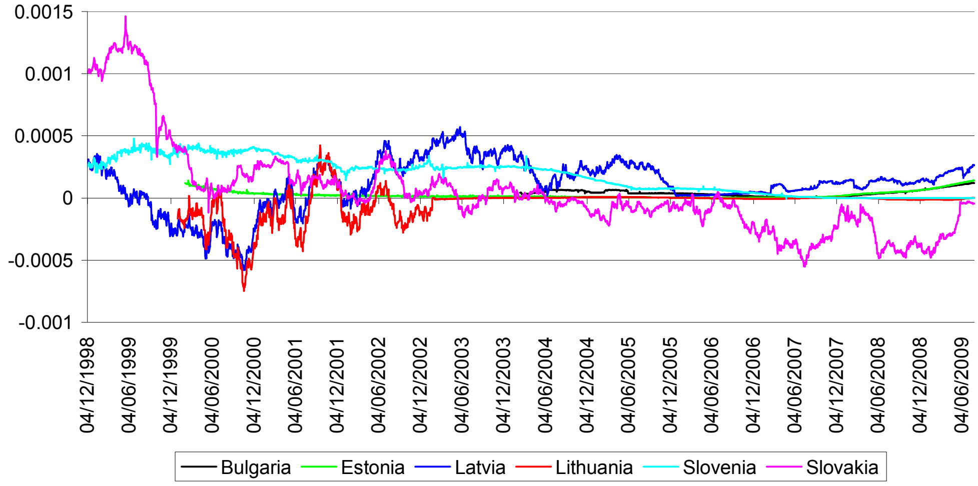
While the analysis above allows us to identify some sources of contagion in NMS exchange rate risk premia, it is also instructive to look at the movement in the level of risk premia over time. We can invert equation 3.3.1 in order to derive an expression for the risk premium plus the error component. If we use the assumption that the error term is independently and identically distributed, averaged over a large sample period this can be assumed to revert to a constant term. In order to maximize our sample, we use daily data for 3-month interbank interest rates and spot exchange rates to calculate an implied risk premium plus error component for each of the NMS. We then take a one-year rolling average of this series to net out the error component (or at least the part of the error that is i.i.d.).

Figures 3.3.8a-c plots these estimates of exchange rate risk premia in the three largest NMS economies, in the economies with fixed exchange rates and in Romania (with Poland included as a comparator), which requires a different scale due to its high risk premium in the early part of our sample. In looking at these charts, we should bear in mind that we cannot read much into the absolute level of the calculated series, but only their movement over time. A negative value, therefore, is not necessarily indicative of a negative risk premium, and we cannot strictly compare levels across countries.

## Figure 3.3.8a  Exchange rate risk premia in the largest NMS

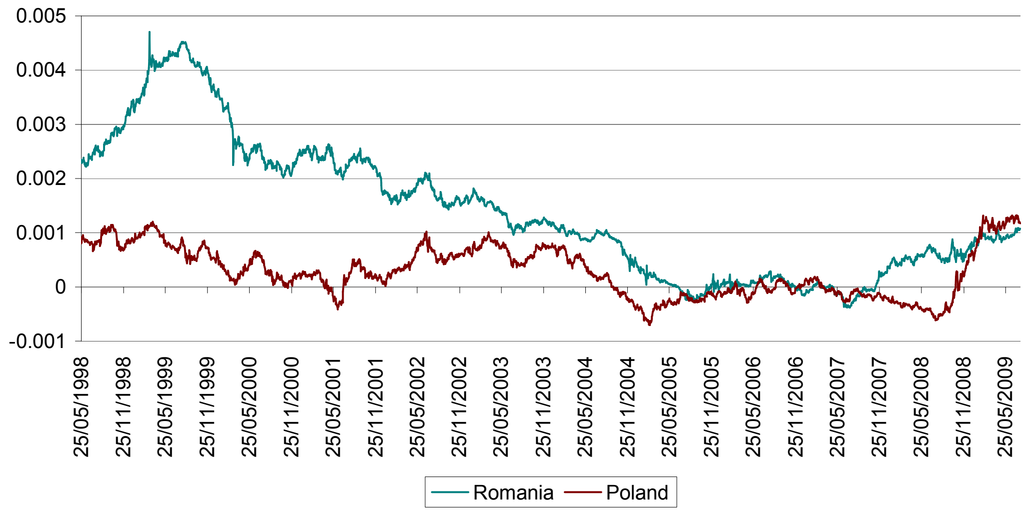



## Figure 3.3.8b  Exchange rate risk premia under fixed regimes




DataStream and NIESR calculations

## Figure 3.3.8c  Exchange rate risk premium in Romania



Exchange rate risk premia were low and stable in most of the NMS over the period 2004-2008. The Hungarian premium rose relative to the other NMS over this period, and there was also a gradual rise in the Latvian risk premium. From early 2007, the exchange rate risk premium in Romania began to increase, suggesting the EU membership did not have a dampening effect on the exchange rate risk premium.

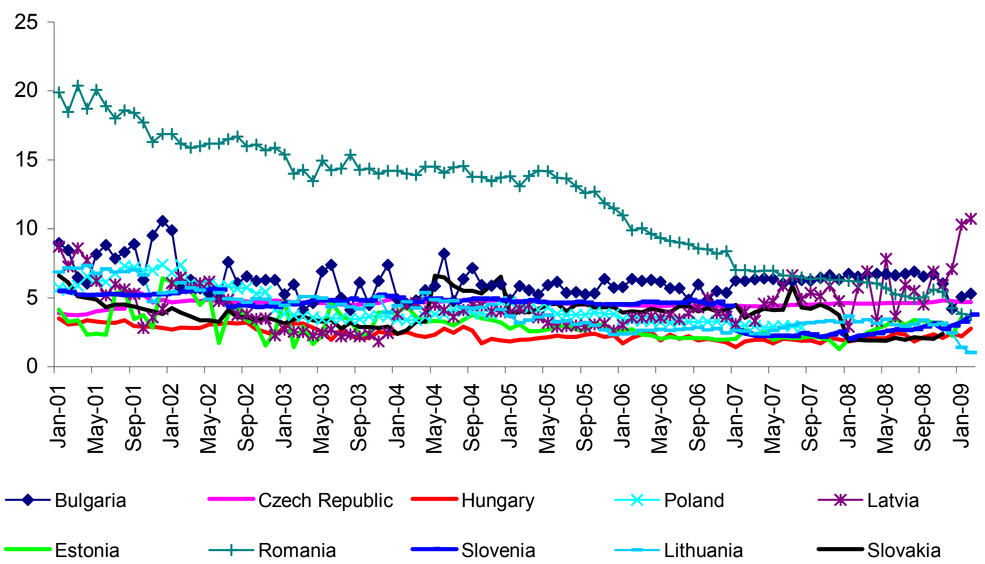
The exchange rate risk premium rose sharply in Poland, Hungary and the Czech Republic in response to the global financial crisis, with the sharpest rise occurring in Poland. This is consistent with the results of our VAR analysis, which finds the Polish exchange rate premium is more sensitive to shocks in advanced economies than the other two. Interestingly, the Romanian risk premium does not seem to have been significantly affected by the crisis. While the Latvian exchange rate risk premium remains low, it has been rising steadily since 2007, and is higher than in the other fixed regime economies. This highlights the sensitivity of the Latvian exchange rate, which has come under pressure recently.

As part of a financial surveillance toolkit, we recommend regular monitoring of exchange rate risk premia in the NMS. Appendix 3c gives details on the calculation of these series.

### 3.3.7 Interest rate spreads

The analysis reported in this section has so far concentrated on interbank interest rates, or the rates banks pay each other in order to borrow cash on a short-term basis. While these are the rates most appropriate for analysing exchange rate arbitrage, it is also of value to look at interest rate spreads within an economy. There are two relevant spreads we consider: the lending wedge, which measures the spread between rates banks charge on money they lend and the rates banks pay on deposits they hold; and the interbank spread over the central bank base rate.

**Figure 3.3.9. Lending wedge**




Source: IMF International Financial Statistics

Figure 3.3.9 shows the lending wedge in the NMS economies since 2001. There are two striking features to observe in this figure. First, the lending wedge in Romania was very high in the early part of our sample, but by the time Romania joined the EU the lending wedge had converged on the level in the other NMS. Second, lending wedges in the other NMS have been remarkably stable over time, and only Latvia has seen a significant rise in the lending wedge in response to the financial crisis. The stability of the lending wedge over time suggests that a majority of loans are arranged with fixed interest rates, so that loan rates can only adjust gradually over time.

The lending wedge feeds into the real economy through personal sector interest income. When the spread widens, the interest income earned by the personal sector declines, dampening consumer spending. This wedge should be analysed in more detail in simulations undertaken with Commission models of these economies.

Figures 3.3.10a-10b show the 3-month interbank rate, the central bank base rate, and the spread between the two in Poland, Hungary, the Czech Republic, Bulgaria and Romania, with the US, Euro Area and UK as comparator countries. As in the rest of the world, this spread increased in the NMS in 2008, due to liquidity shortages in global financial markets. We can divide these countries into two groups. In the first group, spreads remain elevated. This group includes the Czech Republic, Bulgaria, Poland and UK. Interbank markets in these economies remain under strain. Within this group, Bulgaria has the highest level of spread, as about 2.5 percentage points. The second group includes Romania, Hungary, the US and the EU, where interbank spreads have reverted to zero. This suggests that liquidity constraints in financial markets have eased since the onset of the crisis. While Romanian spreads are currently negative, immediately following the collapse of Lehman Brothers last year, Romanian spreads jumped to 8 percentage points, far higher than in any other economy in our sample.

**Figure 3.3.10a Interbank spreads: first group**

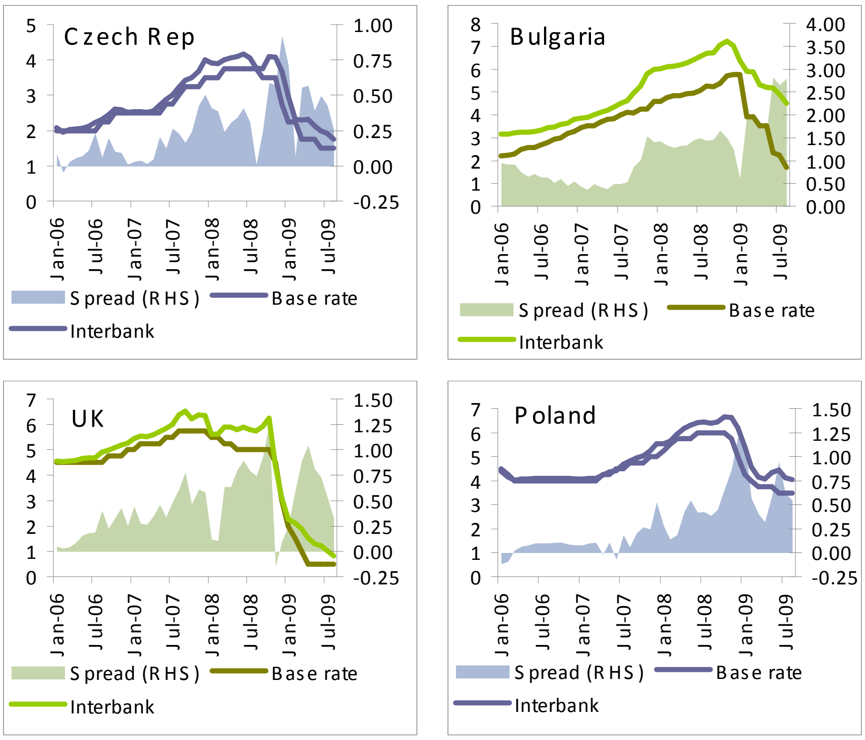
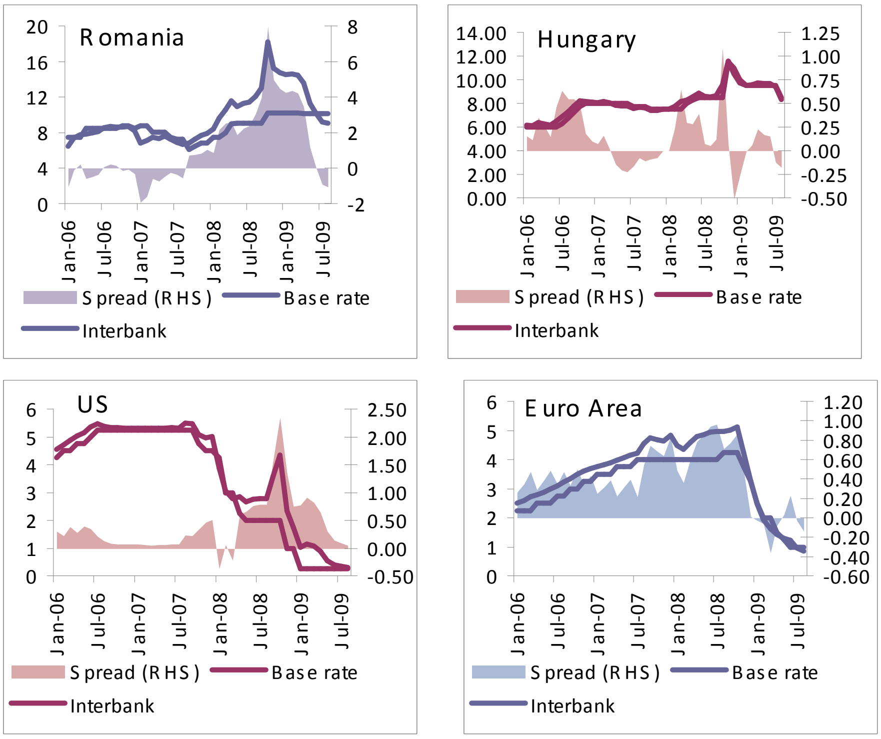


**Figure 3.3.10b Interbank spreads: second group**




In table 3.3.3, we look at the cross-country correlations of interbank spreads. All of the countries in our sample have a positive correlation with spreads in the US and the UK. Except in the case of Hungary, correlations with the Euro Area tend to be weaker, and are negative in the case of Bulgaria, the Czech Republic and Poland. Hungarian spreads clearly behaves differently than spreads in the other NMS economies, and they have weak negative correlations with spreads in Bulgaria, the Czech Republic and Poland. The strongest links within the NMS appear to be between the Czech Republic and Poland, where spreads exhibit an 80 per cent correlation.

**Table 3.3.3 Interbank spread correlations**

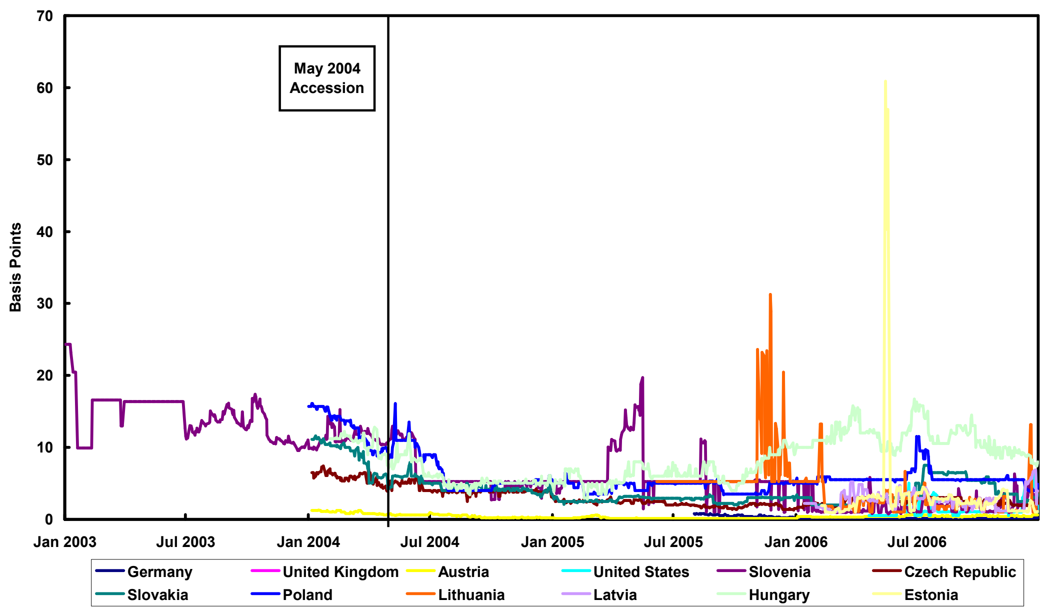
| | Bulgaria | Czech Rep | Hungary | Poland | Romania | Euro Area | UK | US |
|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 1.00 | | | | | | | |
| **Czech Rep** | 0.49 | 1.00 | | | | | | |
| **Hungary** | -0.04 | -0.16 | 1.00 | | | | | |
| **Poland** | 0.60 | 0.81 | -0.23 | 1.00 | | | | |
| **Romania** | 0.38 | 0.63 | 0.19 | 0.64 | 1.00 | | | |
| **Euro Area** | -0.18 | -0.14 | 0.36 | -0.15 | 0.12 | 1.00 | | |
| **UK** | 0.41 | 0.28 | 0.20 | 0.26 | 0.44 | 0.24 | 1.00 | |
| **US** | 0.30 | 0.43 | 0.23 | 0.51 | 0.82 | 0.25 | 0.46 | 1.00 |

### 3.3.8 Credit Default Swaps

Credit Default Swaps (CDS) act as insurance cover for the event of a default on a contractual obligation. The exact definition of a default event is specific to each CDS contract but may include, for example, restructuring interest rates or postponing payment. When a default event occurs, the holder of a CDS is able to claim the notional amount (usually the par value) of the reference obligation from the counterparty of the CDS contract. In exchange, the holder makes regular payments to the counterparty that sum to a fixed percentage of the nominal amount provided no default event occurs during the term of the contract. This percentage is the price (also called spread or premium) in basis points of the notional amount of the reference obligation. In the analysis below, we use the mid-rate premium between the bid- and offer-rate premia reported by the CMA to Datastream for one-year government bonds[19].

The data are daily and run from January 2003 to September 2009. We chart CDS spreads for all NMS for which data are available, together with spreads for the US, UK, Germany and Austria. Since there are almost no data available for 2003, and recent periods of high spreads disguise earlier movements, the sample is split in two: Figure 3.3.11 shows data from January 2003 – December 2006, while Figure 3.3.12 runs from January 2007 to September 2009. In the earlier series, there is clear volatility and high premia relative to the developed countries. There is noticeable decline in the NMS series shortly after they acceded to the EU, suggesting that the accession brought expectations of short-term stability to the sovereign debt markets, but this wore off about 12 months later.

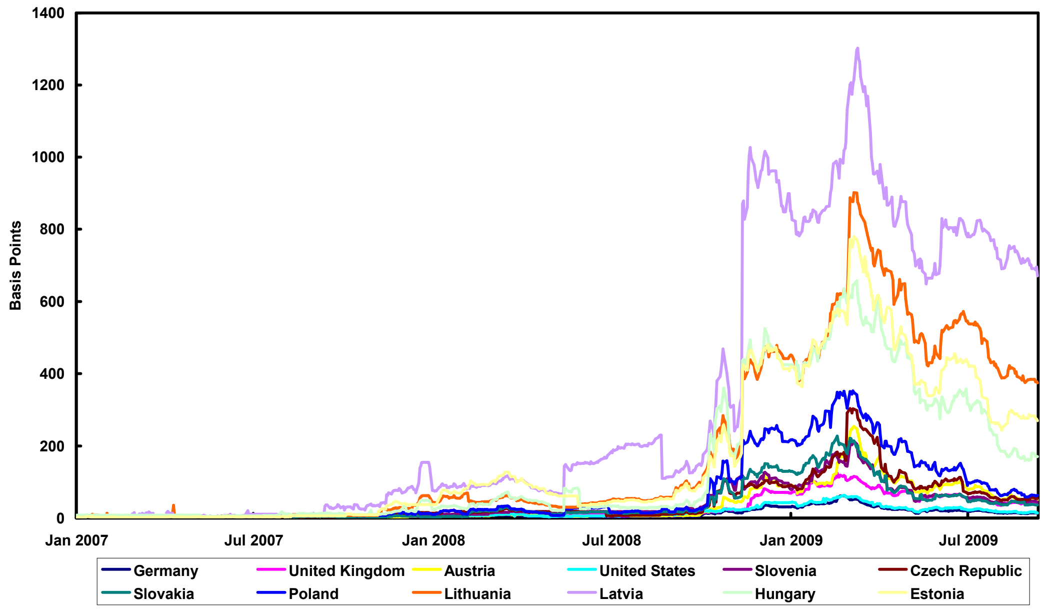
**Figure 3.3.11 Credit Default Swaps (Jan 2003 – Dec 2006)**




DataStream and NIESR calculations

[19] For example, a 400 basis point spread on a one-year CDS with reference par value of $10 million implies the holder will pay the counterparty $400,000 if no default event occurs.

**Figure 3.3.12 Credit Default Swaps (Jan 2007 – Sep 2009)**




DataStream and NIESR calculations

The chart of the latter series shows a dramatic increase in spreads for all countries as a consequence of recent events; although spreads have already fallen somewhat from their highest point in March 2009 and appear to be on a downward trend. Table 3.3.4 reports the absolute (percentage point) and percentage increase in spreads from the average over January 2008 to the average over September 2009 where all economies show a marked rise, though Austria and the UK react more than Germany and the US. For a time, Austria experiences higher spreads than Slovakia, Slovenia, and the Czech Republic, implying that the Austrian government was more likely to default on its obligations than these NMS. By the end of the time-span covered by our data, these four countries together with Poland have converged close to the spreads experienced by the UK. The increase in spreads in absolute terms indicates the change in perceived default risk, and it is very small for Germany and the US, but similar for the UK, Slovenia and Slovakia, whilst it is marginally higher for Poland and the Czech Republic.

**Table 3.3.4 Credit Default Swap Spreads Increase, Jan 2008 – Sep 2009**

| | absolute | % | | Absolute | % |
|---|---|---|---|---|---|
| Germany | 7.7 | 157 | Czech Republic | 40.8 | 210 |
| United Kingdom | 33.3 | 491 | Poland | 53.0 | 276 |
| Austria | 44.3 | 726 | Lithuania | 330.0 | 602 |
| United States | 5.8 | 123 | Latvia | 594.0 | 707 |
| Slovenia | 33.0 | 358 | Hungary | 146.0 | 461 |
| Slovakia | 33.7 | 888 | Estonia | 233.0 | 333 |

These charts imply that markets believe some NMS are significantly more liable to default on their debt obligations than others. Given its stability in other economic dimensions, it is striking that Hungary stands out with the Baltic States as one of those counties more likely to default, although it's not clear whether this reflects economic fundamentals or political attitude towards servicing the debt. The rise in the perceived probability of default is marginally higher in Estonia than in Hungary and noticeably below that in Lithuania. The largest rise in perceived risks, both in absolute and percentage terms is in Latvia, a clear indication that market perceive this economy as facing problems. We turn to this issue below in Chapter 4. At the same time, however, the CDS spreads of several NMS indicate they are as capable as some OMS in their ability to reassure markets of their commitments to fulfil contractual obligations.

As an indicator of contagion, CDS need to be viewed in context. The co-movement of the Baltic States' series may suggest either a co-determination of economic fundamentals which results in mutual reliance in order to meet obligations; or it may reflect a political unity on decision-making within the region that supersedes independent economic ability to avoid default. Since each alternative has a different (and variable) implication for the conduction of crises, careful attention must be paid to the source of these co-movements.

Moreover, on balance, the indication is that NMS are converging to the CDS spreads of OMS and, in the event that they become more closely integrated, it is likely that this convergence will continue. Once again, however, this may reflect either the adoption of OMS' political attitudes to default, or a co-determination of economic fundamentals that underpin each economy's ability to meet its obligations. Most likely, it is a combination of both.

### 3.3.9 Summary

Shifts in exchange rate risk premia can be effected either through the exchange rate or through the domestic interest rate relative to foreign interest rates. A fixed exchange rate regime in the NMS does not itself eliminate the premium, as interest rates can still come under pressure so long as the currency is not formally integrated into the Euro Area. We recommend monitoring the volatility of interest rates in the NMS with fixed exchange rate regimes, as a rise in volatility may indicate pressure on the exchange rate, which could eventually force a devaluation. Interest rate volatility has been elevated in Latvia since 2007, and rose sharply in 2009, indicating severe pressure on the exchange rate. Regular monitoring on interest rate volatility would have given advance warning of this vulnerability.

After joining EMU, the Euro Area exchange rate risk premium replaces the country-specific premium, insulating the economy against idiosyncratic shocks. While all of the NMS economies are obliged to ultimately join the Euro Area, Poland, Hungary, the Czech Republic and Romania all retain flexible exchange rate regimes, while Bulgaria remains outside ERM II, despite pegging the exchange rate to the euro. While a fixed exchange rate regime does not eliminate the exchange rate risk premium, the NMS with flexible regimes have tended to have higher risk premia than those with fixed regimes, and may be more susceptible to contagion from abroad.

The exchange rate risk premium should depend on domestic variables such as expected growth and external debt, and may also be susceptible to contagion effects in response to external shocks. Exchange rates in Poland and the Czech Republic are more sensitive to financial shocks in emerging markets, while interest rates in

Hungary and Romania are more sensitive. The Slovakian exchange rate risk premium was also relatively sensitive to emerging market shocks before joining EMU.

The exchange rate risk premia in Hungary and Poland are more sensitive to shocks originating in other NMS economies, while Romania is more sensitive than in the other NMS to shocks originating in the rest of Europe.

The exchange rate risk premium rose sharply in Poland, Hungary and the Czech Republic in response to the global financial crisis, with the sharpest rise occurring in Poland, reflecting a greater sensitivity to shocks in the US. The Romanian risk premium does not seem to have been significantly affected by the crisis. While the Latvian exchange rate risk premium remains low, it has been rising steadily since 2007, and is higher than in the other fixed regime economies. As part of a financial surveillance toolkit, we recommend regular monitoring of exchange rate risk premia in the NMS. Appendix 3c gives details on the calculation of these series.

## 3.4 Key macro-prudential indicators and their use in surveillance

The literature survey above has helped us to identify some of the key macro-prudential indicators that policy makers should monitor in order to identify heightened risks of a financial crisis. A particular guide in finding such indicators is the IMF list of Financial Soundness Indicators (FSIs), but we do not consider it exhaustive and so we do not confine ourselves to it.

Accordingly, after a section which assesses the generic features of financial instability, we review the behaviour of some of the key macroprudential indicators in the NMS over the last few years. We distinguish between indicators that highlight vulnerability in the banking sector, the household sector and the corporate sector. Some of these key indicators act as inputs into EWS models, as discussed and presented in Section 7. Other additional indicators have not generally been used in empirical modelling work, primarily due to a lack of accessible data across a broad range of countries and relatively short time series. They can still be used in qualitative analysis as used by a variety of central banks and international institutions, so called "macroprudential surveillance", aspects of which are summarised at the end of this section.

### 3.4.1 An overview – generic features of financial instability

The usefulness of any form of financial stability surveillance is based on the generic nature of financial instability. As outlined in Davis (2002, 2009a), there is a growing realisation that financial crises are not random events but share key common features. As highlighted in Table 3.4.1, there are both exogenous and endogenous aspects.

The process often starts with a primary shock to the economy and financial system that is favourable to growth and investment. But this leads to a process of propagation, whereby there is a build-up of vulnerability in the economy and financial system, associated with overextension of balance sheets and build up of financial imbalances. Price based measures of asset values rise and price based measures of risk fall. Balance sheets grow, short term funding increases and leverage falls. These exacerbate the boom and can lead to a crisis when a secondary (adverse) shock hits a vulnerable financial system. In turn, there is further propagation in a crisis period (systemic risk) that typically entails policy reactions if the crisis is sufficiently severe, and considerable adverse economic consequences (the "costs of instability").

**Table 3.4.1. Generic features of financial instability**

| Phase of crisis | Nature | Example of features |
|---|---|---|
| Primary (favourable) shock | Diverse | Deregulation, monetary or fiscal easing, invention, change in market sentiment |
| Propagation - build-up of vulnerability | Common – main subject of macroprudential surveillance | New entry to financial markets, Debt accumulation, Asset price booms, Innovation in financial markets, Underpricing of risk, risk concentration and lower capital adequacy for banks, Unsustainable macro policy |
| Secondary (adverse) shock | Diverse | Monetary, fiscal or regulatory tightening, asymmetric trade shock |
| Propagation – crisis | Common | Failure of institution or market leading to failure of others via direct links or uncertainty in presence of asymmetric information – or generalised failure due to common shock |
| Policy action | Common – main subject of crisis resolution | Deposit insurance, lender of last resort, general monetary easing |
| Economic consequences | Common – scope depends on severity and policy action | Credit rationing and wider uncertainty leading to fall in GDP, notably investment |

Source: Davis (2009a)

Equally, in the past decade, awareness has grown that while traditional banking crises remain a major manifestation of financial instability, especially in emerging market economies as in the NMS, there are alternative forms of crisis that may equally lead to systemic consequences. These are related to the ongoing securitisation of financial systems. One is extreme market price volatility after a shift in expectations (see Davis 2002). Whereas violent price movements may in themselves not have systemic implications , these may emerge when such movements threaten institutions that have taken leveraged positions on the current levels of asset prices. Currency crises, a subset of these, may sharply affect banking systems, giving rise to "twin crises" (Kaminsky and Reinhart 1999) as in Asia in 1997 and Argentina in 2001.

There may instead be protracted collapses of debt or derivatives market liquidity and issuance (see Davis 1994). The risks are acute not only for those holding positions in the market but also for those relying on the market for debt finance or liquidity – which increasingly include banks. The Russia/LTCM crisis of 1998 and, particularly, the US Sub-Prime crisis of 2007-8 showed that these market-liquidity crises are recurrent features of modern financial systems, and given the structure of the modern financial system they rapidly can shift across borders (Barrell and Davis 2008, Davis 2009b). The Sub-Prime crisis has shown that interbank market liquidity can be highly vulnerable as well as that of securitised debt markets. Periodic collapse has been a feature of international interbank markets (Bernard and Bisignano 2000) but had hitherto been less common in domestic interbank markets.

### 3.4.2 Vulnerability of the banking sector to the financial crisis

In this section we present data on key indicators of banking sector performance. Whereas we are in this version partly using data from international organisations, for the toolkit the data should generally be updated using Bankscope, with weighted average data based on country aggregates, which is employed in Tables 3.4.6-3.4.8. A first FSI for banks is the ratio of non –performing loans to total assets.

**Table 3.4.1. Non-performing loans as a share of total loans**

| | Bulgaria | Czech Republic | Estonia | Hungary | Latvia | Lithuania | Poland | Romania | Slovakia | Slovenia |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 12.5 | 31.5 | 2.4 | na | 18.9 | 17.3 | 23.9 | 37.9 | 41.3 | 9.3 |
| 1996 | 15.2 | 30.6 | 2 | na | 20.5 | 32.2 | 14.7 | 48 | 31.8 | 10.1 |
| 1997 | 13 | 30.2 | 2.1 | 6.6 | 10 | 28.3 | 11.5 | 56.5 | 33.4 | 10 |
| 1998 | 11.8 | 31.5 | 4 | 7.9 | 7 | 12.5 | 11.8 | 58.5 | 44.3 | 9.5 |
| 1999 | 17.5 | 37.8 | 2.9 | 4.4 | 6.2 | 11.9 | 14.9 | 35.4 | 32.9 | 9.3 |
| 2000 | 10.9 | 33.8 | 1.3 | 3.1 | 4.5 | 10.8 | 16.8 | 5.3 | 26.2 | 9.3 |
| 2001 | 7.9 | 14.5 | 1.2 | 3 | 2.8 | 7.4 | 20.5 | 3.5 | 24.3 | 10 |
| 2002 | 5.6 | 9.4 | 0.8 | 4.9 | 2 | 5.8 | 24.7 | 2.3 | 11.2 | 10 |
| 2003 | 4.4 | 5 | 0.5 | 3.8 | 1.4 | 2.6 | 25.1 | 1.5 | 9.1 | 9.4 |
| 2004 | 3.7 | 4.1 | 0.3 | 3.7 | 1.1 | 2.4 | 17.4 | 1.7 | 7.2 | 7.5 |
| 2005 | 3.8 | 4 | 0.2 | 3.1 | 0.7 | 0.7 | 11.6 | 1.7 | 5.5 | 6.4 |
| 2006 | 3.2 | 3.8 | 0.2 | 3 | 0.5 | 1 | 7.7 | 1.8 | 7.1 | 5.5 |
| 2007 | 2.5 | 2.8 | 0.5 | 2.8 | 0.4 | 1.1 | 5.4 | 3 | 2.6 | 3.9 |

Source: EBRD

NPLs should be a central part of a fragility toolkit as they indicate the risks to bank solvency. They are used as an indicator of whether a banking crisis has occurred as in Demirguc-Kunt and Detragiache (2005), and are one of the core FSIs proposed by the IMF. There are also associated risks to household plans for consumption. If non-performing loans increase, risks have risen, and households may find it more difficult to obtain finance. Table 3.4.1 illustrates the path of non-performing loans as a share of total loans in the NMS, going back to the earlier days of transition in 1995.

The share of non-performing loans in all the NMS was very low in 2007 compared to the levels seen in the mid to late 1990s. The data suggest that first signs of the ongoing worsening of the macroeconomic situation in Estonia, Lithuania and Romania, with the first decline in loan performance since the 1990s. This highlights the importance of monitoring this indicator as a potential predictor of a crisis.

In terms of the return on assets (Table 3.4.2), the NMS average is broadly in line with the average for all Emerging Markets, but there remain outliers among the NMS. In particular, Estonia, Latvia and Lithuania show higher ROAs than other countries. This may be indicative of the credit boom underway, which boosted returns but in an unsustainable manner. We note too that foreign ownership of banks in the Baltics increased in 2003, leading to an inflow of capital as well as improved funding. In Slovenia the ROA is very low, by contrast.

**Table 3.4.2 Bank return on assets**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Czech Republic | 1.2 | 1.3 | 1.4 | 1.2 | 1.3 | 1.3 |
| Estonia | 1.7 | 2.1 | 2 | 1.7 | 2.6 | ... |
| Hungary | 1.5 | 2 | 2 | 1.8 | 1.4 | ... |
| Latvia | 1.4 | 1.7 | 2.1 | 2.1 | 2 | 1.6 |
| Lithuania | 1.2 | 1.3 | 1.1 | 1.5 | 2 | ... |
| Poland | 0.5 | 1.4 | 1.6 | 1.7 | 1.8 | ... |
| Slovak Republic | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | ... |
| Slovenia | 1 | 1.1 | 1 | 1.3 | ... | ... |
| **NMS average** | **1.2** | **1.5** | **1.6** | **1.6** | **1.7** | **1.4** |
| **Emerging market average** | **1.3** | **1.5** | **1.6** | **1.7** | **1.8** | **1.9** |

Source: IMF: Cihak and Fonteyn (2009)[20]

Similar results can be seen for the return on equity, as illustrated in Table 3.4.3 below. We note that the NMS on average are consistently above the EME average, which may reflect less saturated banking systems generating higher returns, and rapid growth in credit but also a possibility of relatively low capitalisation, see Table 3.4.4. below. In terms of relative ROEs, there has been a degree of convergence up to 2007, with levels reaching over 20% in most countries. It is notable that the Czech Republic banks maintained this level throughout, suggesting it may be sustainable there, whereas elsewhere it may reflect cyclical factors. The marginal decline in 2008 in the Czech Republic supports this suggestion, in contrast to the more marked fall in Latvia. As for ROA, Slovenia shows lower ROE than the average.

**Table 3.4.3 Bank return on equity**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Czech Republic | 23.8 | 23.3 | 25.2 | 22.5 | 24.5 | 23.7 |
| Estonia | 14.1 | 20 | 21 | 19.8 | 30 | ... |
| Hungary | 19.3 | 25.3 | 24.7 | 24 | 18.1 | ... |
| Latvia | 16.7 | 21.4 | 27.1 | 25.6 | 24.2 | 19.5 |
| Lithuania | 11.8 | 13.5 | 13.8 | 21.4 | 27.2 | ... |
| Poland | 5.8 | 17.1 | 20.7 | 21.9 | 23.7 | ... |
| Slovak Republic | 10.8 | 11.9 | 16.9 | 16.6 | 16.6 | ... |
| Slovenia | 11.9 | 12.5 | 13.8 | 15.1 | ... | ... |
| **NMS average** | **14.3** | **18.1** | **20.4** | **20.9** | **23.5** | **21.6** |
| **Emerging market average** | **12.4** | **15** | **16.6** | **17.7** | **18.9** | **19.3** |

Source: IMF: Cihak and Fonteyn (2009)

[20] Sources: National authorities; and IMF staff estimates (Global Financial Stability Report October 2008). Note: Due to differences in national accounting, taxation, and supervisory regimes, FSI data are not strictly comparable
across countries.

In terms of unadjusted capital adequacy (Table 3.4.4), the NMS banking systems are shown to be weaker. Their average capitalisation is consistently below that in Emerging Markets on average. There is also a downward trend in many countries at least up to 2006. Estonia and the Slovak Republic show the highest levels of capitalisation, which has no doubt helped their robustness in the financial crisis of 2008. Czech banks on the other hand are lowly capitalised, which may on the one hand help to explain the high ROE shown above, and on the other may indicate future risks for financial stability (see for example Barrell et al 2009 which shows for OECD countries that capital adequacy, liquidity and house prices are key risks for financial instability).

**Table 3.4.4 Bank capital ratios (leverage ratio)**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Czech Republic | 5.7 | 5.6 | 5.7 | 6.2 | 5.6 | 6.1 |
| Estonia | 11.3 | 9.8 | 8.6 | 8.4 | 8.6 | ... |
| Hungary | 8.3 | 8.5 | 8.2 | 8.3 | 8.3 | ... |
| Latvia | 8.4 | 8 | 7.6 | 7.6 | 7.9 | 8.4 |
| Lithuania | 9.8 | 8.7 | 7.2 | 7.1 | 7.4 | ... |
| Poland | 8.3 | 8 | 7.8 | 7.6 | 7.4 | ... |
| Slovak Republic | 8.9 | 7.7 | 9.7 | 8 | 10.6 | ... |
| Slovenia | 8.3 | 8.1 | 8.4 | 8.4 | ... | ... |
| **NMS average** | **8.6** | **8.1** | **7.9** | **7.7** | **8** | **7.3** |
| **Emerging market average** | **10.4** | **10.3** | **9.9** | **9.8** | **10** | **10.1** |

Source: IMF: Cihak and Fonteyn (2009)

Table 3.4.5 shows that the Basel risk adjusted capital adequacy ratio shows some similar patterns in that NMS countries are consistently below EMEs, with the shortfall increasing over time. This is indicative of heightened vulnerability to shocks. In individual countries, there are also declines up to 2006-7 in most countries, with capitalisation almost halving in the Slovak Republic. It also fell sharply in Poland from 2004 to 2007. In 2007 only Estonia is significantly above the NMS average. Again, this indicator suggests heightened vulnerability of the banking system in 2007-8.

**Table 3.4.5 Bank risk weighted capital ratios**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Czech Republic | 14.5 | 12.6 | 11.9 | 11.4 | 11.5 | 12.9 |
| Estonia | 14.5 | 13.4 | 11.7 | 13.1 | 14.8 | ... |
| Hungary | 11.8 | 12.4 | 11.6 | 11 | 10.8 | ... |
| Latvia | 11.7 | 11.7 | 10.1 | 10.2 | 11.1 | 12.6 |
| Lithuania | 13.3 | 12.4 | 10.3 | 10.7 | 10.9 | ... |
| Poland | 13.7 | 15.5 | 14.5 | 13.2 | 11.8 | ... |
| Slovak Republic | 22.4 | 18.7 | 14.8 | 13 | 12.4 | ... |
| Slovenia | 11.5 | 11.8 | 10.6 | 11.8 | ... | ... |
| **NMS average** | **14.2** | **13.6** | **11.9** | **11.8** | **11.9** | **12.7** |
| **Emerging market average** | **16.9** | **16.6** | **15.7** | **15.2** | **14.8** | **15.6** |

Source: IMF: Cihak and Fonteyn (2009)

The ratio of net interest income to total income has on average been flat, implying that there has not been major structural changes in the balance of loan and security business for example. Levels reflect financial development to some extent, so for example Bulgaria has a high ratio, reflecting low levels of financial development. Some countries such as Slovakia and Hungary have seen a marked fall in this ratio. Comparing Table 3.4.2, this is partly reflecting the decline in the return on assets.

**Table 3.4.6 Net interest income to total gross income**

| | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Bulgaria | 64.4 | 67.0 | 71.0 | 71.2 | 70.5 |
| Czech Republic | 59.0 | 49.8 | 53.4 | 64.1 | 65.2 |
| Estonia | 62.7 | 59.6 | 56.9 | 61.3 | 64.9 |
| Hungary | 61.0 | 64.9 | 64.1 | 54.3 | 53.0 |
| Latvia | 49.4 | 54.5 | 58.1 | 61.0 | 63.6 |
| Lithuania | 55.6 | 58.2 | 60.0 | 62.0 | 65.2 |
| Poland | 56.4 | 54.7 | 56.7 | 55.9 | 55.5 |
| Romania | 63.9 | 57.7 | 60.3 | 59.5 | 58.1 |
| Slovakia | 69.7 | 65.4 | 56.3 | 48.1 | 41.2 |
| Slovenia | 58.4 | 59.0 | 61.3 | 59.6 | 60.5 |
| **NMS average** | **60.0** | **59.1** | **59.8** | **59.7** | **59.8** |

Source: Bankscope

Table 3.4.7 depicts the cost-income ratios of the banking systems of the NMS. In general the outturn is positive as it declines over time, indicating increasing efficiency. Particularly marked falls are apparent in the Czech Republic, Latvia, Lithuania, Poland and Romania. On the other hand the cost income ratio is flat or rising in Slovakia and Hungary. The level of the cost income ratio in 2007 suggests that the Estonian banking system is particularly efficient, and the Slovak one very inefficient – although the ratio must be interpreted also in cyclical terms since the income figure may be more cyclically dependent than expenses (as e.g. staff expenses are relatively fixed).

**Table 3.4.7 Noninterest expenses to total gross income**

| | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Bulgaria | 61.0 | 63.0 | 61.9 | 57.1 | 57.6 |
| Czech Republic | 82.2 | 67.8 | 62.7 | 60.5 | 57.8 |
| Estonia | 58.2 | 52.1 | 52.9 | 49.8 | 47.1 |
| Hungary | 68.1 | 60.5 | 63.4 | 64.4 | 71.1 |
| Latvia | 69.1 | 61.7 | 54.6 | 53.3 | 52.8 |
| Lithuania | 73.5 | 71.7 | 70.8 | 59.6 | 53.4 |
| Poland | 86.0 | 73.9 | 67.1 | 63.4 | 59.5 |
| Romania | 78.6 | 66.4 | 69.6 | 69.0 | 69.2 |
| Slovakia | 74.0 | 64.0 | 75.1 | 71.8 | 76.4 |
| Slovenia | 76.2 | 77.0 | 76.3 | 71.4 | 68.1 |
| **NMS average** | **72.7** | **65.8** | **65.4** | **62.0** | **61.3** |

Source: Bankscope

A final table for the banking system depicts the ratio of liquid assets to total assets, which is a key indicator of liquidity risk. Over the period 2003-7, it is apparent that banks have tended to reduce their liquid assets in the NMS, from an average of 16% in 2003 to a mere 9% in 2007. In 2007, very low levels of liquid assets are apparent in Hungary and Slovenia, indicating major liquidity risk. Of course, there is an alternative source of liquidity which is the wholesale funding market, but the 2007-8 crisis showed the limitations of reliance on this (Davis 2009b). Liquidity has been maintained at higher levels in the less developed financial systems of Romania and Bulgaria, although declines are apparent even there.

**Table 3.4.8 Liquid assets to total assets**

| | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Bulgaria | 13.6 | 15.8 | 17.8 | 14.5 | 13.0 |
| Czech Republic | 16.1 | 9.8 | 15.3 | 10.4 | 7.7 |
| Estonia | 13.3 | 13.6 | 15.4 | 7.8 | 6.1 |
| Hungary | 8.8 | 8.4 | 7.5 | 5.8 | 3.9 |
| Latvia | 14.3 | 11.6 | 10.9 | 12.7 | 11.7 |
| Lithuania | 21.7 | 8.0 | 9.3 | 13.7 | 9.6 |
| Poland | 13.7 | 15.4 | 12.8 | 12.8 | 10.2 |
| Romania | 19.2 | 22.8 | 20.9 | 19.9 | 16.7 |
| Slovakia | 34.8 | 33.8 | 16.3 | 15.0 | 11.0 |
| Slovenia | 6.6 | 5.7 | 5.7 | 2.8 | 1.6 |
| **NMS average** | **16.2** | **14.5** | **13.2** | **11.5** | **9.1** |

Source: Bankscope

### 3.4.3 Vulnerability of the household sector to the financial crisis

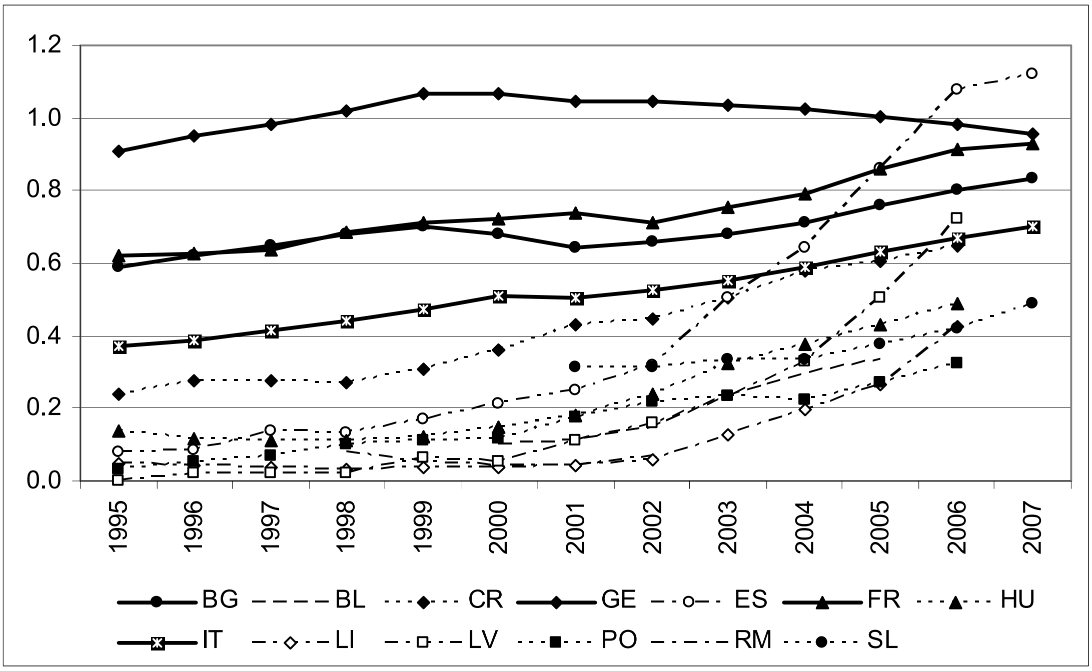
One of the FSI proposed by the IMF is the household debt to GDP ratio. As we discuss in the literature survey, a number of studies have highlighted the link between rapid private sector credit growth and financial fragility. The level of private credit to GDP is an important correlate of crises for two reasons. Firstly, the variable is a proxy for institutional development in an economy since increased credit relative to output is more likely to be associated with competitive banking systems that multiply credit via securitisation and other forms of financial engineering. Conversely, in countries where intermediation is less evolved, credit to GDP levels will be lower. The second reason why this variable is important arises from the observed association of rapid credit growth with previous banking crises. High credit to GDP will arise if either banks lend excessively relative to output or if for a given level of lending, output declines. In the first case, usually associated with a boom, risk is underpriced which increases financial fragility, whilst in the latter case a decline in GDP growth may increase the rate of defaults or non-performing loans.

Over recent years household indebtedness has been growing rapidly in a number of Central and Eastern European countries. The expansion of household debt observed in the new members of the EU may result from two factors: the convergence process - in which case the expanding indebtedness constitutes a necessary element of the long term macroeconomic equilibrium - and short term borrowing trends driven by the business cycle - which may result in credit booms, posing risks of overheating to the economy. In order to investigate these issues, we first look at the evolution of personal sector debt stocks in the NMS, and we then go on to discuss the rise of foreign currency borrowing and the risks associated with this. Increases in borrowing from these two sources may have fuelled house price increases, and we discuss these in detail.

### 3.4.3.1 Personal Sector Indebtedness

Figure 3.4.1 shows the ratio of personal sector debt to personal income in ten new member states: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, Slovakia, and four economies of the Euro Area: Belgium, France, Germany and Italy. In general debt to income ratios are higher in richer countries. The developments in the NMS can be a combination of structural changes following from the transition process, increases in debt to income ratios that result from relatively rapid income growth and also from excessively rapid deregulation.

**Figure 3.4.1. Personal sector debt to personal income ratios**




Note: BG=Belgium, BL=Bulgaria, CR=Czech Republic, GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PO=Poland, RM=Romania, SL=Slovenia

Source: EUROSTAT

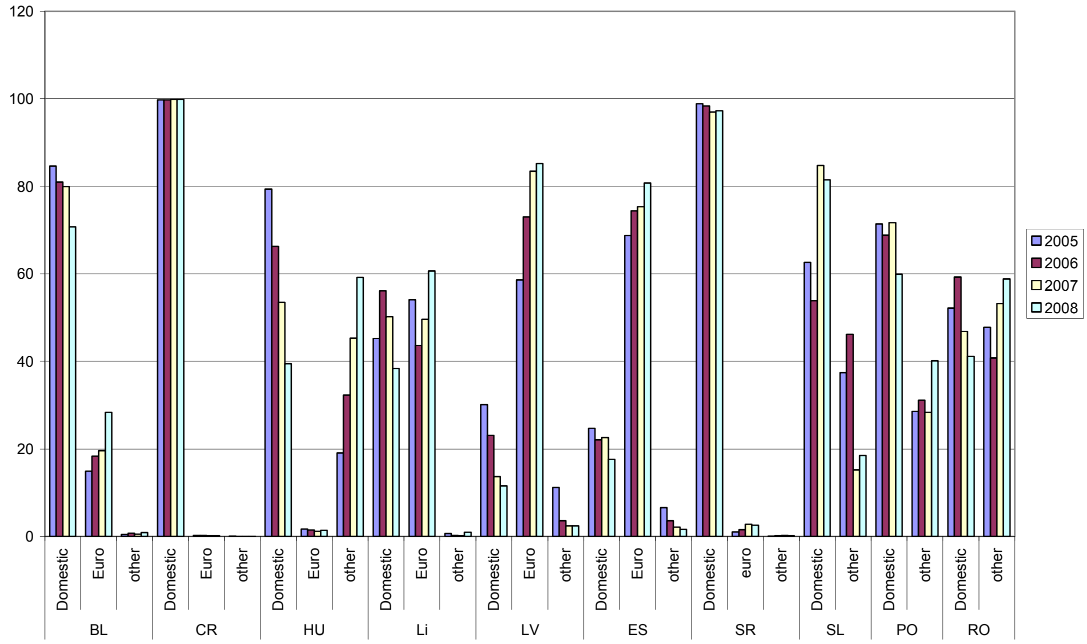
The figure illustrates that debt levels in the new member states' have been rising toward levels observed in the old members of the EU (the solid lines illustrate the debt to personal income paths for the four countries of Western Europe, the thin lines correspond to the debt to income trajectories for the new member states). The fastest pace of debt growth has been recorded in the Baltic States. The levels of debt in Estonia and Latvia have reached Western European levels, and in the case of Estonia exceeded all the old member states in our sample by 2006. The rapid debt growth has contributed to the overheating of the Baltic economies, and consequently to the "hard landing" the Baltic countries have been experiencing. The debt to income ratios in Poland, Hungary and the Czech Republic have been increasing relatively moderately. The levels of household debt in countries of Southern Europe, Romania and Bulgaria, although increasing, have remained at low levels, which may be due to a relatively lower level of financial development in these countries.

A separate paper (Barrell et al 2009) builds on the discussion of key household indicators in this section, and develops an empirical model of the household debt to income ratio. The results of this paper indicate that the personal sector debt to income ratio in the new member states has largely evolved in line with its fundamentals - that is GDP per capita, the real interest rate and house prices. There is, however, evidence of a high risk of excessive household indebtedness in Estonia, and also in Hungary in the short- to medium-term, while there is a low risk of excessive household indebtedness in the Czech Republic and Poland.

### 3.4.3.2 Foreign Currency Borrowing

Borrowers in the new member states are also exposed to risks coming from increased, unhedged foreign currency borrowing. Similar risks actually materialised during the SE Asian (1997) and Latin American (1982) crises and were apparent in Italy and the Nordic countries during the early 1990s (Drees et al., 1998 and Rosenberg, 2008). While foreign currency lending allows borrowers to take advantage of lower interest rates and less restricted credit from abroad, it introduces direct risks and indirect risks to both lenders and borrowers, and the magnitude of these risks depends on the borrower, the denominated currency and the domestic currency regime.

**Figure 3.4.2. The currency composition of household debt in NMS**




Note: BL=Bulgaria, CR=Czech Republic, ES=Estonia, HU=Hungary, LI=Lithuania, LV=Latvia, PO=Poland, RO=Romania, SL=Slovenia, SR=Slovakia

Source: national central banks

Figure 3.4.2 shows the currency composition of household debt across countries using central bank sources for each country, whilst Table 3.4.9 gives total household foreign currency borrowing as a proportion of nominal GDP (the ratio of foreign currency loans to total loans is given in Appendix A and a detailed description of the data is given in Appendix C). The table gives an indication of risks faced by households when the domestic exchange rate changes against all other currencies, whilst the currency compositions can indicate specific risks if there is a large share of borrowing in currencies other than the euro, as in Hungary.

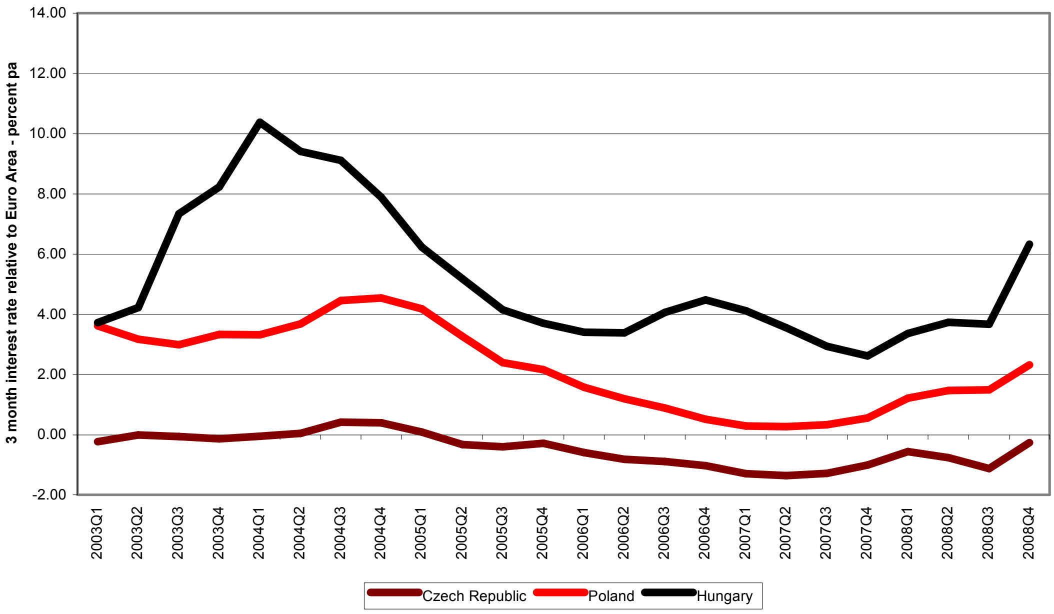
**Table 3.4.9. Household sector's foreign currency borrowing as percent of GDP**

| | BL | CR | ES | HU | LI | LV | PO | RM | SL | SR |
|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 0.01 | 0.00 | 0.13 | 0.01 | 0.03 | 0.10 | 0.03 | 0.00 | 0.03 | 0.00 |
| 2005 | 0.02 | 0.00 | 0.21 | 0.04 | 0.07 | 0.19 | 0.04 | 0.03 | 0.06 | 0.00 |
| 2006 | 0.03 | 0.00 | 0.31 | 0.07 | 0.08 | 0.30 | 0.06 | 0.05 | 0.08 | 0.00 |
| 2007 | 0.05 | 0.00 | 0.35 | 0.11 | 0.13 | 0.35 | 0.07 | 0.09 | 0.03 | 0.01 |
| 2008 | 0.08 | 0.00 | 0.40 | 0.17 | 0.17 | 0.35 | 0.10 | 0.11 | 0.04 | 0.01 |

Note: BL=Bulgaria, CR=Czech Republic, ES=Estonia, HU=Hungary, LI=Lithuania, LV=Latvia, PO=Poland, RO=Romania, SL=Slovenia, SR=Slovakia

Source: National central banks, ECB and Eurostat

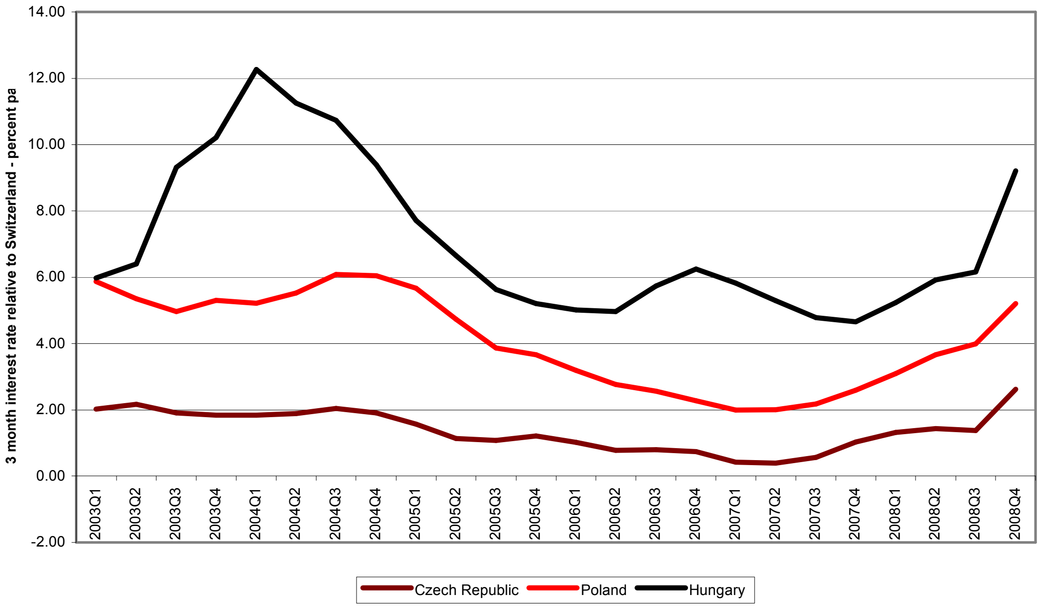
**Figure 3.4.3. Interest rate comparisons to the Euro Area**




Source NiGEM database three month interbank rate differentials

The level of foreign currency borrowing has increased significantly in recent years in the NMS. Taking a loan in foreign currency may be attractive to households in the short run for a lower interest rate, as we can see from Figure 3.4.3 and 3.4.4. Interest differentials against the Euro Area and Switzerland were highest in Hungary, and low or negative in the Czech Republic. Hence the gains from borrowing in euro have been around 4 percent per annum in Hungary in the last few years, much more moderate in Poland and negative for the Czech Republic. The interest differential against Switzerland was even larger, giving a gain of almost 6 percentage points in Hungary. The lack of a differential with the Czech interest rate has meant that there has been no incentive to take on these risks, but for the other countries the 'carry trade' gain could be quite large. In the longer term this will expose them to risks of a depreciation of the domestic currency and an increase in foreign interest rates. As access to foreign currency borrowing is relatively new in these economies, a lack of risk awareness appears to exist among households in many countries and equally among lenders. Insufficient risk awareness has encouraged "herd behaviour" in foreign currency borrowing in some countries, as borrowers followed the borrowing behaviour of others rather than relying on their own risk information (ECB 2006). This type of behaviour can leave economies overexposed to risk.

**Figure 3.4.4. Interest rate comparisons to Switzerland**




Source NiGEM database three month interbank rate differential

The highest level of borrowing in foreign currencies is found in Estonia, although its currency-board supported exchange rate peg is probably the most credible in the region. Foreign currency borrowing as a percent of nominal GDP is almost as high in Latvia, which has a euro peg but no currency board, but is lower in the other Baltic state, which has a currency board and euro-peg, Lithuania. Household borrowing in foreign currency as a proportion of nominal GDP is as high in floating rate Hungary as it is in euro-pegged Lithuania, and hence risks have to be seen as high in Hungary. The growth of borrowing is also worrying in that country. Poland and Romania have less foreign currency borrowing and are less subject to bankruptcy risk in the household sector, and such risks seem to be absent in the Slovak and Czech Republics where foreign currency borrowing is almost completely absent.

The currency structure of household debt varies across countries. The composition of household sector debt is highly biased towards foreign currencies (and the euro in particular) in the Baltic countries. As long as the Baltic States' currencies and Bulgarian lev are pegged to the euro, the borrowers' vulnerability to shifts in exchange rates is limited, although historical experience with such pegs has shown their vulnerability to realignment. Relatively large and unsecured borrowing in foreign currency (and mainly the Swiss franc) characterises the borrowing of the Hungarian household sector. Almost 60 per cent of household debt is denominated in foreign currencies and the recent substantial depreciation of the forint has increased the risk of insolvency of Hungarian borrowers. Households in Poland and Romania also have a relatively high exposure to exchange rate risk.

The accession of Slovenia to the Eurozone has significantly reduced risks to households borrowing in foreign currency, as a large share of the debt was denominated in euro. Almost all loans granted to households in the Czech Republic and Slovakia have been in domestic currency. While there is no explicit regulation that prevents households from borrowing in foreign currencies, there is clearly a strong bias against foreign currency borrowing. This may reflect the early adoption of inflation targeting by the Czech National Bank, as inflation and interest rates in the Czech Republic have been in line with the Euro Area since at least 2000. Once Slovakia entered the Eurozone, the tiny share of euro denominated loans in Slovakia became loans denominated in domestic currency.

The share of borrowing in foreign currencies in New Member States has tended to rise over time. This results from the rising integration of new member states' financial markets with their Western European counterparts, reflected also in the importance of foreign-owned banks. The greater demand for capital resulting from the convergence processes also plays a role. The shortage of capital in domestic markets means that investors tend to borrow in foreign markets, and lower foreign interest rates increase the attractiveness of loans denominated in foreign currency. The interest rate differentials plotted in Figures 3.4.3 and 3.4.4 are major factors taken into account by households, while they apparently disregarded currency risk, or feel that is covered by the carry trade gain.

While the growth of borrowing in foreign currencies is, to some extent, a feature of the catching up process in Europe, the enhanced volatility of New Member States currencies accompanying the recent global financial crisis poses a serious risk to borrowers' solvency. A depreciation of the domestic currency will hamper the repayment capability of households and consequently raise the risk of the default. The exchange rate risk can be exacerbated – or mitigated – by currency regimes within which countries operate. In the case of borrowing in euro, the accession to the Eurozone fully eliminates the exchange rate risk; pegging the domestic currency to the euro in ERM II may reduce the risk significantly. Table 3.4.10 shows the exchange rate regimes in the new member states.

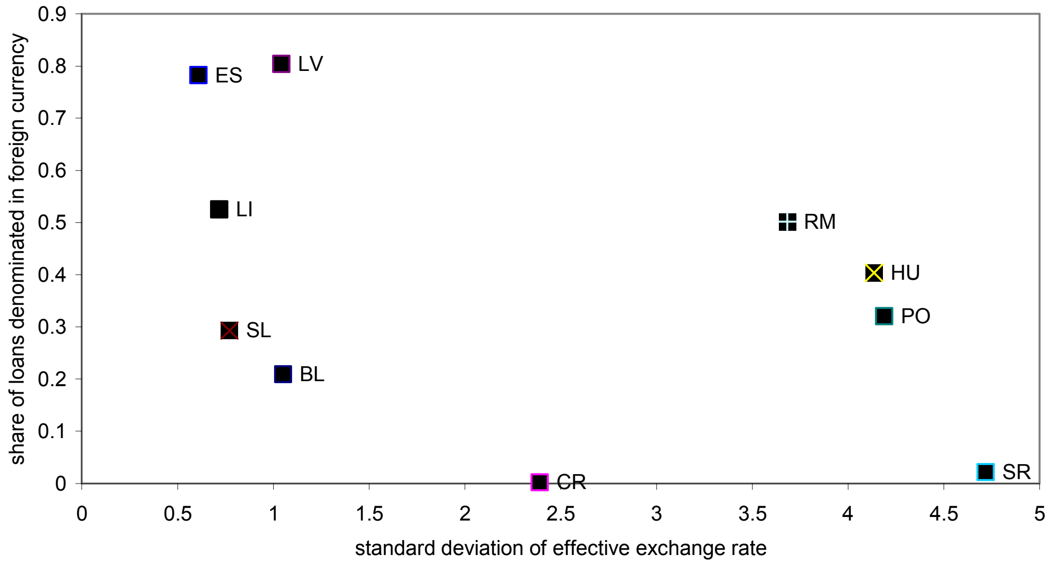
**Table 3.4.10. Exchange rate regimes in the new member states**

| **Regime** | **Country** | | | |
|---|---|---|---|---|
| **EMU** | Slovenia | Slovakia | | |
| **Peg to the Euro** | *Latvia* | | | |
| **Floating exchange rate** | Czech Republic | Poland | Hungary | Romania |
| **Currency Board** | *Bulgaria* | *Estonia* | *Lithuania* | |

(countries in italics fix the central exchange rate)

By joining the euro area, Slovakia practically eliminated the exposure of household debt to exchange rate risk, while Slovenian households retain some debt that may be denominated in currencies other than the euro. The exposure of households in Estonia, Latvia and Lithuania to exchange rate risk is linked to the reliability of the peg to the euro, since most of the foreign currency borrowing is denominated in euro. This is especially true in Latvia which has a peg but no currency board. Historical experience has shown the limitations of the protection of such pegs against foreign exchange exposures, given the potential for realignment. Similar comments apply to the currency board regime that shelters Bulgarian borrowers in foreign currency. Furthermore, as the currency remains outside ERM II they face a greater risk of exchange rate realignment than those in the Baltics do. In countries with floating exchange rates – Poland, Hungary, Czech Republic and Romania – exchange rate risk remains relatively substantial, although households in the Czech Republic face little risk as they have little exposure. In effect, economies with a floating exchange rate and larger shares of borrowing in foreign currency (e.g. Hungary and Romania) may be exposed to serious risks. Figure 3.4.5 shows the relationship between exchange rate volatility and the share of foreign currency borrowing, highlighting the exposure of Hungary, Romania and Poland.

**Figure 3.4.5. Foreign currency borrowing and exchange rate volatility, 2005-2008**




Note: BL=Bulgaria, CR=Czech Republic, ES=Estonia, HU=Hungary, LI=Lithuania, LV=Latvia, PO=Poland, RM=Romania, SL=Slovenia (2005-2006), SR=Slovakia

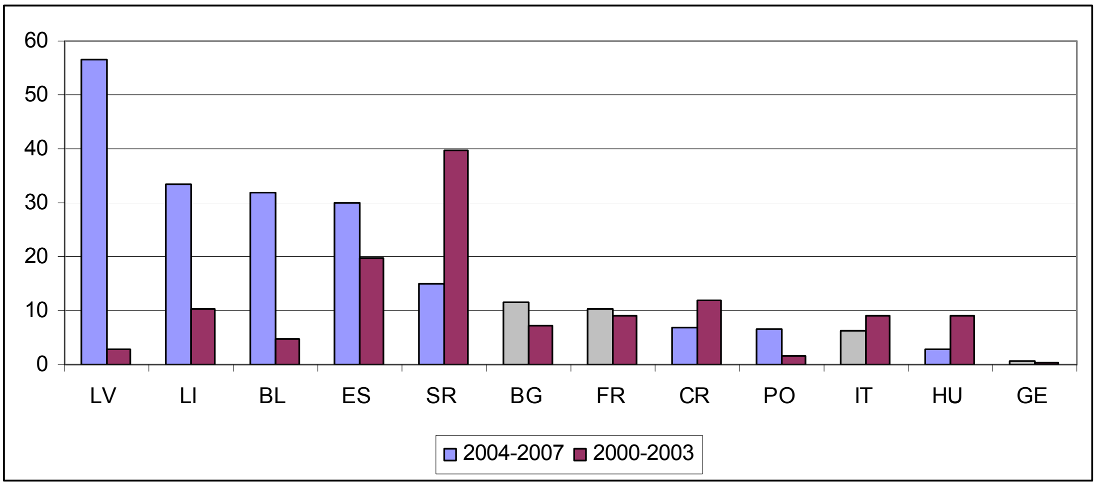
Source: national central banks, NIGEM

### 3.4.3.3 Developments in House Prices

In this section we investigate recent house price developments. As we discuss in the literature survey, rapid growth in asset prices, and real estate prices in particular, is often a precursor to a financial crisis[21], and real estate prices are one of the FSI selected by the IMF. A significant proportion of the rise in personal sector debt has been secured on housing assets. House price bubbles, which should be regarded as a more distorting deviation from equilibrium than a cyclical deviation, may have developed in some of the New Member States, putting household borrowers at serious risk. If lending has exceeded the value of property, as in the UK and the US in the run up to the crisis, then households will become exposed when house prices fall, as the value of their real asset may not be enough to cover the value of their loan. Once the bubble bursts, the level of debt cannot adjust immediately, but may generate significant defaulting on loans, especially when it is associated with periods of high interest rates. Figure 3.4.6 and table 3.4.11 shows growth rates of house prices in new members of the EU and major economies of the Euro Area.

[21] See Allen (2005) for a model of the links between asset price bubbles and financial fragility.

**Figure 3.4.6. House prices growth in the new member states and the major economies of the Euro Area**




Note: BG=Belgium, BL=Bulgaria, CR=Czech Republic, GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PO=Poland, SR=Slovak Republic

Source: ECB

Countries reporting the highest growth of house prices have been the Baltics, where credit growth has also expanded the most rapidly, as well as Bulgaria and Slovakia. Over the period 2000-2007 the average growth rate of house prices in the new member states significantly exceeded the average growth rate of house prices in the selected old members of the EU. The volatility of NMS house price growth also remained higher than that of the old members of the EU; 21.2 per cent in the new versus 3.5 per cent in the old members, where we compute the volatility of house prices growth over the period 2000-2007 and take the average across the new and the old member states.

**Table 3.4.11. House price growth**

| | Bulgaria | Czech Republic | Estonia | Latvia | Lithuania | Hungary | Poland | Slovakia |
|---|---|---|---|---|---|---|---|---|
| 1998 | | | 19.3 | | | | | |
| 1999 | | 9.3 | -0.4 | | | | | |
| 2000 | | 13.5 | 1.6 | | -9.7 | | | |
| 2001 | 0.3 | 9.5 | 34.3 | | 23.8 | | | |
| 2002 | 1.9 | 13.1 | 29.5 | | 9.5 | | | |
| 2003 | 12.2 | 11.4 | 12.9 | 2.7 | 18.1 | 10.9 | | 39.6 |
| 2004 | 47.6 | -0.8 | 27.8 | 2.3 | 9.9 | 9.1 | -6.1 | 15.4 |
| 2005 | 36.5 | 0.6 | 31.0 | 20.0 | 51.7 | 0.8 | 20.0 | -10.3 |
| 2006 | 14.7 | 6.5 | 51.7 | 159.3 | 39.2 | -0.8 | 3.8 | 16.8 |
| 2007 | 28.9 | 21.1 | 10.1 | 45.1 | 33.5 | 1.7 | 45.3 | 23.9 |
| 2008 | 24.9 | | -7.5 | | | | | |

Source: the data were obtained from the ECB (which is gratefully acknowledged)

The higher NMS house price growth rates are partially driven by fundamentals: an acceleration in income growth, relatively low interest rates and higher demand for housing generated by baby boomers of the 1970s entering their prime earning age (Egert and Mihaljek, 2007). These trends are augmented by transition-related factors such as the development of housing markets and housing finance and the greater provision of long term housing loans by banks. In addition, while it is difficult to obtain data on the level of house prices, the available evidence suggests that house prices started at a relatively low level, given the standard determinants of equilibrium house prices such as income and real interest rates. However, strong demand on new member states' housing markets, suggests the possible existence of property price bubbles. The supporting paper develops a framework for assessing house price developments in the NMS for price bubbles. This relies on a comparison of house price developments relative to a filtered trend and house price growth to the rise in the cost of new dwellings. There appears to be some evidence of a house price bubble developing in Estonia between 2000 and 2006.

### 3.4.4 Vulnerability of the corporate sector to financial crises

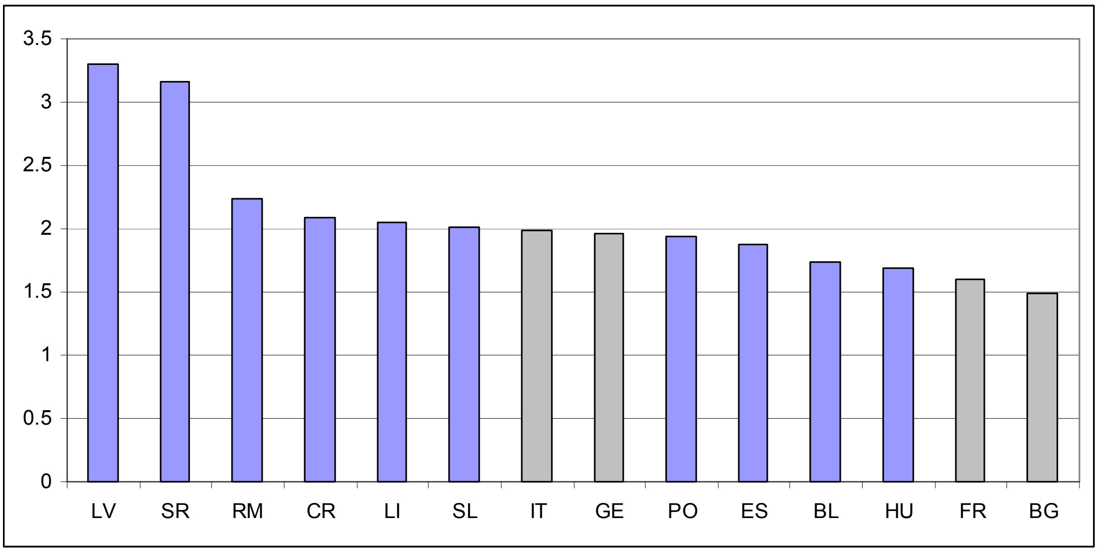
#### 3.4.4.1 Debt to equity ratio

The debt to equity ratio in the business sector, or corporate leverage, is an important predictive factor which may help to assess both the possibility of the crisis and its impact, and is one of the FSI identified by the IMF. It indicates the extent to which businesses finance their activities through liabilities other than their own funds and equity issues. Debt entails interest and principal payments, so high corporate leverage increases the vulnerability of nonfinancial corporations in the event of a shock, and may affect their repayment capacity. In a crisis interest rate margins on debt normally rise, increasing strains on firms who have floating debt or who are refinancing debt fixed. Equity also acts as a shock absorber when prospects turn down, as they do in a crisis. Figure 3.4.7 shows debt to equity ratios for the 10 new members of the EU and 4 comparator countries.

The debt to equity ratio in the corporate sector in new member states varied between 1.5 and 3.5 in 2007. The highest ratios, exceeding the value of 3, were recorded in Latvia and Slovakia, suggesting that the corporate sector in these economies may be vulnerable to a financial shock, especially when borrowing margins rise for a sustained period of time, as they have been doing in the last two years. The debt to equity ratio was lowest in Poland, Hungary, Estonia and Bulgaria, indicating that the corporate sector may be more resilient in these countries.

The debt to equity ratio constitutes one of the informative measures describing the financial standing of a company, potential bankruptcy risk and moral hazard. The value of the indicator for the business sector as a whole may, however, depend also on individual countries' financial structures. In particular, the measure may vary depending on the inclination of firms to borrow funds through the banking system (bank-dominated countries) or to acquire them through the equity market (market-oriented countries). In countries where firms tend to acquire funds through borrowing from banks the ratio of debt to equity for the corporate sector will be higher than in countries where firms tend to finance investments through equity issuance.

**Figure 3.4.7. Debt to equity ratio in 2007**

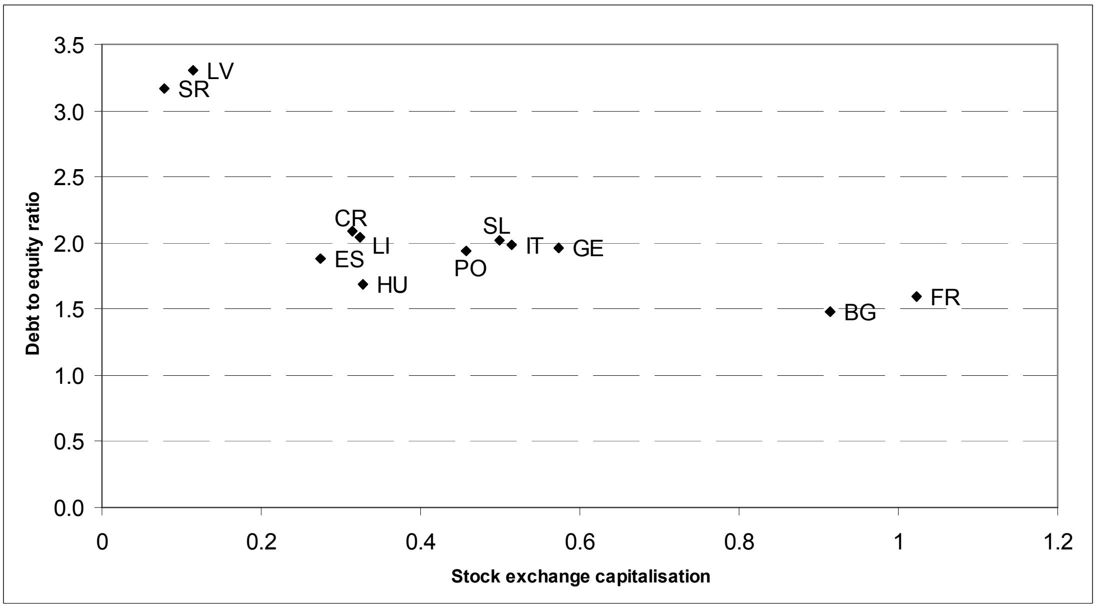



Note: BG=Belgium, BL=Bulgaria, CR=Czech Republic (in 2006), GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PO=Poland (in 2006), RM=Romania, SL=Slovenia, SR=Slovakia

Source: EUROSTAT

Figure 3.4.8 shows the relationship between the debt to equity ratio and stock market capitalisation as a share of GDP in the new EU members and comparator countries.

**Figure 3.4.8. Debt to equity ratio and stock market capitalisation to GDP**



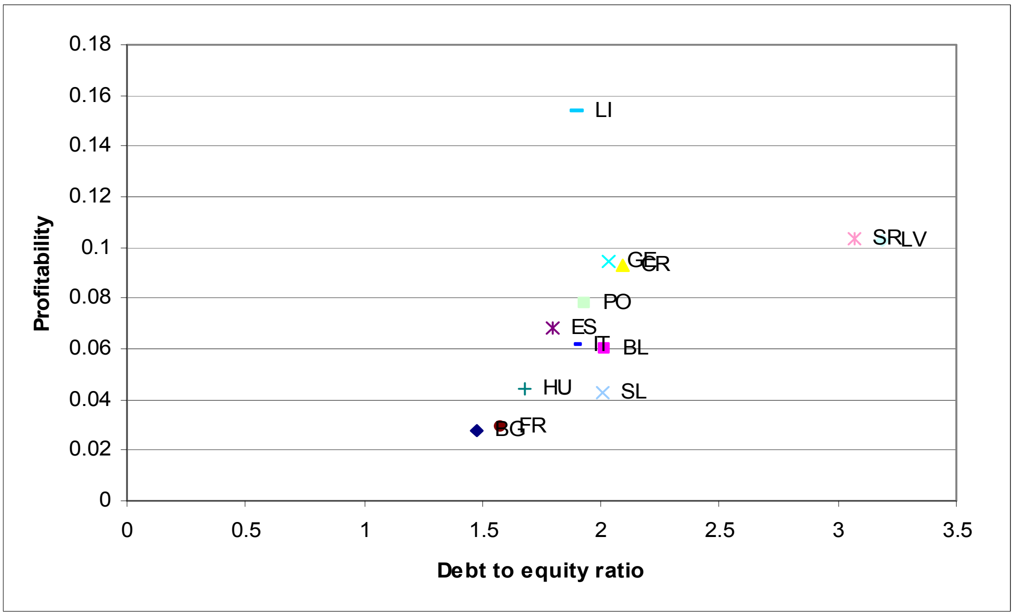

Note: BG=Belgium, CR=Czech Republic, GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PO=Poland, SL=Slovenia, SR=Slovakia

Source: EUROSTAT, NIGEM

A higher stock market capitalisation implies greater depth of financial markets and greater possibilities for firms to raise funds in the equity market. The figure shows that Belgian and French firms prefer to finance their investments through issuance of equities or retained earnings while Italian and German enterprises tend to base their funding on the banking system. Among the new member states Poland and Slovenia have strong equity markets (the capitalisation of the Polish stock exchange is the largest in the region, exceeding also the Austrian stock exchange). The Slovak and Latvian firms are most dependent on the financing through the banking system, with relatively undeveloped stock markets.

As the majority of firms in new member states are financed via the banking system, the profitability of the business sector and the debt to equity ratio are both higher since banks are more eager to lend to creditworthy companies – see figure 3.4.9.

**Figure 3.4.9. Profitability and indebtedness in the corporate sector**




Note: BG=Belgium, BL=Bulgaria, CR=Czech Republic, GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PO=Poland, RM=Romania, SL=Slovenia, SR=Slovakia

Source: EUROSTAT

### 3.4.4.2 Determinants of bankruptcy in the corporate sector

Following the approach developed by Pomerleano (1998), we assess the vulnerability of the corporate sector in the NMS to financial crises from a microeconomic and a macroeconomic perspective. We start by examining financial performance ratios for the corporate sector in individual member states using the methodology developed by Altman (1968). This index is a combination of microeconomic indicators of financial performance usually used to assess the probability of the bankruptcy of a firm. We extrapolate this to the macro level, as an input into a model of the bankruptcy rate of the corporate sector. We estimate an illustrative model of the insolvency rate in the corporate sector in which the insolvency rate depends on both the microeconomic factors proxied by the macro-level Altman index and macroeconomic factors such as GDP growth and volatility of the exchange rate.

The Altman index is a measure that combines five business ratios that are thought to signal the probability of the bankruptcy of a firm: working capital to total assets; retained earning to total assets; earnings before interest and taxes to total assets; market value of equity to book value of total liabilities; and sales to total assets. To compute the Altman index for corporate sectors at an economy wide level, the indicators were approximated by: liquid assets to total assets; balance of primary income to total assets; operating surplus (before taxes) to total assets; equity to debt; market output to total assets[22]. The components of the index, as well as the index itself, should form part of a toolkit for the analysis of financial fragility. The individual components are tabulated below in Table 3.4.12, but as they may move in different directions they may not contain clear information.

**Table 3.4.12 Components of the Altman index**

| 2005 | *Liquid assets to total assets* | *Reinvested profits to total assets* | *Earnings before taxes to assets* | *Equity to liabilities* | *Market output to total assets* |
|---|---|---|---|---|---|
| Belgium | 0.05 | 0.03 | 0.03 | 0.64 | 0.38 |
| Bulgaria | 0.08 | 0.08 | 0.05 | 0.44 | 0.53 |
| Czech Republic | 0.07 | 0.08 | 0.06 | 0.47 | 0.74 |
| Germany | 0.07 | 0.04 | 0.06 | 0.47 | 0.49 |
| Estonia | 0.09 | 0.08 | 0.09 | 0.55 | 0.63 |
| France | 0.03 | 0.03 | 0.03 | 0.60 | 0.32 |
| Hungary | 0.05 | 0.04 | 0.04 | 0.60 | 0.45 |
| Italy | 0.05 | 0.04 | 0.05 | 0.53 | 0.53 |
| Lithuania | 0.07 | 0.07 | 0.12 | 0.54 | 0.61 |
| Latvia | 0.07 | 0.07 | 0.08 | 0.38 | 0.63 |
| Poland | 0.05 | 0.06 | 0.05 | 0.51 | 0.54 |
| Romania | 0.07 | 0.09 | 0.05 | 0.47 | 0.55 |
| Slovenia | 0.04 | 0.05 | 0.03 | 0.50 | 0.51 |
| Slovakia | 0.21 | 0.01 | 0.00 | 0.30 | 0.06 |

| 2006 | *Liquid assets to total assets* | *Reinvested profits to total assets* | *Earnings before taxes to assets* | *Equity to liabilities* | *Market output to total assets* |
|---|---|---|---|---|---|
| Belgium | 0.06 | 0.03 | 0.03 | 0.68 | 0.35 |
| Bulgaria | 0.10 | 0.08 | 0.05 | 0.50 | 0.53 |
| Czech Republic | 0.07 | 0.07 | 0.07 | 0.48 | 0.79 |
| Germany | 0.07 | 0.04 | 0.06 | 0.49 | 0.49 |
| Estonia | 0.08 | 0.06 | 0.08 | 0.56 | 0.56 |
| France | 0.03 | 0.03 | 0.03 | 0.63 | 0.31 |
| Hungary | 0.05 | 0.04 | 0.04 | 0.59 | 0.45 |
| Italy | 0.06 | 0.04 | 0.05 | 0.53 | 0.52 |
| Lithuania | 0.07 | 0.06 | 0.12 | 0.53 | 0.62 |
| Latvia | 0.10 | 0.06 | 0.08 | 0.31 | 0.63 |
| Poland | 0.06 | 0.06 | 0.05 | 0.52 | 0.54 |
| Romania | 0.07 | 0.09 | 0.05 | 0.45 | 0.53 |
| Slovenia | 0.04 | 0.05 | 0.04 | 0.50 | 0.52 |
| Slovakia | 0.15 | 0.01 | 0.01 | 0.33 | 0.06 |

[22] We approximate the value of nonfinancial assets in the business sector by (3*GDP-FDI)/2

| 2007 | *Liquid assets to total assets* | *Reinvested profits to total assets* | *Earnings before taxes to assets* | *Equity to liabilities* | *Market output to total assets* |
|---|---|---|---|---|---|
| Belgium | 0.06 | 0.03 | 0.03 | 0.67 | 0.34 |
| Bulgaria | 0.10 | 0.08 | 0.05 | 0.58 | 0.53 |
| Czech Republic | 0.07 | 0.14 | 0.07 | 0.48 | 1.35 |
| Germany | 0.08 | 0.04 | 0.06 | 0.51 | 0.49 |
| Estonia | 0.08 | 0.05 | 0.06 | 0.53 | 0.54 |
| France | 0.03 | 0.03 | 0.03 | 0.63 | 0.31 |
| Hungary | 0.05 | 0.04 | 0.04 | 0.59 | 0.45 |
| Italy | 0.06 | 0.04 | 0.05 | 0.50 | 0.52 |
| Lithuania | 0.07 | 0.06 | 0.10 | 0.49 | 0.58 |
| Latvia | 0.10 | 0.06 | 0.08 | 0.30 | 0.63 |
| Poland | 0.06 | 0.08 | 0.05 | 0.52 | 0.88 |
| Romania | 0.07 | 0.09 | 0.05 | 0.45 | 0.53 |
| Slovenia | 0.04 | 0.06 | 0.04 | 0.50 | 0.53 |
| Slovakia | 0.16 | 0.01 | 0.01 | 0.32 | 0.06 |

* numbers in red indicate extrapolated data

Source: Based on Eurostat series

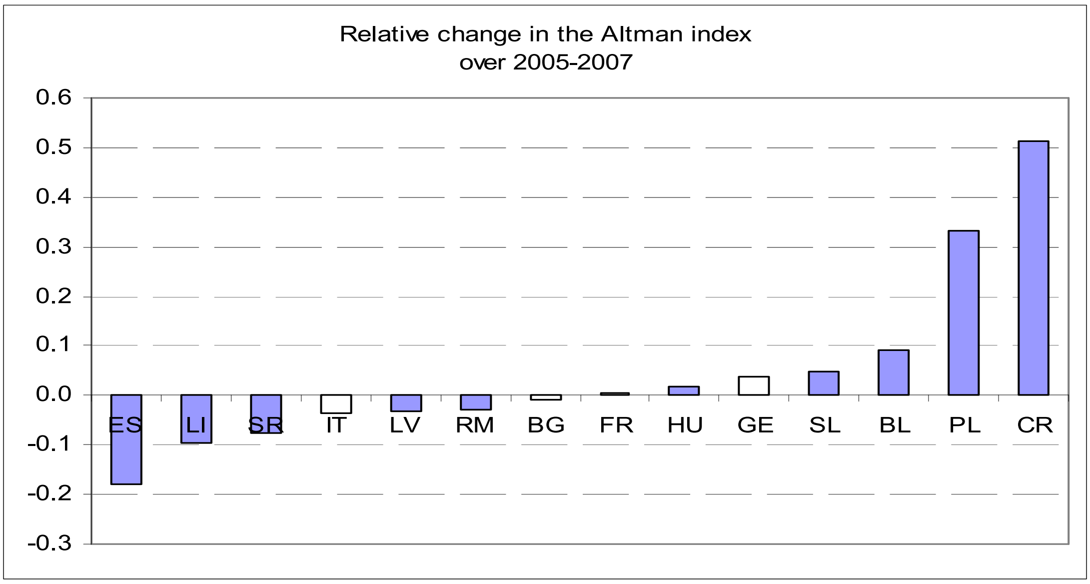
In order to ensure comparability with other studies we use Altman's original elasticities: 1.2 for liquid assets to total assets, 1.4 for reinvested profits to total assets, 3.3 for earnings before taxes to total assets, 0.6 for equity to liabilities and 1 for market output to total assets, to weight these variable together. A positive movement in the index implies and improving position for the corporate sector. Table 3.4.13 shows the level of the index in 2005-2007, and figure 3.4.10 shows the relative change in the index that materialised over this period. This illustrates the scale of deterioration or improvement in fundamentals of the corporate sector in the new member states over this period.

**Table 3.4.13 Computed Altman indices**

| | 2005 | 2006 | 2007 |
|---|---|---|---|
| Belgium | 0.96 | 0.96 | 0.95 |
| Bulgaria | 1.18 | 1.24 | 1.28 |
| Czech Republic | 1.41 | 1.50 | 2.14 |
| Germany | 1.12 | 1.14 | 1.16 |
| Estonia | 1.48 | 1.33 | 1.21 |
| France | 0.85 | 0.85 | 0.85 |
| Hungary | 1.04 | 1.07 | 1.06 |
| Italy | 1.14 | 1.12 | 1.10 |
| Lithuania | 1.52 | 1.49 | 1.37 |
| Latvia | 1.32 | 1.27 | 1.27 |
| Poland | 1.16 | 1.17 | 1.54 |
| Romania | 1.21 | 1.18 | 1.18 |
| Slovenia | 1.04 | 1.06 | 1.09 |
| Slovakia | 0.51 | 0.46 | 0.48 |

Source: Based on Eurostat series

**Figure 3.4.10. Change in the Altman index.**




Note: BG=Belgium, BL=Bulgaria, CR=Czech Republic, GE=Germany, ES=Estonia, FR=France, HU=Hungary, IT=Italy, LI=Lithuania, LV=Latvia, PL=Poland, RM=Romania, SL=Slovenia, SR=Slovakia

Source: own calculations on the basis of EUROSTAT data

To analyse the probability of a crisis in the corporate sector, taking into account macroeconomic information, we estimate a panel model of the bankruptcy rate in individual new member states and selected countries of the Euro Area (the sample encompasses the Czech Republic, Estonia, France, Hungary, Italy, Lithuania, Latvia, Romania, Slovenia, Slovakia). The model is relatively simple and, given the scarcity of the data (the panel is unbalanced, see table 3.4.14 below), it should be regarded as an elegant way of looking at the insolvency rates in new member states rather than a full-fledged model of the probability of crisis.

**Table 3.4.14: Bankruptcy rates**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Czech Republic | | 9.31 | 8.88 | 10.62 | 12.84 | |
| Estonia | 12.66 | 11.84 | 7.81 | 10.93 | 12.24 | 10.34 |
| France | | | | | 6.97 | 6.8 |
| Italy | | 6.54 | 7.15 | 6.39 | 6.5 | 7.52 |
| Latvia | 13.17 | 9.25 | 10.26 | 9.37 | 11.61 | 7.86 |
| Lithuania | 13.43 | 7.24 | 8.85 | | | |
| Hungary | 9.91 | 10.41 | 9.3 | 8.95 | 8.87 | 12.01 |
| Romania | 11.23 | 11.61 | 11.31 | 9.87 | 10.46 | 9.56 |
| Slovenia | 6.16 | 6.35 | 7.15 | 6.08 | 7.18 | 4.41 |
| Slovakia | 8.92 | 10.9 | 10.37 | 9.47 | 5.18 | |

Source: Eurostat

We quantify the relationship between the bankruptcy rate in the business sector and its microeconomic and macroeconomic determinants. The microeconomic factors are approximated by the Altman index computed above and the macroeconomic factors encompass GDP growth and the volatility of the exchange rate. Results of the estimation are the following:

$$BKRP_t = \underset{(13.1)}{15.63} - \underset{(-4.9)}{5.84} ALTMAN_t - \underset{(-5.8)}{0.21} \Delta \log(GDP_{t-1}) + \underset{(4.4)}{0.11} ERVOL_t \qquad (1)$$

$R^2$=0.91, DW=2.65

where *BKRP* denotes the bankruptcy rate in the corporate sector, *ALTMAN* – is the Altman index computed above, *GDP* – denotes GDP in real terms, and *ERVOL* is the volatility of the exchange rate, measured as a three year volatility of quarterly effective exchange rate. A rise in the Altman index significantly reduces the bankruptcy rate, as does strong GDP growth, while increased exchange rate volatility raises the bankruptcy rate.

Over the period of 2005-2007 the corporate sector's fundamentals deteriorated in the Baltic States, Romania and Slovakia. The performance of the corporate sector in Central Europe, and especially the Czech Republic and Poland, improved over the period 2005-2007. We can expect these changes to be reflected in bankruptcy rates over the same period. As this data is released at irregular intervals and with a significant lag, monitoring the Altman index would clearly be an informative addition to any early warning system for emerging financial problems.

#### 3.4.4.3 Foreign currency exposure

There is little reliable data on the foreign currency exposure of non-financial firms in the NMS. We can extract some indicators of the relative scale of exposure through a comparison of total private sector foreign currency borrowing as a per cent of GDP to the household sector foreign currency borrowing as a per cent of GDP reported in table 3.4.9 above[23]. Table 3.4.15 gives BIS sourced data on non-bank private sector borrowing in foreign currencies from international banks whilst table 3.4.2 above gives total household foreign currency borrowing (from Central Bank sources) both as a proportion of nominal GDP. The difference between the two is corporate borrowing in foreign currencies from banks plus any borrowing in foreign currencies from domestic banks by households. Corporate borrowing in foreign currencies appears to be lowest in Poland and the Czech Republic, with Romania, Slovenia and Slovakia also having less than 20 per cent of GDP covered by such borrowing. Perhaps Hungary looks the most vulnerable of the non-pegged, with borrowing probably over 20 per cent of GDP. Amongst the currency board or fixed rate countries the Estonians followed by the Latvians look the most vulnerable, but they may be protected by their exchange rate regime to the extent there is not a realignment.

[23] The data reported in table 4 is from the BIS database, while figures in table 2 were derived from individual central banks, and the series are not strictly comparable. However, they give some guide to corporate sector exchange rate exposure.

**Table 3.4.15. Private sector's foreign currency borrowing as percent of GDP**

| | BL | CR | ES | HU | LI | LV | PO | RM | SL | SR |
|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 0.14 | 0.10 | 0.62 | 0.17 | 0.19 | 0.17 | 0.10 | 0.10 | 0.12 | 0.08 |
| 2005 | 0.21 | 0.13 | 0.66 | 0.23 | 0.28 | 0.30 | 0.10 | 0.11 | 0.20 | 0.12 |
| 2006 | 0.32 | 0.15 | 0.92 | 0.30 | 0.34 | 0.58 | 0.11 | 0.34 | 0.24 | 0.15 |
| 2007 | 0.41 | 0.14 | 0.97 | 0.36 | 0.42 | 0.78 | 0.14 | 0.38 | 0.28 | 0.19 |
| 2008 | 0.47 | 0.12 | 0.97 | 0.38 | 0.47 | 0.78 | 0.14 | 0.28 | 0.22 | 0.19 |

Note: BL=Bulgaria, CR=Czech Republic, ES=Estonia, HU=Hungary, LI=Lithuania, LV=Latvia, PO=Poland, RO=Romania, SL=Slovenia, SR=Slovakia

Source: BIS

The level of corporate borrowing in foreign currencies has tended to rise over time. However, unlike the household sector, the corporate sector cut its foreign currency borrowing somewhat in 2008. This may suggest a relatively greater currency risk awareness of entrepreneurs, or lower foreign currency revenues of exporting firms that may limit their hedging possibilities.

## 3.4.5 The trade relations matrix

Further background to understanding contagion is the pattern of trade across CEE countries, and vis a vis Western Europe. By showing potential for contagion by the trade channel, this is relevant to qualitative macroprudential surveillance but also to model simulations (Section 5), interpretation of volatility covariances (Section 6) and early warning models (Section 7).

Figure 3.4.11 illustrates the exposure of NMS export market to the major regions of the world. Clearly the vast majority of exports are sent to destinations within Europe. In all the NMS, at least 85 per cent of exports remain within Europe, with Estonia and Bulgaria having the greatest exposure outside of Europe. Latvia and Lithuania send a smaller proportion of exports to the old EU member states, but have a high level of exposure to the other NMS and also to Russia and other Europe, which includes Norway and Switzerland as well as the former Soviet Republics, Turkey and states of the former Yugoslavia. The export channel could introduce contagion from financial shocks in other EU economies, in Russia (especially in the Baltic States) and other non-EU countries of Europe. Bulgaria is also relatively exposed to developments in the Middle East.

Figure 3.4.12 illustrates the source of imported goods in the NMS, as exchange rate fluctuations against these currencies may also affect the real economy. Again, there is a clear bias towards importing goods from within Europe, with more than 85 per cent of all imports sourced from other European economies. Hungary imports slightly less from Europe as a whole than the other countries, but this reflects a relatively limited exposure to non-EU European countries in favour of China, with EU imports in line with the NMS average. Bulgaria sources the smallest share of imports from other EU economies.

**Figure 3.4.11. Destination of NMS exports (2007)**

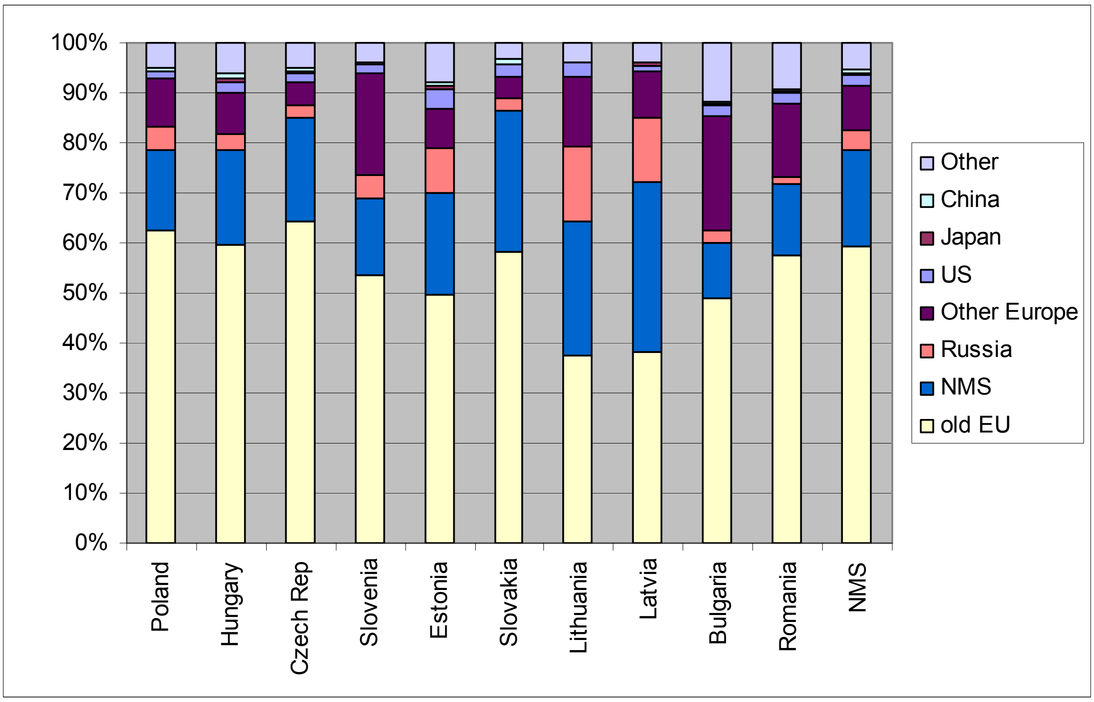
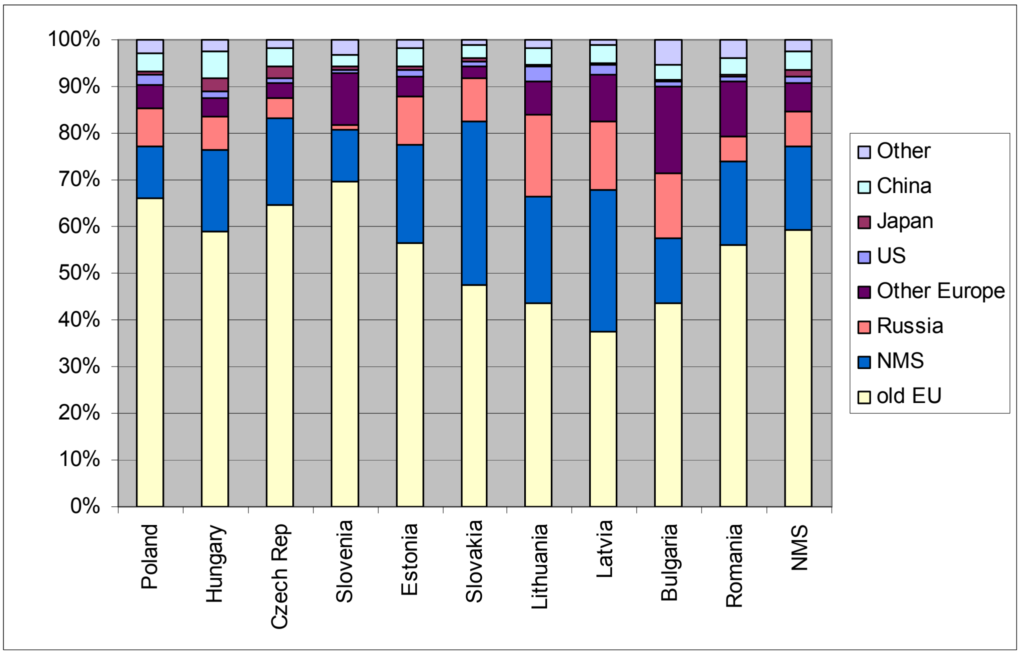


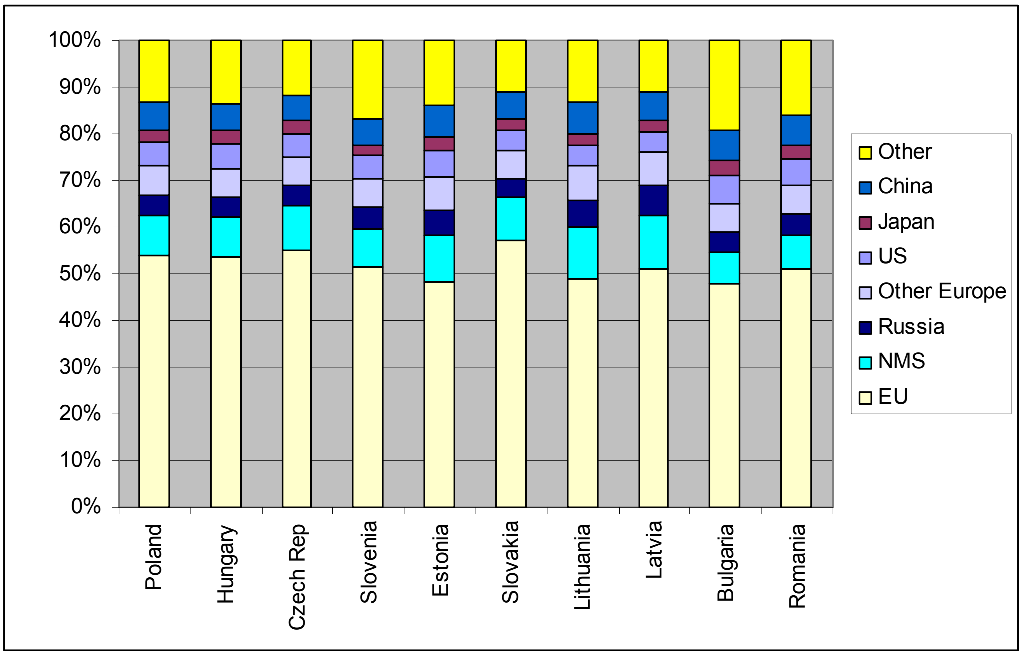

**Figure 3.4.12. Source of NMS imports (2007)**




IMF Direction of Trade Statistics 2005 - Goods

Figure 3.4.13 illustrates the sources of export market competition for the NMS. These are calculated from a double weighted trade matrix. For example, we look at the share of exports from Poland going to market A, and the source of other imports in country A. These are Poland's competitors in country A. We sum these across a full global trade matrix. Sources of competitiveness are somewhat more evenly spread across the world. Although competition remains centred on Europe, there is also a significant degree of competition form other countries in America, Asia and the major oil producing economies.

**Figure 3.4.13. Sources of export market competition**




## 3.4.6 Undertaking practical macroprudential surveillance

In a final section of this chapter showing key data and indicators for the NMS which are relevant to contagion and financial fragility, we provide a short summary of the potential uses to which such data can be put. This is the procedure of qualitative macroprudential surveillance, which is complemented by use of the models in Sections 5-7.

As outlined in Davis (2009a), owing to costs of crisis, it has been realised that there is an immense premium on timely warnings regarding systemic risks as an input to policy decisions as well as to strategies and market behaviour of financial institutions. Accordingly, in the last decade 'macroprudential surveillance' – defined as monitoring of conjunctural and structural trends in financial markets so as to give warning of the approach of financial instability – has become a core activity for many central banks and international organisations.

Typically, central banks and international organisations institute regular "Financial Stability Reviews" to assess the outlook for financial stability. Already by end-2005, 50 central banks had done so (Cihak 2006), often prompted by IMF/World Bank Financial Sector Assessment Programmes (FSAPs).

Drawing on theory and experience, Davis (1995, 1999, 2003) identifies certain common features to all types of crisis, which are helpful in anticipating crisis events. Indeed, he argues that examination of the features of diverse financial crises, suggests that there are common *generic patterns* in advance of crises. Key aspects are:

- *Regime shifts*, first to laxity (such as deregulation) which provokes a credit cycle, later to rigour (e.g. monetary tightening) that triggers a crisis;
- Easing of *entry conditions* to financial markets, leading to heightened competition and risk taking;

- *Debt accumulation* and asset price booms, generating vulnerable balance sheets in the financial and non financial sectors;
- *Innovation* in financial markets, which increases uncertainty during the crisis; and
- *Risk concentration* and lower capital adequacy for banks, which reduces robustness to shocks.

He saw these as providing the most basic dataset of indicators common to crises[24], acknowledging that many of these features have occurred separately without entailing a crisis, and indeed are part of the normal functioning of a market economy. It is their combination and acuteness (i.e. the degree of deviation from norms) that is crucial to the occurrence of financial instability. And many of them are encapsulated in financial soundness or macroprudential indicators.

Indeed, following the sections above, data needs (Davis 1999) include macroeconomic and financial data for assessing conjunctural conditions, non-financial sector debt, leverage and asset prices for considering vulnerability of borrowers, and in the light of these, bank balance sheets and income and expenditure for considering robustness of banks. Risk measures derived from financial prices complement leverage and income indicators. Stress tests and forecasts of indicators and derived stability indicators such as defaults and bankruptcies, including risks to the central projection are needed to tell a full story. In more detail, the recommended data for such macroprudential surveillance are as follows:

**Whole economy:**

Macroeconomic forecasts and related simulations (Chapter 5), including fiscal debts and deficit projections

Prediction of crisis from logit model (main focus on Asia estimate) (Chapter 6) using current outturns and macro forecasts

Prediction of crisis from signal extraction indicators (main focus on Asia estimate) (Chapter 6) using current outturns and macro forecasts

Prediction of crisis from binomial recursive tree model (main focus on Asia estimate) (Chapter 6) using current outturns and macro forecasts

CDS spreads (Section 3.3)

Conditional volatility of industrial production, retail sales and inflation (Chapter 7)

**Banking sector:**

Non performing loans as a share of total loans (Section 3.4)

Banks' return on assets (Section 3.4)

Banks' return on equity (Section 3.4)

Banks' unadjusted capital adequacy (Section 3.4)

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24 See also Demirguc Kunt and Detragiache (1998a and b) and Kaminsky (1999).

Banks' risk adjusted capital adequacy (Section 3.4)
Net interest income to total gross income (Section 3.4)
Non interest expenses to total gross income (Section 3.4)
Liquid assets to total assets (Section 3.4)
Foreign borrowing by banking sector (Section 3.1)
Interbank spreads (Section 3.3)

**Household sector:**
Sectoral debt to personal income ratios (Section 3.4)
Currency composition of household sector debt (Section 3.4)
House prices (Section 3.4)

**Corporate sector:**
Debt to equity ratio (Section 3.4)
Corporate profitability (Section 3.4)
Altman index and its components (Section 3.4)
Corporate bankruptcy rate (Section 3.4)
Currency composition of corporate sector debt (Section 3.4)

**Market indicators (Chapter 5):**
Standard deviation and correlation of equity prices (Section 3.2)
Equity risk premium and correlations (Section 3.2)
Nominal and real interest rate volatility (Section 3.3)
Exchange rate risk premia (Section 3.3)
Conditional volatility and covariance of equity prices (Chapter 7)
Conditional volatility and covariance of exchange rates (Chapter 7)
Key macro determinants of equity and exchange rate volatility (Chapter 7)

**Background structural features:**
Trade relations matrix (Section 3.4)
Exchange rate regime and its sustainability (Section 3.4)
Size and foreign ownership of banking system (Section 3.1)
Size of equity market (Section 3.2)
VAR results for equity market spillovers (Section 3.2)
VAR results for interest rate and exchange rate spillovers (Section 3.3)

Key lesson learnt in surveillance practice for these data include:

- economy in terms of the number of indicators employed. Failure in this regard may lead to including virtually all financial and economic data in macroprudential surveillance, and thus risking to fail to distinguish key warning patterns. Even from the list above there may be justifiable reasons for focusing on a subgroup of indicators in a given report.
- to derive data needs directly from theory and experience. A central issue is then to assess what combinations of variables can offer consistent warning signs for potential turbulence, and its potential severity. What, in other words, can help us to give advance warning of a crisis?
- the data needs will have to be sufficiently qualitative and general to cater for the fact that crises in the future are likely to differ from those in the past, whether in terms of markets affected, incidence or nature of resulting contagion.
- there will be an important qualitative aspect which extends beyond data per se to the inferences and assessments that central banks, supervisory authorities and market players may draw in the course of their normal operational activities.
- to assess what the benchmark is for assessing risks to financial stability, a norm against which a current situation may be judged. For example average spreads over a long period provide a benchmark for the price of credit although judgement is needed in the light of changes in the credit quality of borrowers, as well as the occurrence of financial liberalisation. A more sophisticated approach would be to estimate equations for spreads (which could make credit quality and liberalisation exogenous variables) and assess deviations from predicted values out of sample. Cross- country benchmarks may in this context be helpful, although "normal levels" in terms of prices or quantities may also depend on the nature of financial relations and broad elements of financial structure within an economy. For example, traditionally relationship-banking countries have been able to sustain higher levels of corporate debt relative to equity or GDP than is prudent in those characterised by transactions banking (and, correspondingly, financial-asset price volatility is seen as less damaging to the macroeconomy). Even these patterns are not fixed, however, and a decline in the scope of banking relations may warrant, for example, a lower debt-equity ratio than would otherwise be the case. Another set of norms based in quantity data may be in terms of the abnormal growth of a certain financial market, which may indicate that risk-taking is high or increasing, and/or less experienced players are becoming involved. (However, indicators of pricing are needed to confirm adverse shifts in risk-taking.)
- cross border as well as domestic influences need to be taken into account, not least given the internationalisation of banking.
- new players such as hedge funds need to be incorporated when they become relevant.

There is a need for observation of overall patterns in the light of past occurrences of financial instability, both at home and abroad, developments in theory and the generic view set out in Davis (2002). Data can show either shocks (e.g. triggering boom or crisis) or propagation mechanisms (showing a boom is underway). But since shocks are random, the vulnerabilities are the main focus. Davis and Karim (2008) suggest a checklist of such generic indicators, drawing on the analysis in Section 3.4.1 above, including:

- *Regime shifts*, first to laxity (such as deregulation) which provokes a credit cycle, later to rigour (e.g. monetary tightening) that triggers a crisis;
- Easing of *entry conditions* to financial markets, leading to heightened competition and risk taking;
- *Debt accumulation* and asset price booms, generating vulnerable balance sheets in the financial and non financial sectors;
- *Innovation* in financial markets, which increases uncertainty during the crisis; and
- *Risk concentration* and lower capital adequacy for banks, which reduces robustness to shocks.

These need to be assessed relative to trends in actual data series highlighted above so as to seek to perceive patterns of vulnerability.

Then there is a need for a judgmental approach in drawing conclusions, using again a conceptual framework derived from theory (how vulnerable is the system – what shocks could take place?) Fell and Schinasi (2005) suggest the use of an implicit corridor of financial stability, akin to an exchange rate target, with judgements made as to whether the system is inside the corridor, approaching the edge, just outside or systematically outside, which will imply different policy recommendations.

As an example of a procedure for macroprudential surveillance, the ECB undertake a 7-point vulnerabilities exercise, first identifying vulnerabilities and imbalances, then translating them into potential risk scenarios, identifying triggers (shocks) for the scenarios, assessing the likelihood of scenarios arising, estimating the costs for the financial system, assessing robustness to such shocks and then ranking the risk. They note the need to include endogenous sources of risk (within institutions, markets and infrastructure) as well as exogenous risks from the macroeconomy. Fell and Schinasi (2005) give a check list of criteria for sound analysis including: Is the process systematic? Are the risks identified plausible? Are the risks identified systemically relevant? Can linkages and transmission (or contagion) channels be identified? Have risks and linkages been cross-checked? Has the identification of risks been time consistent?

An appropriate use of the toolkit is to incorporate model findings as in Sections 5-7 with the qualitative and judgemental approach in arriving at an overall view about the risk to financial stability.

# 4 Case studies

## *4.1 Crises in countries of Central and Eastern Europe – an overview*

This subsection sets the scene for a detailed comparative case study analysis of ramifications of the global financial crisis for four new members of the EU: Poland, Hungary, Latvia and Estonia. We present an overview of crises that occurred in the region over 1990-2009, briefly discussing their origins and effects for countries affected. The character of our analysis is qualitative. We discuss various macroeconomic and financial indicators - and the set of chosen variables differs across crises – as differ individual crises' causes and consequences, as well as the macroeconomic environment in which particular crises happened (over 1990-2009 the region went through a substantial structural change).

### 4.1.1 The idiosyncratic crises of the mid 1990s

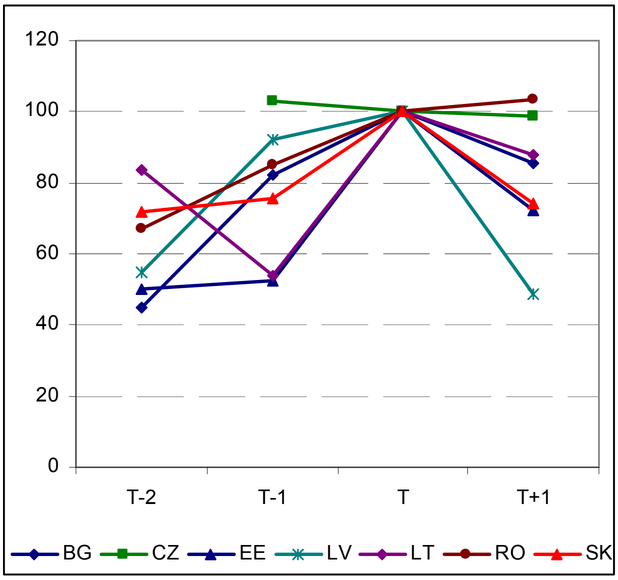
Central and Eastern Europe experienced several banking crises in the mid 1990s: in 1995 turbulence hit Lithuania and Latvia, 1996 saw crises in the Czech Republic, Bulgaria and Romania, and in 1998 serious problems of the banking system were recorded in Estonia and Slovakia (source: IMF and WB data). There are a few generic factors that might have contributed to the crises of the mid 1990s: the transition process, external shocks and macroeconomic conditions (Tang et al., 2000).

The transition shock which took place at the beginning of the 1990s resulted in serious distortions to the functioning of economies of Central and Eastern Europe and affected the stability of their banking systems. The transition from a central planned economy to a market economy implied that commercial banks created from state-owned banks inherited large amounts of bad loans. Internal and external liberalisation, as well as removal of enterprise subsidies cut firms' profitability, adversely affecting their loan repayment abilities (figure 4.1.1a shows the development of non performing loans in the run up to the crisis, the year of the crisis is the base year).

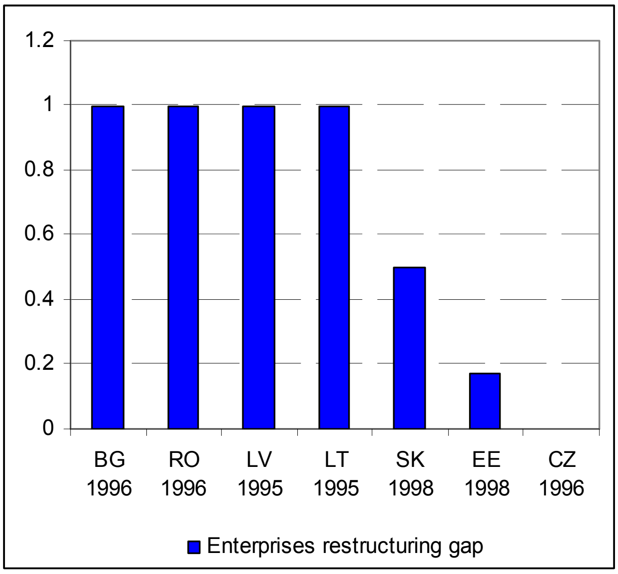
New firms also lacked experience with operating in the new market environment (which probably resulted in higher bankruptcy rates). The low degree of enterprise development made the economies more vulnerable to crises. This is illustrated by an enterprises' restructuring gap measured with the EBRD index of enterprises' restructuring. The gap is computed as a difference between the value of the index for Poland and Hungary, the two best performing economies in the group (neither of them experienced a crisis) and the value of the index for the analysed crisis economies. The gap is shown in Figure 4.1.1b.

**Figure 4.1.1. Transition-related determinants of the crisis: a) nonperforming loans in the run up to the crisis; b) the enterprises restructuring gap**

a) Nonperforming loans.
The year of the crisis T =100




b) The enterprises' restructuring gap in the year of the crisis

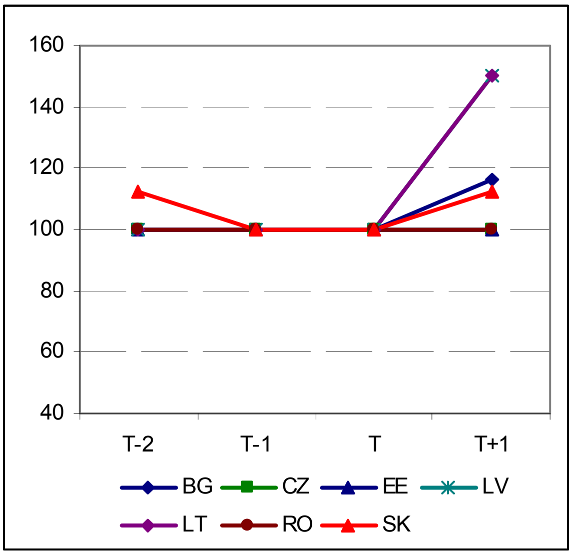



BG Bulgaria, CZ Czech Rep, EE Estonia, LV Latvia, LT Lithuania. RO Romania, SK Slovakia
Source EBRD

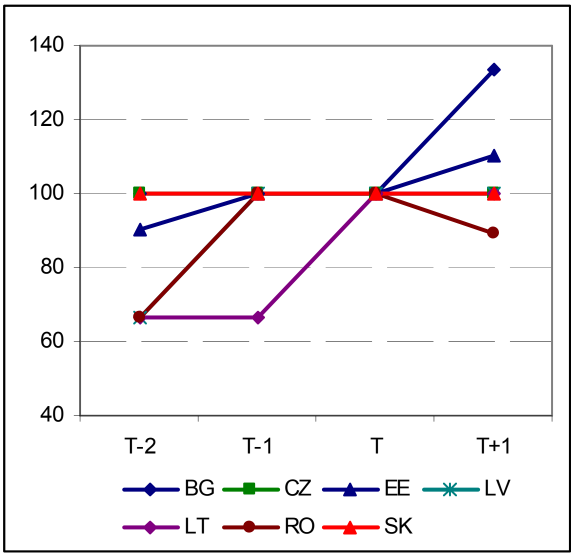
The banking crises can be viewed as an integral element of the transition process. From the Schumpeterian point of view the crises might have acted as catalysts of changes leading to improvement in the functioning of both banks and enterprises. Figure 4.1.2 shows normalised EBRD indices of enterprises' restructuring and the banking sector reform with the value of the index equal to 100 in the year of the crisis. A year after the crisis we record increases in at least one of the indices for the majority of the countries.

**Figure 4.1.2. Crises as catalysts of changes**

Enterprises' restructuring




Banking sector reform




BG Bulgaria, CZ Czech Rep, EE Estonia, LV Latvia, LT Lithuania. RO Romania, SK Slovakia
Source EBRD

Some countries were hit by unfavourable external shocks. In particular, Lithuania and Latvia experienced sharp reductions in the profitability of the banking sector resulting from declines in trade financing opportunities following price liberalisation in Russia. The region might have also suffered from the liquidation of the CMEA (Council for Mutual Economic Assistance) foreign trade system.

Macroeconomic conditions in Central and Eastern European countries in the run-up to a crisis varied. The occurrence of a crisis was not directly preceded by negative economic growth (see table 4.1.1), undoubtedly however, effects of the transition shock for the macroeconomic situation of both households and enterprises were spread over time. The crises erupted under various exchange rate frameworks – a floating exchange rate regime in Bulgaria, a crawling peg in the Czech Republic and a currency board in Latvia and Estonia. The economies of Central Europe did not experience a major depreciation of their currencies prior to crises (see table 4.1.1[25]). The implementation of stabilisation policies (which resulted in increased interest rates) might have contributed to increased difficulties in debt servicing, especially at the beginning of the 1990s. By the mid 1990s when the idiosyncratic crises occurred, its role had probably weakened (see table 4.1.1). Further information on the idiosyncratic crises of the mid 1990, with a focus on the situation of the banking system is presented in table 4.1.2.

**Table 4.1.1. Macroeconomic conditions**

| | | GDP growth* | | | | | | Exchange rate change** | | | | | | Real interest rates*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | t-4 | t-3 | t-2 | t-1 | **t** | t+1 | t-4 | t-3 | t-2 | t-1 | **t** | t+1 | t-4 | t-3 | t-2 | t-1 | **t** | t+1 |
| Bulgaria | t=1996 | - | - | + | + | **-** | - | + | + | + | + | **+** | + | + | - | + | + | + | + |
| Czech Republic | t=1996 | - | + | + | + | **+** | - | + | + | + | + | **+** | - | + | + | + | - | + | + |
| Estonia | t=1998 | - | + | + | + | **+** | - | + | + | + | - | **+** | + | - | - | - | - | + | + |
| Lithuania | t=1995 | | - | - | - | **+** | + | | + | + | + | **+** | + | - | - | - | - | - | + |
| Latvia | t=1995 | | - | - | 0 | **-** | + | | - | + | + | **+** | + | - | - | - | - | - | - |
| Romania | t=1996 | - | + | + | + | **+** | - | - | - | - | - | **-** | - | - | - | - | - | + | - |
| Slovakia | t=1998 | + | + | + | + | **+** | + | + | + | + | + | **+** | - | + | - | + | + | + | + |

* + denotes positive growth ** + denotes appreciation *** + denotes positive real interest rates
NiGEM Database and own calculations

**Table 4.1.2. The idiosyncratic crises**

| | **Idiosyncratic crises** |
|---|---|
| Bulgaria 1996 | The initial cause of the crisis was bad loans made during 1991-1995. Serious liquidity problems emerged in the second half of 1994. Two endangered state banks were bailed out in mid 1995, but the public lost confidence in the banking sector and withdrawals of deposits started. 1996 saw a bank run. The government stopped bailing out banks and 19 banks went bankrupt. |
| Czech Republic | The crisis was induced by a failure of a small bank (due to a fraud) in 1994, which triggered runs at other small banks. By the end of 1995 two small banks failed. This |

[25] In the 1990s. the appreciation of CEE currencies to a large extent was attributed to the Balassa-Samuelson effect (assessment of how much stronger the currencies would have been if there were no crises is difficult).

| | |
|---|---|
| 1996 | led to a restructuring of 18 banks in 1996. |
| Estonia 1998 | 3 banks failed (the largest accounted for 3% of banking system assets) |
| Latvia 1995 | The negative net worth of the banking system was estimated at 7% of GDP in 1995. Over the period 35 banks were closed or ceased operations. Aggregate losses in 1998 were 3% of GDP. |
| Lithuania 1995 | In 1995 12 banks were closed, 3 large private banks (accounting for 29% of banking system deposits) failed, and 3 state-owned banks were deemed insolvent. |
| Romania 1996 | 6 state-owned banks faced insolvency problems as up to 30% of loans were deemed nonperforming in 1998. 1 bank was recapitalised, the Central Bank injected 0.6% of GDP in the largest state bank in 1998. |
| Slovakia 1998 | The ratio of nonperforming loans to total loans increased to 35% in 1998. A restructuring plan was launched. |

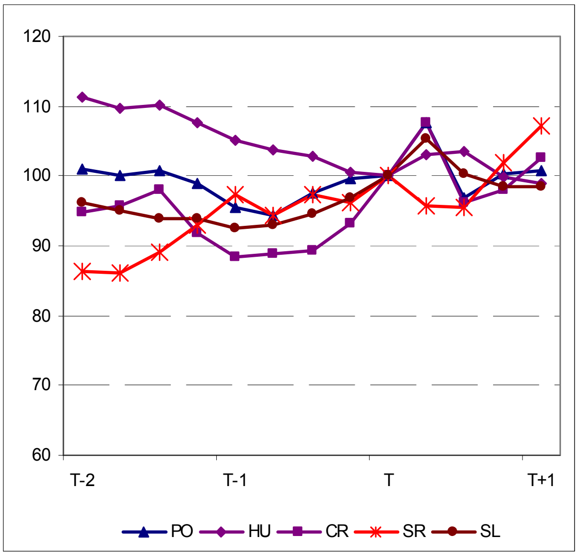
Source National Central Banks various publications

### 4.1.2 The Russian crisis of 1998

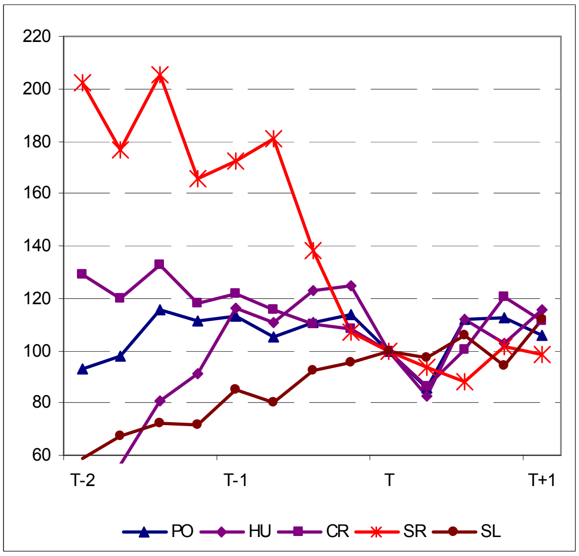
On August, 17, 1998 the Russian Federation devalued the rouble and declared a moratorium on its debt. The turmoil in Russia affected world markets. The crisis had serious consequences for countries in the region which felt its effects directly. The extent to which individual countries were hit by the turbulence coming from the Russian economy varied, as the strength of trade and financial linkages between individual CEE economies and Russia differed. For example the overall impact of the crisis on the larger countries of Central Europe was milder than the experience of the Baltic economies.

**Figure 4.1.3. a) Exchange rate pressures, b) Equity prices developments**
The quarter of the crisis (1998Q3) T=100

Exchange rates




Equity prices




PO Poland, HU Hungary, CR Czech Rep, SR Slovakia, SL Slovenia
NiGEM Database

The Russian crisis followed the Asian crisis, increasing the nervousness of the financial markets (volatility of both exchange and equity markets increased considerably – see the GARCH section in chapter 7). The economies of Central Europe experienced capital outflows leading to exchange rate pressures, rising interest rates and falling equity prices (Slovakia was forced to give up its fixed exchange rate regime, while interventions of the Hungarian Central Bank to defend the forint were substantial). The outflow of capital manifested itself in a halt to portfolio investment flows rather than cuts to foreign direct investments (although the FDI inflow slowed down). The impact of falling equity prices on the real economy was relatively limited as the capitalisation of the stock exchange remained low (the stock markets in the Visegrad countries were still young and shallow). The contagion proved temporary and mild (see figure 4.1.3a and 4.1.3b showing the scale of exchange rate and equity prices falls where T=1998Q3) in comparison with the 2008 contagion (compare figure 4.1.4a and 4.1.4b) and outflows came to a halt after a quarter. The Central European countries retained access to international capital markets, while yield spreads, although declining after an initial hike, remained at elevated levels some time after the crisis.

On the real side, the crisis led to a collapse of CEE countries' eastwards trade, enforcing structural changes, both in the structure of production and labour force utilisation, oriented at increases in competitiveness. Countries affected tried to redirect exports, and competition increased both in foreign and domestic markets. This resulted in an introduction of new trade barriers within CEFTA (Central European Free Trade Association) to which the CEE belonged.

The impact of the crisis on the Baltic economies was much stronger than elsewhere. The crisis hit not only the corporate and household sector. The banking system suffered as well. The corporate sector felt the closure of the Eastern market immediately. Exports to Russia fell significantly in 1998 in all Baltic States. Table 4.1.3 shows the scale of the decline of the Russian market from the perspective of individual countries' exports. Before the crisis Russia remained the main trading partner of Estonia, Latvia and Lithuania. After the crisis Russia ranked third.

**Table 4.1.3. Export shares to Russia (percent).**

| | Estonia | Latvia | Lithuania |
|---|---|---|---|
| 1997 | 18.8 | 21 | 24.5 |
| 1998 | 13.4 | 12.1 | 16.7 |

Statistical Office of Estonia, Statistics Department of Latvia, Lithuanian Statistics Department; after Taro L., Korhonen I., 2000, Baltic economies in 1998-1999. Effects of the Russian financial crisis; in:Komulainen T., Korhonen I. (ed.), Russian crisis and its effects, Kikomura Publications, Helsinki

The crisis revealed the vulnerability of the export sector that was concentrated on foodstuffs (and transportation services), for which Russia remained the main market. Strong mutual trade relations in the region (also with Belarus and Ukraine which were heavily dependent on trade with Russia) deepened difficulties of exporters.

While the Lithuanian and Estonian foreign reserve assets remained at a sound level, Latvian reserves came under pressures. The Latvijas Banka intervened keeping the lat stable and the market calmed down eventually. The general economic slowdown transmitted itself to the banking system. The immediate impact of the Russian debt default on Baltic banks assets varied. Latvian banks had particularly large GKO treasury bills (rouble-denominated short term government papers) holdings (about 8 per cent of their assets were invested in Russia), while Estonian and Lithuanian banks had less direct exposure in the GKO market.

Table 4.1.4 briefly summarises the impact of the Russian crisis on selected economies of Central and Eastern Europe: three Visegrad countries: Poland, Hungary, the Czech Republic and three Baltic economies: Estonia, Latvia and Lithuania.

**Table 4.1.4. The Russian crisis**

| | **Regional crisis** |
|---|---|
| Czech Republic | As investors started withdrawing from the region, the Czech equity and bond markets reacted promptly and the volatility in financial markets increased considerably. The exchange rate depreciated. The impact on the real economy was, however, limited as the Czech Republic had very limited trade and financial ties to Russia. The indirect effects of the crisis materialised in the form of increasing pressures on imports due to production surpluses in neighbouring countries (whose eastward trade collapsed). |
| Estonia | The Russian crisis hit the real economy badly, enforcing significant changes in the structure of exports (eastwards exports of food were, to some extent, replaced by exports of machinery and equipment to Finland and Sweden).<br>The second half of 1998 saw a wave of mergers and restructuring in the banking sector. As the mergers were completed, Swedish banks entered the Estonian banking system (providing refinancing, however, at a high cost). The worsening situation in Russia had a negative effect on small banks - the Eesti Pank initiated bankruptcy proceedings on one of the banks, as about 15% of its assets consisted of Russian government bonds. |
| Hungary | The crisis caused a sharp drop in the equity market. Even before the Russian crisis occurred, the stock exchange index was on a downward trend (which was a consequence of the Asian crisis). This was exacerbated by the Russian crisis; the index was dragged down by falls in share prices of firms oriented at exports to Russia. Hungarian exports to Russia fell sharply. In effect, Hungary re-oriented its exports westwards. The Hungarian financial sector was not seriously hit (because its exposure to the Russian bond market was low). The crisis had a negative effect on the forint; the MNB intervened. |
| Latvia | The first to feel the effects of the crisis were banks, which had invested in Russian securities and exporters. The crisis affected several export-oriented sectors of the economy (the production of food, the manufacture of chamicals and machniery and equipment). As transactions with Russian banks decreased and barter became more significnat in trade with Russia, a fall in the volume of interbank foreign exchange market transactions occurred. |
| Lithuania | The crisis induced an outflow of capital from Lithuania. Fearing devaluation of the lit, Lithuanians started converting their lit deposits into dollars. The central bank intervened.<br>The crisis hit the real economy badly, as the majority of the Lithuanian exports were oriented towards Russia, Belarus and the Ukraine. |
| Poland | The Russian crisis resulted in sharp decreases in equity prices and a fall in stock market capitalisation. Although stock market developments did not have a significant impact on the real sector of the economy (before the crisis the stock market capitalisation accounted for about 13% of GDP), they might have affected expectations concerning future macroeconomic conditions. The Russian crisis affected the economy mainly through the trade channel (and the channel of unclassified transactions on the balance of payments), as the collapse of the Eastern market resulted in substantial falls in exports. The ensuing orientation of producers at Western markets was accompanied by deep adjustments in costs of production (and utilisation of labour force in particular) aimed at boosting competitiveness. |

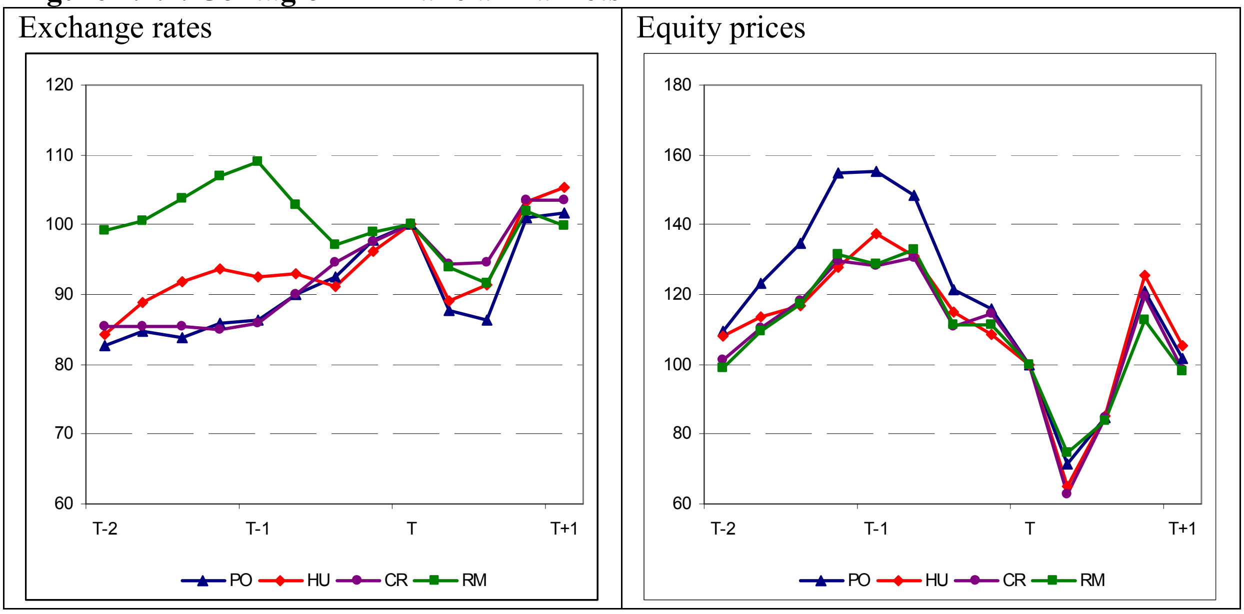
### 4.1.3 The global financial crisis of 2008

On September, 15, 2008 the investment bank Lehman brothers filed for chapter 11 bankruptcy protection. The bankruptcy had worldwide ramifications as the international financial markets reacted sharply and further spillover effects for the global economy were marked. The impact of the global financial crisis on NMS economies was indirect rather than direct. The NMS had no direct exposure to products of the US mortgage market. The crisis spread to Central and Eastern Europe through financial and trade linkages and the performance of individual new members varied greatly during the crisis.

While the NMS share a lot of similarities (they are very open to trade and capital flows, share similar economic structures, are “catching up” economies, and are in the run up to the euro), the region has remained relatively heterogeneous with the greatest degree of differentiation manifesting itself between the Baltic economies and the larger countries of Central Europe. The different reaction of the NMS economies resulted from various imbalances with which they entered the crisis. However, as the markets perceived the region as a homogenous group, on the wave of contagion, they started withdrawing capital from the whole region (including countries with good fundamentals).

The economies of Central Europe suffered from increased volatility of their exchange rates. The Hungarian forint, the Polish zloty, the Czech koruna and the Romanian leu experienced major depreciations, although the degree of vulnerabilities of individual economies varied substantially. The nervousness in the exchange market was equally visible in the equity and money markets. Figure 4.1.4 shows the scale of 2008 depreciation, 2008 falls in equity prices. This was also apparent in conditional volatility and covariance as shown in chapter 7.

**Figure 4.1.4. Contagion in financial markets**

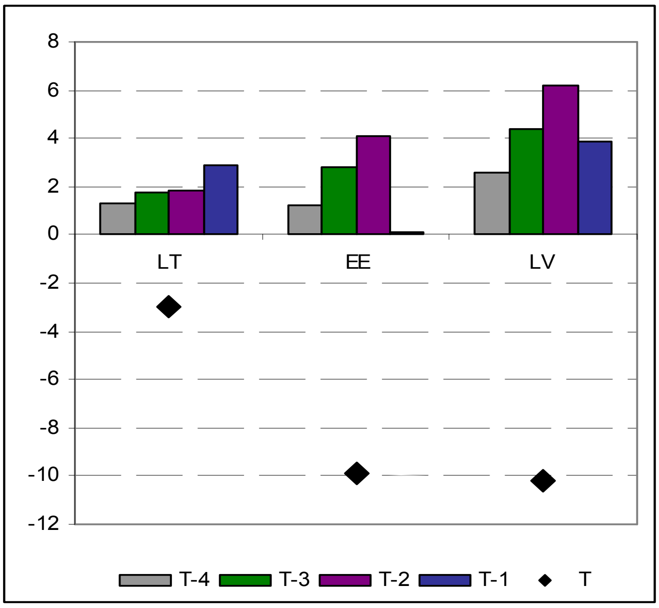



PO Poland, HU Hungary, CR Czech Rep, RM Romania

The exchange rate fluctuations in combination with large shares of corporate and household sector loans denominated in foreign currencies, put borrowers at serious risk. The economy suffered the more, the more open it was. The large and relatively closed economy of Poland managed to escape a recession, while the small open economies of Slovakia and the Czech Republic suffered a more marked slowdown (although their starting positions might have been regarded as similar).

The Baltic States entered the crisis with overheated economies. Figure 4.1.5 shows the run-up to the crisis and adjustment in aggregate demand following the outbreak of the global turmoil in Estonia, Latvia and Lithuania. The scale of the imbalance is measured as the difference between annual GDP growth rate recorded in four years preceding the crisis and the average GDP growth rate over the period 1995-2008. The figure shows that the greater the imbalance was, the harder the adjustment will probably be.

**Figure 4.1.5. Overheating in the years preceding the crisis and adjustment in the crisis year – the Baltic States**




(LT Lithuania, EE Estonia, LV Latvia)

Large credit booms of previous years added to the severity of the recession coming from the Baltic States' trade partners significantly. Although the "hard landing" created some pressures on the Baltic currencies (and the Latvian lat in particular), the pegs were maintained. Table 4.1.5 briefly summarises the development of the crisis in selected NMS (discussion of remaining countries – available from authors upon request).

**Table 4.1.5. The global crisis**

| | **Global financial crisis** |
|---|---|
| Bulgaria | The banking system entered the recession with a high capital ratio and still positive profitability (mainly thanks to cushions created by regulation in previous years). The early stages of the crisis saw the banking system stable; banks used their 2008 profits to increase capital (rather than pay out dividends). The fixed exchange rate shielded Bulgarian private sector balance sheets from pressures. Although the nonperforming loans ratio increased, capital buffers of banks remained relatively strong. The crisis was reflected in balance of payments data (suggesting that Bulgaria was experiencing a severe shock). Net capital inflows decreased significantly. FDI dropped. Eventually, the crisis spilled to the real sector of the economy. |
| Czech Republic | The Czech financial system entered the crisis in a good starting position. The banking system remained less vulnerable to the crisis due to several factors. The system was relatively isolated - banks had enough funds to provide loans from primary deposits, they did not provide loans in foreign currencies, the ratio of "toxic" assets was negligible, and banks remained relatively well capitalised and profitable. Among the NMS the Czech Republic had the highest ratio of deposits to loans, and a virtually zero share of foreign currency loans to total loans to households. At the beginning of the crisis the koruna appreciated dramatically, probably due to the liquidation of carry trades for which the koruna was used as the financing currency. In late 2008 the confidence in the region declined which manifested itself in depreciation of the Czech |

| | |
|---|---|
| | currency. The crisis resulted in an increase in market volatility and a decrease in market liquidity. |
| Hungary | The Hungarian banking sector had no direct exposure to US mortgage market products, but increasing risk premia resulted in rising funding costs and shortening maturities of foreign funds. There were serious disturbances in Hungarian financial markets. In October 2008 the forint depreciated significantly, which put many borrowers at risk (as 60% of private sector loans are denominated in foreign currencies). The government signed an agreement with the IMF on a loan worth $15.7 bn. In addition to the financial assistance from the IMF, the rescue program was also supported by $8.4 billion from the European Union, and $1.3 billion from the World Bank. |
| Latvia | The crisis hit the Latvian economy harder than other NMS economies. Latvia had based its high growth of previous years on an unbalanced economy, increasing foreign borrowing, and trade and budget deficits.<br>The strong dependence of the Latvian banking system on foreign financing, in combination with contraction in the economy (and the real estate market especially) amplified the vulnerability of the Latvian financial market. The economic downturn (drying up the loan portfolio growth), higher costs of financing and the necessity to make large provisions for doubtful debts reduced the profitability of banks. Banks' aggregate loan portfolio decreased, and its quality deteriorated significantly marred by delinquent payments and increase in NPL (mainly resulting from the developments in the real estate market (house prices dropped significantly - after a period of excessive growth)). In February 2009 the Latvian government nationalised the Parex Bank, the country's second largest bank.<br>The Latvian economy collapsed. In December 2008 the IMF granted Latvia a loan worth $2.35 bn. Coordinated international package involving the European Union, Nordic countries, the World Bank and the EBRD followed. As part of the programme foreign banks operating in Latvia affirmed their commitment to provide their subsidiaries with adequate financing. The IMF granted Hungary a second tranche of help.<br>The crisis induced also political changes. After protests against the handling of the crisis by the government, the Latvian government stepped down in February 2009. |
| Poland | The banking system did not suffer much at the early stage of the crisis due to limited exposure to products of the US mortgage market. Banks did not record significant losses related to foreign financial institutions; the risk of a withdrawal of funds by parent banks did not materialise either (despite losses recorded by many foreign parent entities, most banks decided to retain profits of NMS subsidiaries in 2008 in capital; some banks also received liquidity support from their parent institutions) The liquidity in the banking sector decreased. The decrease in mutual confidence among banks led to a reduction in interbank transactions. The increase in global risk aversion contributed to a depreciation of the zloty (which was deeper than warranted by fundamentals). The zloty depreciation translated into an increase in loan repayment burden of households; this was, however, to a large extent offset by falls in foreign interest rates. The corporate sector suffered more, as some companies bore costs of market-to-market valuation of hedging strategies and exchange rate speculation.<br>In November 2008 Poland received a $20.5 bn Flexible Credit Line from the IMF, an instrument established for countries with strong fundamentals, policies and good track record of their implementation (Platinum Club), to bolster international confidence.<br>The recession in Poland's major trading partners led to a decline in Polish GDP growth rate, however, Poland, as the only country in the EU, seems to have escaped recession. |

Source National Central Banks various publications

## 4.2 Estonia, Hungary, Latvia and Poland - a comparative case study analysis

This section illustrates practical application of the anti-crisis toolkit. We analyse the vulnerability of four new member states of the EU to a crisis: Estonia, Latvia, Poland and Hungary both to the crisis as it has unfolded so far as well as the future.

The set of countries has been chosen to represent the heterogeneity of the group of the new members of the EU. Our sample encompasses two of the Baltic economies, as well as two major Central European economies, and at the same time it covers both countries that seem to have run a risk of a major default, as well as countries that seem to have weathered the crisis relatively well (see Table 4.1.1.). From the time perspective the analysis focuses on analysis using the toolkit of recent developments and the global crisis of 2008 as well as potential risks and forecast events looking ahead.

**Table 4.2.1. The chosen set of countries**

| | Countries with relatively good fundamentals | Countries with relatively bad fundamentals |
|---|---|---|
| Central European economies | Poland | Hungary |
| Baltic economies | Estonia | Latvia |

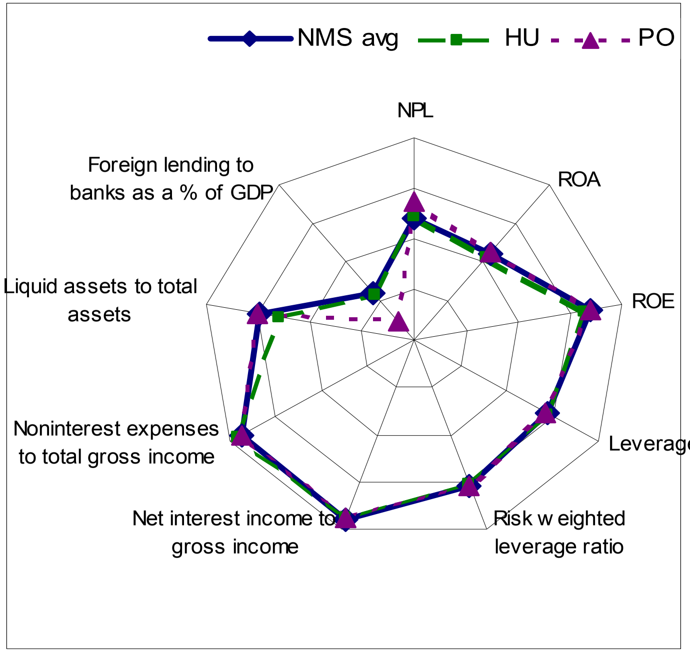
We seek to assess whether countries are outliers from other new member states but also whether the overall situation is threatening. We structure our analysis of individual countries' vulnerability to a crisis as follows. We start with a discussion of low frequency indicators describing the state of the economy in three key sectors: the banking sector, the household sector and the corporate sector. Then we turn to higher frequency data that allow us to monitor current dynamics in financial markets. The study closes with macroeconomic forecasts and an application of EWS models looking ahead from now. We use currently available data in all cases, noting that for some indicators these are not timely (for example, comparable banking data are for 2007).

Our choice of indicators discussed below is discretionary, although we use most of the "tools" highlighted in this report. Nevertheless, the regular monitoring of new member states' financial stability may focus on a different group of indicators chosen from the wide set of indicators presented in section 3.4, depending on the timing, country concerned and purpose of the surveillance.

### 4.2.1 Banking sector indicators

The soundness of the banking system is assessed on the basis of 9 indicators as outlined in section 3.4 – the share of nonperforming loans in total loans, the return on assets, the return on equity, the leverage ratio, the risk weighted leverage ratio, net interest income to total gross income, noninterest expenses to total gross income, the share of liquid assets in total assets and the share of foreign lending to banks as a percentage of GDP. We note as background that the Latvian and Estonian banking systems are much larger relative to GDP than those in Hungary and Poland, which could show financial development but also the risk of a debt overhang (Figure 3.1.1). Estonian banks are over 90% foreign owned, while the figure in Latvia and Poland is 70% and Hungary only 50%. This is again a double edged sword as foreign ownership gives access to well capitalised institutions but also may generate contagion if the home country has problems. Figure 4.2.1 illustrates the performance of the Estonian, Latvian, Hungarian and Polish banking systems (thin dotted lines) against the average performance of the banking sector in new member states as a whole (thick line).

Figure 4.2.1. Banking sector indicators



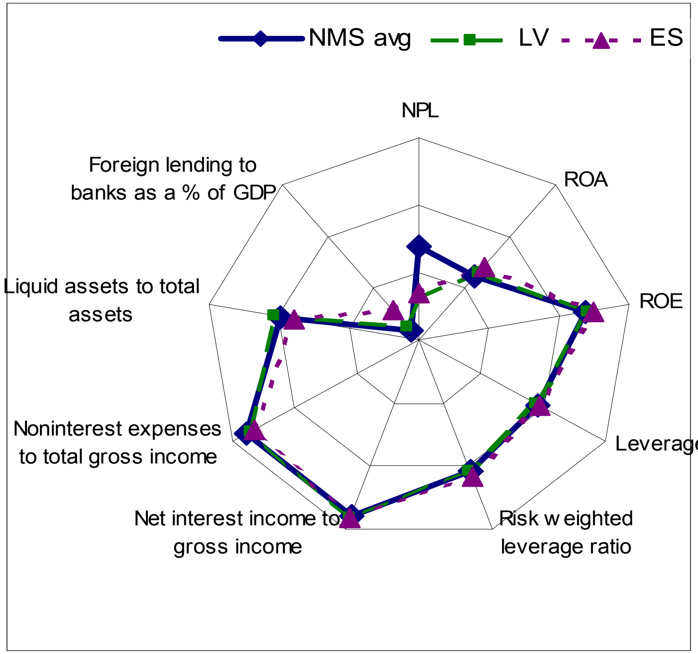
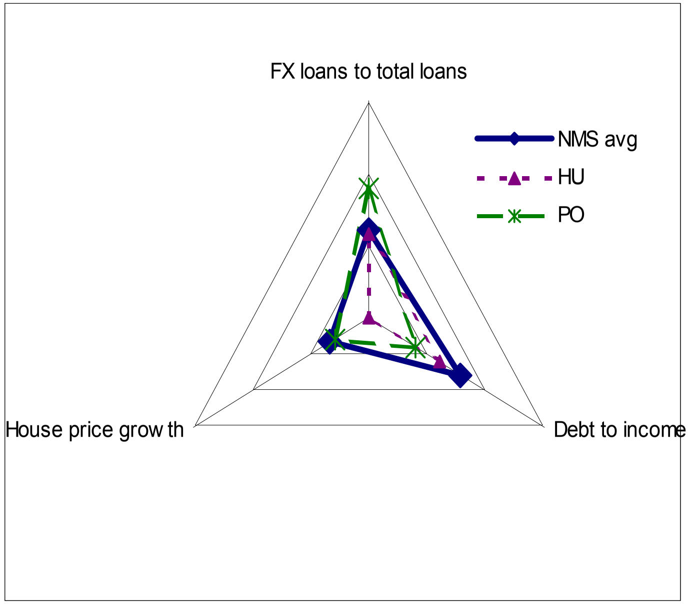
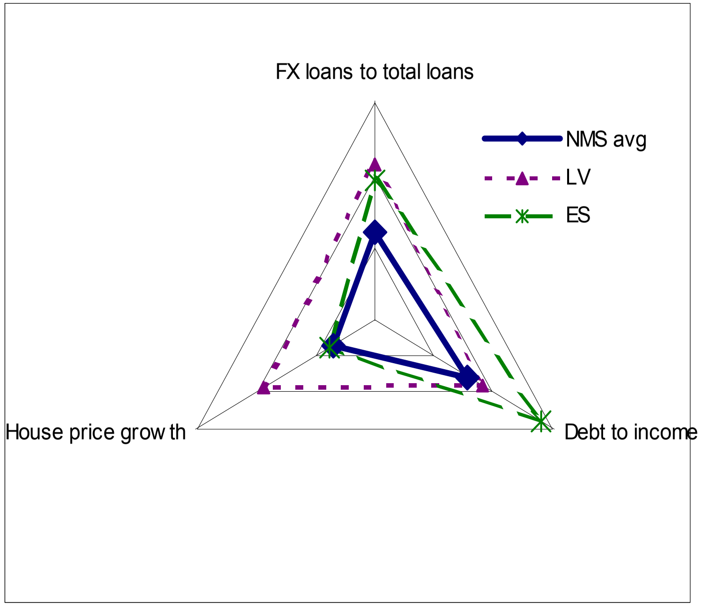




Figure 4.2.2. Household sector indicators



The low frequency data (we use 2007 data) suggest that new member states' banking systems remained relatively healthy from data for that year. The analysed economies did not differ much from the regional average, as depicted in Figure 4.2.1. The time series data shown in Section 3.4 show that NPLs were at historic lows for each country, except for Estonia where a pickup was already apparent. Returns on assets and equity were again historically high, except in Hungary where some decline was apparent in 2007 – although high returns in Estonia may also have shown overheating and risks for the future. Bank capital remained over 10% on a risk adjusted level for each country, and was nearly 15% in Estonia – above the NMS average but only just in line with the average for Emerging Market Economies. In terms of liquidity the Hungarian banks showed a worryingly low level of 3.9%, well below the NMS average. Finally, foreign lending to banks is low in Poland and Hungary – 3% and 12% whereas there is more exposure to exchange rate risk in Estonia and Latvia where foreign lending is 20-40%.

The relative soundness of the banking systems in Poland, Hungary, Estonia and Latvia resulted from their low exposure to toxic products of the US mortgage market. The deteriorating macroeconomic situation may, however, take a toll on the banking sector with a lag (through increasing ratios of nonperforming loans to total loans and decreasing profitability of banks). Furthermore even in 2007, Hungarian banks showed low liquidity and returns were already declining, while the Baltic states were both vulnerable to currency risk and banking performance showed signs of the economic overheating.

### 4.2.2 Household sector indicators

We look at the household sector from the perspective of three indicators: the ratio of household debt to personal income, the growth of house prices and the share of foreign currency loans to total loans. Figure 4.2.2 illustrates the performance of the household sector in Estonia, Latvia, Poland and Hungary against the NMS average (using 2007 data).

The figure illustrates some serious disequilibria building up in the Baltic economies. The household sector has over borrowed, as indicated by the fact that the level of debt to personal income in the Baltic economies has significantly exceeded that observed not only in the other new member states, but also in old members of the EU (Figure 3.4.1). Although there is the protection of the currency board and peg in Estonia and a peg in Latvia, these arrangements have historically been vulnerable to realignment – at which point the foreign debt of households equivalent to 35%+ of GDP would be very threatening. Furthermore, the growth of credit to the housing sector was accompanied by potentially excessive rises in house prices.

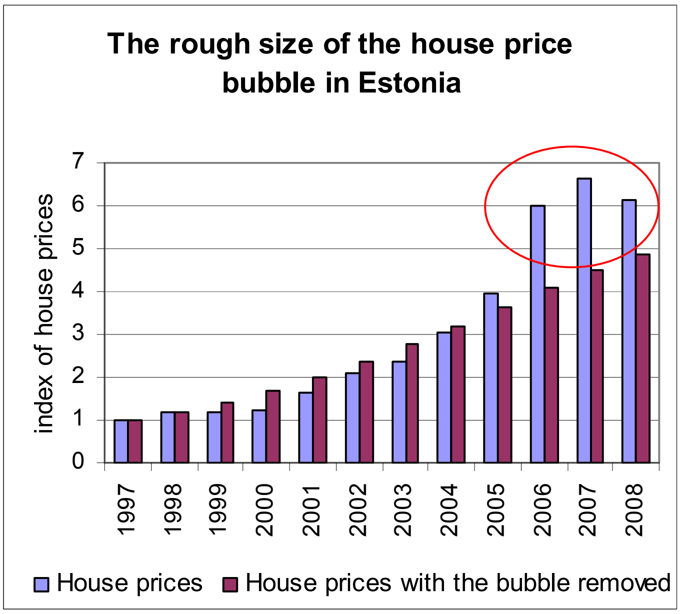
It is estimated that for instance that in Estonia the growth of house prices from 2005 (which is when the dynamic credit expansion started) was in excess of an equilibrium based on fundamentals. The subsequent years witnessed prices drifting from equilibrium even further[26]. Figure 4.2.3 shows the estimated scale of the house price bubble in Estonia (Barrell, Davis, Fic, Orazgani, 2009).

[26] The growth of house prices, as such, is a positive phenomenon implying price convergence - in 2007 the level of house prices in Tallinn constituted 50 per cent of the house price level recorded in Helsinki

The situation in the Central European states, Hungary and Poland, remained more balanced in terms of overall debt and house prices. On the other hand, the share of foreign currency borrowing to Hungarian households at 17% of GDP and over 40% of the total exceeded the level that could be perceived as safe, not least because it was in non-euro currencies.

Taking an overall view, although house price growth and rising debt to income ratios are indicators of catch-up, their high growth was a warning sign for the new member states. Similarly, the average level of foreign currency borrowing remained at elevated levels notably in Hungary and the Baltics. Hence the risk of financial instability beginning with the household sector was significant.

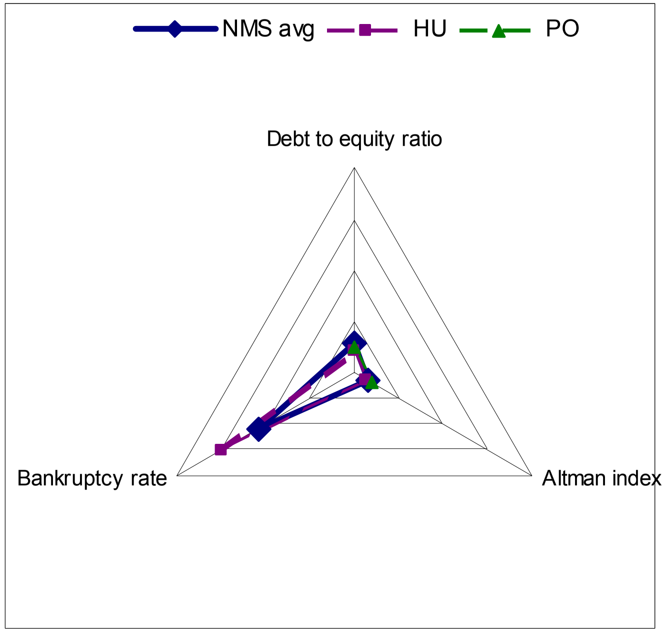
**Figure 4.2.3. The size of the house price bubble in Estonia**




## 4.2.3 Corporate sector indicators

The performance of the corporate sector in Estonia, Latvia, Hungary and Poland is assessed by looking at three indicators: the debt to equity ratio, the Altman index and the rate of bankruptcies – see figure 4.2.4. Note that the consistent bankruptcy data were only available for 2005. The ratio of debt to equity in Latvia and the bankruptcy rate in Hungary remained somewhat higher than the regional averages suggesting that there can be some intrinsic vulnerabilities in these economies that might be exacerbated should a crisis arrive. Altman indices were above Western European levels but not excessive, although the Polish index had increased sharply over 2005-7. Furthermore, foreign currency exposure was greater than for the household sector, except in Poland, amounting to around 57% of GDP for Estonia, 44% for Latvia and 21% for Hungary. Hence, there is marked vulnerability to realignment or depreciation, respectively.

**Figure 4.2.4. Corporate sector indicators**



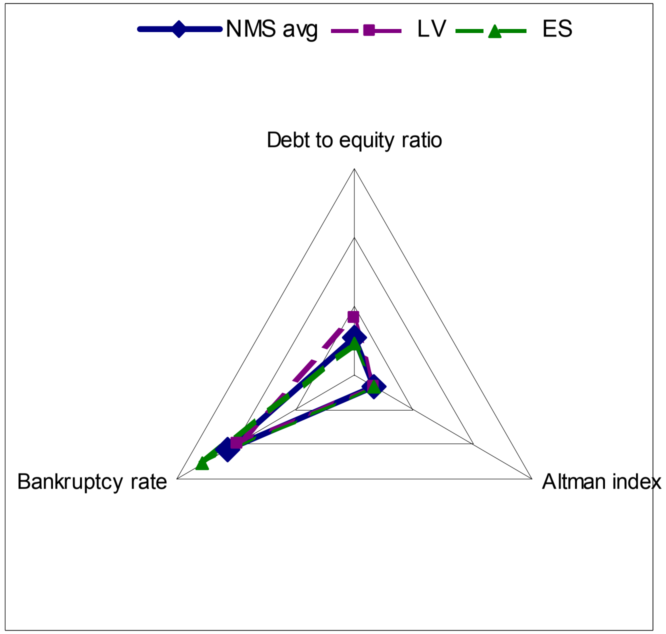
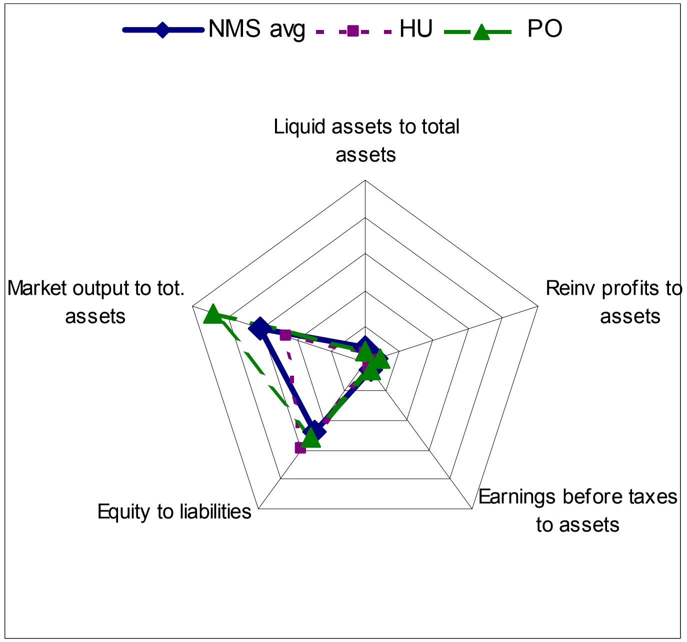
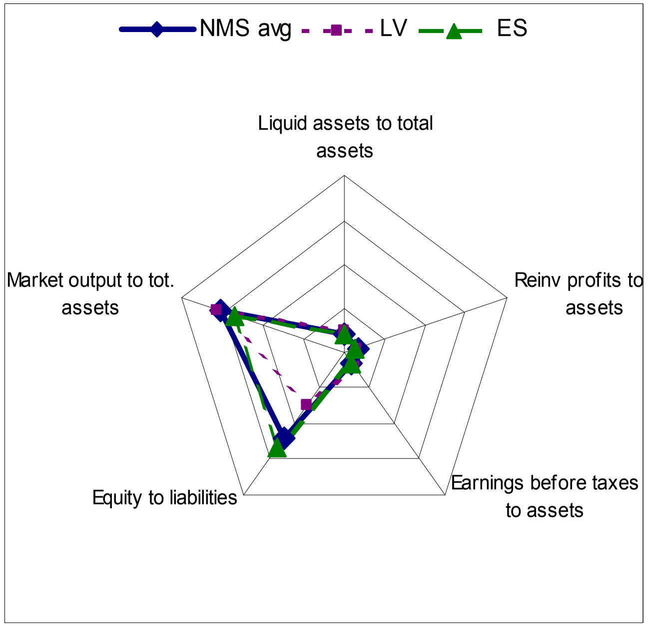




**Figure 4.2.5. Altman index components**



We also look closer at individual components of the Altman index. The index allows us to assess the performance of the corporate sector from the microeconomic perspective. In particular the soundness of the corporate sector is viewed from the perspective of five indices: liquid assets to total assets; balance of primary income to total assets; operating surplus (before taxes) to total assets; equity to debt; market output to total assets[27]. Figure 4.2.5 shows estimated values of the components of the Altman index for the four analysed economies (we use 2007 data). Analysis of the individual microeconomic indicators suggests that the Estonian and Latvian corporate sectors were in a relatively good position (in line with the fast developing economy). In the case of Latvia a sign of overheating, which eventually led to the macroeconomic unsustainability of the Latvian economy, was a relatively low ratio of equity to liabilities. This could have signalled the necessity of adjustments in the real sphere of the economy.

The Polish and Hungarian data on corporate sector performance sketched a positive picture. On the other hand, the lower market output to total assets in Hungary as compared to the regional average might have suggested difficulties building up on side of internal demand (domestic demand started to decline in 2006 already, and 2007 saw a drop in this category of 1.8 per cent).

On balance, the corporate sector data suggest a somewhat more positive picture than for the household sector, but the foreign currency exposure remained a cause for concern.

To recap, the examination of low frequency data shows that the household and corporate sectors developed some imbalances. The imbalances were especially visible in the Baltic economies and Hungary (this was later confirmed by the scale of adjustment in GDP - see section 4.1). While the major source of imbalances in the Baltic economies was the household sector (with all three indicators - the share of foreign currency borrowing, house prices growth and debt to income ratios - exceeding regional standards), the Hungarian difficulties, although less broadly based and less apparent, materialised both in the household and corporate sector (the share of foreign currency borrowing of households and the bankruptcy rate of firms were higher than regional averages).

It might be suggested that the household sector was less aware of risks related to unsustainable, short sighted decisions than the corporate sector (which eventually results in a build up of large imbalances). This is apparent when analysing for instance the private sector's foreign currency borrowing as a per cent of GDP (Table 3.4.15), and in particular its decomposition to borrowing to households and borrowing to enterprises (subtract Table 3.4.9, see below). In 2008, the corporate sector, unlike the household sector, cut its foreign currency borrowing. This may suggest that entrepreneurs were more risk aware than households.

[27] As the data on nonfinancial assets is not available we approximate the value of nonfinancial assets in the business sector by (3*GDP-FDI)/2

**Table 4.2.2. Estimated corporate sector borrowing as percent of GDP**

| | ES | HU | LV | PO |
|---|---|---|---|---|
| 2004 | 0.49 | 0.16 | 0.07 | 0.07 |
| 2005 | 0.45 | 0.19 | 0.11 | 0.06 |
| 2006 | 0.61 | 0.23 | 0.28 | 0.05 |
| 2007 | 0.62 | 0.25 | 0.43 | 0.07 |
| 2008 | 0.57 | 0.21 | 0.43 | 0.04 |

Note: ES=Estonia, HU=Hungary, LV=Latvia, PO=Poland
The figures are those in Table 3.4.15 minus those in Table 3.4.9, and are likely to be approximate owing to different data sources.
Source: BIS and national central banks

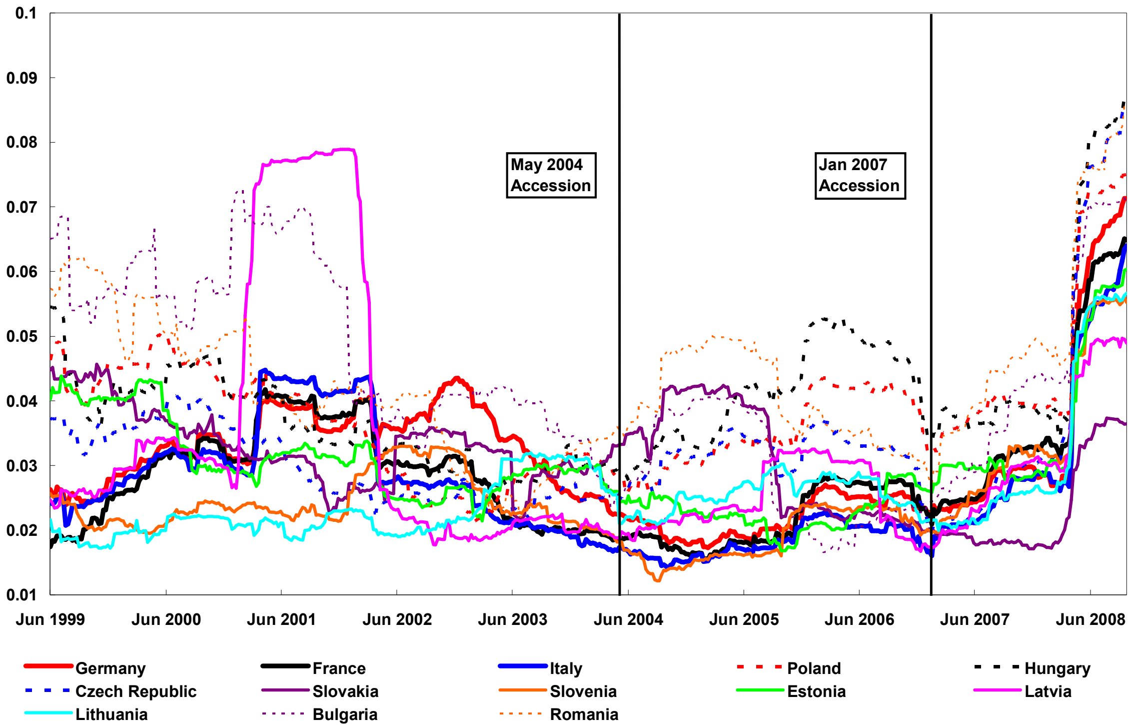
Concluding this section, during the recent period of crisis, the banking sector in the four analysed countries was affected by the crisis through spillovers from the real economy – affected in turn by the situation in the household and corporate sectors highlighted above - rather than direct effects of the global banking turbulence. Also reflecting the rather similar condition of banks in 2007 as depicted above, the severity of the slow down in these four new member states was reflected in the condition of the banking sector. The more severe the recession, the higher impact on banks it exerted. In particular, the dramatic, record collapse of the Latvian economy was accompanied by intensifying troubles in the Latvian banking sector, with the government forced to nationalise one of the largest banks. This turmoil was no doubt an additional reason for high interbank interest rate volatility as discussed in the section below. The three remaining countries managed to escape major nationalisations although bank provisions and write-offs are likely to have increased.

### 4.2.4 Market indicators

While the low frequency indicators help us to identify intrinsic vulnerabilities of individual sectors in the economy (that may affect how the economy responds to a crisis), the high frequency data allow us to monitor dynamics of financial markets in real time. In particular, in our analysis we look at the volatility of equity, exchange and money markets and developments in financial risk premia.

Figure 4.2.6 shows the volatility in the Polish, Hungarian, Latvian and Estonian equity markets (we compute unconditional volatilities of the weekly change in share prices, adjusted by the exchange rate so that all equity prices are considered in a common currency). Equity prices seem to be relatively well synchronised, however, as the depth of the equity markets in new member states differs, the "bandwidth" of the stock market channel of transmission of financial shocks to the real economy may be greater in the larger economies of Central Europe (the capitalisation of the stock exchange in Poland and Hungary is greater than that in Estonia and Latvia). The volatility of equity markets increased significantly in summer 2008.

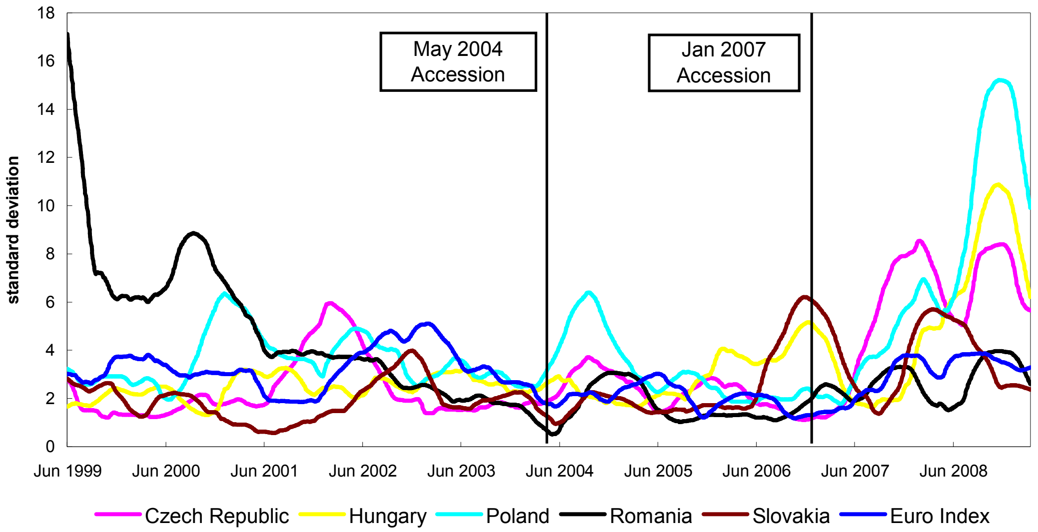
**Figure 4.2.6. Equity market volatility in the four analysed economies**




Source DataStream

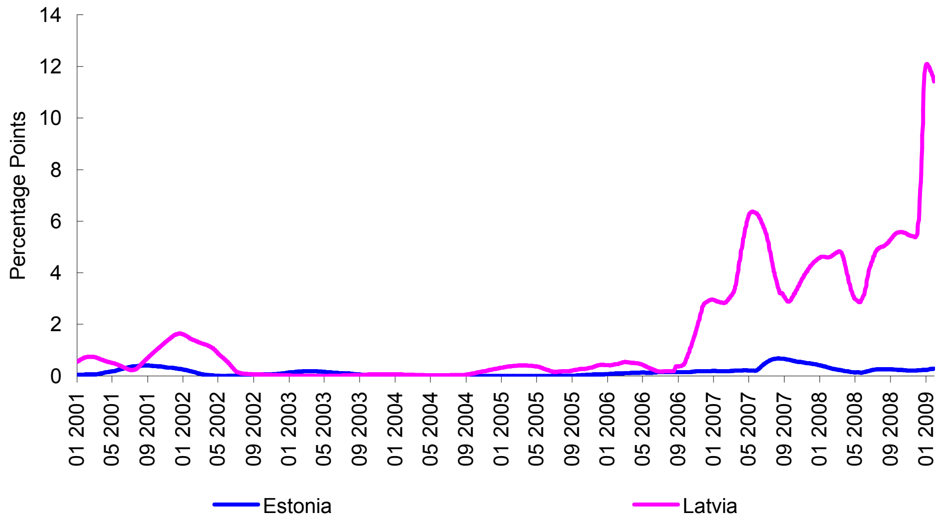
The increase in volatility in the equity markets coincided with an increase in the volatility of the exchange market (see also Section 3.3. and Chapter 7). The volatility of exchange rates in free floating Hungary and Poland rocketed dramatically in the third quarter of 2008 (see figure 4.2.7). On the wave of international speculation all currencies depreciated significantly as investors withdrew capital from the whole region (including countries with good fundamentals such as Poland). The increased nervousness in the exchange markets of Central Europe created pressures also for the Baltic currencies pegged to the euro, and the Latvian lat especially. The fixed exchange rate regimes, within which the Baltic economies operate, sheltered the domestic economy from external shocks during times of tranquility, however, during times of turbulence, they may expose the currency to speculative attacks or force absorption of large external shocks through sharp domestic adjustments. In particular, the increased pressure on the Baltic currencies was apparent, inter alia, in increased volatility of interest rates (see figure 4.2.8). The volatility of the Latvian 3-month interest rate increased already at the turn of 2006/2007 when the first symptoms of the coming adjustment appeared. In 2008 the volatility of the Latvian interest rates went up even higher. The Estonian interest rates remained most stable among the countries of the region operating within fixed exchange regimes. This may suggest the relative soundness of the Estonian economy as compared to the neighbouring Baltic countries, not least because the interest rates shown are interbank spreads and hence include an allowance for credit risk. Note that Hungarian and Polish volatility has remained comparable to that in Estonia.

**Figure 4.2.7 Effective exchange rate volatility**




Note: Standard deviation of daily effective exchange rates, +/- 6 month, calculated using JP Morgan broad indices
Source DataStream and own calcualtions

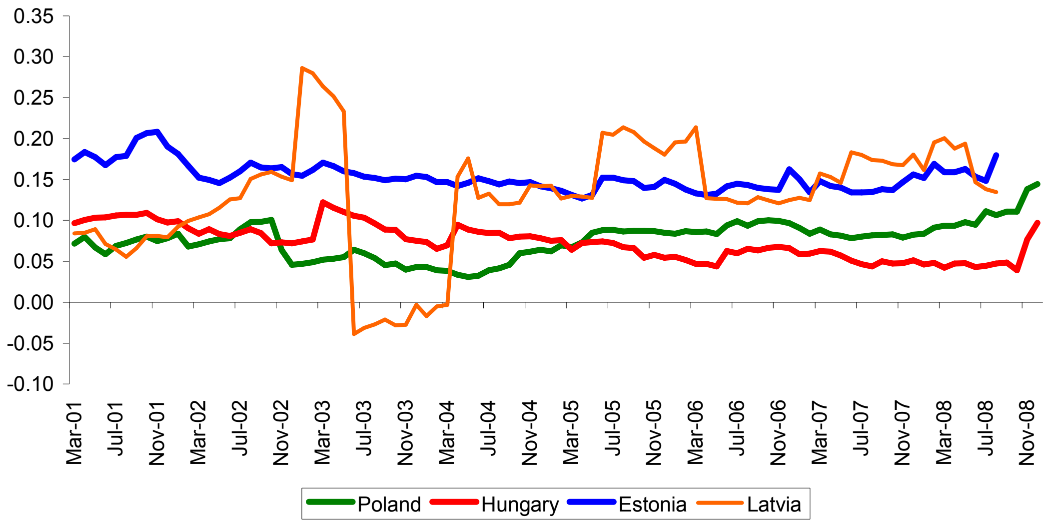
**Figure 4.2.8. Nominal interest rate volatility**




Note: Standard deviation of daily 3-month interbank rates, +/- 6 month
Source DataStream and own calculations

To distinguish between equity and exchange markets correlation and contagion we look at estimated values of equity and exchange rate risk premium. Figure 4.2.9 shows equity risk premium series for the four analysed countries. The equity risk premium increased somewhat in the final months of 2008. The moderate increases, however, may suggest that the equity risk premium channel does not play the dominant role in the transmission of a crisis. The stronger reaction of Hungary may reflect greater dependence of the Hungarian stock exchange on market sentiment and herding behaviour.

**Figure 4.2.9. Equity risk premium**




Source Own calculations

The exchange risk premium (computed as an inverted function of the UIP relation (augmented with risk premium)), for both the Polish zloty and the Hungarian forint, surged dramatically in autumn 2008 (see figure 4.2.10). The Hungarian economy entered the crisis structurally weakened after the period of protracted internal imbalance triggered by a major fiscal crisis of 2006. The surge in the exchange risk premium could thus reflect adjustments in investors' perception of the sensitivity of the Hungarian economy to the crisis. In the case of Poland, however, the sharp movement in the exchange rate risk premium remained inconsistent with Polish macroeconomic fundamentals and can be classified as a classical effect of herding behaviour. The Polish economy remained robust to the crisis (up till now it has been recording positive growth rates, the only country in the EU to do so) avoiding recession. This was a result of limited openness of the Polish economy and its large internal market. The weakening of the currency helped Polish exporters to gain a competitive edge over their competitors during the crisis times. However, had the depreciation been deeper it could have had extremely adverse and dangerous consequences for the real economy and the stability of the financial system.

In Latvia and Estonia, countries fixing their exchange rates, the risk premium increased slightly in the period of global turmoil. The rising risk premium may reflect an intensification of speculative attacks on the Baltic currencies, and on the Latvian lat especially.

We complement the estimates of volatility and risk premia with the output of the VECH multivariate GARCH equations, which show both conditional volatility and conditional covariance. These are not available for the Baltics except for Estonia (equities). Table 4.2.3 shows the relevant results for the equity market VECH equations.

**Figure 4.2.10. Exchange rate premium in Poland and Hungary**

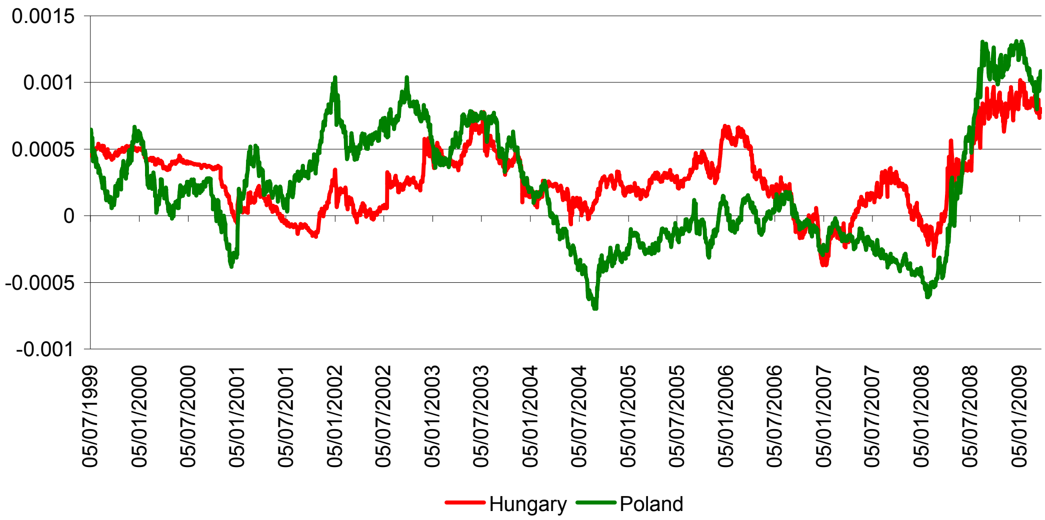



**Figure 4.2.11. Exchange rate premium in Estonia and Latvia**

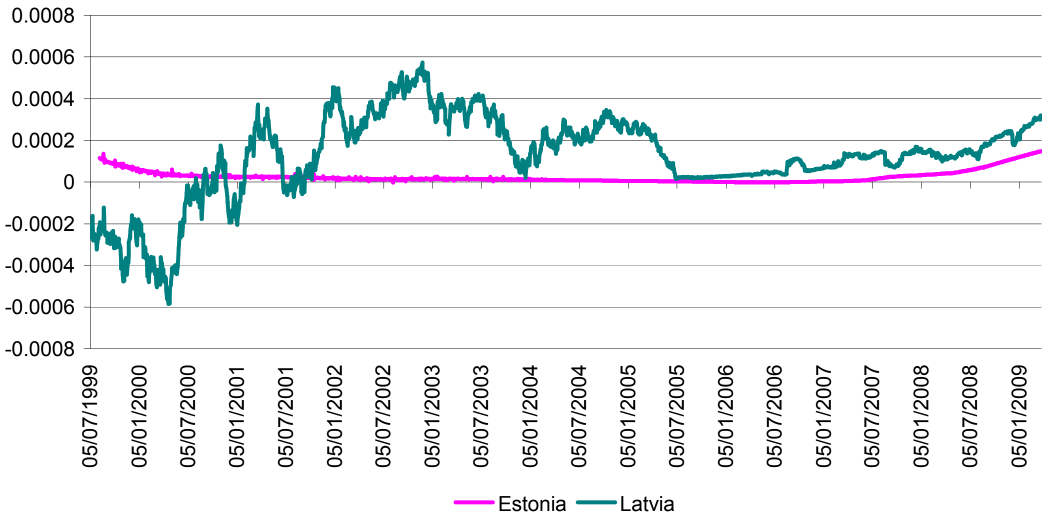



**Table 4.2.3. Conditional variances (CV) and covariances (CC) for equity markets**

| | Estonia | | | Hungary | | | Poland | | |
|---|---|---|---|---|---|---|---|---|---|
| Daily | CV | CC(NMS) | CC(EU) | CV | CC(NMS) | CC(EU) | CV | CC(NMS) | CC(EU) |
| 2006 | 0.00012 | 3.50E-05 | 4.52E-05 | 0.00033 | 9.10E-05 | 0.000152 | 0.00028 | 8.81E-05 | 0.000134 |
| 2007 | 0.000228 | 4.06E-05 | 5.51E-05 | 0.00025 | 9.24E-05 | 0.000119 | 0.000254 | 0.0001 | 0.000105 |
| 2008 | 0.000612 | 0.000203 | 0.000268 | 0.001052 | 0.000498 | 0.000545 | 0.000707 | 0.000411 | 0.000511 |
| 2009 | 0.000553 | 0.000176 | 0.0002 | 0.000992 | 0.00041 | 0.0005 | 0.000903 | 0.000414 | 0.000495 |
| Indices | | | | | | | | | |
| 2006 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 2007 | 189 | 116 | 122 | 76 | 101 | 78 | 91 | 114 | 78 |
| 2008 | 509 | 581 | 592 | 319 | 547 | 358 | 253 | 466 | 381 |
| 2009 | 460 | 504 | 443 | 301 | 450 | 328 | 323 | 470 | 369 |

Notes: CV indicates the conditional variance, CC(NMS) the conditional covariance with other NMS and CC(EU) the conditional covariance with the OMS markets

For the equity markets the greater covariance with other NMS and EU than for Estonia is apparent throughout, showing integration but also risk of contagion. Conditional volatility of these markets is also higher. In terms of trends, it is apparent that the crisis has generated a higher covariance for all three markets vis a vis both the NMS and the EU. On the other hand, there is little to distinguish between the Polish and Hungarian markets to suggest a greater risk of economic crisis in the latter, although covariances with other NMS and EU markets are higher in Hungary in 2008 than for Poland.

**Table 4.2.4. Conditional variances (CV) and covariances (CC) for effective exchange rates**

| | Hungary | | | Poland | | |
|---|---|---|---|---|---|---|
| Daily | CV | CC(NMS) | CC(EU) | CV | CC(NMS) | CC(EU) |
| 2006 | 3.18E-05 | 9.4853E-06 | 2.82864E-07 | 2.5E-05 | -1.02857E-06 | 6.1376E-06 |
| 2007 | 2.65E-05 | 7.0586E-06 | 4.16962E-07 | 1.69E-05 | -3.32684E-07 | 4.2268E-06 |
| 2008 | 8.66E-05 | 3.0221E-05 | 7.24886E-06 | 7.02E-05 | 7.69251E-06 | 2.2287E-05 |
| 2009 | 0.000131 | 5.3913E-05 | 1.04916E-05 | 0.000146 | 7.68986E-06 | 3.8416E-05 |
| Indices | | | | | | |
| 2006 | 100 | 100 | 100 | 100 | 100 | 100 |
| 2007 | 83 | 74 | 147 | 68 | 32 | 69 |
| 2008 | 272 | 319 | 2563 | 281 | -748 | 363 |
| 2009 | 412 | 568 | 3709 | 583 | -748 | 626 |

Notes: CV indicates the conditional variance, CC(NMS) the conditional covariance with other NMS currencies and CC(EU) the conditional covariance with the Euro

Looking at effective exchange rates for Hungary and Poland in Table 4.2.4., we see a pattern of greater covariance of Hungary with other NMS while the higher Polish covariance is with the Euro. Indeed in 2006 and 2007 the Polish effective rate was negatively correlated with other NMS rates. This is a potential indicator of greater risk for Hungary both in itself and as a source of regional contagion. On the other hand, the overall conditional volatility of the rates is comparable over the crisis period, and for Poland it is higher than Hungary in 2009.

A summary of market concerns over the countries' fiscal situation is obtainable from credit default swaps, as discussed in Section 3.3. The following table shows that of the four countries, there was greatest concern for Latvia, followed by Hungary. The rise in CDS spreads in Poland and Estonia was much more moderate. Accordingly, the spreads highlighted the countries worst hit by the crisis as being most likely to default on their government debt, be it for economic reasons or also due to political difficulties.

On balance, markets both foreshadowed and indicated crises in Hungary and Latvia, and this is apparent in the data. However, it is clear that both Estonia and Poland were also affected by market turbulence, offering signals that needed careful interpretation in the light of understanding of herding and contagion.

### 4.2.5 Macroeconomic projections

This section sets the scene for an analysis of risks of a crisis using EWS tools. We discuss recent developments and current macroeconomic projections for Estonia, Latvia, Poland and Hungary.

The new member states constitute a highly heterogeneous group. After several years of operating much above potential the Baltic economies experienced a sharp adjustment. A slow down in the Baltic economies was expected, its scale, however, exceeded the gloomiest projections. Indeed, the Baltic countries recorded the hardest landing amongst the OECD countries. The current forecasts for Estonia and Latvia envisage rates of decline in GDP in 2009 of 13.4 and 17.9 per cent, respectively. The current severe economic crisis is a mixture of local and global shocks: adjustments in domestic demand following a strong credit expansion, and a collapse in global demand.

**Table 4.2.5. Macroeconomic projections for Poland, Hungary, Latvia, Estonia**

| | GDP growth | | | | | Inflation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Poland | 6,2 | 6,8 | 4,8 | 1,1 | 2,9 | 1,3 | 2,6 | 4,2 | 3,7 | 2,5 |
| Hungary | 4,1 | 1,2 | 0,4 | -5,8 | 1 | 4 | 7,9 | 6 | 4,4 | 3,3 |
| Latvia | 12,2 | 10 | -4,2 | -17,9 | -1,4 | 6,6 | 10 | 15,3 | 3,9 | -3 |
| Estonia | 10 | 7,2 | -3,6 | -13,4 | -1,1 | 4,4 | 6,7 | 10,6 | -0,5 | 1,2 |

Source NiGEM database and projections

The scale of imbalances in the larger economies of Central Europe, Poland and Hungary, was much lower at the outset of the crisis. The macroeconomic situation of these two economies was also very different. The Hungarian economy entered the crisis weakened after a period of painful adjustments triggered by a major fiscal crisis of 2006. On the contrary, in the years preceding the crisis the Polish economy was booming (the scale of the boom was not, however, as unsustainable as in the case of the Baltics). The global crisis deepened the expected slow down in Poland somewhat, it seems, however that the Polish economy has weathered the crisis relatively well (Poland is the only country in the EU that has managed to escape recession). Poland's resilience to the global turbulence has resulted mainly from the limited level of openness of the economy and a large internal market. Adjustments in the labour market forced during previous crises (and the Russian crisis in particular) may add to the picture. Table 4.2.5 shows our current economic projections for the four analysed countries.

The crisis has taken a severe toll on public finances. The budget deficits have soared. The European Commission has already launched excessive deficit procedures against Latvia and Poland. In the context of adoption of the euro, the budget deficit criterion seems the biggest hurdle at the moment to all four countries.

## 4.3 Early Warning System tools

We apply signal extraction, logit model and binominal tree methods to four countries: Estonia, Latvia, Poland and Hungary. We report results for three variants of each method: the Asian approach, the Latin American approach and the Asian/Latin American approach.

Table 4.3.1 shows results for the signal extraction approach. The exercise was performed for the sample period 2007-2010. For years 2009 and 2010 we use NIGEM forecast values and expert judgement.

The table suggests that the number of warning signs increased significantly in 2008 as compared to 2007 in all analysed economies except Poland. The year 2009 saw a continuation of realisation of unfavourable signs with Latvia recording the highest number of warnings. This coincided with markets' perception of the state of the Latvian economy, as witness inter alia the rise in CDS spreads. 2009 was a particularly difficult year for Latvia. The global financial crisis hit both the financial system and the real sphere of the economy badly. The external crisis shock coincided with the inevitable adjustment in the domestic economy following a period of deep macroeconomic imbalances built up in the preceding years. The banking system, exposed to crisis-driven changes in foreign financing, was also affected by the domestic economic downturn. Banks' aggregate portfolios decreased and their quality deteriorated, marred by delinquent payments and increases in nonperforming loans. In effect, the government was forced to nationalise one of the largest banks, the Parex Bank. The macroeconomic collapse was broadly based, affecting most sectors of the economy. The highest drop in GDP materialised in the first quarter of 2009 when the economy shrank by 11 per cent in quarterly terms. The extremely unfavourable macroeconomic developments took their toll on the political life of Latvia. After protests against the handling of the crisis by the government, the cabinet of I. Godmanis stepped down in February 2009.

To summarise the intensity of signals in individual years we construct a synthetic measure of crisis warnings which is computed as a sum of signals from all models materialising in a particular year in a particular country (see table 4.3.2).

**Table 4.3.1. Signal extraction applied to Estonia, Latvia, Poland, Hungary**

| | Estonia | | | | | Hungary | | | | | Latvia | | | | | Poland | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | Credit growth | GDP growth | Depreciation | Budget deficit | Inflation | Credit growth | GDP growth | Depreciation | Budget deficit | Inflation | Credit growth | GDP growth | Depreciation | Budget deficit | Inflation | Credit growth | GDP growth | Depreciation | Budget deficit | Inflation |
| **Asian model** | | | | | | | | | | | | | | | | | | | | |
| Percentile | | 3.5 | 3.5 | 3.5 | | | 3.5 | 3.5 | 3.5 | | | 3.5 | 3.5 | 3.5 | | | 3.5 | 3.5 | 3.5 | |
| Point on distribution | | -2.04 | -1.4 | -3.28 | | | 0.74 | -9.3 | -9.10 | | | -2.34 | -4.7 | -3.95 | | | 1.36 | -5.8 | -6.03 | |
| 2007 | | NS | NS | NS | | | NS | NS | NS | | | NS | NS | NS | | | NS | NS | NS | |
| 2008 | | S | NS | S | | | S | NS | NS | | | S | NS | S | | | NS | NS | NS | |
| 2009 | | S | NS | S | | | S | NS | NS | | | S | NS | S | | | S | S | NS | |
| 2010 | | NS | NS | NS | | | NS | NS | NS | | | NS | NS | S | | | NS | NS | NS | |
| **Latin American model** | | | | | | | | | | | | | | | | | | | | |
| Percentile | 10 | 0.5 | | 4 | | 10 | 0.5 | | 4 | | 10 | 0.5 | | 4 | | 10 | 0.5 | | 4 | |
| Point on distribution | 13.4 | -3.4 | | -3.2 | | 4.0 | 0.4 | | -9.1 | | 15.4 | -3.9 | | -3.9 | | 5.1 | 1.3 | | -6.0 | |
| 2007 | S | NS | | NS | | S | NS | | S | | S | NS | | NS | | S | NS | | NS | |
| 2008 | S | S | | NS | | S | S | | S | | NS | S | | S | | S | NS | | NS | |
| 2009 | NS | S | | S | | NS | S | | S | | NS | S | | S | | NS | S | | NS | |
| 2010 | NS | NS | | NS | | S | NS | | S | | NS | NS | | S | | S | NS | | NS | |
| **Asian/Latin American model** | | | | | | | | | | | | | | | | | | | | |
| Percentile | | 0.5 | | 4 | 6 | | 0.5 | | 4 | 6 | | 0.5 | | 4 | 6 | | 0.5 | | 4 | 6 |
| Point on distribution | | -3.4 | | -3.2 | 1.7 | | 0.4 | | -9.1 | 3.7 | | -3.9 | | -3.9 | 2.1 | | 1.3 | | -6.0 | 1.0 |
| 2007 | | NS | | NS | S | | NS | | NS | S | | NS | | NS | S | | NS | | NS | S |
| 2008 | | S | | NS | S | | S | | NS | S | | S | | S | S | | NS | | NS | S |
| 2009 | | S | | S | NS | | S | | NS | S | | S | | S | S | | S | | NS | S |
| 2010 | | NS | | NS | NS | | NS | | NS | NS | | NS | | S | NS | | NS | | NS | S |

**Table 4.3.2. A synthetic measure of crisis warnings**

| Number of signals | | | | |
|---|---|---|---|---|
| | **Estonia** | **Hungary** | **Latvia** | **Poland** |
| **2007** | 2 | 3 | 2 | 2 |
| **2008** | 6 | 6 | 7 | 2 |
| **2009** | 6 | 5 | 7 | 4 |
| **2010** | 0 | 2 | 3 | 2 |

While the signal extraction model constructed for the purposes of the anticrisis toolkit utilises percentile threshold values based on historical developments of individual variables, the method can be modified to take account of Maastricht criteria thresholds – in particular, the historical percentile thresholds in case of inflation, budget deficits and exchange rates can be replaced by the Maastricht thresholds.

**Figure 4.3.1. Probabilities of a crisis in Estonia, Latvia, Poland and Hungary**

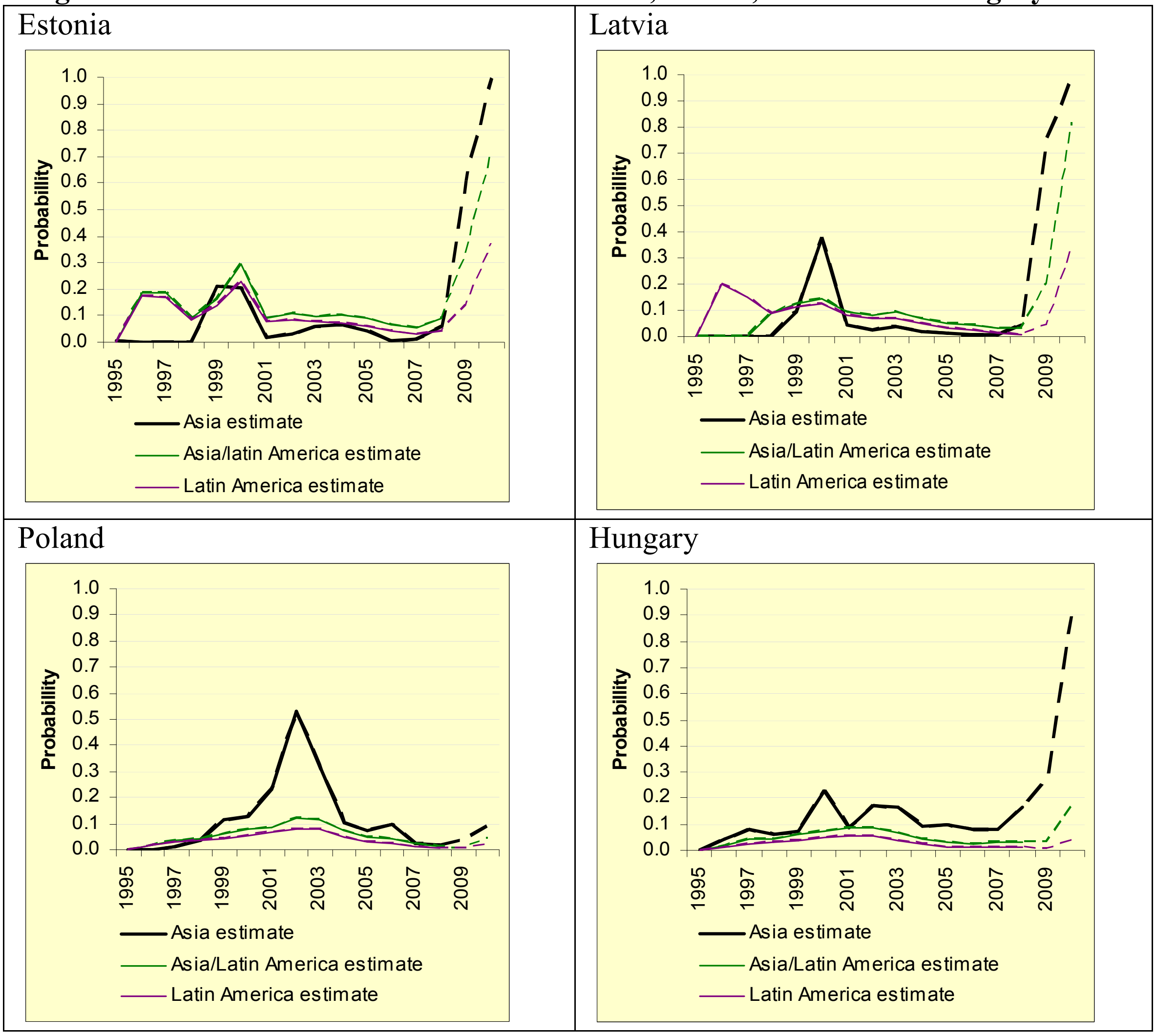



Figure 4.3.1 shows probabilities of a crisis generated with logit models for the four analysed economies: Estonia, Latvia, Hungary and Poland. The focus of the exercise is on current developments. Bear in mind that the Asian model features credit growth, GDP per capita, the real interest rate, depreciation, the credit/GDP ratio, GDP growth and M2 as a proportion of FX reserves; the Latin American model features only GDP

growth and GDP per capita while the combined model features these two variables together with credit/GDP.

The exercise suggests that while the Baltic economies and Hungary may be exposed to increased risks of macro and financial turbulences, the Polish economy should escape the negative scenario. Outcomes of the logit exercise depend on the approach applied. The Asian model produces the highest probabilities of a crisis, while the Latin American estimates are the lowest. Driving the increase in crisis probabilities in Estonia, Latvia and Hungary is mainly growth rates of GDP and credit.

**Table 4.3.3. Probabilities of a crisis using binominal trees along with a synthetic measure of a crisis**

| | Probability of a crisis (in %) using | | | |
|---|---|---|---|---|
| | **Asian tree** | **Asian/Latin American tree** | **Latin American tree** | **Synthetic measure of a crisis** |
| Latvia | 79,4 | 57,1 | 39,4 | 175,9 |
| Estonia | 79,4 | 12,2 | 39,4 | 131 |
| Hungary | 79,4 | 12,2 | 39,4 | 131 |
| Poland | 0 | 12,2 | 39,4 | 51,6 |

Finally, to analyse the vulnerability of individual economies to a crisis we apply the binominal tree method. Results for Estonia are shown below as an example (we use 2008 data). Table 4.3.3 summarises results for all four countries using three types of the binominal recursive tree: Asian, Asian/Latin American and Latin American. The table presents probabilities of a crisis in individual countries. As in the case of the logit model we construct a synthetic measure of a crisis (which is calculated as a sum of probabilities obtained using individual methods). The higher the measure, the greater the exposure of a country to a crisis. The exercise shows that the country most prone to a crisis was Latvia (this is consistent with markets' view on the state of the Latvian economy and developments in Eastern Europe). Estonia and Hungary ranked second. The Polish economy remained most robust to the global financial turmoil. This reflected strong fundamentals.

## *4.4 Conclusion*

We have assessed the range of data from the toolkit for indicators of comparative vulnerability in Estonia, Latvia, Hungary and Poland. We have utilised the majority of the tools which have been outlined in the paper. The analysis has both enabled us better to understand recent developments and also allowed some projections for the future.

On balance, the longer term data implied vulnerability both of households and corporations, notably to currency movements but also owing to high indebtedness and overvaluation of real estate in some of the countries. The banking systems entered the crisis in reasonable shape for the most part, which has enabled them to withstand shocks to the real economy and financial markets, with the exception of a major bank in Latvia. Financial market volatility, risk premia and CDS spreads have been consistent with a greater risk of crisis in Latvia and Hungary than in Estonia and

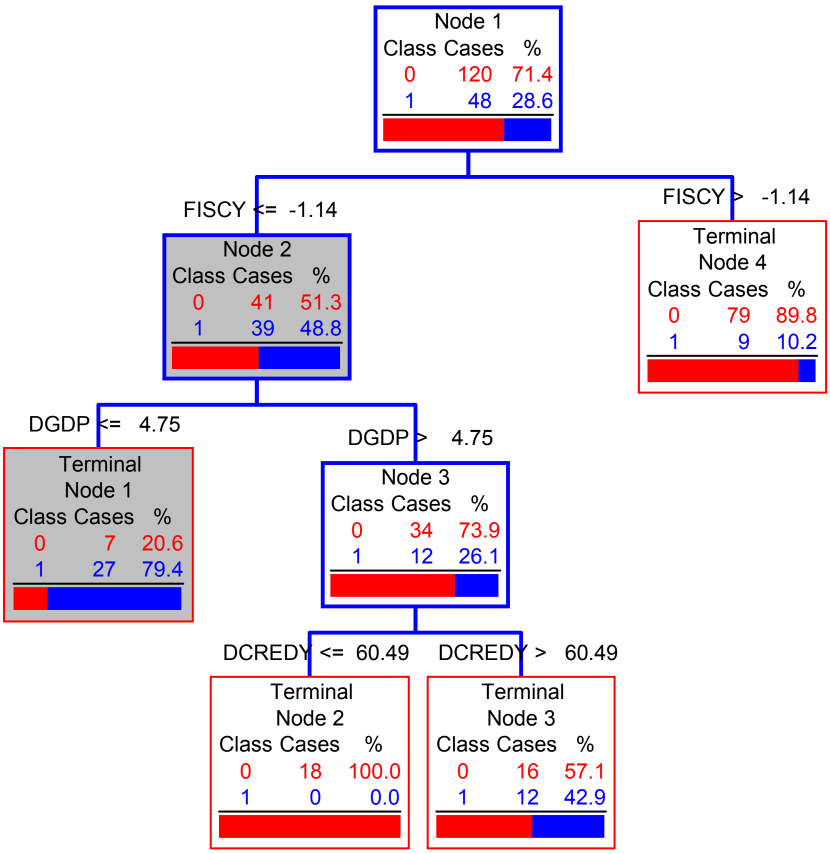
Poland, although markets remain cautious about the peg in Estonia combined with high levels of debt in foreign currency.

Looking forward, the severe macroeconomic shocks in the Baltic countries entail risks for further aggravation of the situation, especially if there are further currency pressures. The EWS models suggest a heightened risk of crisis in 2010, using current forecasts, except in Poland. Even if a crisis does not supervene, banks in the Baltics are likely to make further losses, which would bear mainly in foreign parents. So long as they continue to support subsidiaries, the danger of systemic risks is low. But there remains the risk that in some circumstances, there could be abandonment of such subsidiaries (e.g. if a shock were to hit Sweden or Austria).

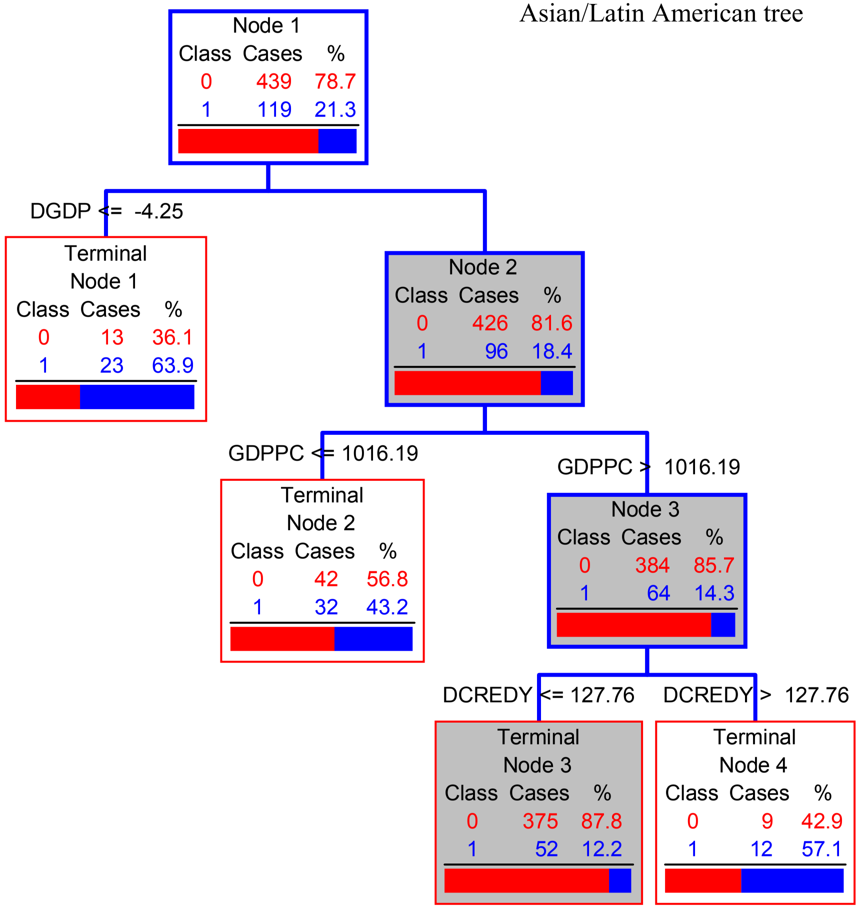
Overall, developments are in line with the "checklist" of generic indicators noted in Section 3.4, suggesting that crises may follow vulnerability due to a positive regime shift (financial liberalisation, market reforms) easing of entry conditions to financial markets (due to foreign bank entry), debt growth and rising asset prices (generating vulnerable balance sheets in the financial and non financial sectors), financial innovation (foreign currency debt), but that systemic risk may be avoided if the banking section is sufficiently robust.

**Figure 4.3.2. Binary trees for Estonia**

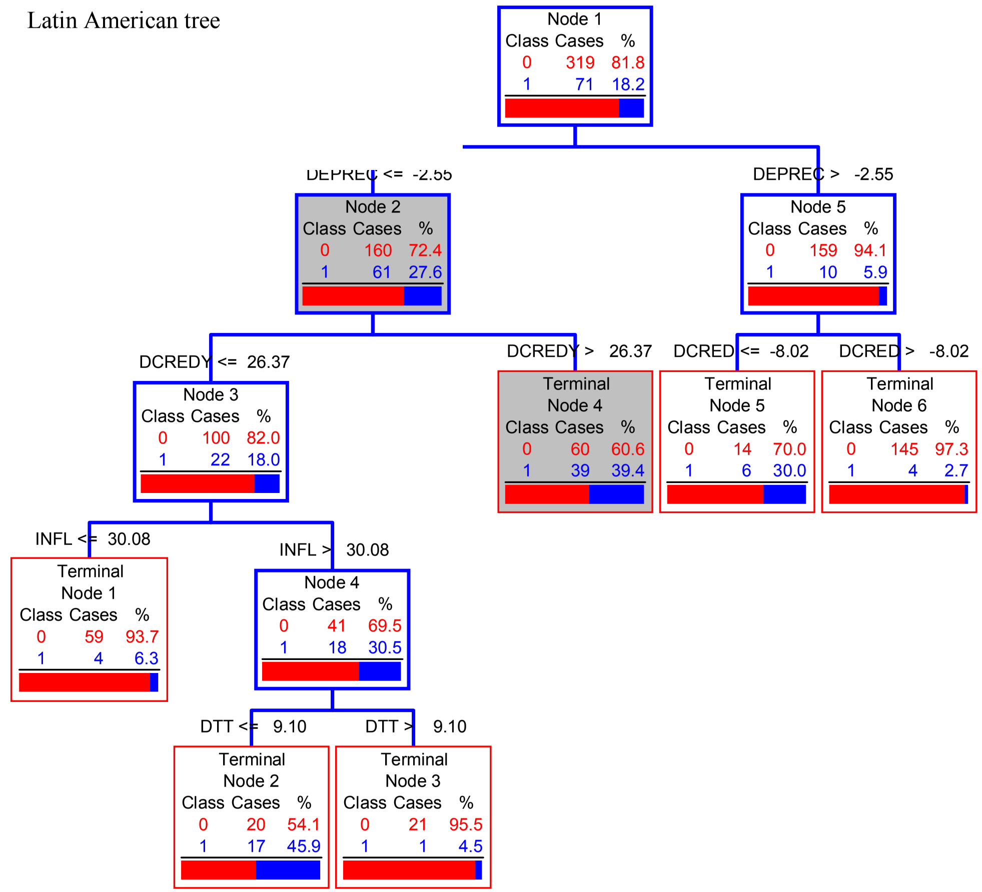
Asian tree



Asian/Latin American tree




Latin American tree



# 5 Contagion using a large structural macro model

The impacts on New Member States of shocks to financial markets and real economies outside the New Members as well as within them will depend upon the structure of the economies in question. Links through trade, financial markets, exchange rates and banking systems will all pattern the impact of shocks. Contagion between financial markets in the New Member States will also depend upon structures of trade, policy commitments and inter-linkages between banking and financial systems. As we stress in chapter 3.1 above these links may not just be direct, but also through third parties. The objective of this chapter is to demonstrate how these patterns can be evaluated using a large scale macro model, in this case NiGEM. We produce a set of results for some simple scenarios and some examples of detailed analyses on some issues facing policy makers. In both cases we produce a set of instructions on how to set up a model and how to operationalise scenarios on NiGEM. These can be applied to in-house models at the Commission.

The first section of the chapter describes the NiGEM model, and concentrates on the structure of the New Members. The three large established members, Poland, Hungary, and the Czech Republic, all have models of the same scale as those of countries such as Germany and France, and hence a full range of analyses can be undertaken. The smaller or newer member states all have complete models, but on a smaller scale, and more limited analyses can be undertaken. However, linkages between countries through trade and financial markets are complete in all cases. We describe both the equations on the model and the basic data that pattern the effects of shocks.

In the second section of the chapter we analyse the impacts of global financial stress on the New Members. Following Barrell, Hurst and Kirby (2008) we shock global risk premia in much the way we have seen in the last year, and analyse the impacts on the New Members first by shocking all countries other than the NMS and then including them in the financial market shock. This allows us to isolate the effects of spillovers through trade and through financial markets to the New Members, and we discuss the importance of trade openness in determining these patterns. In this section we also undertake a sequence of shocks to output through financial distress in each of the New Members alone in order to gauge spillovers from one New Member to another. These spillovers depend both upon patterns of trade, as Montalbano et al (2005) suggest, but also on the impacts of shocks and policy response on competitiveness.

Much of the impact of financial stress is mediated by cross border ownership of banks, and in the third section of the report we analyse the importance of the patterns of ownership in the New Members. Chapter 3.1 above shows that Swedish Banks have a large presence in the Baltic States, and Austrian Banks have a large presence in the Central European countries. We first look at the impact of financial market distress in these countries and in the UK and Germany to assess the role of contagion within the banking sector. We then look at the impact of financial distress in the New Members alone on the countries that own their banking systems. In each case this requires that we undertake a set of scenarios where there are no banking sector links and then repeat them with those links in place. This section also allows us to look at third party contagion, where shocks in one group of New Members propagate to other New Members through the home banking centre.

The size and structure of private and personal sector debts can also influence the spread of shocks across countries. Some of the problems in the New Members come from a build up of borrowing in foreign currencies, especially in Poland and Hungary, but also effectively in those countries with fixed exchange rates against the euro. Borrowing in foreign currencies leaves the borrowers subject to exchange rate risk, and hence their net wealth is vulnerable to changes in the exchange rate. Wealth effects are present in all consumption relationships in NiGEM, and hence can we analyse the balance sheet effects of devaluations on demand and output in the New Members. These shocks allow us to gauge the fragility of these countries in the current market turmoil. The scale of personal sector borrowing also affects the impact of financial market distress, as Barrell and Holland (2007) discuss. In a financial crisis the spread between borrowing and deposit rates widens, and this reduces personal incomes and impacts on consumption. In addition a devaluation changes the real value of a foreign currency debt and raises the real interest burden it carries, and this may induce some consumers to default. If they do then credit rationing may follow, and risk premia will definitely rise. These in turn will induce a fall in domestic demand, contracting output. In order to analyse the effects of default we add similar effects on domestic demand and risk premia to those seen in the UK and the US recently We analyse this in detail for the Czech Republic, Hungary and Poland in order to demonstrate why the scale as well as the structure of borrowing should be monitored, and why a toolkit should contain analytical structures to evaluate impacts. We look at the other countries in less detail.

The role of equity markets in corporate finance the New Members is limited, but they nevertheless are of significance, and patterns of linkages can be uncovered using VAR and GARCH analyses as we can see in chapter 3.2 above and chapter 7 below. We can shock equity markets outside the New Members to see the automatic spillovers through trade and interest rates, and we can compare this to a similar sized shock to all equity markets in Europe including the New Members. Our VAR and GARCH analyses give us a pattern for shocks that includes the New Members based on historical correlations, and following Barrell and Davis (2006) we could introduce this and compare it to a situation where there are no such correlation or where pass through is complete. However, as is discussed in chapter 3.2, the role of equity markets in these countries is limited, and there are noticeable effects only in the Czech Republic, Poland and Slovenia as well as Hungary.

## 5.1 Financial Market Contagion and the NiGEM models of the New Member States

For a macroeconometric model to be useful for policy analyses, particular attention must be paid to its long-term equilibrium properties. At the same time, we need to ensure that short-term dynamic properties and underlying estimated properties are consistent with data and well-determined. As far as possible the same long run theoretical structure of NiGEM has been adopted for each of the major industrial countries, except where clear institutional or other factors prevent this. As a result, variations in the properties of each country model reflect genuine differences in data ratios and estimated parameters, rather than different theoretical approaches. The model has been in use at the National Institute since 1987, but it has developed and changed over that time and since 1995 it has been funded by its user community of public sector policy institutions. These currently include the Bank of England, the ECB, the IMF, the Bank of France, the Bank of Italy and the Bundesbank as well as most other central banks in Europe, along with research institutes and finance ministries throughout Europe and elsewhere.

Each quarter, the model group produces a forecast baseline that is published in the Institute *Review.* The forecast is currently constructed and used out to beyond 2031 each quarter, although the projection beyond 2015 is a stylized use of the long run properties of the model. In policy analyses, the model can be switched between forward, rational expectations mode and adaptive learning for consumers, firms, labour and financial markets. Policy environments are very flexible, allowing a number of monetary and fiscal policy responses.

### 5.1.1 Production and price setting

Small country models where no capital stock data are available are based on a Cobb Douglas production functions with neutral technical progress. The major country models, including those for Hungary, Poland and the Czech Republic rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress.

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-1/\rho}$$

where Q is real output, K is the total capital stock, L is total hours worked and t is an index of labour-augmenting technical progress. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feed into the price system. Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital output ratio depends on the real user cost of capital

$$Ln(L) = \left[\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p)$$

$$Ln(K) = \left[\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - \sigma \ln(c/p)$$

where w/p is the real wage and c/p is the real user cost of capital. The user cost of capital is influenced by corporate taxes and depreciation and is a weighted average of the cost of equity finance and the margin adjusted long real rate, with weights that vary with the size of equity markets as compared to the private sector capital stock. Risk premia induced by changes in financial markets influence the user cost of capital, and hence this variable is central to our analyses in this chapter. Private sector investment in Hungary, Poland and the Czech Republic is determined by the error correction based relationship between actual and equilibrium capital stocks. Government investment depends upon trend output and the real interest rate in the long run. Prices are determined as a constant mark-up over marginal costs in the long term. In the smaller new member states because of restrictions on the availability of data the investment equation is subsumed in to the equation determining the level of domestic demand, but the factors affecting investment are explicitly described.

An example of a labour demand equation for a new member state is given below. HU represents Hungary, EE is employees in employment, WAGE is compensation per person hour, Y is GDP, YCAP is capacity GDP, HOURS are hours per quarter, PY is the GDP deflator, SIGMA is the elasticity of substitution and TECHL is labour augmenting technical progress (t stats in brackets – details in model coding).

```
log(huee)=   log(huee(-1)) -0.624182 + 0.51*log(huy/huy(-1))
                                        (5.1)
     - 0.172892*( log(huee(-1)/huycap(+1))
            (5.6)
     + husigma*log(huwage(-1)*huhours(-1)/(hupy(-1)))
            (4.9)
```

- (husigma-1.0)*(hutechl) )
(3.3)
- 0.189659* log(huwage*huhours/(huwage(-1)*huhours(-1)))
(2.9)

Employment equations of this form are present for all New Member States. Trend labour input, which depends upon the NAIRU as well as labour supply, affects capacity output. Where capital stock data are not available there is an equation for capacity output that depends upon trend labour supply and on technical progress. Technical progress depends upon the gap between home country technical progress levels and frontier country technology, with a larger gap giving more rapid technical progress. In the long run output and growth converge on capacity output in all countries.

### 5.1.2 Labour markets

NiGEM assumes that employers have a right to manage, and hence the bargain in the labour market is over the real wage. Real wages, therefore, depend on the level of trend labour productivity as well as the rate of unemployment (U), as we can see in error correction equation for Poland (PO) below. Trend productivity growth depends upon the production function parameter, RHO, and on technical progress, TECHL. Labour markets embody rational expectations and wage bargainers use model consistent expectations. The dynamics of the wage market depend upon the error correction term in the equation and on the split between lagged inflation and forward inflation as well as on the impact of unemployment on the wage bargain (Anderton and Barrell 1995). There is no explicit equation for sustainable employment in the model, but as the wage and price system is complete, the model delivers equilibrium levels of employment and unemployment. An estimate of the NAIRU can be obtained by substituting the mark-up adjusted unit total cost equation into the wage equation and solving for the unemployment rate. Labour supply is determined by demographics, migration and the participation rate (details in model coding – t stats in brackets).

log(powage)= log(powage(-1)) - 0.085125 - 0.016949*(log(powage(-1))
(2.6) (3.8)
+ (1.0+porho)* log(poee(-1)/poycap(+1)) + porho*(potechl))
(3.3)
+ 0.153039*pou(-1))

*5.1.3 Consumption, personal income and wealth*

Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C) = \alpha + \beta \ln(RPDI) + (1-\beta)\ln(RFN + RTW)$$

where *C* is real consumption, *RPDI* is real personal disposable income, *RFN* is real net financial wealth and *RTW* is real tangible wealth. The dynamics of adjustment to the long run are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints. As Barrell and Davis (2007) show, changes in financial (dlnNW) and especially housing wealth (dlnHW) will affect consumption, with the impact of changes in housing wealth having five times the impact of changes in financial wealth in the short run. They also show that adjustment to the long run equilibrium shows some inertia as well.

$$dlnC_t = \lambda(lnC_{t-1} – lnPI_{t-1}) + b_1 dlnRPDI_t + b_2 dlnNW_t + b_3 dlnHW_t$$

The equation below is an example of a relationship in the model (details in model coding).

```
log(poc)=  log(poc(-1))+ 0.00531375

 -0.110783*( log(poc(-1))

 -0.897375* log((popi(-1)-potax(-1))*100./poced(-1))

 -(1.0-0.897375)* log(ponw(-1)/poced(-1)*100.))

 - 0.000648206*porr + 0.437413* log(poc(-1)/poc(-2))

 + 0.061324* log(((popi-potax)*100./poced)/
 ((popi(-1)-potax(-1))*100./poced(-1)))
```

The equation is in error correction form, and C is consumption, (PI-TAX) is personal disposable income, CED is the price level, NW is net financial wealth, and RR is the real interest rate. Lack of time series data on house prices and housing wealth in these countries means that we cannot include them in our estimated equations. Al Eyd and Barrell (2005) discuss borrowing constraints, and investigate the role of changes in the number of borrowing constrained households. It is common to associate the severity of borrowing constraints with the coefficient on changes in current income. In the smaller New Members, the factors affecting consumption are subsumed into domestic demand and wealth effects flow mainly from net foreign assets.

### 5.1.3 Financial markets

We generally assume that exchange rates are forward looking, and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and risk premia, solving an uncovered interest parity condition, and these, in turn, are determined by policy rules adopted by monetary authorities as discussed in Barrell, Hall and Hurst (2006):

$$RX(t) = RX(t+1)[(1+rh)/(1+ra)](1+rprx)$$

where *RX* is the exchange rate, *rh* is the home interest rate set in line with a policy rule, *ra* is the interest rate abroad and *rprx* is the risk premium. . Nominal short term interest rates are set in relation to a standard forward looking feedback rule. Forward looking long rates should be related to expected future short term rates

$$(1+LR_t) = \Pi^T_{j=1}, \ (1+SR_{t+j})^{1/T}$$

We assume that bond and equity markets are also forward looking, and long-term interest rates are a forward convolution of expected short-term interest rates. Forward looking equity prices are determined by the discounted present value of expected profits

### 5.1.4 Public sector

In the three large New Members we model corporate (CTAX) and personal (TAX) direct taxes and indirect taxes (ITAX) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate (?TAXR) to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (GI) and consumption (GC) rising in line with trend output in the long run, with delayed adjustment to changes in the trend. They are re-valued in line with the consumers' expenditure deflator (CED). Government interest payments (GIP) are driven by a perpetual inventory of accumulated debts. Transfers (TRAN) to individual are composed of three elements, with those for the inactive of working age and the retired depending upon observed replacement rates. Spending minus receipts give us the budget deficit (BUD, and this flows onto the debt stock.

$$BUD = CED*(GC+GI)+TRAN+GIP-TAX-CTAX-MTAX$$

We have to consider how the government deficit (BUD) is financed. We allow either money (M) or bond finance (debt).

$$BUD = \Delta M + \Delta DEBT$$

rearranging gives:

$$DEBT = DEBT_{t-1} - BUD - \Delta M$$

In all policy analyses we use a tax rule to ensure that Governments remain solvent in the long run (Barrell and Sefton 1997). This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = f(\text{target deficit ratio - actual deficit ratio})$$

If the Government budget deficit is greater than the target,(e.g. -3 % of GDP and target is -1% of GDP) then the income tax rate is increased. A reduced version of this model is implemented in the smaller New Members.

### 5.1.5 External trade

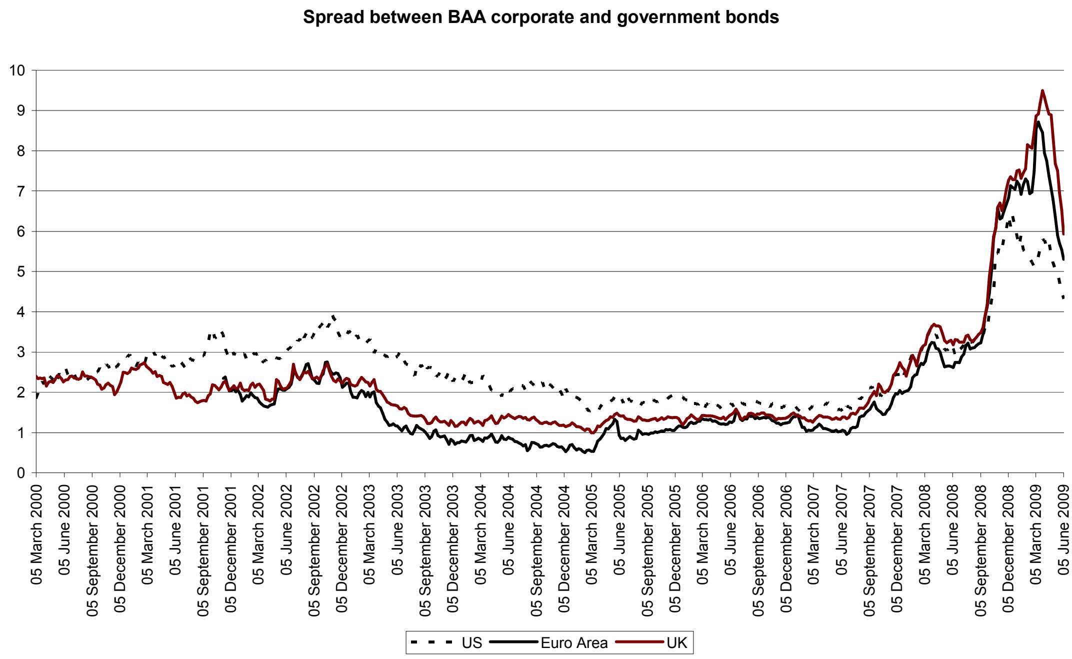
International linkages come from patterns of trade, the influence of trade prices on domestic price, the impacts of exchange rates and patterns of asset holding and associated income flows. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs. The estimated relationships also include measures to capture globalization and European integration and sector-specific developments. It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices; and demand is given by a share of imports in the markets to which the country has previously exported. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. As exports depend on imports, they will rise together in the model. The overall current balance depends upon the trade balance and net property income form abroad which comprised flows of income on gross foreign assets and outgoings on gross foreign liabilities. Gross National Product (GNP) is gross Domestic Product (GDP) plus net factor income from foreigners.

## 5.2 *The impact of the recent financial crisis on the New Member States*

The financial crisis that began in August 2007 and worsened in September 2008 has been associated with a perception that risk was under priced. If risk is to be re-priced we are likely to see a lower level of equilibrium capital and hence a lower level of sustainable output in the longer term. In the shorter term the disruption to credit markets induced by the collapse of Lehman Brothers led to severe credit rationing by banks and significant increases in the mark up of risky borrowing over risk free rates. Figure 5.2.1 plots the spread of BAA corporate bonds over risk free rates in the UK, the US and the Euro Area. Credit rationing on this scale led to a severe collapse in stocks and hence in imports and as a result world trade and output in all countries fell markedly, even where the countries in question were little affected by the financial crisis.

There were perhaps two major structural changes in 2007 and 2008 associated with a significant increase in risk premia. Barrell and Kirby (2008) argued in early September 2008 that the increase in risk premia we had seen after the start of the crisis in mid-2007 would reduce the level of sustainable output in the UK by 1½–2 percentage points. Their estimate was based on the observed increase of 200 basis points over this period in the BAA spread for corporate bonds over risk-free government bonds. They suggested this would raise risk premia going forward and therefore increase the user cost of capital and hence reduce equilibrium output.

**Figure 5.2.1: Corporate bond spreads in the UK, the USA and the Euro Area**




Source Thompson Datastream weekly data

The impacts of the crisis spread both through trade and through financial linkages, and these effects can be analysed with a structural macro model such as NiGEM that incorporates information on patterns of trade and inter linkages between financial market holdings. Exports of each country on the model depend upon the level of imports into its normal markets as well as the level of competitiveness, as measured by elative prices. Wealth effects are present as a factor affecting consumption in all countries, and foreign assets and liabilities are part of the portfolio of assets that are ultimately consumed by the personal sector.

We follow Barrell, Hurst and Kirby (2008) and shock the economy with a compound risk premium shock. We raise risk premia by 700 basis points for six quarters, and then leave them 100 basis points higher permanently, reflecting the widely discussed repricing of risk that is currently under way. This feeds into the user cost of capital directly in the three large New Members, and indirectly in the smaller countries. We calculate the user cost of capital according to a standard Hall-Jorgensen formula:

$$user_t = \frac{pdk_t}{py_t}\left[wacc_t + kdep_t - \Delta \ln\left(\frac{pdk_t}{py_t}\right)^e\right] \Big/ (1 - ctaxr_t)$$

where *pdk* is an investment deflator, *py* is the GDP deflator, *wacc* is the real cost of finance, *kdep* is the depreciation rate, *e* denotes expectations and *ctaxr* is the corporate tax rate. The real cost of finance as defined by Brealey and Myers (2000), $wacc_t$, can be written as the weighted average cost of capital,

$$wacc_t = b_{1t}(E_t/P_t) + (1-b_{1t})(lrr_t + iprem_t))*(1-ctaxr_t) \quad (7)$$

This weights together the cost of equity finance which depends on the earning price ratio (E/P) and cost of debt finance. The weights are given by the share of capital in the economy that is listed on the stock market which we denote $b_1$. The cost of debt finance is calculated as the risk-free long real interest rate ($lrr_t$), plus a measure of corporate spreads ($iprem_t$). Borrowing costs are adjusted by the corporate tax rate, reflecting the tax deductibility of borrowing. In our analysis below, corporate spreads are calculated as the absolute difference between average corporate bond yields and yields on 10-year government bonds.

**Figure 5.2.2 Impacts of a synthetic crisis affecting risk premia on GDP**


Source NiGEM simulations

In order to evaluate the role of spillovers from the rest of Europe to the NMS we first shocked all European countries except the NMS and then included them in our shock. The effects of our compound shock on European and Euro Area GDP are plotted in Figure 5.2.2. The long run effects are permanent, and depend on the structure of the economies in question, with output in the UK and the Euro Area being marginally more affected than in Sweden, as Barrell (2009) shows. The short run effects are noticeably smaller in part because the percent increase in the user cost of capital is smaller[28]. In addition on the model Sweden has a lower elasticity of substitution than the Euro Area average, and hence investment falls less in response to a rise in t user cost. The lower elasticity of substitution is also associated in our estimation with slower reactions to this negative impulse. We assumed forward looking financial markets, myopic consumers and active monetary policy responses to keep inflation on target

A recession on this scale would have noticeable effects on output in the NMS, and Table 5.2.1 gives details over the years in question. The pattern of effects depends mainly upon trade, and the Baltic counties are hence less affected than the Central Europeans because of the different weights on Sweden and the Euro Area. The Baltic countries also trade heavily with Russia, and we do not shock that country in this scenario, although there will be trade related spillovers. The spillover effects on output have a positive correlation of 0.53 with the share of exports going to Russia, and a negative correlation of -0.45 with the share of exports going to the old EU countries we have shocked. As Barrell, Hurst and Kirby (2008) discuss, Germany is amongst the worst affected countries in Europe because of its high capital output ratio and its large traded goods sector, and hence its trading partners are adversely affected.

**Table 5.2.1 Trade related spillovers to the NMS**

GDP, percent difference from baseline

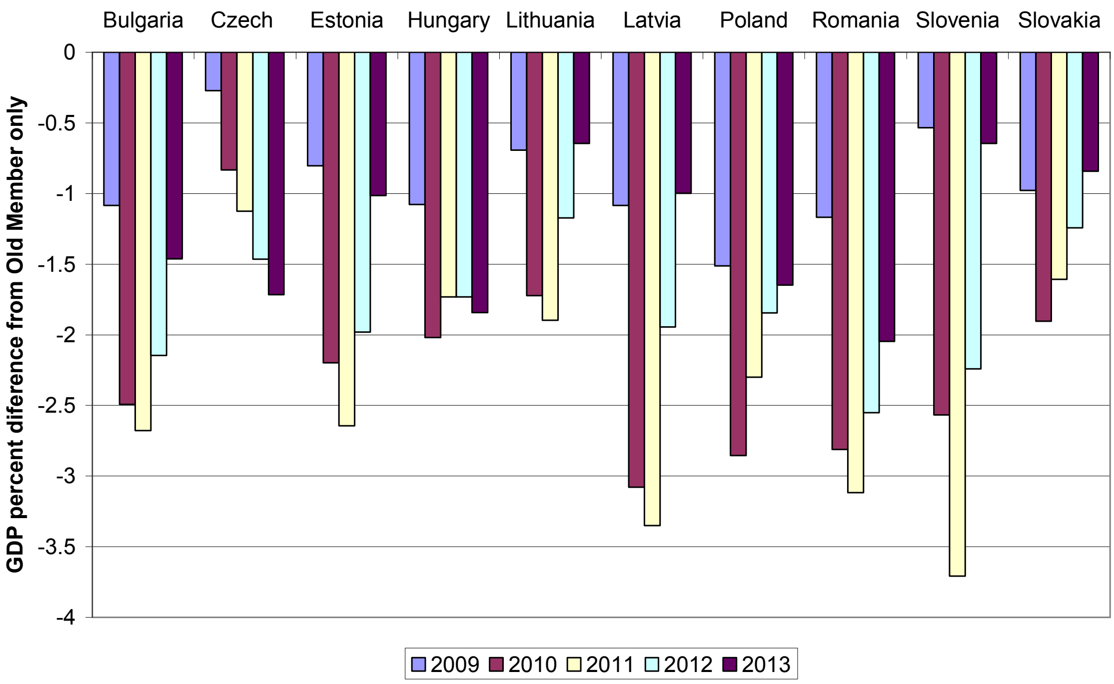
| | Bulgaria | Czech | Estonia | Hungary | Lithuania | Latvia | Poland | Romania | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | -1.33 | -0.82 | -1.08 | -2.29 | -1.66 | -0.44 | -0.27 | -1.61 | -0.15 | -2.48 |
| 2010 | -2.12 | -2.82 | -1.64 | -4.47 | -1.72 | -1.29 | -0.97 | -2.70 | -1.66 | -3.94 |
| 2011 | 1.17 | -1.83 | 1.09 | -0.35 | 2.92 | 0.81 | 0.33 | 0.41 | -0.77 | 2.22 |
| 2012 | 1.60 | -0.10 | 1.31 | 1.94 | 1.38 | 2.14 | 1.93 | 0.54 | 2.19 | 3.21 |
| 2013 | 1.05 | 0.76 | 1.35 | 2.40 | 0.02 | 1.09 | 2.57 | 0.08 | 2.77 | 1.33 |

Source NiGEM simulations

The spillover effects are also strongly related to the openness of the economy, defined by the ratio of exports plus imports to GDP, with more openness going with larger negative effects with a correlation of -0.62 in the first year and of -0.82 in the second year, much as we would expect. Poland, for instance is relatively closed, and it has been less affected by the crisis than have other NMS. In this scenario the medium term effects of the crisis are generally positive for the NMS because we have not shocked the user cost of capital in these countries. NiGEM scenarios use forward looking financial markets everywhere, and these bring forward longer term effects. A rise in risk premia in the Old Members reduces the level of investment permanently and hence changes the saving and investment balance in the European economies. This in turn reduces global and European real interest rates in future, and with forward looking financial markets we see an immediate fall in long term interest rates. This reduces the user cost of capital and hence raises real output in the longer term in the NMS where we have not shocked risk premia. Output rises on average by around half a percentage point in these countries in the long run in this counterfactual simulation, with the impact being larger in the smaller countries than in Hungary, Poland and the Czech Republic because we assume that the elasticity of substitution between capital and labour is higher there.

[28] On our baseline the user cost of capital in Sweden is 50 percent higher than in Germany, and hence the percent increase in the user cost (and subsequent fall in capital investment) is two thirds the size.

**Figure 5.2.3 Additional output effects from increased NMS risk premia**




Source NiGEM simulations

In Figure 5.2.3 we plot the additional output effects that we would see if risk premia rose in the New Members as well as in the Old Members, much as we would expect. The additional impact of a domestic increase in risk premia is strongly related to openness, with the additional output effect in the second year having a positive correlation of 0.68 with openness as less of the additional impulse is absorbed by imports. The additional effect of a rise in risk premia at home is also related to the elasticity of substitution on the model, and it is 25 percent larger in the smaller countries, where we assume a Cobb Douglas production function, than in Hungary, Poland and the Czech Republic where we estimate the elasticity of substitution to be around 0.6.. The dispersion of effects declines across new members when we shock them as well, much as we would expect. The overall effects on the Old Members of increased risk premia in the New Members is negligible, as the impacts of reduced trade are largely offset by the effects of lower real interest rates. Spillovers from trade within the NMS are also small, with a correlation of only 0.13 with the share of trade going to other NMS countries. However, countries with a strong orientation to non-EU members, Romania and Bulgaria in particular, are less affected by the shock because this trade is not so heavily impacted in out simulation exercise.

**Table 5.2.2 One percent of GDP shocks to home which spillover to GDP in partner**
Percent difference in GDP from baseline

| | Bulgaria | Czech | Estonia | Hungary | Lithuania | Latvia | Poland | Romania | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|---|---|
| Bulgaria | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.01** | 0.00 | 0.00 |
| Czech | 0.00 | | 0.00 | **0.03** | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | **0.18** |
| Estonia | 0.00 | 0.00 | | 0.00 | **0.02** | **0.01** | 0.00 | 0.00 | 0.00 | 0.00 |
| Hungary | **0.01** | 0.01 | 0.01 | | **0.01** | 0.00 | 0.00 | **0.02** | 0.00 | **0.04** |
| Lithuania | 0.00 | 0.00 | 0.02 | 0.00 | | **0.01** | 0.00 | 0.00 | 0.00 | 0.00 |
| Latvia | 0.00 | 0.00 | 0.02 | 0.00 | **0.02** | | 0.00 | 0.00 | 0.00 | 0.00 |
| Poland | **0.01** | 0.02 | 0.01 | **0.02** | **0.03** | **0.01** | | 0.01 | 0.00 | **0.05** |
| Romania | **0.02** | 0.00 | 0.00 | **0.02** | 0.00 | 0.00 | 0.00 | | 0.00 | **0.01** |
| Slovenia | **0.01** | 0.00 | 0.00 | **0.01** | 0.00 | 0.00 | 0.00 | **0.01** | | **0.01** |
| Slovakia | 0.00 | **0.03** | 0.00 | **0.02** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |

Source NiGEM simulations

Trade spillovers within the NMS are limited, and we detail one pattern in Table 5.2.2. We have undertaken 100 basis point premium shocks in each of the countries on their own. The shocks come from the countries detailed in column 1 and are normalised on a one percent of GDP change in that country. As the trade matrix in Section 3.4.5. suggests, spillovers within the NMS are small, with the largest spillovers from shocks to the Czech Republic with noticeable effects on Slovakia. The impacts on Slovakia are also quite large from shocks in Poland and Hungary, whilst the next largest are from Poland to Lithuania

### 5.2.1 Contagion through Banks

Contagion from the Old Members can take place through the ownership structure of the banking system which we discuss in Section 3.1 above. During a financial crisis banks may either be short on liquidity, which squeezes the interbank market, or as the crisis develops they may become short on capital as losses on their loan and asset books mount. As a solvency crisis develops, banks must find ways to rebuild their capital base or go bankrupt. If they have time to do so they will rebuild capital from their gross operating surplus, and they will do their best to raise that surplus during a crisis. The margin between loans and deposits is a major determinant of the gross operating surplus, and during a crisis we can expect this to be increased. Banks are unlikely to discriminate between markets when they need to raise their gross operating surplus, and if a bank in an Old Member is in difficulties it is likely to raise its margins in New Members where it has operations. We analyse this contagion from Old to New Members by undertaking two scenarios:

1. We raise banking market related risk premia in the Old Members by 100 basis points permanently and allow this to feed through to output as it raises the user cost of capital[29] and hence reduces the equilibrium capital stock. The long run impact of this shocks varies across Old Members with UK output eventually settling around half a percentage point lower than it would otherwise have done, whilst output in the Euro Area is affected by around twice this amount, reflecting the greater reliance on bank finance in the latter region.
    a. We assume financial markets are forward looking, and long rates immediately adjust downwards, with long term real interest rates falling by around 12 basis points immediately. Exchange rates are also free to jump in the first period, and both the UK and the Euro Area depreciate by about 1 percentage point against the US in the first period. Investment decisions depend upon the expected level of capital output four years ahead and hence they take account of the change in the equilibrium level of output.
    b. We assume that Sweden and Denmark shadow the euro, as do all New Members, whereas the UK operates its own monetary policy. Interest rates are endogenous in relation to the shock, and monetary authorities are assumed to follow a two pillar strategy targeting a nominal aggregate and an inflation target. We assume this is the same rule in the UK and the Euro Area in order to avoid rule induced differences in the dynamics of behaviour.
    c. We assume that the Old Members banks with holding in the New Member do not pass on the increase in gross operating margins that they would need to cover this increase in their costs.
2. We compare this shock to one where the banks do pass on the increase in costs and raise gross operating margins in the New Members. Table 5.2.3 gives the differences in the impact on the level of output from these two shocks

[29] We assume that equity premia are unaffected in this thought experiment, but corporate borrowing costs rise inline with bank borrowing costs. There is strong evidence in Barrell et al (2009) that is indeed is the case..

**Table 5.2.3 Permanent 100 basis point increase in IPREM in the Old Members, spreading through bank ownership**
Percent difference from baseline in GDP

| | Bulgaria | Czech | Estonia | Hungary | Lithuania | Latvia | Poland | Romania | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | -0.07 | -0.04 | -0.07 | -0.09 | -0.05 | -0.08 | -0.16 | -0.10 | -0.05 | -0.02 |
| 2010 | -0.19 | -0.14 | -0.25 | -0.21 | -0.17 | -0.30 | -0.37 | -0.27 | -0.27 | -0.03 |
| 2011 | -0.35 | -0.29 | -0.49 | -0.30 | -0.33 | -0.57 | -0.51 | -0.47 | -0.54 | -0.06 |
| 2012 | -0.46 | -0.42 | -0.64 | -0.39 | -0.41 | -0.69 | -0.59 | -0.61 | -0.62 | -0.09 |
| 2013 | -0.53 | -0.54 | -0.69 | -0.48 | -0.44 | -0.71 | -0.65 | -0.71 | -0.59 | -0.12 |

Source NiGEM simulation

As this report forms part of a toolkit, it is useful for us to spell out exactly what we have done in order that it can be replicated. We first simulate the standard model. The Commission should then programme up the pattern of links in the banking sector. This could be done in the QUEST model or elsewhere, and the new version of the model would contain a new ‘dummy’ variable for each New Member that fed into the user cost of capital for each of them. This dummy has to reflect the proportions of foreign ownership within the New Members, and we report our equations below. The host country investment premium (IPREM) needs to remain a model variable, but carry only the weight represented by domestic banks. The rest of the dummy that feeds into the user cost must reflect the ownership weights in Chapter 3.1 above. The mnemonics for countries are those used on NiGEM, and a prefix ‘d’ represents a dummy used in this experiment. The overall pattern of results suggests that banking sector links could worsen the impact of an Old Member crisis by around half a percentage pint of GDP, with the largest effects being in Estonia, Latvia and Romania. There is a 0.66 correlation between the effects in 2013 and the proportion of banks owned by foreigners, suggesting that much of the extra contagion comes through banks. We should note that the dummies for Lithuania and Latvia depend upon the investment risk premium in Estonia, ESIPREM, and the links from Sweden to these countries through Swedish ownership of Estonian banks will be fully accounted for.

**Table 5.2.4 Dummy equations for IPREM in New Members**

Estonia
desiprem = 0.931*sdiprem+(1-.931)*esiprem
Lithuania
d dliiprem = 0.334*sdiprem+0.299*desiprem+0.208*dkiprem+0.052*geiprem
+(1-.893)*liiprem
Latvia
dlviprem = 0.179*sdiprem+0.265*desiprem+0.107*dkiprem+0.038*oeiprem
+(1-.624)*lviprem
Slovakia
dsliprem =0.636*oeiprem+0.202*geiprem
+(1-0.896)*sliprem
Slovenia
dsriprem = 0.051*itiprem+0.056*friprem+0.119*oeiprem
+(1-.227)*sriprem
Hungary
dhuiprem = 0.225*oeiprem+0.090*bgiprem+0.102*geiprem+0.055*usiprem
+(1-.472)*huiprem

Bulgaria
dbliprem = 0.283*sdiprem+0.157*dhuiprem+0.039*bgiprem+0.302*oeiprem
+(1-.82)*bliprem
Romania
drmiprem = 0.030*nliprem+0.172*griprem+0.176*friprem+0.463*oeiprem
+(1-.841)*rmiprem
Czech Republic
dcriprem = 0.054*usiprem+0.031*nliprem+0.179*friprem+0.234*bgiprem
+0.341*oeiprem
+(1-0.853)*criprem
Poland
dpoiprem = 0.115*usiprem+0.016*sdiprem+0.096*nliprem+0.198*itiprem
+0.066*iriprem+0.020*friprem+0.032*geiprem+0.066*bgiprem
+0.034*iriprem
+(1-.702)*poiprem

The New Member states banking systems could also suffer from their own crises and to the extent that they are owned by foreign banks their crises will feed back into the Old Members. The crisis will affect the gross operating profits of the banks, and hence its impact on New Members will depend upon the proportion of their banking sector assets covered by asset in the New Members and also by the structure of ownership within the New Members. We can analyse this with an experiment where we shock the risk premiums in the New Members and allow the trade effects to affect the Old Members. We can then programme up a set of banking sector links from New to Old based on the links discussed in Section 3.1 above after consolidating the Estonian ownership of Lithuanian and Latvian banks into the ultimate owners, in Sweden. We use the same assumptions as in the previous pair of experiments. Some representative risk premium dummies are set out below, along with one example of the user cost of capital. These must be constructed for all countries with banking sector links. We need a new equation for the user cost of capital as it not only affects investment but also affects capacity output directly. As we would expect, the only noticeable effects in Table 5.2.5 are on Austria and to a lesser extent Sweden, as these countries are the most exposed.

**Table 5.2.5 Permanent 100 basis point increase in NMS IPREM spilling over into banks and IPREMs in the Old Members**
Percent difference from baseline in GDP

| | UK | Euro Area | Austria | Germany | Greece | France | Italy | Sweden | Denmark |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 0.00 | 0.00 | -0.04 | 0.00 | -0.01 | 0.00 | 0.00 | -0.01 | 0.00 |
| 2010 | 0.00 | -0.01 | -0.12 | 0.00 | -0.02 | 0.00 | -0.01 | -0.03 | -0.01 |
| 2011 | 0.00 | -0.01 | -0.17 | -0.01 | -0.03 | 0.00 | -0.02 | -0.05 | -0.02 |
| 2012 | 0.00 | -0.02 | -0.21 | -0.01 | -0.03 | 0.00 | -0.03 | -0.07 | -0.02 |
| 2013 | 0.00 | -0.02 | -0.24 | -0.01 | -0.04 | 0.00 | -0.03 | -0.09 | -0.02 |

Source: NiGEM simulations

**Table 5.2.6 IPREMs and the user cost in the Old Members**

Sweden
d dsdiprem = 0.175*(0.020*criprem+0.243*liiprem+0.188*lviprem+0.504*esiprem
+0.045*poiprem) +(1-0.175)*sdiprem
user cost of capital, Sweden
sduser = ((1-dsdeqps)*(sdlrr/100.+dsdiprem)*(1.0-sdctaxr)

+ dsdeqps*(sdlrr/100+dsdiprem) + sdkbdep )
/(1.0-sdctaxr)

Austria
d doeiprem = (1-0.266)*oeiprem + 0.266*(0.051*bliprem+0.337*criprem
+ 0.159*huiprem+0.00*liiprem+0.007*lviprem+0.00*esiprem+0.177*sriprem
+ 0.035*sliprem+0.040*poiprem+0.194*rmiprem)
Belgium
d dbgiprem = (1-0.080)*bgiprem + 0.080*(0.068*bliprem+0.581*criprem
+ 0.159*huiprem+0.00*liiprem+0.00*lviprem+0.00*esiprem+0.00*sriprem
+ 0.000*sliprem+0.193*poiprem+0.00*rmiprem)
Denmark
d ddkiprem = (1-0.024)*dkiprem + 0.024*(0.00*bliprem+0.00*criprem
+ 0.00*huiprem+0.531*liiprem+0.304*lviprem+0.00*esiprem+0.00*sriprem
+ 0.000*sliprem+0.165*poiprem+0.00*rmiprem)
Germany
d dgeiprem = (1-0.004)*geiprem + 0.004*(0.137*bliprem+0.174*criprem
+ 0.151*huiprem+0.098*liiprem+0.00*lviprem+0.00*esiprem+0.00*sriprem
+ 0.000*sliprem+0.193*poiprem+0.00*rmiprem)
France
d dfriprem = (1-0.006)*friprem + 0.006*(0.038*bliprem+0.587*criprem
+ 0.00*huiprem+0.00*liiprem+0.00*lviprem+0.00*esiprem+0.00*sriprem
+ 0.055*sliprem+0.077*poiprem+0.244*rmiprem)

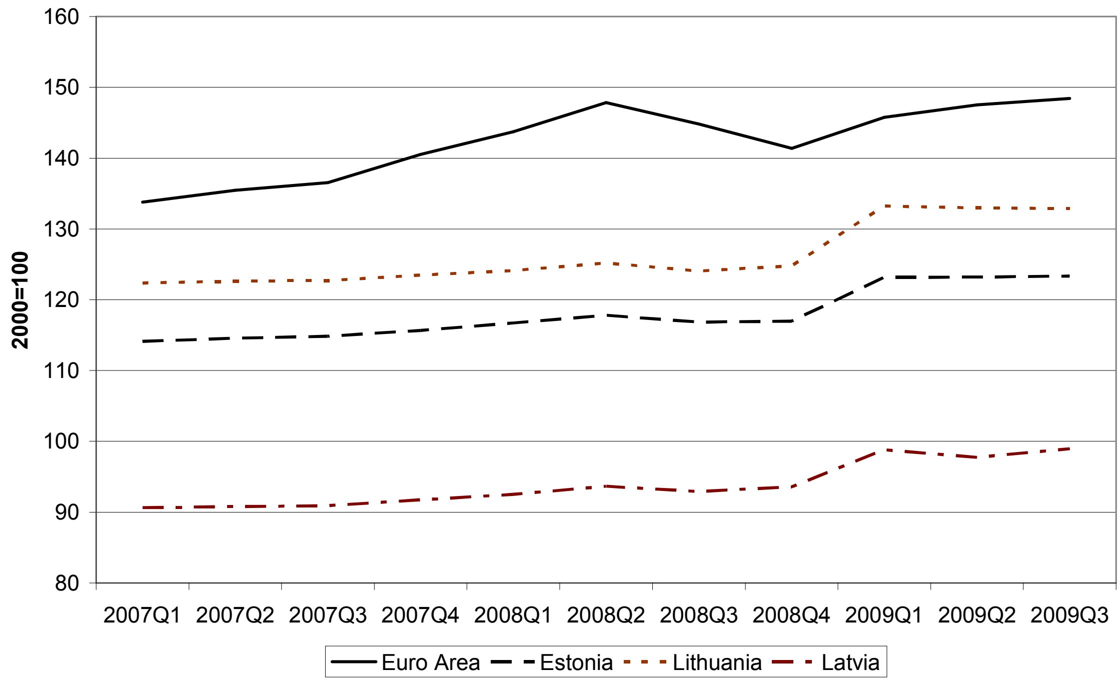
It is clear from these links that contagion effects are likely to be small except in a few cases, and only in the cases of the Czech Republic, Hungary, Slovakia and Austria are inter-linkages spreading shocks from one host country through a home country onto another host likely to be important. Once the Commission has set up a modelling structure as part of its toolkit it would be possible to evaluate these links one country at a time with shocks from Austria affecting new members in proportion to Austrian ownership, for instance, and alternatively as an example the impact of problems in the Slovak banking system on other New Members could also be analysed. There are a myriad of other pattern the Commission could analyse as well.

### 5.2.2 Devaluations and foreign currency assets

Realignments and devaluations are of interest in both the Baltic States and in the three large New Members in central Europe. In all of them except the Czech Republic there has, however, been a worrying rise in debts denominated in foreign currency. If a downward realignment were to take place, these debts would change in value and this would reduce personal sector wealth and hence consumption. These effects could potentially offset some of the gains in competitiveness and hence output that a realignment could bring. However, it is useful to scale the relative effects of these factors, and any toolkit for analysis should contain models that allow such an evaluation to take place.

The recent financial market turmoil has put significant pressure on a number of countries, and has also changed patterns of exchange rates. The euro, in particular, has strengthened by almost ten percent in effective terms since the middle of 2007, and as a result Estonia has appreciated by 7 ½ percent in effective terms, Lithuania by over 8 percent and Latvia by 9 percent. These changes will have contributed significantly to the slowdown in economic activity we have see Baltic states, and have been significantly worsened by the further deterioration in competitiveness induced by excess inflation especially in Latvia and Lithuania.

**Figure 5.2.4 Effective Exchange Rates**

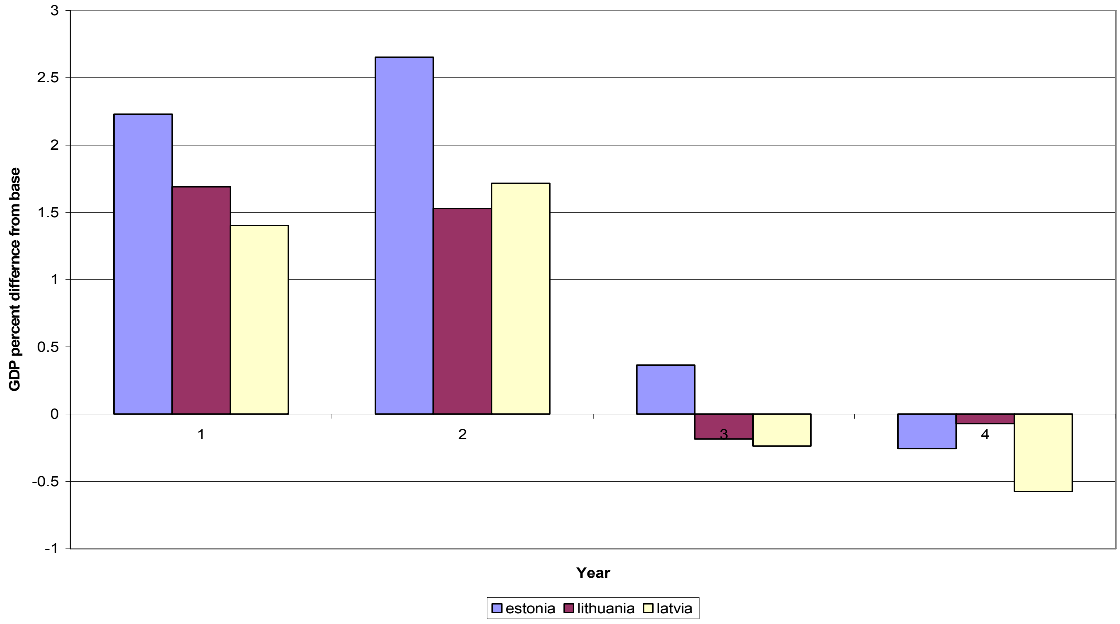



Source: NiGEM simulations

In the long run the gains from a realignment are likely to be illusionary, but a change in the exchange rate might bring significant release to these small open economies. The estimated equations on NiGEM display large trade elasticities for these countries, with an export price elasticity of 1.25 for all of them, based on a panel analysis, and import competitiveness elasticities of around 0.6 for Lithuania and Estonia and 0.5 of Latvia. These are larger than the average on the model and it is clear that short term trade related gains from realignment would be significant. Trade elasticities are lower in the Czech Republic, Hungary and Poland, with panel based export price competitiveness elasticities of around 1.0 and import price elasticities of 0.4 for Poland and the Czech Republic and 0.25 for Hungary. These are still high in comparison to the rest of the model.

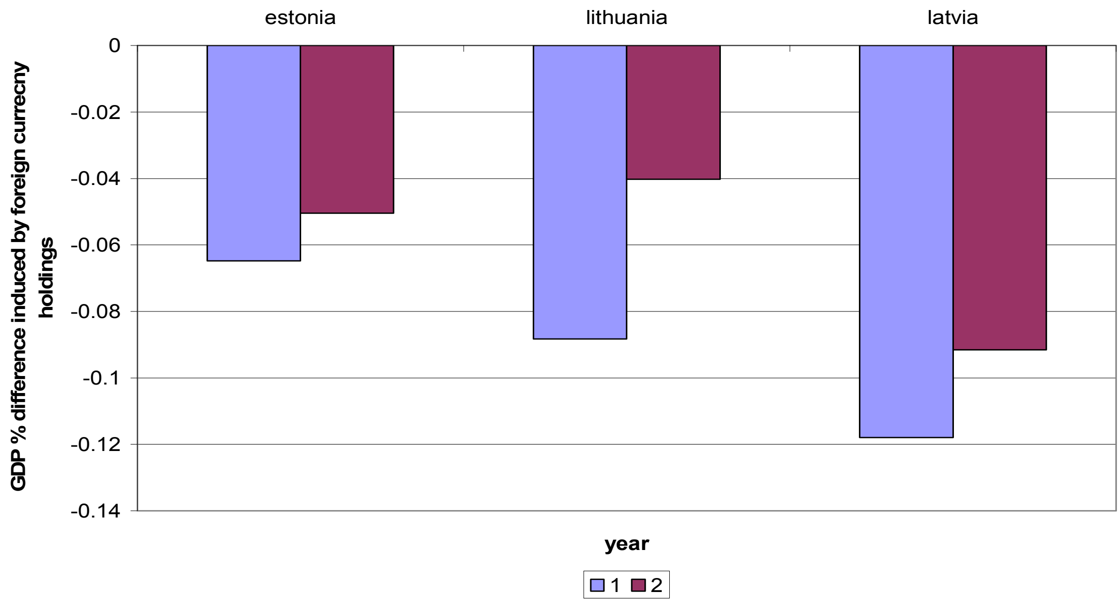
We have undertaken four experiments for the Baltic States, all involving a ten percent devaluation of the exchange rate, ending up with a new fixed rate, but with different assumptions about wealth effects and defaults by firms and consumers and their effects in the banking sector. In the first experiment we have embedded the foreign currency component of gross liabilities, which feeds into wealth, into the model, and we remove this component in the second experiment to evaluate its importance. This is most important for Estonia where foreign currency debt is 97 percent on nominal GDP, whilst it is 78 percent in Latvia and 47 percent in Lithuania. We then allow for a potential banking crisis induced by the re-evaluation of risk because of a re-evaluation of the business sectors prospects of repaying debts. This would raise the investment risk premium (??IPREM), and we calibrate the increase of 700 basis points for six quarters from the post Lehman increase plotted for the UK, the US and the Euro Area in Figure 5.2.1 above. A banking crisis induced by a devaluation may also see significant defaults by consumers and subsequent credit rationing, and this will induce a reduction in consumption and domestic demand. In our fourth scenario we add a cumulative endogenous 10 percent fall in domestic demand below baseline over two years, much as has been seen on the UK and the US in the first two years of this crisis.

**Figure 5.2.5 Effects of a 10 per cent devaluation of GDP in the Baltic States**




Source: NiGEM simulations

**Figure 5.2.6 The impacts on output in a devaluation of adding wealth effects**




Source: NiGEM simulations

Figure 5.2.5 details the pattern of output gains in response to such a realignment even with wealth effects being present, but with no financial crisis and they are clearly very large in the short term, although as we would expect there are no long run gains from such a re-pegging of the exchange rate as it does not change anything in the fundamentals. As we can see from Figure 5.2.6, it would appear that the direct wealth effects from foreign currency revaluations would be small. Although the wealth effects reduce consumption significantly these economies are very open, and much of the fall in consumption would be offset by a fall in imports, with the largest effect in Estonia where import are the same size as GDP, with smaller offset in Lithuania where they are around 80 percent of GDP and in Latvia where they are around 60 percent. Indeed, import propensities help explain the relative size of the wealth offset we see in Figure 5.2.6.

In figure 5.2.7 we report on the effects of a six quarter rise of 700 basis points in the investment risk premia accompanied by a 10 percent devaluation. In the first year the output effects of the devaluation would remain positive in all countries, but it would be much smaller. The effects continue to increase into the third year, as it takes time for business sector investment decisions to be changed, and the overall output effect is negative in the second year except in Estonia, where it is only negative in the third year. The effects are small in Estonia because it is more open, and more of the drop in demand is absorbed into imports, and they are largest in the least open economy, Latvia.

**Figure 5.2.7 Impacts of a temporary 700 basis point rise in risk premia after a devaluation**

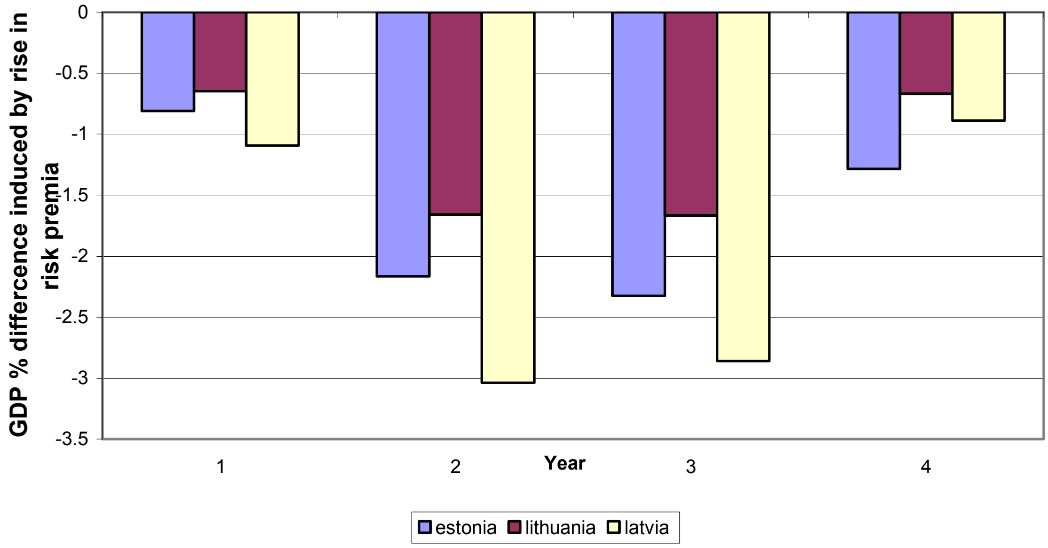
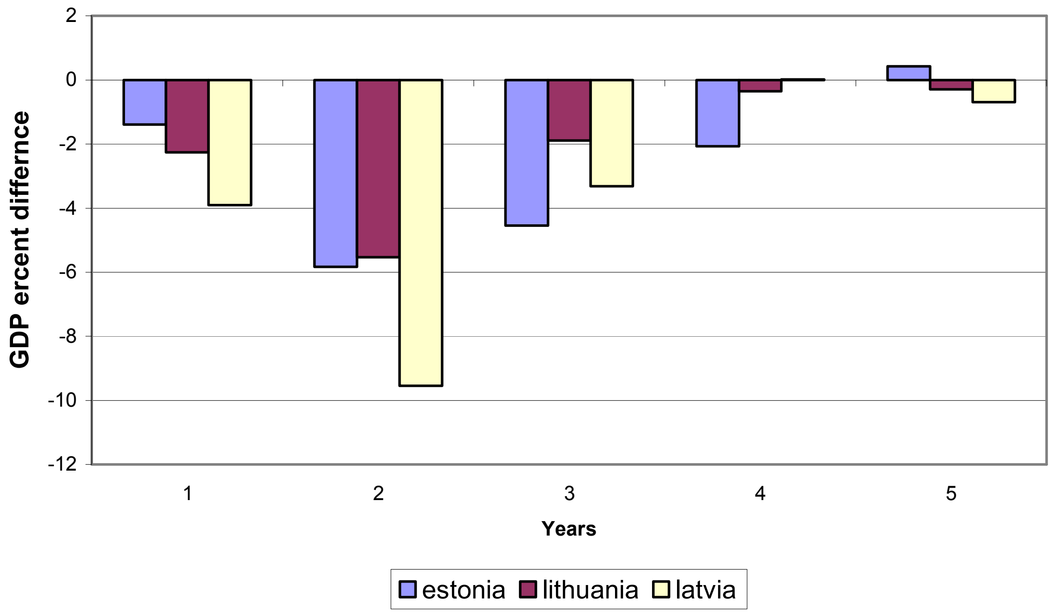



**Figure 5.2.8 Overall effects of a devaluation with a financial crisis**




Sources: Nigem simulation

If domestic demand were to fall as a result of a collapse in consumption because of credit rationing induced by foreign currency borrowing defaults then output would fall even after taking into account the positive effects of a devaluation on trade. We assume that domestic demand falls by 5 percent a year for two years, much as it has in the UK and the US in the wake of the banking crisis. The shock is to the equation intercept (the saving ratio) and hence if foreign assets build up as a result of the devaluation the increase in wealth partly offsets the domestic shock. Figure 5.2.8 plots the effects on output in the Baltic States after a devaluation of ten percent that is accompanied by a full blown default induced financial crisis. Output would fall in the first year, and growth would be negative in the second year before recovery began, and the effects would be largest in the least open economy, Latvia, as it is more difficult to disperse the crisis through lower imports

### 5.2.3 Risk driven devaluations and foreign currency assets

The Hungarians and Poles also have significant levels of foreign currency debt in the personal sector, but they face a different policy problem from either the Baltic States or from each other. The stresses in the Hungarian economy are larger than in Poland, but both have seen major declines in their currencies in the last year. Currency changes with flexible exchange rates can reflect a number of factors, but the most important are change in the perceptions of relative inflation in the medium term and changes in relative risk premia. The former may induce a devaluation if inflation risks have relatively risen, but will not cause any change in longer term fundamentals, and hence will only give a temporary boost to output. If however, there has been a re-evaluation of risk premia, then a devaluation can be associated with a long term deterioration in the prospects for output, although the devaluation itself is not a cause of the deterioration[30]. We analyse a realignment, evaluating the role of foreign currency debts.

The liabilities of the personal sector (liabs) depend in the long run on personal disposable income (pi- tax) but are affected in the short run by revaluations associated with the exchange rate. Around 47 percent of personal sector liabs in Hungary (and 30 percent in Poland) were in foreign currencies at the end of 2007, with most of these denominated in euros. If their currencies were to move against the euro (as represented by hurx/elrx and porx/elrx where the ??rxs are domestic currency per dollar and el is the Euro Area) then there would be a significant revaluation of liabilities in domestic currencies. This would change wealth and hence consumption and may on occasion result in bankruptcies.

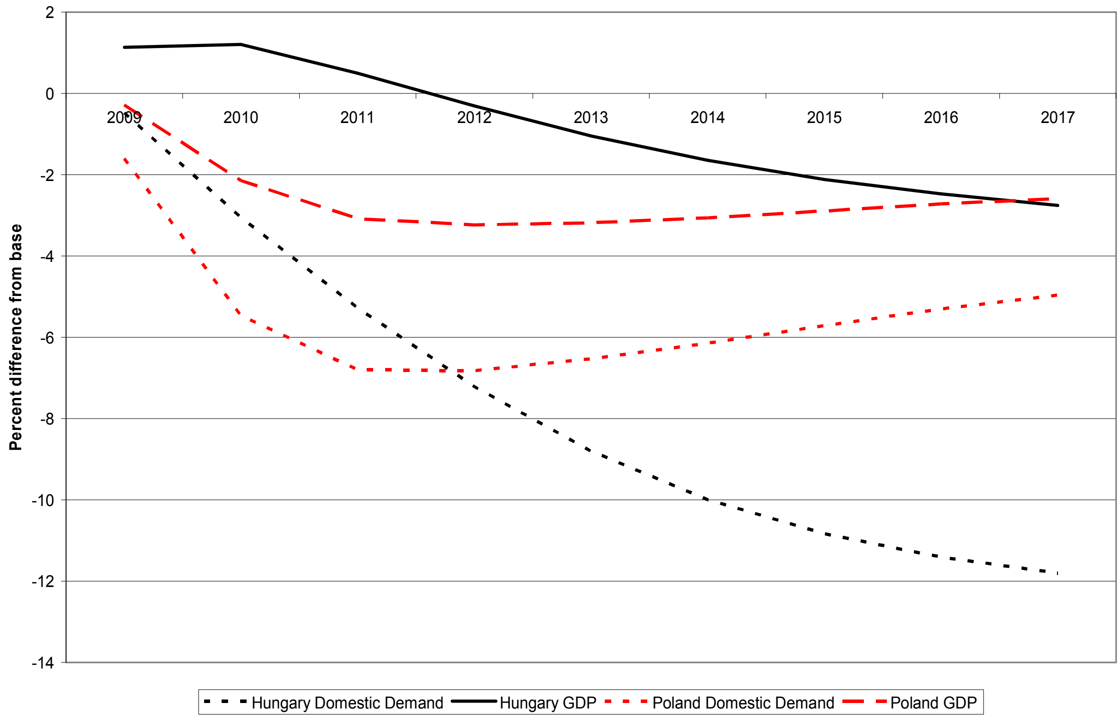
```
log(huliabs) = log(huliabs(-1))
        - 0.125*(log(huliabs(-1))-log(hupi(-1)-hutax(-1)))
        +0.47*log((hurx/elrx)/(hurx(-1)/elrx(-1)))
        +0.2*log((hupi(-1)-hutax(-1))/(hupi(-2)-hutax(-2)))

log(poliabs) = log(poliabs(-1))
        - 0.125*(log(poliabs(-1))-log(popi(-1)-potax(-1)))
        +0.30*log((porx/elrx)/(porx(-1)/elrx(-1)))
        +0.1*log((popi(-1)-potax(-1))/(popi(-2)-potax(-2)))
```

The endogenous risk premium related devaluation of around a 13 percent on the effective exchange rate has different effects in Hungary and Poland. The simulations are undertaken with a policy rule in place. The real equilibrium of the economy changes as real interest rates rise significantly reducing sustainable output and the equilibrium capital stock. As we can see

[30] These issues are discussed at length in Barrell, Holland and Hurst (2008)

from Figure 5.2.9, the medium to long term impacts on output are the same in both countries, and after almost a decade output is around 3 percent lower than it would otherwise have been. However, we should note Hungary is much more open than Poland, with exports and imports together in 2007 covering 2.3 times GDP whilst in Poland they covered 85 percent in the same year. Hence net exports rise much more in Hungary and output is above baseline for the first three years of the simulation. Domestic demand does similar things and falls from the start of the simulation in both countries. The changes are structurally comparable, given that is it endogenous and hence the stronger level of demand in Hungary just reflects higher output Differences in structure suggest that the period of relatively slow growth that follows from a risk premium induced realignment is delayed in Hungary

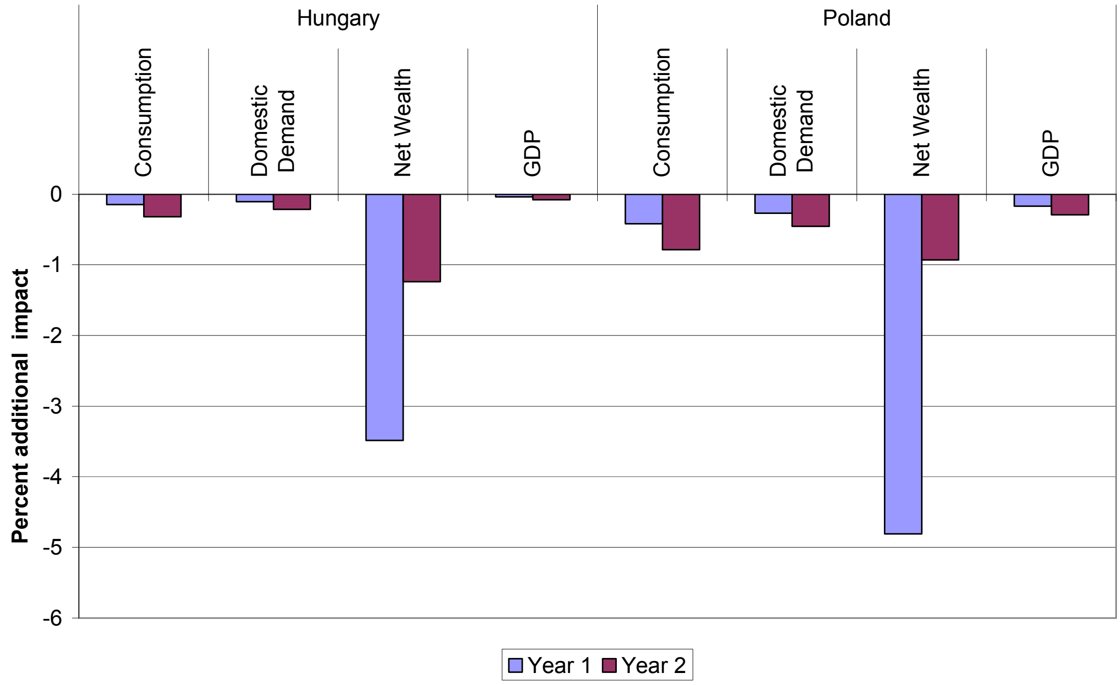
**Figure 5.2.9 Impacts of a risk premia induced realignment in Hungary and Poland**




Source: NiGEM simulations

As we can see from Figure 5.2.10 the impacts on consumption and domestic demand, hence in GDP, are a little larger in short run because of foreign currency effects. Although there is less foreign borrowing in Poland there is a bigger effect on GDP from the revaluation effect because imports as a share of GDP are much lower, and hence the effects are felt largely on the domestic economy. It is clear from these simulations that worries about the role of foreign currency borrowing may be exaggerated. Even when they are fully and correctly taken into account in the evaluation of wealth in Poland and Hungary, their additional effects on output are limited to under half a percent of GDP. As with the evaluation of risks in the Baltic States, once the structure of the economy and the effects of realignments on trade are taken into account, wealth effects are limited in scale. This analysis makes it clear that evaluations of policy options need to be undertaken using tools that can describe all relevant interactions in the economy. Of course change in wealth induced by revaluations of debts may lead to defaults on debts and hence structural problems in the banking system, and our analysis in the previous section can then be applied. An evaluation of the risks of default should form part of a toolkit for the Commission

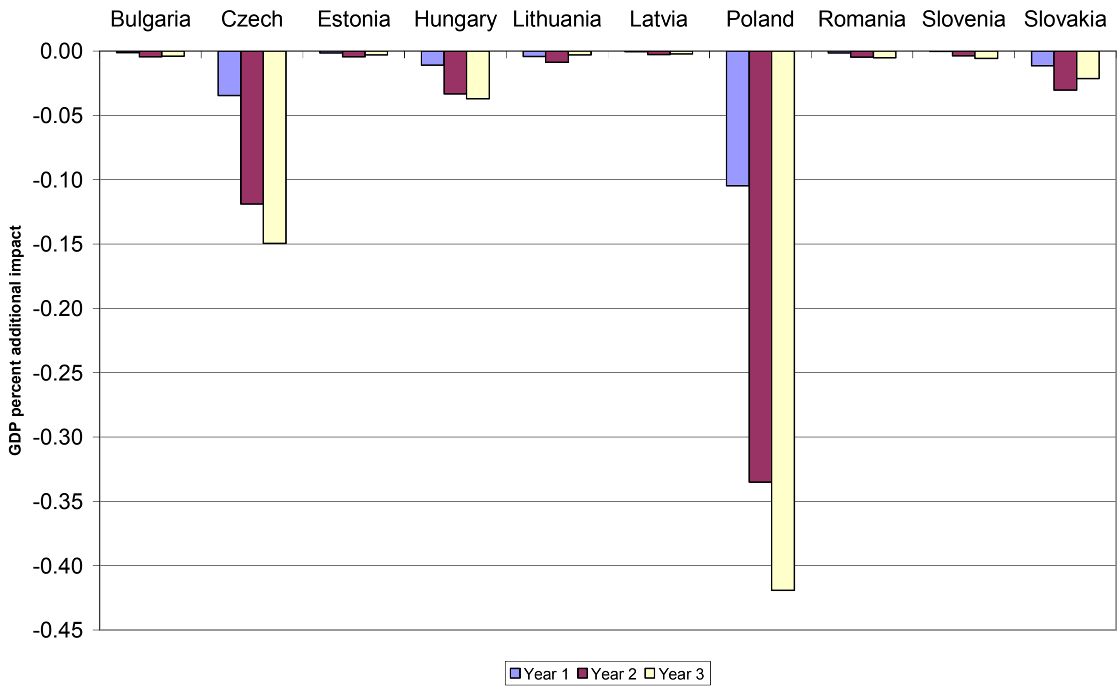
**Figure 5.2.10 Differences induced by taking account of foreign currency borrowing**




Source NiGEM simulations

## 5.2.4 Contagion through equity markets.

**Figure 5.2.11 Additional impacts of a 10 percent fall in equity prices in the New Members**




Source NiGEM simulations

Equity markets are relatively thin in the New Members, as is discussed above in section 3.2, and we would not expect there to be major impacts from changes in equity prices. We have undertaken two experiments. In the first we reduce equity prices by 10 percent in the Old Members and allow effects to propagate through trade. We then repeat the experiment with a

10 percent fall in equity prices added to the New Members as well. The additional impacts on output are plotted in Figure 5.2.11, and as we can see the effects are most noticeable in Poland, with some in the Czech Republic, and minor effects in Hungary and Slovakia. The pattern of results is consistent with our analysis in 3.2 above

## 5.3 Conclusions

There are considerable worries about the degree of contagion one might see both from Old to New Members and amongst New Members. Our analysis of risk premium shocks suggest that most contagion comes through trade effects unless there are direct links to banking systems. Links between New members through trade are very limited with noticeable effects only from the Czech to the Slovak Republics. If there is a financial crisis in the Old Members but not the NMS, then the output effects on NMS are strongly correlated with trade openness. Banking crisis propagate directly through the effects of capital losses on the need for a larger gross operating surplus and hence higher borrowing costs. There is a significant level of banking sector penetration in the Baltic States from Sweden, and hence a banking crisis in Sweden will impact on these countries, and conversely. However, the scale of effects on Sweden does not appear to be great. More importantly for policy makers in Europe, the Austrian banking system is heavily involved in Hungary and the Czech and Slovak Republics. The Austrian economy is hence vulnerable to shocks to the banking sectors in these economies, and they are vulnerable both to Austria and to each other.

Realignments of exchange rates can take place either as a result of a policy innovation or it could flow from a reassessment of inflation risks or of fundamental risk premia. A. realignment of the Baltic States would bring large short term benefits as they are very open and competitiveness elasticities are large. Although these benefits are ultimately transitory, they would help alleviate current problem. High levels of foreign currency borrowing would partly offset these gains, as they would result in a revaluation of wealth and hence a reduction in consumption. Much of this would be absorbed in lower imports, and output would probably only be marginally affected unless the revaluation led to large scale defaults and hence banking sector crises. As part of its toolkit the Commission should undertake such joint analyses, but we advise that the devaluation effects would almost beyond doubt overwhelm any costs form currency revaluations. Risk premium induced realignments, in Hungary and Poland for instance, may have long term effects on the sustainable level of output. Similar devaluations in these countries may lead to different effects in the short term, as Hungary is much more open than Poland. Devaluations raise competitiveness, and net trade improves. In our scenarios this effect more than offsets the risk premium induced reduction in output in the first three years in Hungary, but not in Poland. In both countries there is a noticeable negative impact on output from the revaluation of foreign currency denominated debts, and the effect is larger in Poland despite its lower level of foreign currency debt because it is less open than Hungary and hence imports absorb less of the fall in consumption and the multiplier is higher.

We would conclude that the use of a large structural model with trade and policy embedded in it is a central part of a toolkit, and would encourage the Commission to use one. Although the analysis of equity markets reinforces other work, our evaluation of realignments helps put the problem of foreign currency debts into perspective. In small open economies with high levels of imports a devaluation leads to output gains in the short run, even when there are significant levels of debt in foreign currencies.

# 6 EARLY WARNING SYSTEMS

## 6.1 Early warning Systems for crises using the logit estimator

Our aim in this section is to estimate multivariate logit equations for countries comparable to those in Eastern Europe – we follow the same procedure for the signal extraction and binary recursive tree specified below. The reason for this indirect approach is that data are generally not available for the banking crisis periods for Eastern European countries, which took place early on in the process of transition. We choose countries from Latin America[31] and Asia that have a similar level of development to those in Eastern Europe (i.e. middle-income countries). These are hoped to give sensitive early warning indicators that can then be calculated on a regular basis for Eastern European countries by desk officers. (The appendix gives a "Users Guide" to these different approaches). Table 6.1.1 lists the countries used in our estimations.

**Table 6.1.1: Country Sample**

| | |
|---|---|
| Asia | Indonesia |
| | Korea |
| | Malaysia |
| | Philippines |
| | Singapore |
| | Thailand |
| Latin America | Argentina |
| | Bolivia |
| | Brazil |
| | Chile |
| | Ecuador |
| | El Salvador |
| | Guatemala |
| | Honduras |
| | Mexico |
| | Panama |
| | Paraguay |
| | Peru |
| | Uruguay |
| | Venezuela |

As noted in the literature survey, Demirguc-Kunt and Detragiache (1998) used the multivariate logit technique to relate the probabilities of systemic banking crises to a vector of explanatory variables. The banking crisis dependent variable, a binary banking crisis dummy, is defined in terms of observable stresses to a country's banking system, e.g. ratio of non-

[31] We exclude Nicaragua and Guyana from the sample as these cross-sections are outliers in terms of inflation.

performing loans to total banking system assets exceeds 10%[32], and it occurs in around 5 per cent of all time and country observations in that paper. Demirguc-Kunt and Detragiache (2005) updated the banking crises list to include more years, and more crises. We use the same dependent variable in our current work.

Also following them, in this section we use the cumulative logistic distribution which relates the probability that the dummy for crises takes a value of one to the logit of the vector of n explanatory variables:

$$\Pr ob\left(Y_{it} = 1\right) = F\left(\beta X_{it}\right) = \frac{e^{\beta' X_{it}}}{1 + e^{\beta' X_{it}}} \qquad (1)$$

where $Y_{it}$ is the banking crisis dummy for country i at time t, $\beta$ is the vector of coefficients, $X_{it}$ is the vector of explanatory variables and $F(\beta\ X_{it})$ is the cumulative logistic distribution. The log likelihood function which is used to obtain actual parameter estimates is given by:

$$Log_e\ L = \sum_{i=1}^{n}\sum_{t=1}^{T}\left[\left(Y_{it}\log_e F\left(\beta' X_{it}\right)\right) + \left(1 - Y_{it}\right)\log_e\left(1 - F\left(\beta' X_{it}\right)\right)\right] \qquad (2)$$

Although the signs on the coefficients are easily interpreted as representing an increasing or decreasing effect on crisis probability, the values are not as intuitive to interpret. Equation (2) shows the coefficients on $X_{it}$ are not constant marginal effects of the variable on banking crisis probability since the variable's effect is conditional on the values of all other explanatory variables at time t. Rather, the coefficient $ß_i$ represents the effect of $X_i$ when all other variables are held at their sample mean values. Whilst this makes the detection of non-linear variable interactions difficult, (the logit link function is linear), the logistic EWS has the benefit of being easily replicable by policy makers concerned with potential systemic risk in their countries, including desk officers in the Commission.

Regarding independent variables, Demirguc-Kunt and Detragiache (2005), who had 77 crises in their sample, found that they were correlated with macroeconomic, banking sector and institutional indicators. Crises occurred in periods of low GDP growth, high interest rates and high inflation, as well as large fiscal deficits. On the monetary side, the ratio of broad money to Foreign Exchange reserves and the credit to the private sector/GDP ratio, as well as lagged credit growth were found to be significant. Institutionally, countries with low GDP per capita are more prone to crises, as are those with deposit insurance. All these results were broadly in line with their 1998 paper which featured 31 crises, except that depreciation and the terms of trade ceased to be significant.

Since the world dataset of banking crises is itself dominated by crises in middle income countries, and that these variables are those typical of crises in such countries as well as those in Eastern Europe, we employ the same set of independent variables as for Demirguc-Kunt and Detragiache (2005) also (see Box 6.1). These variables are constructed using the IMF's International Financial Statistics (IFS) database and World Bank Development (WDI) data. We omit deposit insurance because some form of it was present throughout the data period for all the countries. We added current account/GDP and external short term debt/GDP at the request of the Commission.

[32] Their actual criteria are: the proportion of non-performing loans to total banking system assets exceeded 10%, or the public bailout cost exceeded 2% of GDP, or systemic crisis caused large scale bank nationalisation, or extensive bank runs were visible and if not, emergency government intervention was visible.

| **Box 6.1: List of Variables (with variable key)** | |
|---|---|
| Variables used in previous studies: Demirguc-Kunt and Detragiache (2005); Davis and Karim (2008). | 1. Real GDP Growth (%) (YG) |
| | 2. Real Interest Rate (%) (RIR) |
| | 3. Inflation (%) (INFL) |
| | 4. Fiscal Surplus/ GDP (%) (BB) |
| | 5. M2/ Foreign Exchange Reserves (%) (M2RES) |
| | 6. Real Domestic Credit Growth (%) (DCG) |
| | 7. Real GDP per capita (GCAP) |
| | 8. Domestic credit/GDP (%) |
| | 9. Depreciation (%) (DEP) |
| | 10. Change in Terms of Trade (%) (TOT) |
| Additional variables requested by EC | 11. Current account/GDP (%) |
| | 12. External short term debt/GDP (%) |

We undertook estimations using all crisis periods as dependent variables as shown in Tables 6.1.2-6.1.4. For independent variables we use the first lag in each case, so as to obtain a true early warning indicator that would be missed if using contemporaneous variables. We also tested down from a general equation with all variables included (left hand part of tables) to the simplest equation with all remaining significant variables (right hand side of tables).

**Table 6.1.2: Regressions for Latin America and Asia**

| Variable | Coefficient | z-Statistic | Coefficient | Z-statistic |
|---|---|---|---|---|
| DCRED(-1) | -0.008975 | -1.499679 | | |
| GDPPC(-1) | -0.000288 | -5.508222 | -0.000310 | -6.955853 |
| FISCY(-1) | 0.039770 | 1.397688 | | |
| INFL(-1) | -3.95E-05 | -0.073148 | | |
| RIR(-1) | 0.000192 | 0.978935 | | |
| DEPREC(-1) | -0.000279 | -0.740087 | | |
| DCREDY(-1) | 0.011365 | 3.242132 | 0.008273 | 2.906578 |
| DTT(-1) | 0.000922 | 0.210933 | | |
| DGDP(-1) | -0.134869 | -5.033401 | -0.141868 | -6.005834 |
| M2RES(-1) | -4.81E-05 | -0.521275 | | |
| CUACC(-1) | -0.003531 | -0.147292 | | |

**Table 6.1.3: Regressions for Latin America**

| Variable | Coefficient | z-Statistic | Coefficient | z-Statistic |
|---|---|---|---|---|
| DCRED(-1) | -0.008072 | -1.202927 | | |
| GDPPC(-1) | -0.000244 | -3.242089 | -0.000326 | -7.832812 |
| FISCY(-1) | 0.065775 | 1.716205 | | |
| INFL(-1) | 0.000381 | 0.659712 | | |
| RIR(-1) | 0.000467 | 1.337654 | | |
| DEPREC(-1) | -0.000256 | -0.603217 | | |
| DCREDY(-1) | -0.006509 | -0.843001 | | |
| DTT(-1) | 0.004547 | 1.019467 | | |
| DGDP(-1) | -0.119092 | -3.626533 | -0.118849 | -4.510090 |
| M2RES(-1) | 3.31E-05 | 0.346272 | | |
| CUACC(-1) | -0.073313 | -2.003944 | | |
| STEDEBT(-1) | -0.029693 | -1.348373 | | |

**Table 6.1.4: Regressions for Asia**

| Variable | Coefficient | z-Statistic | Coefficient | z-Statistic |
|---|---|---|---|---|
| DCRED(-1) | -0.034811 | -1.923758 | -0.032416 | -2.046609 |
| GDPPC(-1) | -0.000227 | -3.055021 | -0.000235 | -3.535302 |
| FISCY(-1) | 0.030621 | 0.429792 | | |
| INFL(-1) | -0.105266 | -2.144565 | | |
| RIR(-1) | 0.076262 | 1.433605 | 0.113567 | 2.612414 |
| DEPREC(-1) | 0.057408 | 2.423032 | 0.044323 | 2.712526 |
| DCREDY(-1) | 0.019783 | 2.327958 | 0.021231 | 2.959820 |
| DTT(-1) | 0.010993 | 0.455080 | | |
| DGDP(-1) | -0.288111 | -3.748319 | -0.276748 | -4.192324 |
| M2RES(-1) | -0.000498 | -1.918494 | -0.000536 | -2.190088 |
| CUACC(-1) | -0.019997 | -0.417555 | | |
| STEDEBT(-1) | 0.119082 | 1.911818 | | |

A general point is that many of the variables are not significant in the regressions, once we test down from the most general specification. The most consistent indicators are GDP growth (crises occur in recessions) and GDP per capita (crises are less common in richer countries). For the combined Latin America and Asia sample, where there are 26 crises, the equation with all crisis observations also includes the credit to GDP ratio (crises are most likely in more financially developed countries where the ratio is high). Note that the external short term debt variable and the current account variable are not significant in any of the most restricted equations, being insignificant at the standard 5% level once testing down has occurred.

Looking at the sample for Latin America alone, with 17 crises, the estimate includes again GDP per capita as well as GDP growth. The sample for Asia includes 9 crises. In this case the regression includes not only GDP per capita and GDP growth but also there is an effect of credit growth (crises are more likely when credit is already contracting), a higher real interest rate tends to precede crises, as does exchange rate appreciation, a high domestic credit/GDP ratio and, counter to intuition, a low M2/reserves ratio.

These results provide a menu of possible frameworks for analysing the crisis risk in Eastern European countries. The full sample benefits from a wider range of crises that should provide more econometric precision. On the other hand, it could be argued that the typical problems in the Asian countries differ from those in Latin America prior to crises, with the former being more typical of Eastern Europe. Accordingly, we recommend use of either the whole sample or the specific Asian version for all crises.

As regards output from the models, we use data for three NMS, namely Poland, Hungary and Czech Republic for the same variables as those in Asia and Latin America as defined above. We are then able to evaluate crisis probabilities on the basis that the countries' behaviour will resemble that of Latin America and Asia together; Asia alone; Latin America alone. In each case we use the "all crisis periods" estimate and calculate using Excel. The Excel file is part of the toolkit being delivered in this project. As shown in the charts below, a notable feature, particularly in the Asia and Asia/Latin America estimates is that the projection for Hungary is for a somewhat higher and increasing crisis probability than for the other two countries. This is consistent with current analysis and shows the value of this logit approach, also for having already signalled an upturn in crisis probabilities in 2007. Meanwhile the logit estimates accurately show the vulnerability of these economies and their financial systems to financial crises in the 1990s (bold figures). The areas of zero prediction early in the sample reflect the lack of data for these Eastern European countries on M2/reserves.

**Figure 6.1.1: Crisis probabilities for Czech Republic**

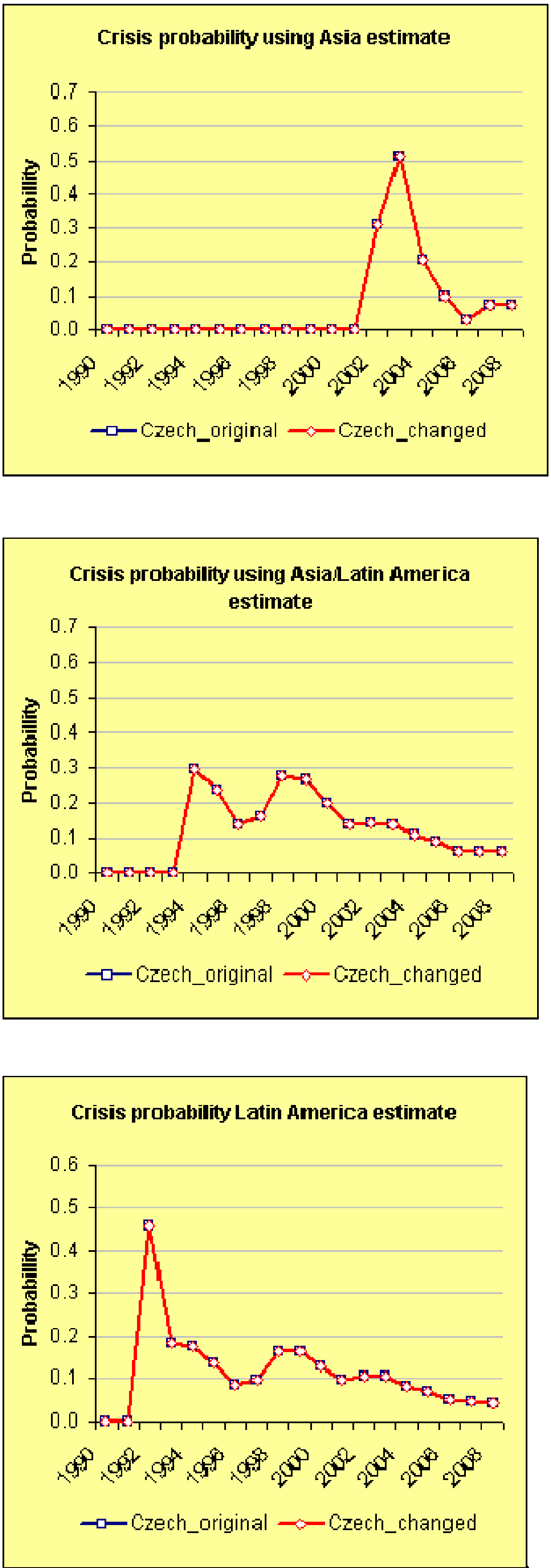
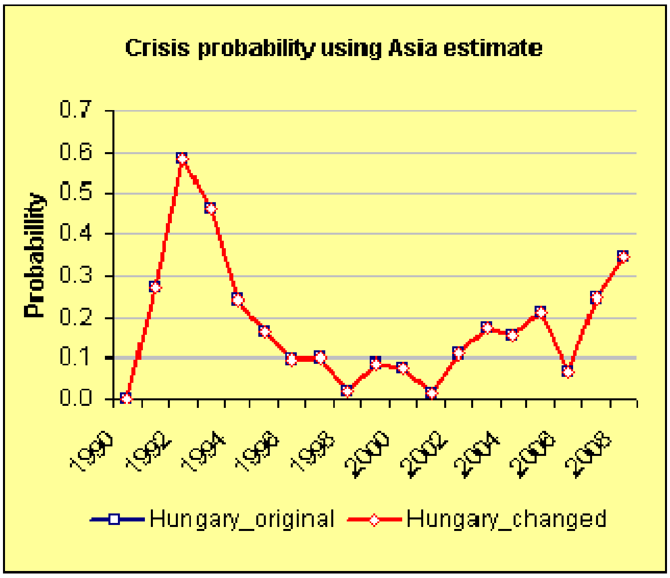
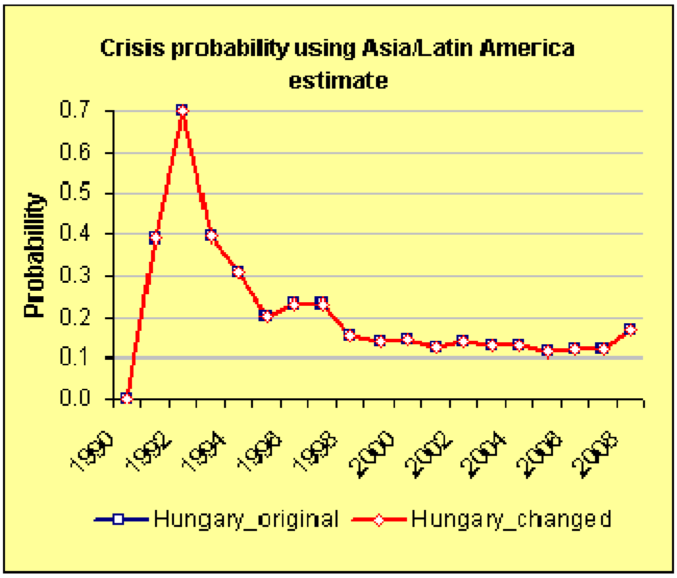


**Figure 6.1.2: Crisis probabilities for Hungary**



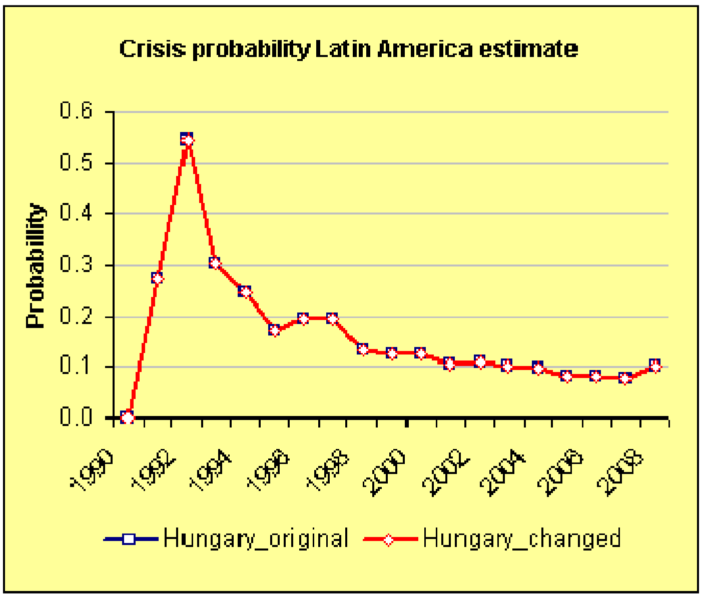
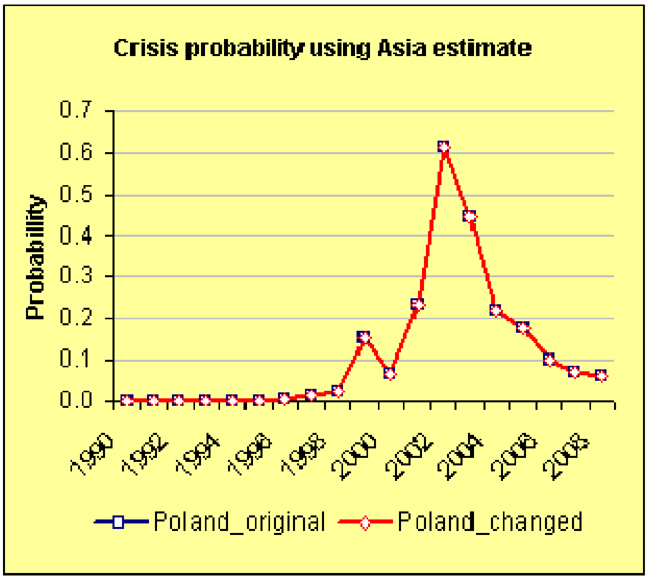
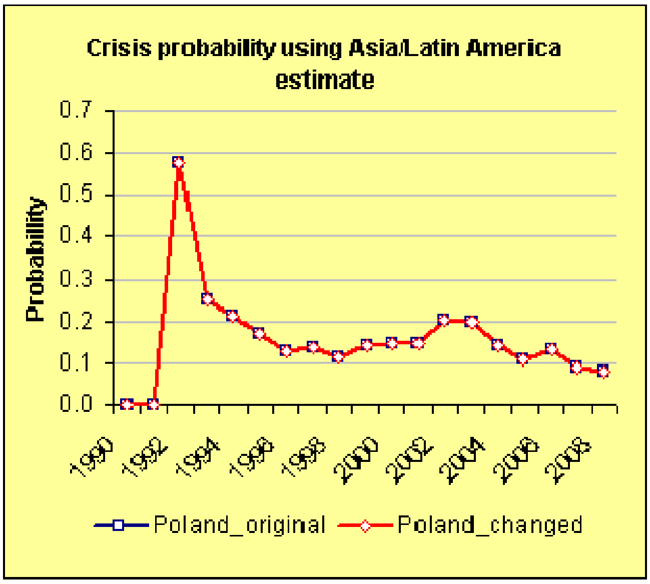
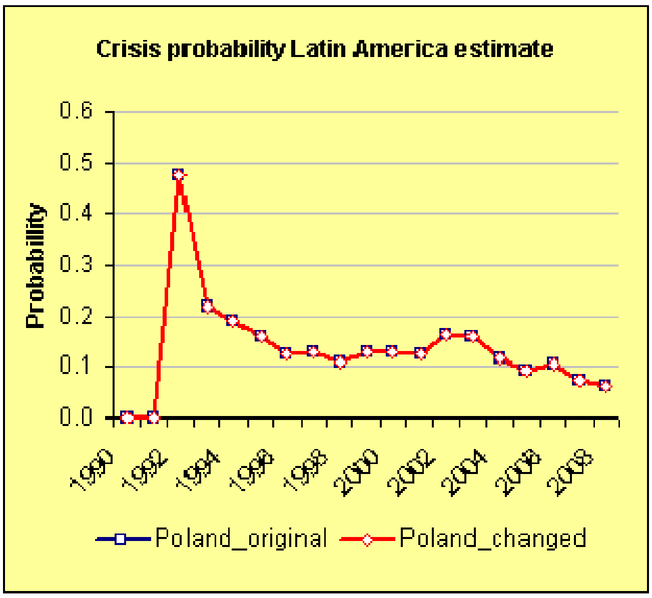



**Figure 6.1.3: Crisis probabilities for Poland**



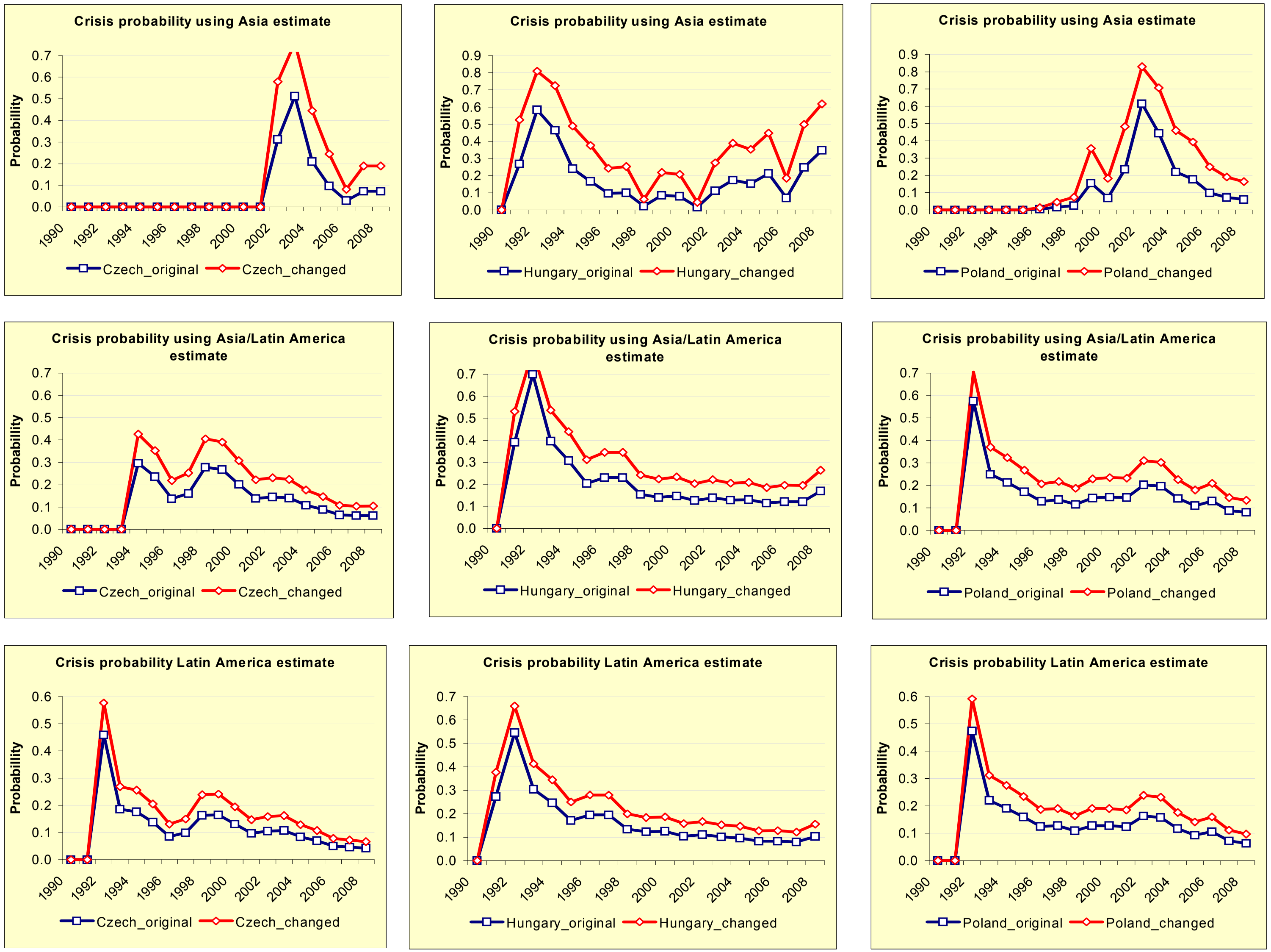



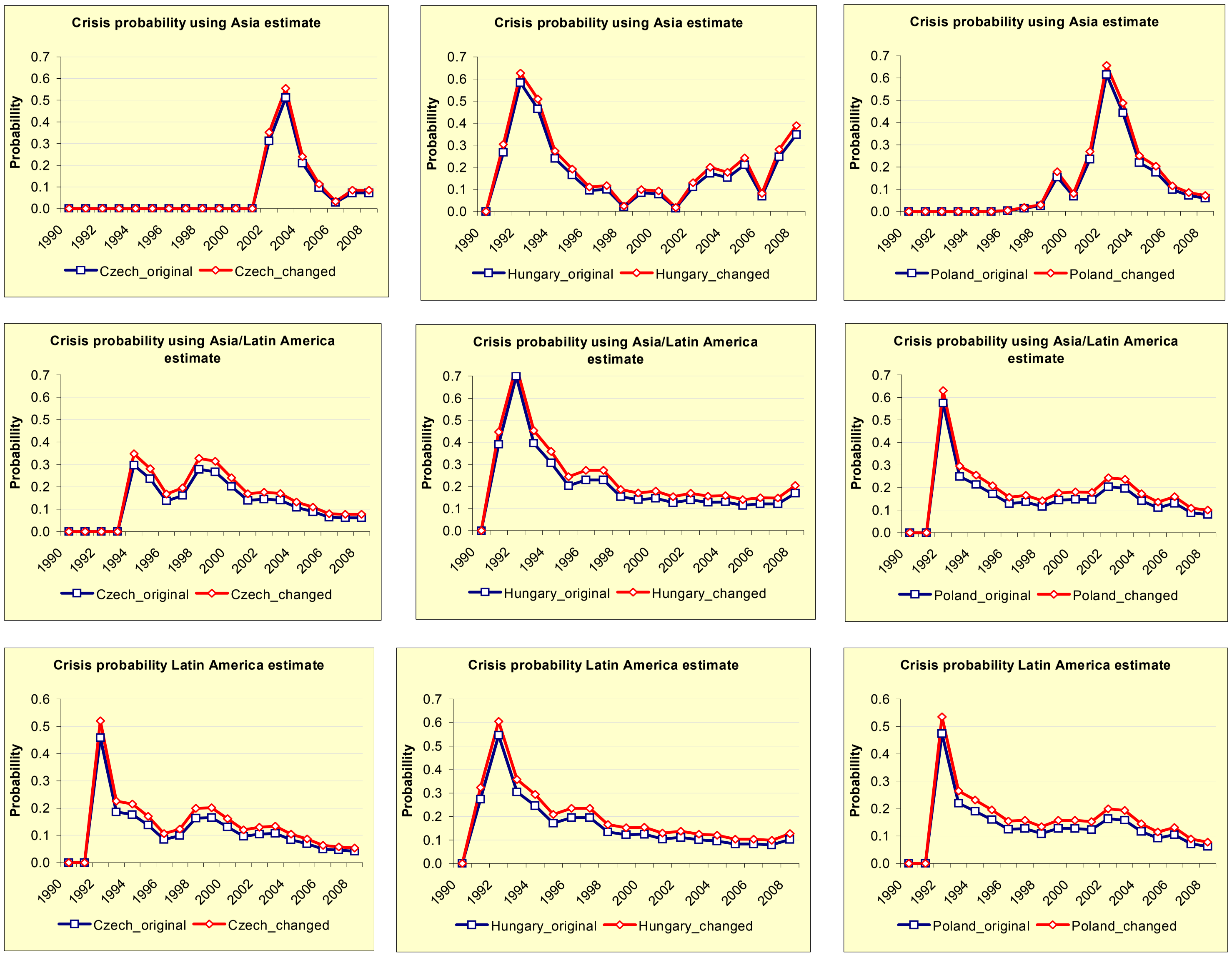
The Excel file has been constructed to allow for simulations to be done with changes in the input variables, to show how shocks could affect crisis probabilities. We illustrate this below for several events – a 4 percentage point fall in GDP growth (Figure 6.1.4), a lowering of GDP per capita by 10% (Figure 6.1.5), and (with Asia only), 10 percentage point lower credit growth (Figure 6.1.6), 3 percentage point higher real interest rates (Figure 6.1.7) and 10 percentage point currency appreciation (Figure 6.1.8). Generally, the recession has the most powerful effect over the sample, and at the present time in Hungary for the Asia estimate. Changes in GDP per capita are less dramatic in their impact despite the large size of the shock. The three Asian shocks again have their largest impact on Hungary, with rises in crisis probabilities of around 5-10 percent in each case.

In a final chart (Figure 6.1.9) we undertake a joint shock with the Asian estimate, combining the above impacts, i.e. 4% off GDP growth, 10% currency appreciation and 3% higher real interest rates as well as a 10% fall in credit growth. The outturns for 2007 are for a very high risk of crisis in Hungary of 80% while that in Czech and Poland is 40%. We contend that these simulations underline the usefulness of the logit approach.

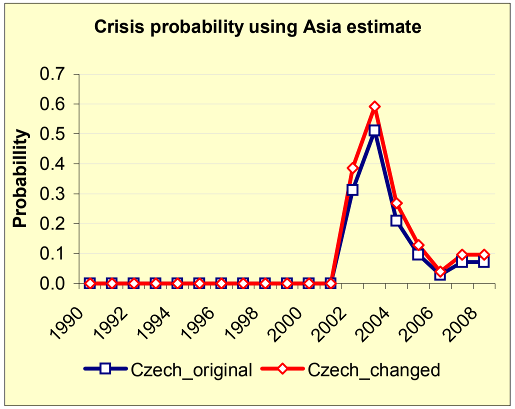
**Figure 6.1.4: Effects on crisis probabilities of 4% lower GDP growth**

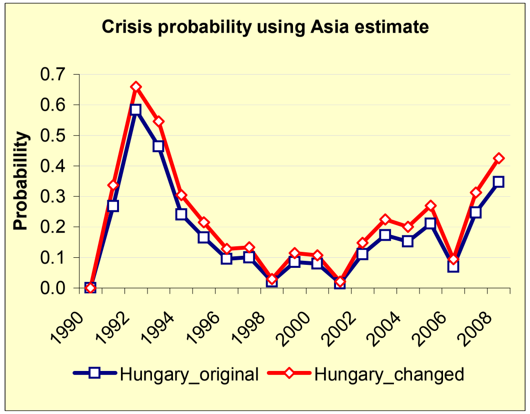


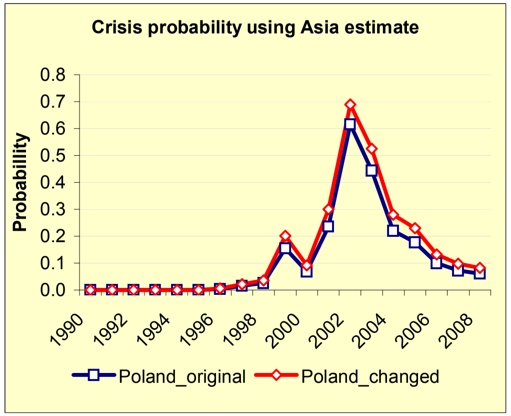
## Figure 6.1.5: Effects on crisis probabilities of 10% lower GDP per capita



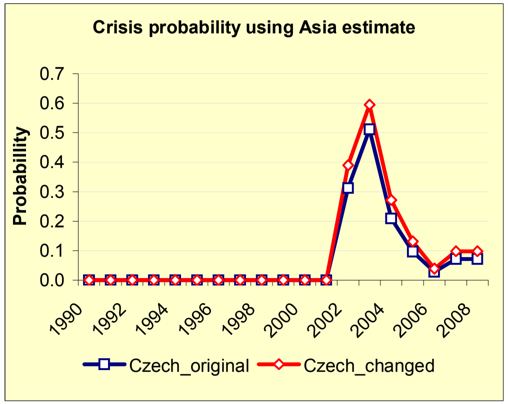
## Figure 6.1.6: Effect on crisis probabilities of 10 percentage point lower credit growth

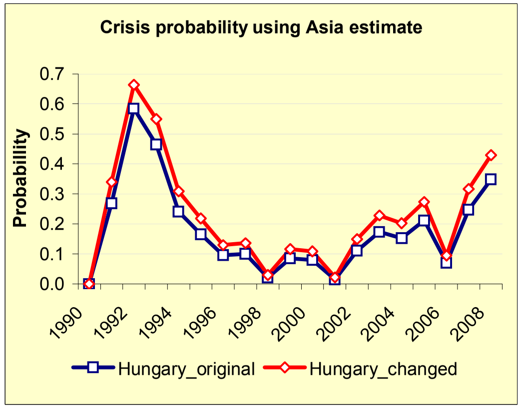



## Figure 6.1.7: Effect on crisis probabilities of 3 percentage point higher real interest rates



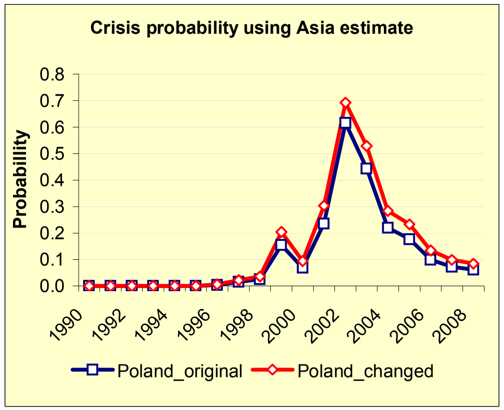



**Figure 6.1.8: Effect on crisis probabilities of 10 percentage point currency appreciation**

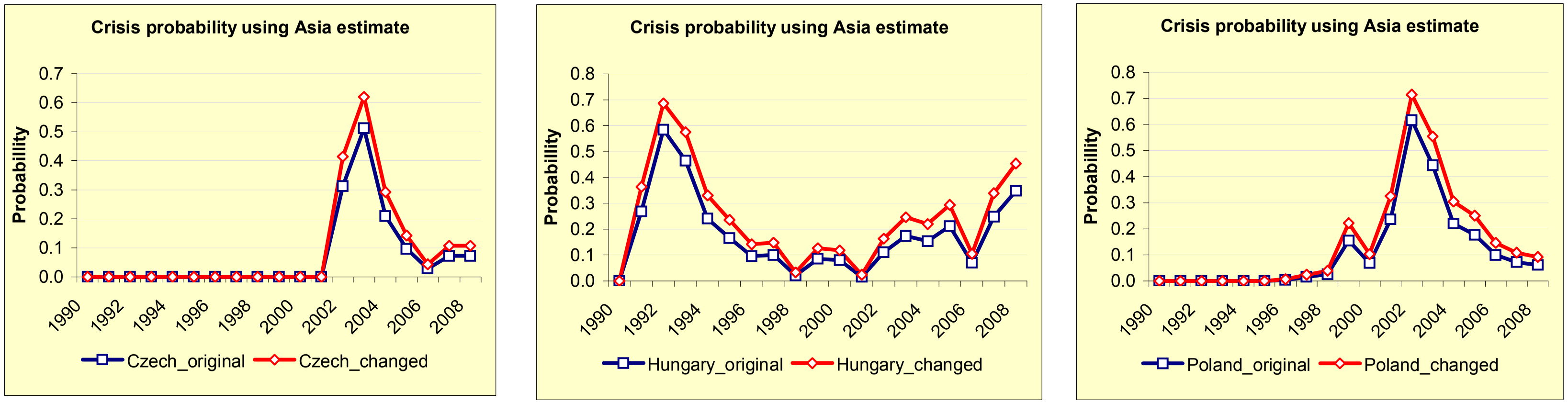
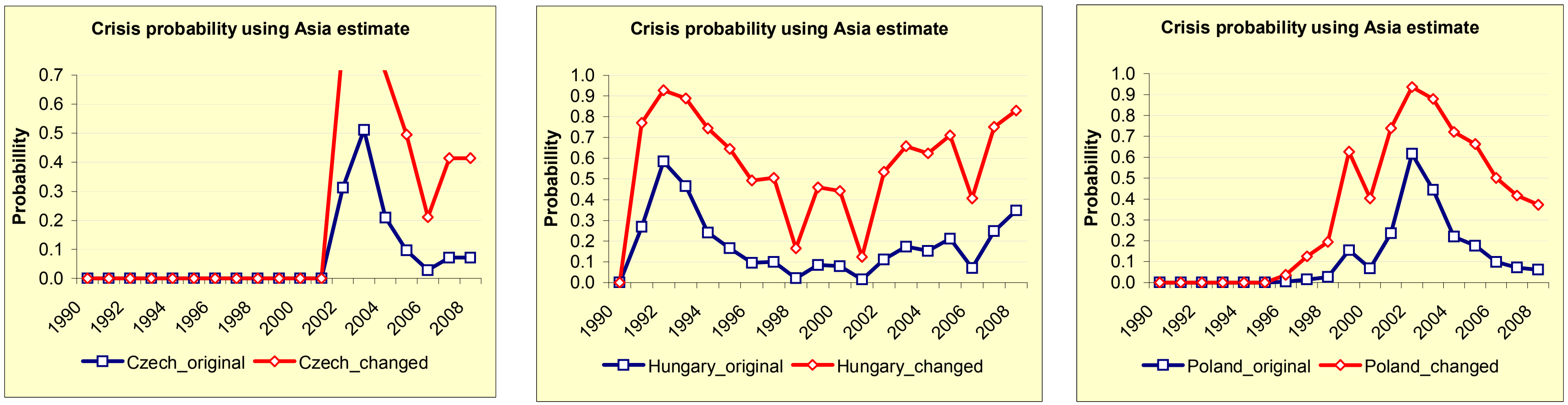



**Figure 6.1.9: Combined shocks to GDP growth, exchange rate, real rate and credit growth using the Asian estimate**



## *6.2 Early Warning Systems for crises using the signal extraction approach*

The signal extraction approach is a non-parametric one which assesses the behaviour of single variables prior to and during crisis episodes. As noted in the literature survey, the logic is that if aberrant behaviour of a variable can be quantitatively defined then whenever that variable moves from tranquil to abnormal activity, a crisis is forewarned. Let:

i = a univariate indicator
j = a particular country
S= signal variable
X = indicator

An indicator variable relating to indicator i and country j is denoted by $X_i^j$ and the threshold for this indicator is denoted as $X{*}_i^j$. A signal variable relating to indicator i and country j is denoted by: $S_i^j$ . This is constructed to be a binary variable where $S_i^j = \{0,1\}$. If the variable crosses the threshold, a signal is emitted and $S_i^j = 1$. This happens when

$$\{ S_i^j = 1 \} = \{ \mid X_i^j \mid > \mid X{*}_i^j \mid \} \qquad (3)$$

If the indicator remains within its threshold boundary, it behaves normally and does not issue a signal so $S_i^j = 0$,

$$\{ S_i^j = 0 \} = \{ \mid X_i^j \mid < \mid X{*}_i^j \mid \} \qquad (4)$$

Hence in a global EWS, panel data are used to derive a threshold for each variable, which distinguishes between normal and aberrant behaviour. Notice the directional sign may vary depending on whether the indicator in question has an upper or lower bound; hence the variables and thresholds in equations (3) and (4) are expressed in absolute terms. Thus for a time series of t observations for country j and indicator i we can obtain a binary time series of signal or no-signal observations. This series is then checked against actual events to construct a measure of predictive accuracy. There are four possible scenarios:

| | CRISIS | NO CRISIS |
|---|---|---|
| SIGNAL | A | B |
| NO SIGNAL | C | D |

If the indicator signals crisis and this correlates with an actual crisis, the outcome is denoted ‘A’. If the signal is not matched by a crisis in reality, the outcome is denoted ‘B’. If no signal is emitted by the indicator but there was an actual crisis, the outcome is called ‘C’. If no signal is emitted and there really is no crisis, the outcome is ‘D’.

Hence a perfect indicator would produce outcomes A and D only; it would correctly call all crises and would not issue signals unnecessarily. Outcome C represents a failure to call crisis

(Type I error) and outcome B generates a false alarm (Type II error). Accordingly, a measure of signalling accuracy can be constructed for each indicator, based on the proportion of false alarms and missed crises; there are various criteria (e.g. minimise Type I error only) so the chosen measure will reflect the desires of the policy maker or private institution using the EWS. This is based on the inherent trade-off between Type I and Type II errors which are functions of the threshold; changing the threshold to allow more crises to be picked up necessarily raises the likelihood of false alarms. A policy maker concerned with avoiding crises at all costs may choose to minimise Type I errors even if this entails unnecessary intervention (or at least, investigation) due to more Type II errors. Likewise, in currency crisis models, private sector investors with positions entailing a large amount of exchange rate risk may prefer wider thresholds giving them time to take alternative investment positions. On the other hand, policy makers with relatively stable financial systems may prefer avoiding Type II errors and undue intervention.

Kaminsky and Reinhart (1999) choose to minimise the probability of failing to call crisis and the probability of false alarms simultaneously. Specifically, the Noise to Signal Ratio (henceforth NTSR) is given by (Type II error/ 1 – Type I error). As with normal hypothesis testing, changing the threshold to reduce Type I errors necessarily increases the number of Type II errors. The NTSR measure takes this trade-off into account; the optimal threshold will minimise the numerator and maximise the denominator of the NTSR. Different percentiles of the entire panel (i.e. cross-country) series are taken as thresholds and the corresponding NTSR is evaluated. The percentile that minimises the NTSR is selected and applied to each country to produce a country specific threshold which forms the benchmark for the EWS[33]. The advantage of this non-parametric approach is that it focuses on a particular variable's association with crisis and that it can be based on high frequency data. Furthermore, it may be more comprehensible to the non-economically trained policy maker than the logit model.

In the current exercise we address the signalling properties of the variables listed in Box 6.1. We employ the same sample as in the logit model outlined above: Asia, Latin America and a combination of both. We restrict our discussion to the results since the reader can refer to the "Practical Guide to Early Warning Systems" document appended for specific methodological steps.

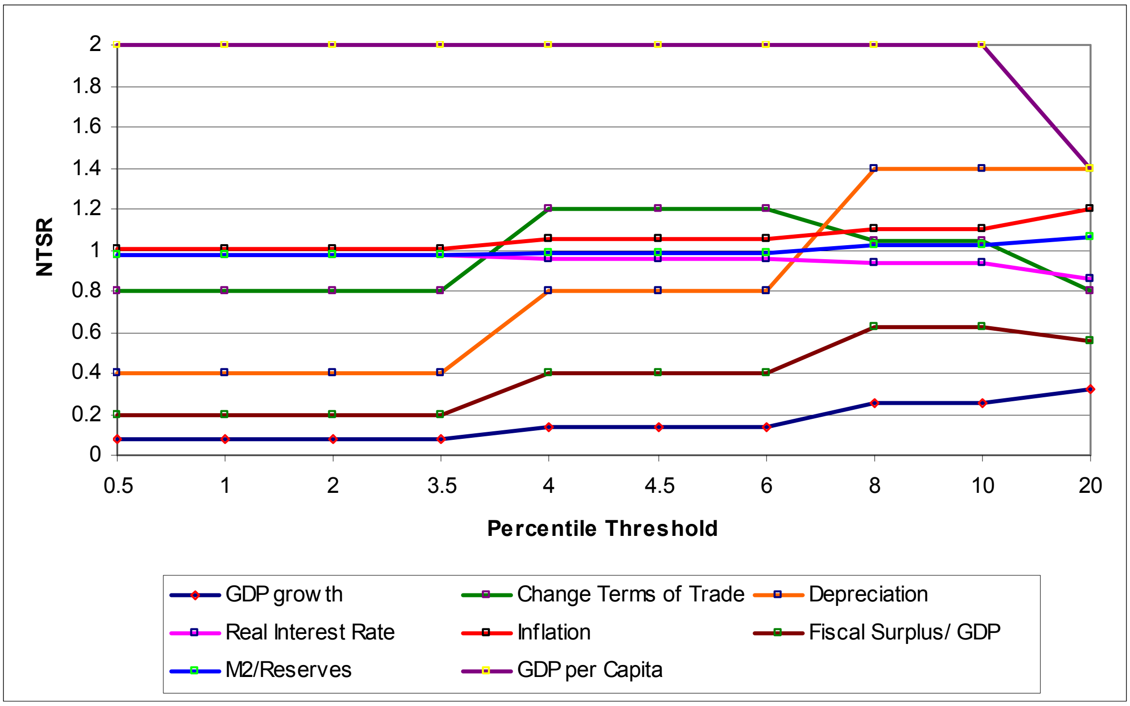
In assessing the performance of each indicator, we make no assumption with regards to the policy maker's relative aversion towards crisis episodes as opposed to non-crisis episodes. This means we implicitly assume the policy maker places equal weight on correctly calling both crisis and non-crisis states. Therefore, we assume a cut-off level of "noise" relative to a correct "signal" of 50% is acceptable; higher NTSRs mean the information carried in the signal is more likely to be incorrect than correct. Accordingly, in our discussion of each model below, we will focus on the top three indicators in terms of their NTSR performance, since the remaining indicators generate NTSRs above 50%.

Figure 6.2.1 shows the signalling properties of each variable in the Asian country model. The best indicator is GDP growth since it is associated with the lowest NTSR for any given threshold. This result accords with the logit results above as well as Demirguc-Kunt and Detragiache (1998, 2005) and Davis and Karim (2008) who found GDP growth to be an important leading indicator of banking crises across a heterogeneous range of countries. The procyclicality of financial instability implies GDP growth should capture boom and bust cycles and since credit risk increases during financial downturns (due to decreases in

[33] The exact steps used to derive the thresholds are demonstrated in the "Practical Guide to Early Warning Systems" in the Appendix.

collateral values, especially property prices), recessions are associated with higher levels of non-performing loans than periods of high economic growth.

**Figure 6.2.1: NTSR vs Threshold, Asia**

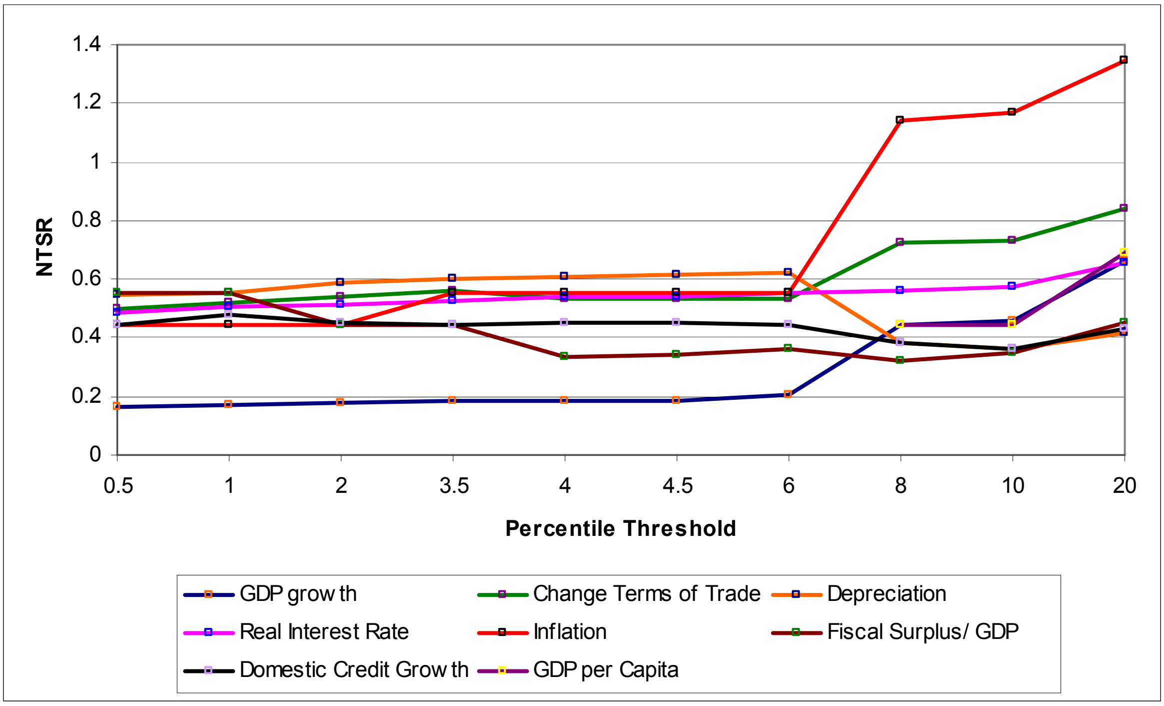



The second best predictor of the banking crises in Asia is the fiscal surplus to GDP ratio. Reinhart and Rogoff (2009) highlight the detrimental impact of banking crises on government finances so that fiscal surpluses can rapidly convert to deficits in the wake of banking crises. If countries have fiscal deficits alongside banking system vulnerability, their ability to bail out their banking systems is restricted so that systemic crises become more likely.

The third best predictor of the Asian banking crises is the percentage deprecation experienced by their currencies. Although large currency devaluations were a characteristic of the SE Asian crises, they may not necessarily be associated with banking crises in economies to such a degree. As we discuss below, depreciation is not one of the best performing leading crisis indicator in the Latin American countries.

Note that GDP growth, fiscal surplus/ GDP and depreciation appear to have identical optimal thresholds. Although the NTSR remains constant between the range T = 0.5 to 3.5, the optimal threshold would be 3.5 since this allows GDP growth and fiscal surpluses to deteriorate over this range before a signal is considered by the policy maker. Similarly, depreciation can worsen over the threshold range before the policy maker must accept a crisis is imminent. Since all the remaining variables generate much higher NTSRs than the three indicators discussed above, we will not rely on them as leading indicators. We next discuss the variable performances in the Latin American country model which are shown in Figure 6.2.2.

**Figure 6.2.2: NTSR vs Threshold, Latin America**




When considering the prediction of banking crises that occurred in Latin American countries over the years 1980 – 2007, GDP growth appears again to be important. This coincides with the Asian result for the same period, once again highlighting the importance of recessions in causing crises. The second best indicator is the fiscal surplus/ GDP. Again, this result accords with the Asian country result and therefore confirms the importance of sound government finances in mitigating the realisation of banking crises in emerging market economies.

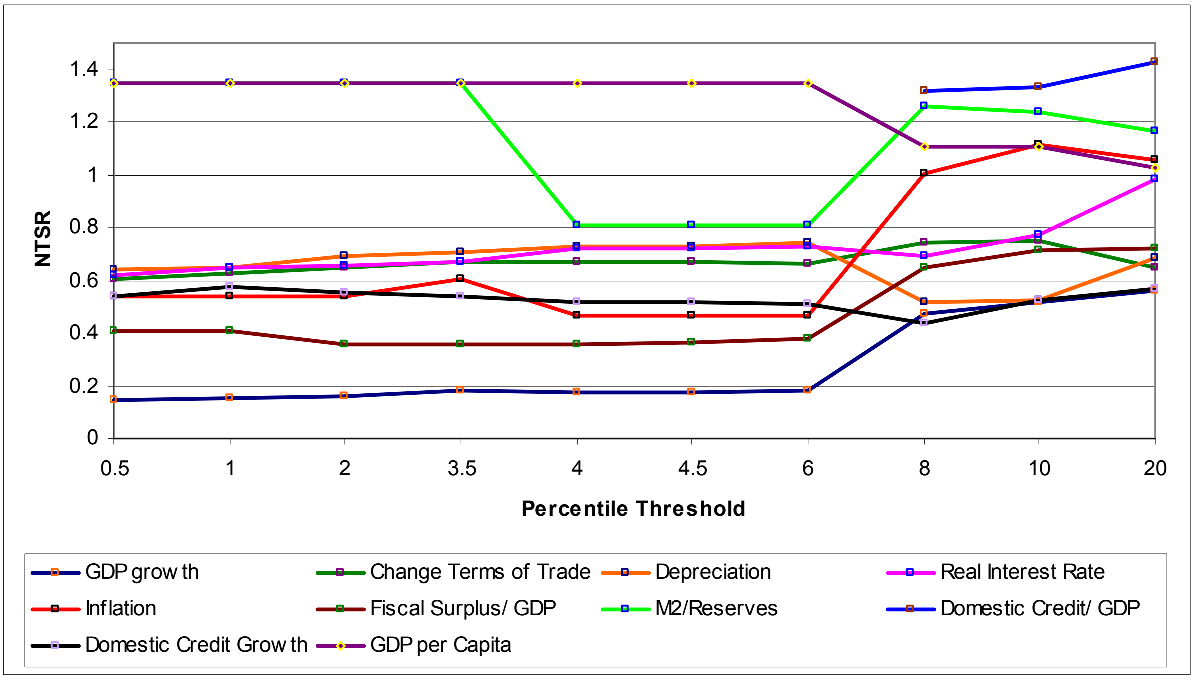
Unlike the Asian sample, however, the third best predictor of Latin American crises is the rate of domestic credit growth. This may be associated with the financial liberalisation policies of the 1980s in these countries since such policies lead to deepening of financial markets and consequent increases in credit risk. In the Kaminsky and Reinhart (1999) sample, over 70% of banking crises were preceded by financial liberalisation within the last five years and the probability of banking crisis conditional on financial liberalisation having occurred is higher than the unconditional probability of banking crisis. Demirguc-Kunt and Detragiache (1998) also find financial liberalisation increases crisis risk within a few years of the liberalisation process.

While we will not consider the remaining indicators separately due to their relative poor performances in terms of the NTSR, it is worth noting the exceptionally inferior performance of the domestic credit to GDP ratio as a banking crisis predictor in the Latin American countries. Despite Demirguc-Kunt and Detragiache (1998, 2005) including this variable as a proxy for financial and institutional development, in our sample this variable did not signal crises (either correctly or incorrectly) at lower thresholds. However, at higher thresholds (T = 8 to T = 20) the NTSR starts to fall, indicating that credit/ GDP would have to be substantially high before any useful information on financial stability could be inferred.

Although two of the best leading indicators of Latin American crises coincide with the Asian results, the optimal thresholds for the two samples differ. In Latin America, the occurrence of banking crises is much more sensitive to reductions in GDP growth than in Asia and consequently the optimal threshold for the former is much lower (T = 0.5). The NTSR associated with the fiscal surplus/ GDP in Latin America reaches a minimum when T = 4 unlike in Asia where the same indicator has a lower optimal threshold (T = 3.5).

Since GDP growth and the fiscal surplus/ GDP perform well in both samples, we would expect them to be important in the combined sample. The identity of the third best indicator is harder to predict since this is not common across both samples. Figure 6.2.3 shows the results for the combined sample.

**Figure 6.2.3: NTSR vs Threshold, Asia and Latin America**




As expected, the first and second best leading indicators in the combined sample are GDP growth and the fiscal surplus/ GDP respectively. The respective optimal thresholds are T = 0.5 and T = 4, implying that the Latin American data drives the result in the combined sample. This may explain why the third best leading indicator is inflation with an optimal threshold of T = 6 since this variable was one of the worst performers in the Asia-only sample.

Given that the signal extraction methodology is non-parametric, the performance of these models can only be assessed by their out-of-sample performance. Although we will test the signal approach on the same out-of-sample NMS data used to assess the logit and BRT specifications, it should be noted that the lack of crisis observations in the NMS data means the out-of-sample robustness tests are not as informative as they should be; the model can accurately be assessed in terms of Type II errors but not in terms of Type I errors since the latter requires crisis observations to be missed.

Table 6.2.1 shows the out-of-sample results for the Asian, Latin American and combined models. The Asian and Latin American models do not elicit any banking crisis signals for Czech Republic, Hungary and Poland in the years 2006 and 2007. Given that there were no actual crises in these countries in these years, the both models appear to yield a zero percent rate of Type II errors; there are no false alarms.

## Table 6.2.1 Out of Sample Signal Extraction

Table 6.5: Out-of-Sample Results for Signal Extraction on New Member States

| | Variable | Percentile | (Optimal NTSR) | Point on Distribution | actual 2006 value | actual 2007 value | 2006 signal | 2007 signal |
|---|---|---|---|---|---|---|---|---|
| Model Type: Asia Only | | | | | | | | |
| Czech | GDP Growth | 3.5 | 0.08 | -5.53 | 6.07 | 5.65 | NS | NS |
| Hungary | GDP Growth | 3.5 | 0.08 | -6.90 | 3.88 | 1.30 | NS | NS |
| Poland | GDP Growth | 3.5 | 0.08 | -2.35 | 6.25 | 6.52 | NS | NS |
| Czech | Budget Surplus/ GDP | 3.5 | 0.2 | -3.82 | -3.03 | na | NS | na |
| Hungary | Budget Surplus/ GDP | 3.5 | 0.2 | -2.95 | -1.84 | -2.26 | NS | NS |
| Poland | Budget Surplus/ GDP | 3.5 | 0.2 | -14.83 | -11.20 | -4.90 | NS | NS |
| Czech | Depreciation | 3.5 | 0.4 | -23.90 | 15.10 | 13.40 | NS | NS |
| Hungary | Depreciation | 3.5 | 0.4 | -24.44 | 10.28 | 9.92 | NS | NS |
| Poland | Depreciation | 3.5 | 0.4 | -44.81 | 10.76 | 16.34 | NS | NS |
| Model Type: Latin America Only | | | | | | | | |
| | Variable | Percentile | (Optimal NTSR) | Point on Distribution | actual 2006 value | actual 2007 value | 2006 signal | 2007 signal |
| Czech | GDP Growth | 0.5 | 0.17 | -10.74 | 6.07 | 5.65 | NS | NS |
| Hungary | GDP Growth | 0.5 | 0.17 | -11.18 | 3.88 | 1.30 | NS | NS |
| Poland | GDP Growth | 0.5 | 0.17 | -6.34 | 6.25 | 6.52 | NS | NS |
| Czech | Budget Surplus/ GDP | 4 | 0.33 | -3.76 | -3.03 | na | NS | na |
| Hungary | Budget Surplus/ GDP | 4 | 0.33 | -2.81 | -1.84 | -2.26 | NS | NS |
| Poland | Budget Surplus/ GDP | 4 | 0.33 | -14.72 | -11.20 | -4.90 | NS | NS |
| Czech | Credit Growth | 10 | 0.36 | -9.78 | 19.42 | 33.78 | NS | NS |
| Hungary | Credit Growth | 10 | 0.36 | 1.92 | 17.11 | 18.87 | NS | NS |
| Poland | Credit Growth | 10 | 0.36 | 7.23 | 24.00 | 32.09 | NS | NS |
| Model Type: Asia + Latin America | | | | | | | | |
| | Variable | Percentile | (Optimal NTSR) | Point on Distribution | actual 2006 value | actual 2007 value | 2006 signal | 2007 signal |
| Czech | GDP Growth | 0.5 | 0.17 | -10.74 | 6.07 | 5.65 | NS | NS |
| Hungary | GDP Growth | 0.5 | 0.17 | -11.18 | 3.88 | 1.30 | NS | NS |
| Poland | GDP Growth | 0.5 | 0.17 | -6.34 | 6.25 | 6.52 | NS | NS |
| Czech | Budget Surplus/ GDP | 4 | 0.33 | -3.76 | -3.03 | na | NS | na |
| Hungary | Budget Surplus/ GDP | 4 | 0.33 | -2.81 | -1.84 | -2.26 | NS | NS |
| Poland | Budget Surplus/ GDP | 4 | 0.33 | -14.72 | -11.20 | -4.90 | NS | NS |
| Czech | Inflation | 6 | 0.46 | 0.20 | 1.98 | 0.22 | NS | **S** |
| Hungary | Inflation | 6 | 0.46 | 3.71 | 3.70 | 5.43 | **S** | **S** |
| Poland | Inflation | 6 | 0.46 | 1.44 | 1.48 | 2.98 | **S** | **S** |

S denotes signal while NS denotes no signal. "na" stands for missing observation

In contrast, the combined Asia and Latin America model generates a crisis signal for the Czech Republic in 2006, Hungary in 2006 and 2007 and a signal for Poland in both years as well, the results being driven by inflation. In terms of Type II errors we conclude the separate Asian and Latin American models perform better than the combined model where the pooling of different types of crises may distort the threshold values of predictors. As noted previously however, this assessment of performance is based on a lack of crisis observations in the NMSs. Nevertheless, we advise that these models are run regularly on new data for the NMSs. The Asian Signal Extraction model should be estimated in particular, due to the similarity between these and the NMS economies.

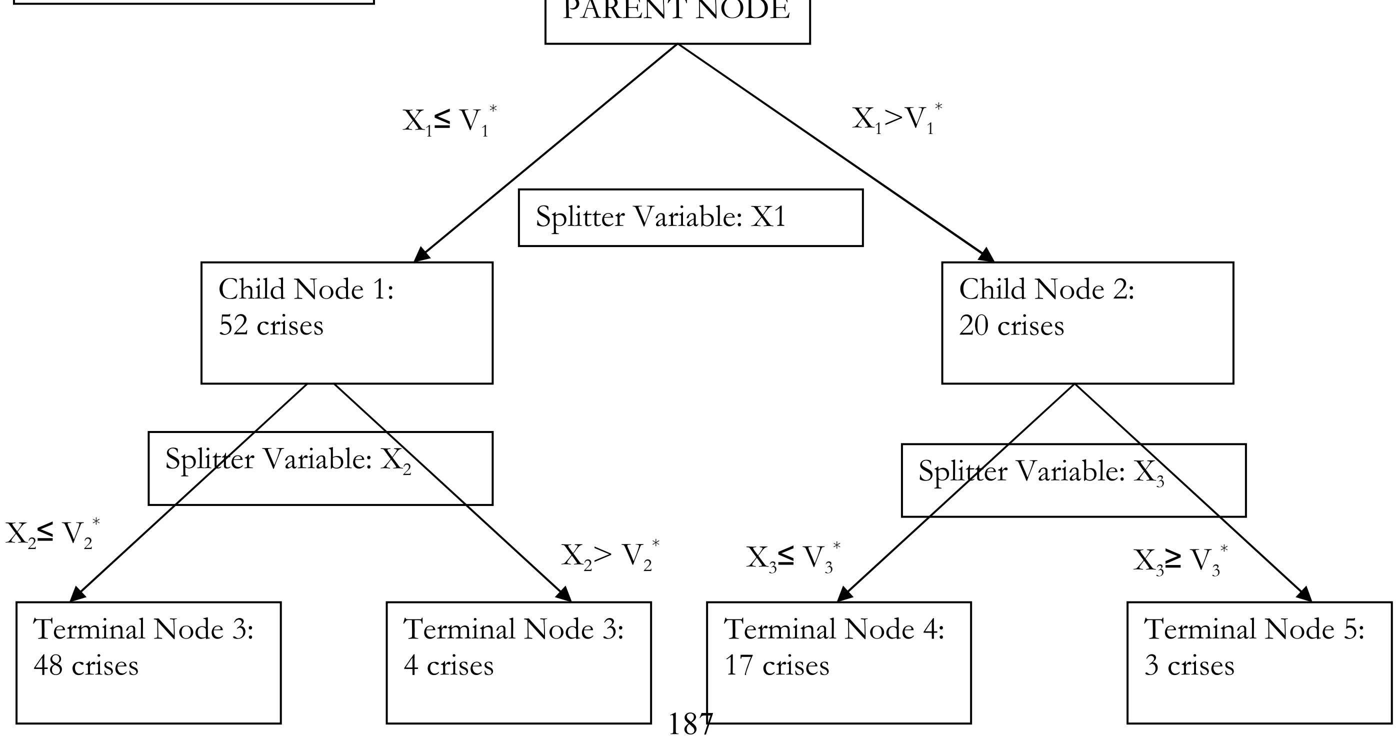
## 6.3 *Early Warning Systems for crises using the binary recursive tree (BRT)*

As discussed in the literature survey, the binary recursive tree is a novel approach in the financial crisis literature. Our work uses a proprietary software package known as “CART” from Salford Systems Inc. to construct the BRT. We give a brief outline of the methodology here; a fuller explanation can be found in Breimen at al (1984) and Steinberg and Colla (1995) and economic applications can be found in Duttagupta and Cashin (2008) who examined banking crises, Manasse et al (2003) who examined sovereign debt crises and Ghosh and Ghosh (2002) who examined currency crises.

The BRT process analyses a sample of data to reveal the particular value of the explanatory variable that best explains the dependent variable. Hypothetically, it could be established that the level of real GDP growth best distinguishes between crisis and non-crisis episodes across the entire sample. CART would then search for the exact threshold level of GDP growth that separates crises from tranquil periods. Assuming this “splitting value” is 4%, all data will be split into two child nodes with observations associated with GDP growth <= 4% in the left child node and remaining observations associated with GDP growth > 4% in the right child node. If low GDP growth were detrimental to banking stability, we would expect the left child node to be concentrated with banking crisis observations relative to the right node; the CART algorithm will search through all possible splitting values of all explanatory variables to find the best discriminator between crises and non-crises across the entire sample.

Once this “primary splitter” has been obtained, CART will apply the same procedure to further split the observations located in the two child nodes and in doing so will generate the BRT. This is schematically represented in figure 6.3.1 where the primary splitter is $X_1$ and the corresponding threshold value is $V_1^*$. Subsequent splitter variables (and their threshold values) are given by $X_2$ ($V_2$) and $X_3$ ($V_3$); these values are used to partition the 72 crises in the sample.

Figure 6.3.1: Schematic Diagram of Binary Recursive Tree (BRT)



The choice between two potential splitters is made on the basis of their comparative abilities to increase node purity, i.e. to concentrate the node further with one type of observation. The change in impurity $(\Delta i)$ that arises from splitting (s) the data at a node (t) is defined as:

$$\Delta i(s,t) = i(t) - P_L i(t_L) - P_R i(t_R) \quad (3)$$

where $i(t)$, $i(t_L)$ and $i(t_R)$ are the impurities associated with each existing node and the left and right child nodes respectively and $P_L$ and $P_R$ are the probabilities of sending an observation in the left and right nodes respectively. To quantify the degree of impurity, we use a criterion called the Gini measure, which is applicable to binary dependent variables (Steinberg and Golovnya, 2007). The Gini measure is given by:

$$i(t) = \sum_{i,j} c(i \mid j) \cdot P(i \mid t) \cdot P(j \mid t) \quad (4)$$

where $c(i \mid j)$ is the cost of misclassifying a non-crisis event given that it is a crisis event, $p(j \mid t)$ is the conditional probability that an observation takes class *j* given that it lies in node t and $p(i \mid t)$ is the conditional probability that an observation takes class i given that it lies in node t (where *j* = crisis and *i* = no crisis).

In this section we employ the tree for the Asian and Latin American samples separately, and then go on to do a joint estimate for both together as with the logit and signal extraction approaches. The aim for Eastern Europe is to give possible key variables and their threshold values that can help discriminate between crisis and non crisis observations.

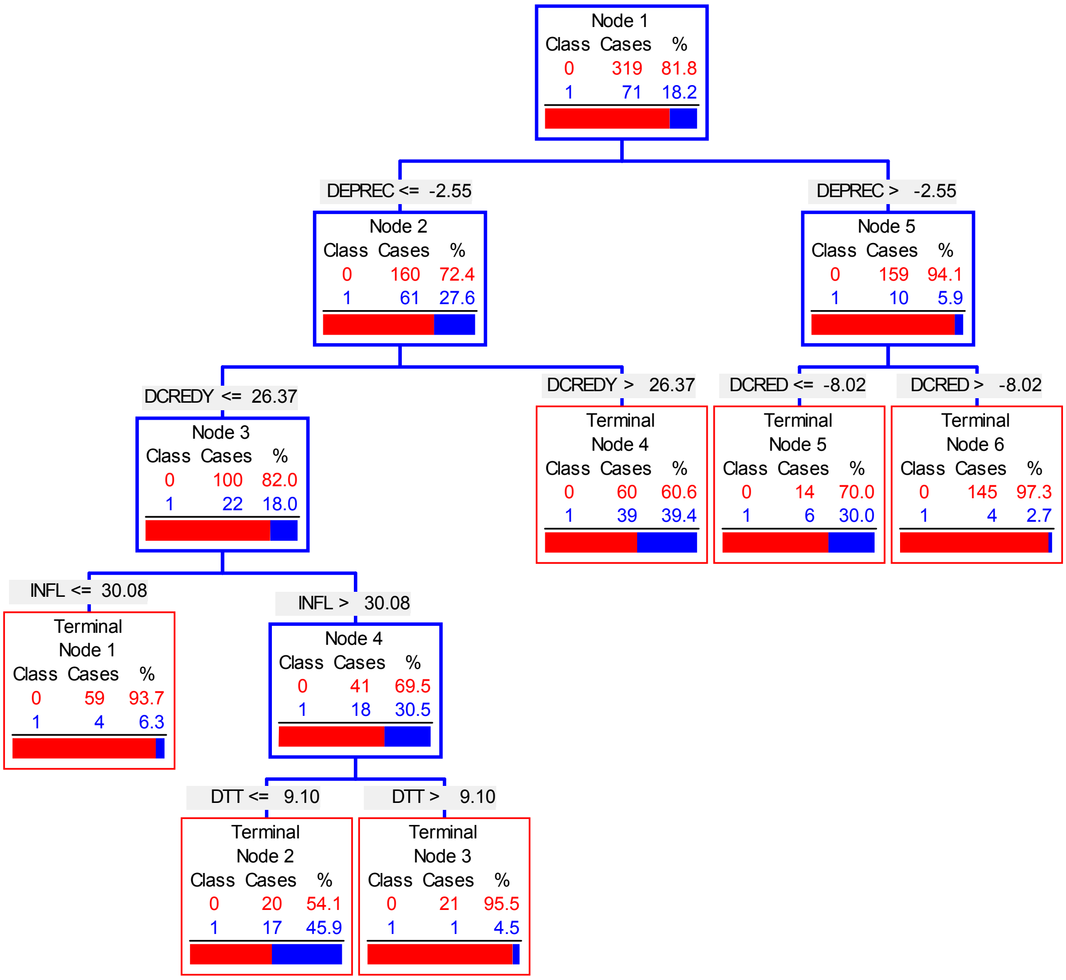
Figure 6.3.2 displays the tree based on the Latin American countries only. Across the entire Latin American sample, the main discriminator between crisis and non-crisis states is the degree of currency depreciation. Specifically, depreciation in excess of 2.55% increases the probability of banking crisis to 28% compared to a 6% crisis probability for less severe deprecations.

Crisis probability may substantially worsen if currency depreciation in excess of 2.6% occurs in the presence of high levels of banking intermediation; if domestic credit/ GDP exceeds 26%, it is possible that higher levels of foreign currency borrowing make bank balance sheets riskier. In this case, the probability of crisis rises to 39%.

Alongside high currency depreciation, levels of domestic credit/ GDP below 26% result in a banking crisis probability of 18%. However, this probability almost doubles (30.5%) if inflation also exceeds 30%, whereas if inflation is contained, crisis probability falls to 6.3%. In the presence of high inflation, a significant improvement in the terms of trade (above 9%) is required to mitigate the probability of crisis, otherwise the likelihood of crisis increases to 46%.

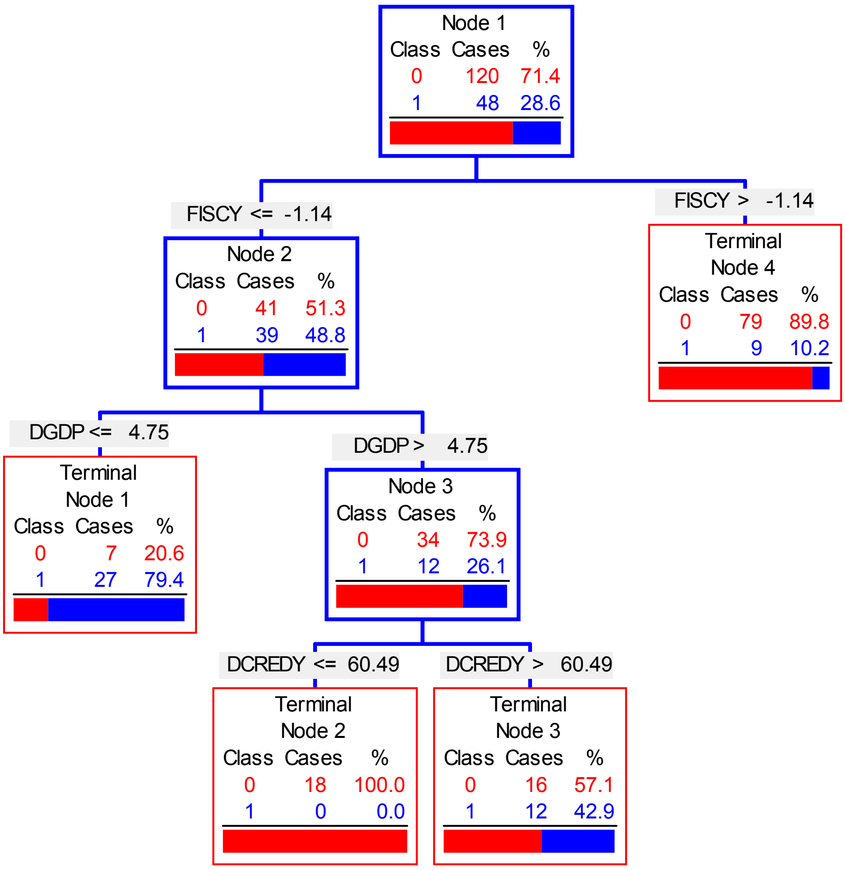
In cases where depreciation is less than 2.55%, the rate of domestic credit growth is the next most important determinant of banking crises. A credit crunch, where the contraction in domestic credit supply is more than 8% raises the crisis probability five fold from 5.9% to 30%. On the other hand, if the credit contraction is less severe and borrowers are able to refinance their debt, then the banking system is less prone to crises with an associated probability of 2.7%.

**Figure 6.3.2: Splitting Variables and Thresholds for the Latin American Countries**




Turning next to the model based on the sub-sample of Asian countries, we note that the degree of fiscal discipline, GDP growth and credit/ GDP are the primary factors associated with the Asian banking crises, as shown in Figure 6.2.4.

**Figure 6.2.3: Splitting Variables and Thresholds for the Asian Countries**



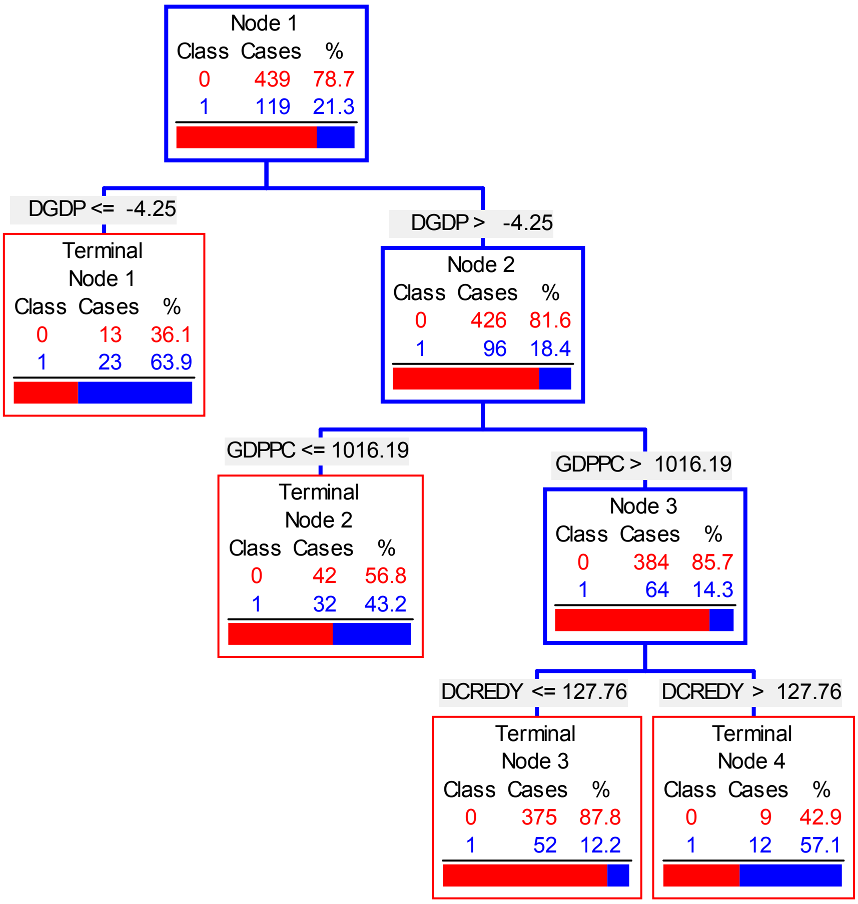

Across the Asian sample, the budget surplus/ GDP is the primary splitter; a threshold value of -1.14% is the single most important discriminator between crisis and non-crisis episodes. Governments that ran deficits of more than 1.14% of GDP put their banking systems in a riskier position (48.8% crisis probability) than those that maintained moderate deficits or surpluses (10.2% crisis probability). This accords with our signal extraction model for Asia; a healthy fiscal position allows governments more flexibly to deal with systemic banking distress – fiscal laxity may also fuel a boom that leads to a banking crisis.

In the presence of fiscal indiscipline, crisis probabilities are elevated if GDP growth is low. The threshold level of 4.75% GDP growth implies that in Asian economies, approximately 5% of GDP growth is required to counteract the fiscal deficits which impede bank bailouts. If GDP growth is below 4.75%, the lack of public financial support to the banking system and the level of non-performing loans put the banking system under stress and the probability of crisis rises to 79.4%.

In contrast, if GDP growth exceeds 4.75%, the probability of crisis is much lower at 26.1%. This is further reduced if the level of domestic credit/ GDP is lower than 60.49% since in such cases, a lesser degree of banking intermediation is associated with lower levels of risky bank lending; if banks do supply higher levels of credit relative to GDP, the lack of public financial support raises crisis probability to 42.9%.

Figure 6.3.4 shows the tree based on the combined sample. Across the Asian and Latin American economies, the main contributor to crisis probability is the level of GDP growth. A recessionary state, where the level of GDP growth is below -4.25%, results in a rise in crisis probability from 21.3% (the unconditional in-sample probability) to 63.9%. This is consistent with the results of the logit estimations and signal extraction which also show the detrimental impact of recessions.

**Figure 6.3.4: Splitting Variables and Thresholds for the Asian and Latin American Countries**




Conversely, if the recession is not as severe, the probability of crisis is lower at 18.4%. In such cases, the level of institutional development of the economy becomes important; despite a mild recession, crisis probability could rise to 43.2% if the institutions required to manage the allocation of resources are not in place. Specifically, economies where the GDP per capita is below $1,016.19[34] face a 43.2% probability of banking system collapse.

In economies where institutions are more sophisticated (i.e. GDP per capita exceeds $1,016.19), the crisis probability is lower at 14.3%. However, stronger institutions are unable to mitigate the effects of risky lending that are likely to be associated with higher levels of bank intermediation. Consequently in countries where domestic credit/ GDP exceeds 127.76%, the probability of crisis increases markedly to 57.1%, whereas countries with less

[34] Based on 2000 USD.

developed banking systems (credit/ GDP below 127.76%) are less prone to crises; these observations are associated with a 12.2% probability of banking crisis.

We next turn to examining the out-of-sample forecasting ability of the three BRT models by applying them to data for the Czech Republic, Hungary and Poland. Table 6.3.1 shows the placement of each observation in a terminal node. The corresponding probability for the terminal nodes is therefore the predicted probability of banking crisis attached to that observation; these probabilities are plotted in Figures 6.3.5 – 6.3.7[35].

**Table 6.3.1 Out of Sample Crisis Predictions**

| Table 6.6: Out-of-Sample Crisis Predictions for Selected NMSs Using BRT Models. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model: | Latin America | | | Asia | | | Asia + Latin America | | |
| | Czech | Hungary | Poland | Czech | Hungary | Poland | Czech | Hungary | Poland |
| 1991 | X | X | X | X | X | X | X | T-Node 3, 12.20% | X |
| 1992 | X | T-Node 5, 30% | X | X | T-Node 4, 10.00% | X | X | T-Node 3, 12.20% | X |
| 1993 | X | T-Node 4, 39.4% | T-Node 2, 45.9% | X | T-Node 4, 10.00% | X | X | T-Node 1, 63.9% | T-Node 1, 63.9% |
| 1994 | X | T-Node 4, 39.4% | T-Node 2, 45.9% | X | T-Node 4, 10.00% | X | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 1995 | X | T-Node 4, 39.4% | T-Node 2, 45.9% | T-Node 4, 10.00% | T-Node 4, 10.00% | X | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 1996 | X | T-Node 1, 6.3% | T-Node 2, 45.9% | T-Node 4, 10.00% | T-Node 4, 10.00% | X | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 1997 | X | T-Node 1, 6.3% | T-Node 5, 30% | T-Node 4, 10.00% | T-Node 4, 10.00% | X | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 1998 | X | T-Node 1, 6.3% | T-Node 1, 6.3% | T-Node 4, 10.00% | T-Node 4, 10.00% | X | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 1999 | T-Node 4, 39.4% | T-Node 1, 6.3% | T-Node 1, 6.3% | T-Node 4, 10.00% | T-Node 4, 10.00% | T-Node 2, 0.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2000 | T-Node 5, 30% | T-Node 1, 6.3% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 2, 0.00% | T-Node 2, 0.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2001 | T-Node 4, 39.4% | T-Node 4, 39.4% | T-Node 4, 39.4% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 4, 10.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2002 | T-Node 4, 39.4% | T-Node 4, 39.4% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 2, 0.00% | T-Node 4, 10.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2003 | T-Node 5, 30% | T-Node 5, 30% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2004 | T-Node 5, 30% | T-Node 5, 30% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2005 | T-Node 5, 30% | T-Node 5, 30% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2006 | T-Node 5, 30% | T-Node 5, 30% | T-Node 5, 30% | T-Node 1, 79.4% | T-Node 2, 0.00% | T-Node 2, 0.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2007 | T-Node 4, 39.4% | T-Node 4, 39.4% | T-Node 4, 39.4% | T-Node 2, 0.00% | T-Node 1, 79.4% | T-Node 1, 79.4% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |
| 2008 | T-Node 5, 30% | T-Node 5, 30% | T-Node 4, 39.4% | T-Node 2, 0.00% | T-Node 1, 79.4% | T-Node 2, 0.00% | T-Node 3, 12.20% | T-Node 3, 12.20% | T-Node 3, 12.20% |

[35] For missing observations a nodal placement is not possible and hence there is a break in the probability series.

**Figure 6.3.5: NMS Crisis Probabilities Based on Latin American Model**

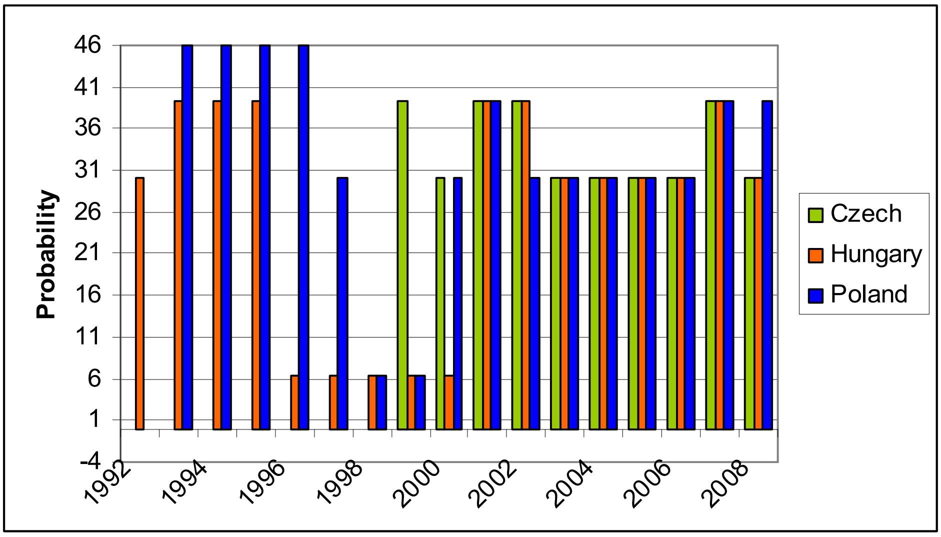



**Figure 6.3.6: NMS Crisis Probabilities Based on Asian Model**

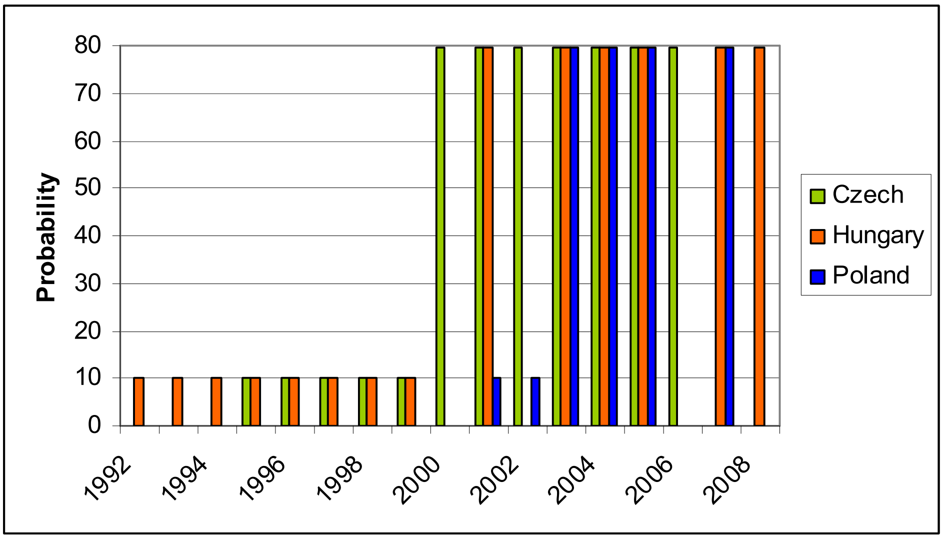
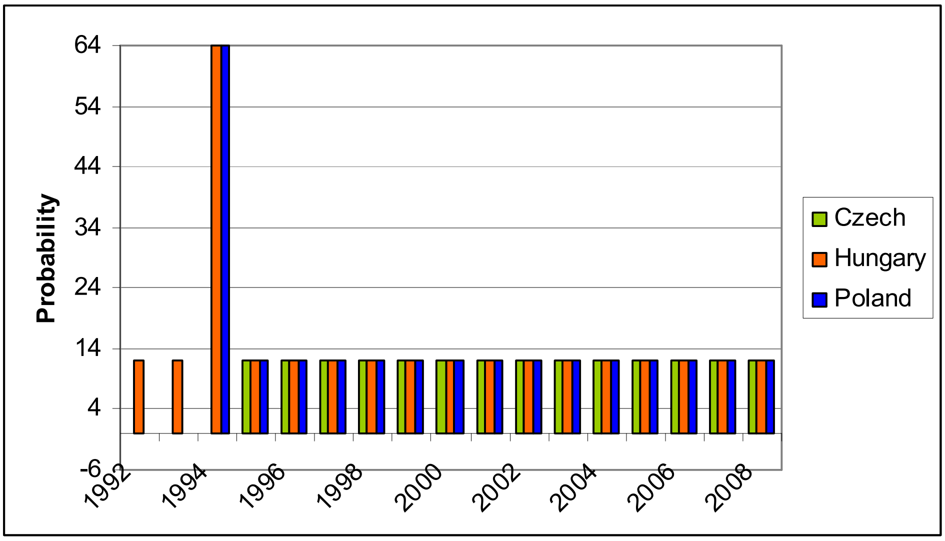



**Figure 6.3.7: NMS Crisis Probabilities Based on Combined Model**



The Asian country model systematically predicts the highest probabilities of crisis across all three countries, followed by the Latin American model, followed by the combined model.

According to the Asian model, the Czech Republic experienced a large increase in crisis probability (79%) in the years 2000 – 2006. To a degree, this increase in predicted financial instability is matched by the results of the Latin American model, which also records an increase in crisis likelihood in the years 2001 and 2002 (39%). The combined model shows no change in the vulnerability of the Czech banking system across the entire data period. Given that the Budget Surplus/ GDP and the rate of GDP growth are unique to the Asian model, the Czech results seem to be driven by these macroprudential indicators, although the rise in intermediation before the crises and subsequent credit rationing as detected by the Latin American model also seem to be contributory factors. The effects of these variables become less significant in the combined model.

The Latin American model shows a moderate increase in crisis probability for Hungary between the years 1993 – 1995 (from 30% to 39%) but a much more drastic increase between 2000 and 2001 (from 6% to 39%). The model also picks up an increase in vulnerability in 2007 over the previous year (from 30% to 39%) which accords with the logit results. This latter episode seems to be driven by an increase in intermediation and concurrent credit availability. Interestingly the increases in Hungary's crisis probabilities are also detected by the Asian model and accordingly the 2007 crisis probability is extremely high at 79%. Again, this is driven by credit growth in the economy. However the Asian model does not detect a rise in crisis vulnerability in 1993, although interestingly, this is clearly observable in the combined model where the crisis probability rises from 12% to 64% due to a substantial reduction in domestic credit/ GDP during 1992 – 1993.

According to the Asian model, the dynamics of financial instability in Poland have been very similar to those in Hungary except that Poland experienced a much more severe period of banking system distress during the early 1990s; during 1993 – 1996, the risk of crisis was 46%. This almost certainly arose due to the massive reduction in domestic credit/ GDP around this time. The Asian model is unable to detect concurrent vulnerability due to the lack of data for this period, however the combined model also records a large crisis probability in 1993 (64%). More recently, Poland's banking system has been subject to distress once more; the Asian model detects a 39% probability of crisis in 2007 and 2008, whilst according to the Latin American model the 79% probability of crisis in 2007 declined to zero in 2008. The Latin America model result is driven by large currency depreciations from 2006 onwards, whilst the Asian model is detecting the combined effects of Poland's recent budget deficits and increased financial intermediation.

Overall, the Asian model appears to be the most sensitive to instability in that it generates higher crisis probabilities than the Latin American model. The combined model is the least sensitive and places almost all observations in the same terminal node (3). Given that each regional model relies on some different macroprudential indicators to detect crisis vulnerabilities, a sensible policy recommendation would be to monitor the combined set of variables. Trees should be constructed for the NMSs based on suitable time series so that appropriate threshold values and nodal crisis probabilities can be identified. Forecasted observations can then be measured against these models to see if the country is likely to switch nodes, such that the emergence of financial system distress from different sources can be avoided.

### 6.4 Conclusion

We conclude with Table 6.4.1 which shows the leading indicators of banking crises according to the logit, signal extraction and BRT specifications across different regions. Some interesting facts emerge: firstly, GDP growth is an extremely important crisis determinant since it is picked up by virtually all model specifications, irrespective of the geographic location of the banking crisis. The fiscal surplus/ GDP ratio also appears to be important in mitigating financial instability since the signal extraction model picks this variable up in the Asian, Latin American and combined models, whilst the BRT model also uses the variable as a splitter in the Asian model.

Both the logit and BRT specifications highlight the association between the scale of financial intermediation and risk taking by banks and the emergence of crises since either domestic credit/ GDP are highlighted by at least two models in each regional sample.

Further commonalities beyond those discussed above are absent. Some variables such as depreciation are detected by different models in different regions (signal extraction and logit for Asia and BRT for Latin America), whilst others are highlighted in specific regions and by different models (terms of trade and inflation in Latin America). These results therefore appear to be underpinned by the different nature of crises in Latin America compared to Asia: the Asian crises are linked to financial variables and currency issues whereas the Latin American crises are underpinned by financial variables with inflationary and trade issues.

The lack of commonalities across the two regions is also due to the nature of the estimators we have used. Of the three specifications, logit is the only parametric estimator such that confidence intervals can be attached to the ranking of leading indicators. Moreover, the logit and BRT models are the only ones that are multivariate; logit detects the interactions of variables with each other when deciding on the best crisis predictors, whilst the BRT model takes this one step further by using non-linear variable interactions to map the dynamics of crises. The signal extraction approach isolates the behaviour of individual variables in the run-up to a crisis. Therefore, if we assume the current status of the NMS economies is more akin to the Asian experience, then from a policy perspective it would make sense to monitor all the variables detected by the Asian models.

Although there are variables common across the three specifications, each model is detecting these predictors based on multivariate interactions (linear or non-linear) or by noting the aberrant behaviour of a particular variable. Given that banking crises extol a high social, economic and political cost, from a policy perspective it would be prudent for the NMSs to estimate all three models on a rolling basis. This should of course be complemented by qualitative macroprudential analysis using financial soundness indicators and other qualitative information as discussed in Section 3.4. The quantitative models should play an important role but they cannot substitute for the role of judgement.

**Table 6.4.1: Leading Indicator Selection by Model Type and Sample**

| | Asia | | | Latin America | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Logit | Signal Extraction | Tree | Logit | Signal Extraction | Tree | Logit | Signal Extraction | Tree |
| Real GDP Growth | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Real Interest Rate | | | | | | | | | |
| Inflation | | | | | | ✓ | | ✓ | |
| Fiscal Surplus/ GDP | | ✓ | ✓ | | ✓ | | | ✓ | |
| M2/ Foreign Exchange Reserves | ✓ | | | | | | | | |
| Real Domestic Credit Growth | ✓ | | | | ✓ | ✓ | | | |
| Real GDP per capita | ✓ | | | ✓ | | | ✓ | | ✓ |
| Domestic credit/GDP | ✓ | | ✓ | | | ✓ | ✓ | | ✓ |
| Depreciation | ✓ | ✓ | | | | ✓ | | | |
| Terms of Trade | ✓ | ✓ | | | | ✓ | | | |
| Current account/GDP | | | | | | | | | |
| External short term debt/GDP | | | | | | | | | |

# 7 GARCH VOLATILITY ESTIMATION

Crises are inseparably related to periods of enhanced macroeconomic and financial uncertainty, with most sectors of the economy witnessing increased volatility and higher risk premia. This chapter identifies periods of increased volatility in both the financial and the real sphere of the NMS economies and seeks indicators of contagion in such volatility.

First, the study applies univariate GARCH models to analyse volatility of NMS exchange rates and equity prices, as well as retail sales, industrial production and inflation. Then, a set of financial multivariate GARCH models is used to study contagion across NMS and its transmission to and from the Euro Area. Finally, we undertake panels for conditional volatility of exchange rates and equity prices across NMS countries, to help find predictors of such volatility. We provide a users guide to GARCH and VECH in the appendix.

## 7.1 Univariate GARCH

As noted in the literature survey, a common method of estimating volatility processes and related scope for contagion is the GARCH methodology. In the GARCH(p,q) model introduced by Bollerslev (1986) we consider the information set $Y_{t-1}$, which contains all information on the variable $y_t$ until time $t$-1. Also we assume the time series $y_t$ can be described as

$$y_t \mid Y_{t-1} = (h_t)^{\frac{1}{2}} \eta_t, \qquad \eta_t \sim NID(0,1) \tag{1}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i y_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \tag{2}$$

where $h_t$ is the conditional variance.[36] Given a coefficient on the lagged squared error $\alpha_1$ greater than zero, volatility will tend to cluster, with large residuals following other large residuals, but of unpredictable sign, while a random, normally-distributed variation in the conditional distribution (error variance) gives the unconditional distribution (error distribution) fatter tails than the normal distribution.[37]

Most of the GARCH studies in the literature, which are for stock returns, the term structure or exchange rates, have found a significant degree of both short and long run shock persistence with high frequency data, thus accounting for the clustering of volatility characteristic of such markets (Bollerslev et al. 1992). Studies of inflation have found similar results (Engel, 1983).

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[36] To ensure a well-defined process, all the parameters in the infinite order AR representation must be non-negative, where it is assumed that the roots of the polynomial lie outside the unit circle. For a GARCH(1,1), a sufficient lag length in most applications according to Bollerslev et al. (1992), this amounts to ensuring that both $\alpha_1$ and $\beta_1$ are non-negative. It follows also that $y_t$ is covariance stationary if and only if $\alpha_1 + \beta_1 < 1$.

[37] Using the coefficient $\beta_1$ on the lagged dependent variable and setting the conditional variance constant, GARCH enables a long run response of the conditional variance to shocks to be calculated. $\alpha_0/[1 - \alpha_1 - \beta_1]$ is the mean level of volatility.

### 7.1.1 Financial markets - Equity prices

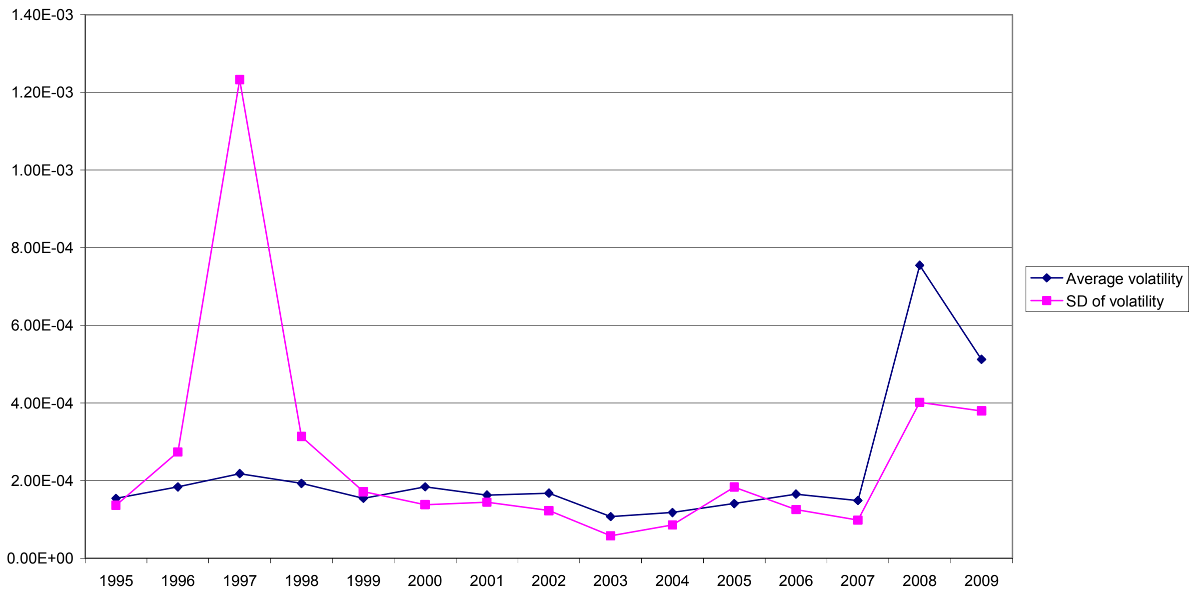
As a first exercise, we estimated simple GARCH (1,1) equations for daily stock market volatility in the CEE countries Czech Republic, Estonia, Hungary, Poland, Slovakia and Slovenia over 1995-2009, as well as for Germany and the Eurozone. The dependent variable is the first difference of the log of daily stock prices. The results as shown below are satisfactory with significant ARCH and GARCH coefficients and stability (with the coefficients generally adding to less than 1).

**Table 7.1.1: GARCH estimates for equity price volatility 1995/1/1-2009/6/30**

| | ***Bulgaria*** | ***Czech Republic*** | ***Estonia*** | ***Hungary*** | ***Poland*** | ***Romania*** | ***Slovakia*** | ***Slovenia*** | ***Eurozone*** |
|---|---|---|---|---|---|---|---|---|---|
| ARCH ($\alpha_i$) | **0.05 (21.9)** | **0.102 (12.6)** | **0.085 (23.8)** | **0.13 (22.4)** | **0.098 (13.6)** | **0.247 (32.4)** | **0.071 (15.5)** | **0.136 (17.0)** | **0.086 (14.1)** |
| GARCH ($\beta_i$) | **0.952 (572.8)** | **0.88 (93.7)** | **0.911 (365.0)** | **0.84 (143.5)** | **0.874 (91.7)** | **0.751 (119.7)** | **0.916 (202.4)** | **0.822 (103.9)** | **0.909 (143.7)** |
| Adjusted R2 | 0.0009 | 0.007 | 0.037 | 0.0087 | 0.015 | 0.0066 | - 0.00017 | 0.035 | 0.007 |
| DW | 2.00 | 2.05 | 2.00 | 2.00 | 2.03 | 2.04 | 1.97 | 1.98 | 1.98 |
| SEE | 0.021 | 0.016 | 0.018 | 0.02 | 0.019 | 0.027 | 0.014 | 0.013 | 0.012 |
| Log Likelihood | 5853.3 | 10945 | 9735 | 10107 | 10050 | 7944 | 10939 | 11669 | 12061 |

T values in parentheses
Source: Derived from Data Stream data.

**Figure 7.1.1: Average equity return volatility in NMS countries and its standard deviation**



Using these estimates, we can generate series for conditional volatility for equity prices that can then be considered in the light of contagion risks. Table 7.1.2 below shows the time series of conditional volatility, together with its means for countries and for time periods. So for example Estonia and Romania have the highest volatility of the group. Most relevant is the average volatility over time and its standard deviation. In periods of contagion it can be expected that both would rise, but the latter less than the former. This is depicted in Figure 7.1.1 below, which highlights 2008, but also 1997-8 as peaks in contagion – notable however is the fact that the standard deviation rose much less in 2008, suggesting greater contagion then than in the earlier period, i.e. much more commonality in reactions to the crisis.

**Table 7.1.2: Average conditional volatility of equity returns from GARCH estimates**

| | *Bulgaria* | *Czech Republic* | *Estonia* | *Hungary* | *Poland* |
|---|---|---|---|---|---|
| 1995 | na | 0.000128 | na | 0.000179 | 0.000464 |
| 1996 | na | 9.08E-05 | 0.000288 | 0.000336 | 0.000255 |
| 1997 | na | 0.000176 | 0.000913 | 0.000526 | 0.000321 |
| 1998 | na | 0.000261 | 0.001043 | 0.000688 | 0.000554 |
| 1999 | na | 0.000204 | 0.000223 | 0.000351 | 0.000405 |
| 2000 | 0.000282 | 0.000259 | 0.000265 | 0.000336 | 0.000431 |
| 2001 | 0.001501 | 0.000215 | 0.000155 | 0.000282 | 0.000288 |
| 2002 | 0.00035 | 0.000181 | 0.000154 | 0.000214 | 0.000217 |
| 2003 | 0.000529 | 0.000125 | 0.000109 | 0.000192 | 0.000197 |
| 2004 | 0.000366 | 0.000147 | 9.87E-05 | 0.000189 | 0.000169 |
| 2005 | 0.000283 | 0.000198 | 0.000165 | 0.000271 | 0.000213 |
| 2006 | 0.00012 | 0.00024 | 0.000113 | 0.000331 | 0.000286 |
| 2007 | 0.000244 | 0.000171 | 0.000215 | 0.000248 | 0.000265 |
| 2008 | 0.00069 | 0.001034 | 0.000559 | 0.001076 | 0.000719 |
| 2009 | 0.000611 | 0.000732 | 0.000546 | 0.001038 | 0.000873 |
| **Average** | **4.97E-04** | **2.78E-04** | **3.46E-04** | **4.17E-04** | **3.77E-04** |

| | *Romania* | *Slovakia* | *Slovenia* | *Average* | *SD* | *Eurozone* |
|---|---|---|---|---|---|---|
| 1995 | na | 0.000264 | 0.000154 | **1.54E-04** | 0.000136 | 5.49E-05 |
| 1996 | 0.000922 | 0.000154 | 0.000276 | **1.84E-04** | 0.000274 | 5.20E-05 |
| 1997 | 0.003591 | 0.000207 | 0.00026 | **2.18E-04** | 0.001233 | 1.31E-04 |
| 1998 | 0.000632 | 0.000294 | 0.000125 | **1.93E-04** | 0.000313 | 2.25E-04 |
| 1999 | 0.000632 | 0.000358 | 0.000105 | **1.54E-04** | 0.000171 | 1.23E-04 |
| 2000 | 0.000531 | 0.000239 | 0.000109 | **1.84E-04** | 0.000138 | 0.000171 |
| 2001 | 0.000555 | 0.000227 | 0.00011 | **1.63E-04** | 0.000144 | 0.000214 |
| 2002 | 0.000506 | 0.00024 | 0.000154 | **1.68E-04** | 0.000123 | 3.35E-04 |
| 2003 | 0.000249 | 0.000191 | 8.95E-05 | **1.07E-04** | 5.77E-05 | 1.94E-04 |
| 2004 | 0.000347 | 0.000184 | 8.82E-05 | **1.18E-04** | 8.56E-05 | 7.50E-05 |
| 2005 | 0.000651 | 0.000205 | 8.32E-05 | **1.41E-04** | 0.000183 | 5.48E-05 |
| 2006 | 0.000421 | 0.000124 | 8.96E-05 | **1.65E-04** | 0.000125 | 8.18E-05 |
| 2007 | 0.000381 | 8.48E-05 | 0.000126 | **1.49E-04** | 9.81E-05 | 1.04E-04 |
| 2008 | 0.001337 | 0.000182 | 0.000475 | **7.55E-04** | 0.000401 | 0.000457 |
| 2009 | 0.001341 | 0.000344 | 0.000292 | **5.12E-04** | 0.000379 | 0.000504 |
| **Average** | **8.64E-04** | **2.20E-04** | **1.69E-04** | **2.24E-04** | **2.57E-04** | **1.85E-04** |

We can also calculate the correlations of conditional volatility as shown in Tables 7.1.3a and 7.1.3b for the subperiods 1995-2001 and 2002-2009. We find that the mean correlation in the earlier period is much lower at 0.086 compared with 0.663 in the later period, indicating closer equity market integration and hence scope for contagion.

**Table 7.1.3a: Correlations of conditional volatility from 1995-2001**

| | *Bulgaria* | *Czech Republic* | *Estonia* | *Hungary* | *Poland* | *Romania* | *Slovakia* | *Slovenia* |
|---|---|---|---|---|---|---|---|---|
| *Bulgaria* | | | | | | | | |
| *Czech Republic* | -0.18497 | | | | | | | |
| *Estonia* | -0.1738 | 0.234132 | | | | | | |
| *Hungary* | -0.23444 | 0.398844 | 0.653329 | | | | | |
| *Poland* | -0.25033 | 0.362015 | 0.48222 | 0.595231 | | | | |
| *Romania* | 0.001177 | -0.06523 | 0.020419 | 0.070413 | -0.03175 | | | |
| *Slovakia* | -0.0733 | 0.160546 | 0.059578 | 0.037268 | -0.00936 | -0.1232 | | |
| *Slovenia* | -0.09335 | -0.05473 | 0.042736 | 0.10117 | -0.00981 | 0.1245 | -0.1232 | |
| *Eurozone* | -0.33175 | 0.520844 | 0.227345 | 0.471912 | 0.41184 | -0.07178 | 0.056203 | -0.1009 |

**Table 7.1.3b: Correlations of conditional volatility from 2002-2009**

| | *Bulgaria* | *Czech Republic* | *Estonia* | *Hungary* | *Poland* | *Romania* | *Slovakia* | *Slovenia* |
|---|---|---|---|---|---|---|---|---|
| *Bulgaria* | | | | | | | | |
| *Czech Republic* | 0.662794 | | | | | | | |
| *Estonia* | 0.708175 | 0.817085 | | | | | | |
| *Hungary* | 0.621484 | 0.952034 | 0.814301 | | | | | |
| *Poland* | 0.650111 | 0.9162 | 0.81589 | 0.914566 | | | | |
| *Romania* | 0.523387 | 0.804599 | 0.727372 | 0.816868 | 0.769207 | | | |
| *Slovakia* | 0.312903 | 0.28322 | 0.305368 | 0.320329 | 0.340026 | 0.37728 | | |
| *Slovenia* | 0.584402 | 0.767675 | 0.757555 | 0.773986 | 0.732646 | 0.781016 | -0.12378 | |
| *Eurozone* | 0.71758 | 0.883718 | 0.845718 | 0.874945 | 0.894142 | 0.732027 | 0.351398 | 0.827255 |

In Section 7.2.1, one of the following sections we report results of more sophisticated multivariate GARCH models that provide more direct measures of spillovers between markets.

## 7.1.2 Financial Markets - Exchange rates

To identify periods of increased volatility in NMS' exchange markets and to assess the scale of possible contagion among them we estimated univariate GARCH models for the Czech, Polish, Hungarian, Slovakian, Slovenian and Romanian effective exchange rates. The exchange rate data come from the JPMorgan database, and the dependent variable is the first difference of the log of daily exchange rates.

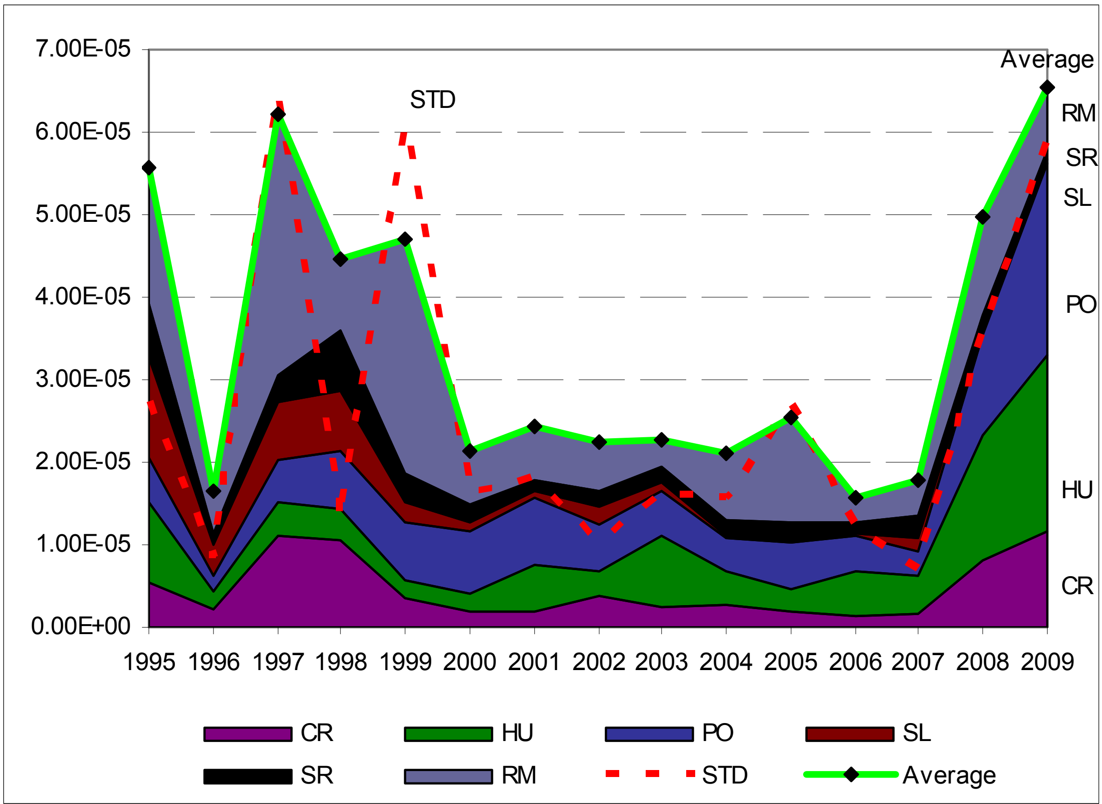
Table 7.1.4 shows estimates of parameters of the variance equation for individual NMS (standard errors in parentheses, ARCH and GARCH coefficients are significant and stable, generally adding to less than 1) and Figure 7.1.2 illustrates the average conditional volatility of NMS exchange rates along with its country decomposition and standard deviation.

**Table 7.1.4 GARCH estimates for exchange rate volatility**

| | *Bulgaria* | *Czech Republic* | *Hungary* | *Poland* | *Slovenia* | *Slovakia* | *Romania* | *Euro* |
|---|---|---|---|---|---|---|---|---|
| ARCH<br>$\alpha_1$<br>$\alpha_2$ | 0.11<br>(33.5) | 0.09<br>(0.006) | 0.21<br>(0.011) | 0.11<br>(0.005) | 0.12<br>(0.004) | 0.1<br>(0.005) | 0.24<br>(0.014)<br>-0.15<br>(0.014) | 0.03<br>(0.003) |
| GARCH<br>$\beta_1$ | 0.907<br>(496.9) | 0.91<br>(0.006) | 0.76<br>(0.011) | 0.87<br>(0.004) | 0.89<br>(0.002) | 0.88<br>(0.004) | 0.91<br>(0.002) | 0.97<br>(0.003) |
| Adjusted R2 | -0.017 | 0.02 | -0.0002 | -0.0004 | 0.11 | 0.004 | -0.021 | -0.001 |
| DW | 1.75 | 2.04 | 1.92 | 1.97 | 2.26 | 1.94 | 1.77 | 1.96 |
| SEE | 0.015 | 0.005 | 0.006 | 0.006 | 0.004 | 0.004 | 0.007 | 0.004 |
| Log Likelihood | 17326 | 15362.2 | 14958.0 | 14560.2 | 17494.5 | 16145.6 | 14142.8 | 15764.5 |

Source: Derived from DataStream data.

**Figure 7.1.2: Average exchange rate volatility, its standard deviation, and country decomposition of contributions to the average**




CR Czech Republic, HU Hungary. PO Poland, SL Slovenia, SR Slovak Rep, RM Romania, STD Standard Deviation

The figure suggests that for the largest Central European countries, the recent turmoil in the exchange market may be regarded as more severe than the one observed in the second half of the 1990s (associated with the Asian and the Russian crises). In 2008 and 2009 Hungary and Poland were the two countries recording the highest increases in conditional volatility of their effective exchange rates. Increases in conditional volatility of the Czech rate observed in the last two years were comparable with those during the mid 1990s. Slovenia and Slovakia seem to have been sheltered from the recent turmoil by having entered the Euro zone (Slovenia joined in 2007) and the ERM II (Slovakia joined in 2006) before the start of the crisis. The Romanian leu experienced relatively smaller fluctuations during the 2008 crisis as compared to the period of the second half of the 1990s (which may be related to transition turbulences affecting the Romanian economy in the 1990s).

The scale of fluctuations in NMS effective exchange rates varied across countries (see the standard deviation of NMS currencies' conditional volatility in Figure 7.1.2), showing the greatest differences in 1997 (which probably corresponded to the aftermath of the Czech crisis), during the Russian crisis of 1998, and during the global financial crisis of 2008.

As for equities, to shed some light on contagion between NMS exchange markets we calculate correlations of individual NMS exchange rates' conditional volatilities for two subperiods: 1995-2001 and 2002-2009 (compare Table 7.1.5). The shadowed areas indicate the direction of change in correlation for individual country pairs, with the dark area showing increases and the light area showing declines. The integration of exchange markets of the largest countries of Central Europe – Poland, Hungary and the Czech Republic – increased significantly over 2002-2009, and the Polish zloty, the Hungarian forint and the Czech koruna kept mirroring the behaviour of the euro to a larger extent than they had before. Between 2002-2009 the Romanian exchange market became more dependent on developments both in the Central European markets and the Euro Area. In recent years the Slovak and the Slovenian currencies seem to have responded to country specific developments rather than to regional events, perhaps reflecting trade patterns inherited from the former Czechoslovakia and Yugoslavia, and more recently joining EMU.

**Table 7.1.5 : Correlations of conditional volatility from 1995-2001 and 2002-2009**

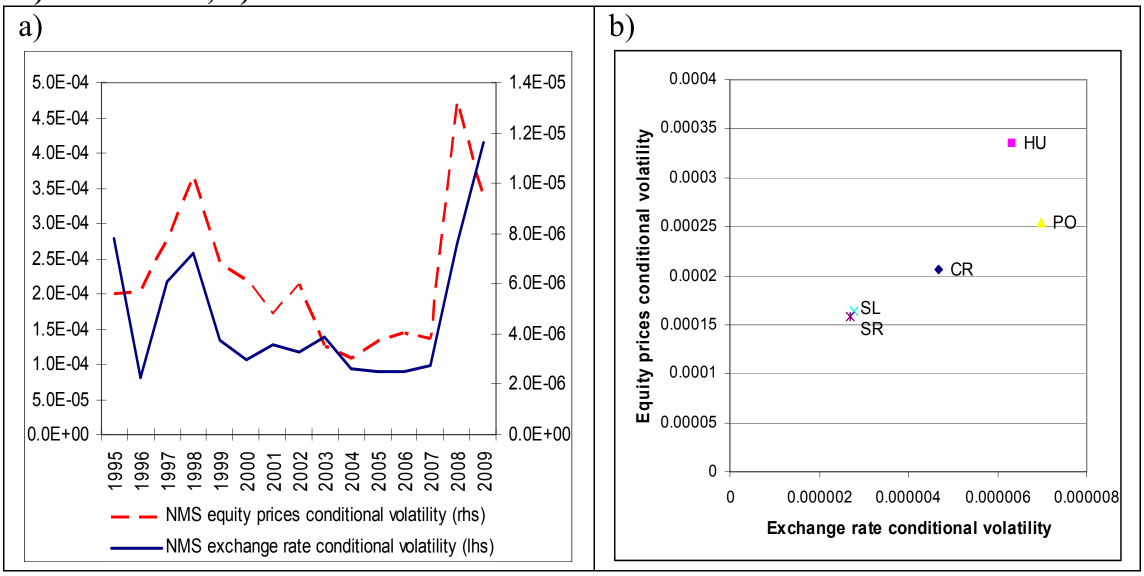
| 1995-2001 | *Czech Republic* | *Hungary* | *Poland* | *Slovenia* | *Slovakia* | *Romania* |
|---|---|---|---|---|---|---|
| ***Hungary*** | 0.1 | | | | | |
| ***Poland*** | 0.2 | 0 | | | | |
| ***Romania*** | 0 | 0 | -0.1 | | | |
| ***Slovakia*** | 0.4 | 0.3 | 0.1 | 0.1 | | |
| ***Slovenia*** | 0.2 | 0.1 | 0.2 | 0 | 0.4 | |
| ***Eurozone*** | 0.1 | 0 | 0.3 | 0 | 0.2 | 0.2 |
| | | | | | | |
| 2002-2009 | *Czech Republic* | *Hungary* | *Poland* | *Slovenia* | *Slovakia* | *Romania* |
| ***Hungary*** | 0.6 | | | | | |
| ***Poland*** | 0.9 | 0.7 | | | | |
| ***Romania*** | 0.2 | 0.2 | 0.3 | | | |
| ***Slovakia*** | 0 | 0 | 0.1 | 0 | | |
| ***Slovenia*** | 0 | 0.1 | 0 | 0 | 0.1 | |
| ***Eurozone*** | 0.7 | 0.4 | 0.6 | 0.1 | 0.1 | 0 |

## 7.1.3 Cross market analysis

Over the analysed period, shocks were transmitted across financial markets quickly. Figure 7.1.3a below shows the average conditional volatility of NMS exchange rates and the average conditional volatility of NMS equity prices for major new member states: Poland, Hungary, the Czech Republic, Slovakia and Slovenia. The figure suggests that there is a relatively strong co-movement in both series.

The correlation of fluctuations in the exchange market and the equity market is visible not only across time, but also across countries – compare Figure 7.1.3b. The countries exhibiting the highest volatility of both the exchange rate and the equity prices are Poland and Hungary (the high volatilities correspond to floating exchange rate regimes and relatively deeper equity markets). In Slovenia and Slovakia fluctuations of the exchange rate and the stock market index are weaker. This is consistent with the findings of Section 3.2.2 which shows that exchange rate arbitrage

**Figure 7.1.3: Contagion between exchange and equity markets: a) across time, b) across countries**




CR Czech Republic, HU Hungary. PO Poland, SL Slovenia, SR Slovak Rep,

## 1.4 Macroeconomic variables - Industrial production and retail sales

To analyse the susceptibility of the real economies of the NMS countries to shocks, we estimated a set of GARCH models for monthly changes in industrial production and retail sales. The results of the estimation for all new members of the EU: Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia and Slovakia, are shown in tables .7.1.6 and 7.1.7.

### Table 7.1.6: GARCH estimates for industrial production volatility 1995-2008

| | *Bulgaria* | *Czech Republic* | *Estonia* | *Hungary* | *Lithuania* | *Latvia* | *Poland* | *Romania* | *Slovenia* | *Slovakia* |
|---|---|---|---|---|---|---|---|---|---|---|
| ARCH<br>$\alpha_1$<br>$\alpha_2$<br>$\alpha_3$ | -0.01<br>(0.09)<br>0.57<br>(0.26) | 0.29<br>(0.14) | 0.08<br>(0.04) | 0.53<br>(0.11) | -0.12<br>(0.09)<br>0.22<br>(0.14) | 0.40<br>(0.11) | 0.41<br>(0.16) | 0.05<br>(0.02)<br>-0.05<br>(0.02) | 0.09<br>(0.13)<br>-0.1<br>(0.12)<br>0.39<br>(0.21) | 0.88<br>(0.23) |
| GARCH<br>$\beta_1$<br>$\beta_2$ | 0.32<br>(0.21)<br>-0.23<br>(0.14) | 0.61<br>(0.19) | 1.6<br>(0.13)<br>-0.8<br>(0.12) | | 0.62<br>(0.42) | | | 0.67<br>(0.02) | 0.66<br>(0.21) | |
| Adjusted R2 | -0.01 | -0.03 | -0.07 | 0.03 | 0.02 | -0.00 | 0.09 | -0.05 | -0.01 | -0.03 |
| DW | 2.04 | 2.08 | 1.63 | 1.76 | 1.92 | 1.6 | 1.87 | 2.0 | 1.91 | 1.35 |
| SEE | 0.05 | 0.02 | 0.03 | 0.03 | 0.06 | 0.02 | 0.02 | 0.03 | 0.08 | 0.04 |
| Log Likelihood | 283.3180 | 349.9 | 306.8 | 307.3 | 203.2 | 282.3 | 436.9 | 305.2 | 317.7 | 272.0 |

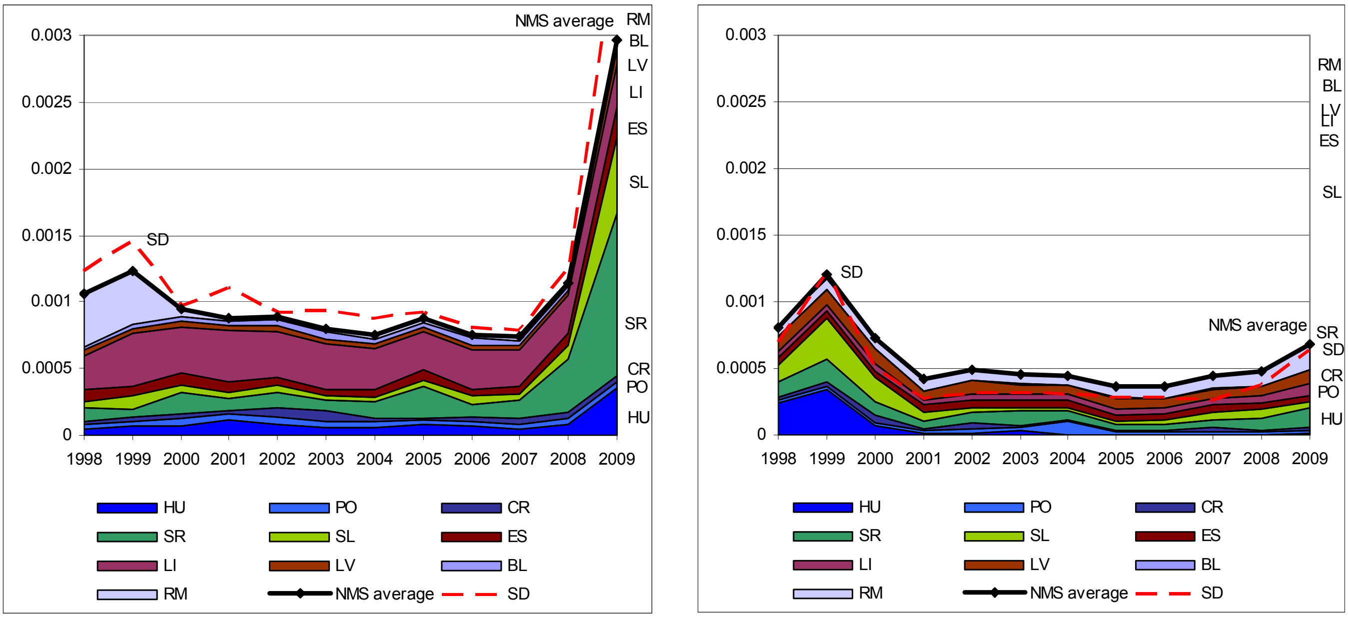
Source: Derived from Eurostat data.

### Table 7.1.7: GARCH estimates for retail sales volatility 1995-2008

| | *Bulgaria* | *Czech Republic* | *Estonia* | *Hungary* | *Lithuania* | *Latvia* | *Poland* | *Romania* | *Slovenia* | *Slovakia* |
|---|---|---|---|---|---|---|---|---|---|---|
| ARCH<br>$\alpha_1$<br>$\alpha_2$ | 0.53<br>(0.24) | 0.77<br>(0.13)<br>-0.02<br>(0.00) | 0.073<br>(0.09)<br>-0.02<br>(0.01) | 0.22<br>(0.09) | 0.27<br>(0.14) | 0.39<br>(0.13) | 0.54<br>(0.21) | 0.06<br>(0.19)<br>0.36<br>(0.21) | 0.05<br>(0.01) | 0.67<br>(0.17)<br>-0.54<br>(0.3) |
| GARCH<br>$\beta_1$<br>$\beta_2$ | | | | 0.76<br>(0.06) | | | | 0.38<br>(0.20)<br>-0.24<br>(0.15) | 0.88<br>(0.12) | 0.82<br>(0.38) |
| Adjusted R2 | 0.65 | -0.04 | 0.006 | 0.51 | -0.03 | 0.06 | 0.03 | 0.04 | -0.01 | 0.14 |
| DW | 1.61 | 2.2 | 2.0 | 1.65 | 1.88 | 2.05 | 1.92 | 1.87 | 1.67 | 2.0 |
| SEE | 0.007 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 | 0.04 | 0.03 |
| Log Likelihood | 408.6 | 432.1 | 397.6 | 419.4 | 358.8 | 288.7 | 317.0 | 245.2 | 296.7 | 386.6 |

The average volatility of NMS industrial production and retail sales and their country decompositions is shown in Figure 7.1.4. The average volatility of industrial production is about twice as high than the average volatility of retail sales (with the relatively low variability of retail sales reflecting consumption smoothing). The 2008 crisis affected the production more seriously than the crisis of the 1998. The volatility of NMS retail sales increased somewhat in 2008. Looking at a more detailed level, the increase in volatility which materialised in 2008 and 2009 would have been comparable with the average increase in volatility during the Russian crisis if it had not been not for surges in retail sales volatility in Hungary and Slovenia recorded in 1999. Such comparability would suggest that consumption smoothing patterns may change during crises in a similar way.

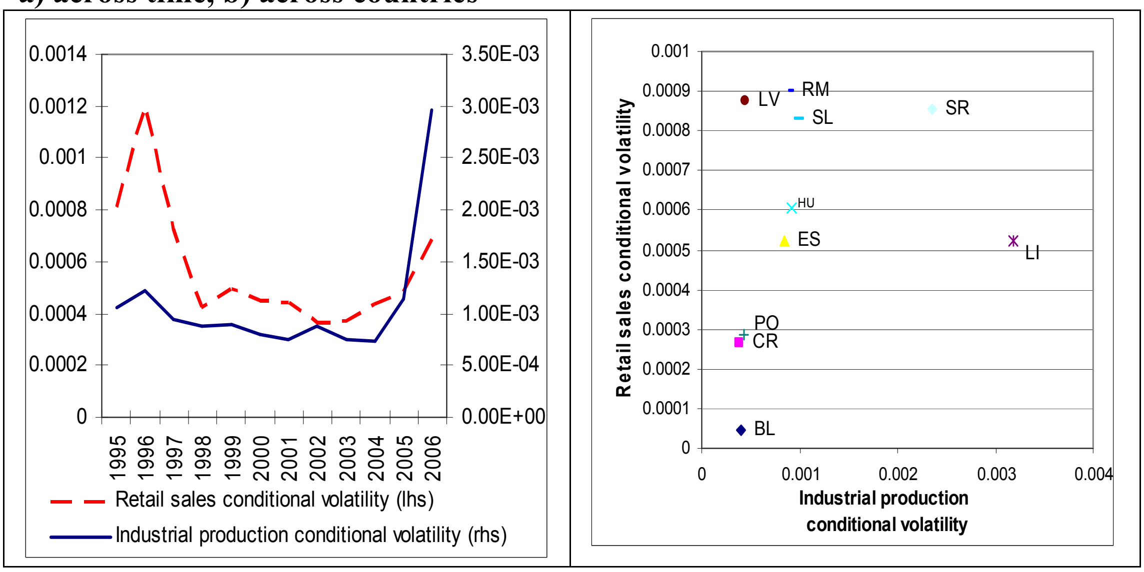
**Figure 7.1.4: Average volatility in the real sector, its standard deviation, and country decomposition of contributions to the average: a) industrial production, b) retail sales**




CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania, SD Standard Deviation

The correlation of the average conditional volatility of the real sector variables across time – see Figure 7.1.5a - is somewhat weaker than that between financial variables (compare figure 7.1.3a). The correlation of the average volatility of retail sales and industrial production across individual new member states is shown in Figure 7.1.5b, it is also apparently weaker than that of the financial variables (Figure 7.1.3b), although note the number of countries differs.

**Figure 7.1.5: Transmission of shocks in the real sector: a) across time, b) across countries**




CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania,

### 7.1.4 Inflation

As CEE countries went through transition and started to integrate to the world economy and specifically with the European Union this leads these economy to become open compared to its previous structure. Therefore price stability is a big factor for both business and individuals in these countries. We estimated simple GARCH (1,1) equations for monthly HICP volatility in the CEE countries Bulgaria, Czech Republic, Estonia, Hungary, Poland, Romania , Slovakia and Slovenia over 1996-2009, as well as the Euro area. The dependent variable is the first difference of the log of monthly harmonised consumer price index. We find that most CEE countries' inflation follows an ARCH (1,0) process, except for Romania which is GARCH (1,1) .The results support either ARCH and GARCH at the 5 percent level for most countries except Latvia and Slovak Republic which is significant at 10 per cent level. It also satisfies the stability condition for all countries. Also we introduce dummies for the most volatile month for Czech Republic and Slovak Republic.

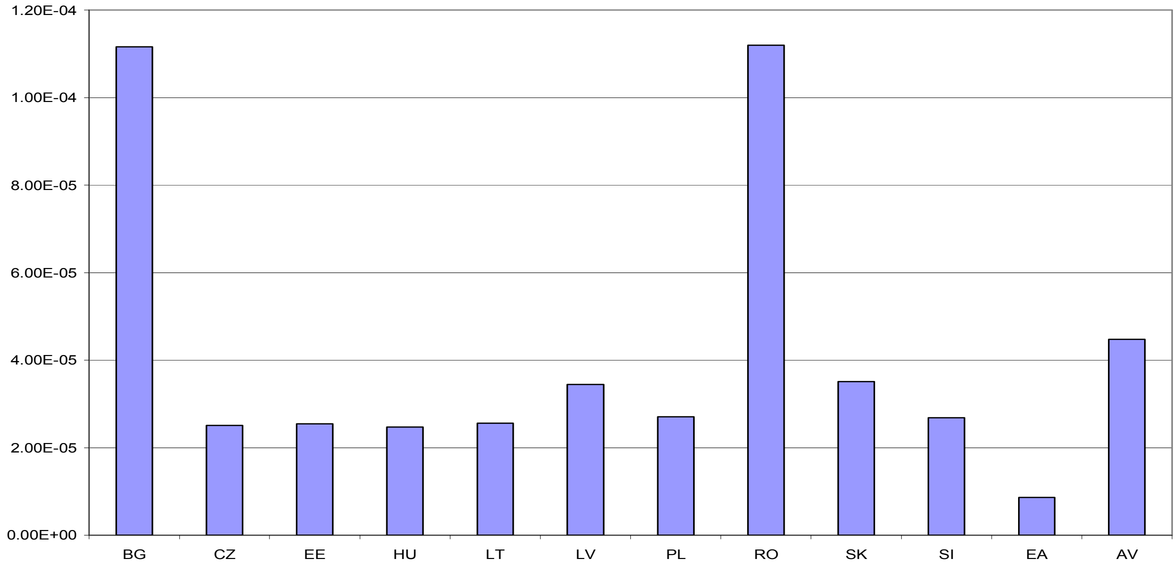
**Table 7.1.8 : GARCH estimates for HICP volatility 1996/01-2009/06**

| | BG | CZ | EE | HU | LT | LV | PL | RO | SK | SI | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Start date | 12/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 | 01/96 |
| ARCH ($\alpha_i$) | 0.44 | 0.20 | 0.36 | 0.60 | 0.31 | 0.41 | 0.82 | 0.30 | 0.46 | 0.17 | 0.97 |
| | (4.55) | (2.89) | (2.84) | (2.65) | (1.89) | (1.77) | (3.20) | (3.55) | (1.87) | (1.95) | (3.41) |
| GARCH ($\beta_i$) | | | | | | | | 0.70 | | | |
| | | | | | | | | (14.02) | | | |
| Adjusted R2 | 0.12 | 0.32 | 0.00 | 0.41 | 0.14 | 0.11 | 0.21 | 0.50 | 0.55 | 0.00 | 0.06 |
| DW | 1.65 | 1.84 | 0.98 | 2.23 | 2.04 | 2.02 | 1.73 | 2.02 | 1.59 | 1.31 | 1.73 |
| SEE | 0.10 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 |
| Log Likelihood | 462.34 | 622.16 | 625.14 | 594.19 | 584.66 | 565.56 | 615.58 | 518.32 | 599.38 | 620.44 | 699.69 |
| dummy | | 98M01 | | | | | | | 99M07 | 03M01 | |
| | | 08M01 | | | | | | | 03M01 | | |
| | | | | | | | | | 04M01 | | |

Source: Derived from Euro stat. data. Time period: Jan 1996-Jun 2009. For some countries data series for 1996 was not available

We follow the same exercise as for the other variables and generate series for the conditional volatility for HICP. The graph below shows average conditional variance series for all CEE countries as well as Euro area from 1998 to 2009.

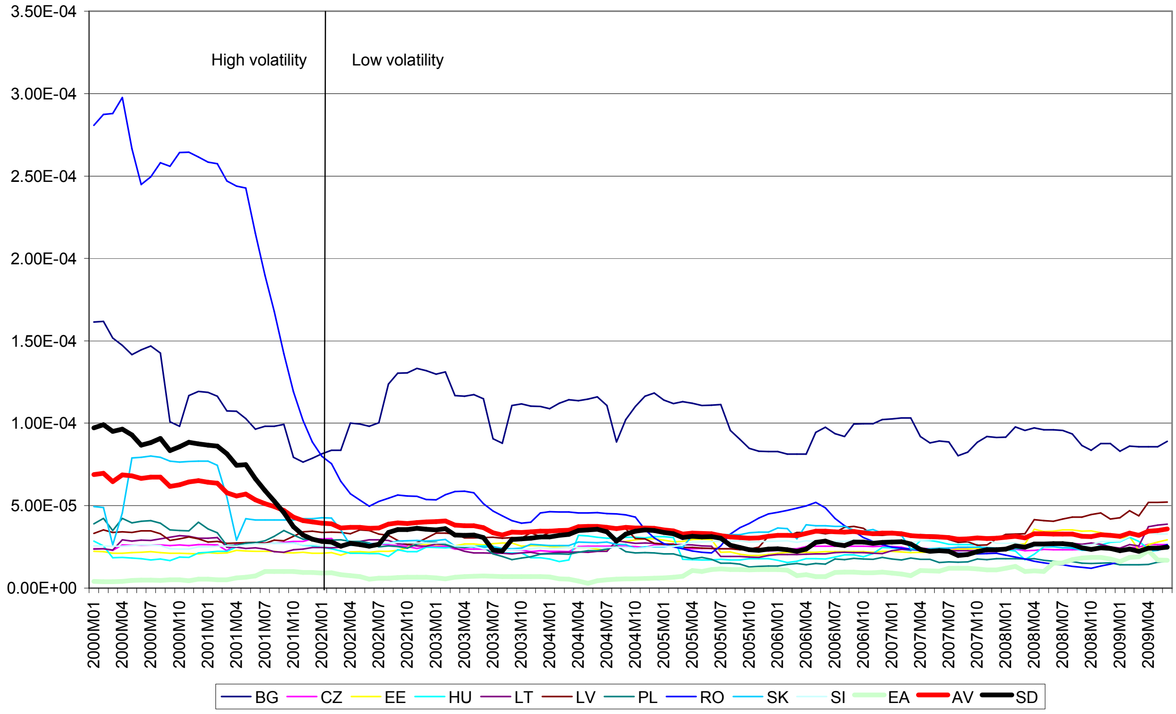
**Figure 7.1.6: Conditional volatility of inflation**




Source: Derived from table 7.1.8 based on Euro stat. data Time period: Jan 1998- Jun 2009.

We can see from the chart that Bulgaria and Romania have the highest volatility on average. We should bear in mind that volatility of price has been declining globally over last decade. If we plot the time series of volatility of these countries we could see that during recent crises Baltic countries are more volatile than others except Bulgaria.

**Figure 7.1.7: Moving average of a rolling 12 month windows of conditional volatility of inflation.**




Source: Derived from table 7.1.8 based on Eurostat. data. Time period: Jan 2000-Jun 2009

CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania, SD Standard Deviation

According to the above Figure 7.1.7 showing a moving average, we could divide the sample between high volatility, before 2002, and low volatility, after 2002 (average - AV) and also is less dispersed (standard deviation - SD). The correlations of the conditional volatility for the sub sample are presented in Tables 7.1.9 and 7.1.10. In the first half of the sample Bulgaria, Romania and Latvia have negative correlations with the Euro area but in the second half Latvia has a positive correlation while the Bulgarian and Romanian correlation volatility become more negative with Euro area. Notably Poland is the only country whose sign of correlation respect to the Euro Area has changed from positive to negative in the second half sample. From the second sub period table we can observe that countries which adopted the Euro or became part of ERMII definitely have positive correlation with Euro area. These countries included Slovenia, Slovakia, Estonia, Lithuania and Latvia.

**Table 7.1.9: Correlations of conditional volatility of inflation from 1996-2001**

| | BG | CZ | EE | HU | LT | LV | PL | RO | SK | SI | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BL | 1.00 | | | | | | | | | | |
| CR | -0.03 | 1.00 | | | | | | | | | |
| ES | 0.00 | -0.04 | 1.00 | | | | | | | | |
| HU | 0.14 | 0.35 | 0.35 | 1.00 | | | | | | | |
| LI | 0.38 | 0.14 | -0.06 | 0.32 | 1.00 | | | | | | |
| LV | 0.34 | 0.16 | 0.03 | 0.34 | 0.31 | 1.00 | | | | | |
| PO | 0.16 | 0.16 | 0.49 | 0.81 | 0.32 | 0.40 | 1.00 | | | | |
| RM | 0.20 | 0.15 | 0.48 | 0.07 | 0.12 | -0.13 | 0.05 | 1.00 | | | |
| SR | -0.05 | 0.11 | 0.11 | 0.22 | 0.12 | 0.06 | 0.25 | -0.12 | 1.00 | | |
| SL | 0.00 | -0.08 | 0.54 | 0.26 | 0.04 | 0.27 | 0.35 | 0.25 | 0.12 | 1.00 | |
| EA | -0.02 | 0.09 | 0.13 | 0.06 | -0.07 | -0.13 | 0.05 | -0.07 | 0.23 | 0.12 | 1.00 |

Source: Derived from table 7.1.8 based on Euro stat. data. Time period: Jan 1996 –Dec 2001. For some countries data series for 1996 was not available
CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania,

**Table 7.1.10: Correlations of conditional volatility of inflation from 2002-2009**

| | BG | CZ | EE | HU | LT | LV | PL | RO | SK | SI | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BL | 1.00 | | | | | | | | | | |
| CR | -0.02 | 1.00 | | | | | | | | | |
| ES | 0.03 | 0.07 | 1.00 | | | | | | | | |
| HU | -0.03 | 0.58 | -0.01 | 1.00 | | | | | | | |
| LI | -0.06 | 0.41 | 0.56 | -0.05 | 1.00 | | | | | | |
| LV | -0.14 | 0.23 | 0.38 | 0.17 | 0.54 | 1.00 | | | | | |
| PO | 0.34 | 0.04 | 0.17 | 0.07 | 0.08 | -0.06 | 1.00 | | | | |
| RM | 0.08 | 0.00 | -0.15 | -0.03 | -0.02 | -0.04 | 0.13 | 1.00 | | | |
| SR | 0.03 | 0.29 | 0.10 | 0.12 | -0.04 | -0.02 | -0.02 | -0.05 | 1.00 | | |
| SL | -0.03 | 0.36 | -0.02 | 0.10 | 0.16 | 0.19 | -0.11 | 0.01 | 0.22 | 1.00 | |
| EA | -0.20 | 0.26 | 0.08 | 0.06 | 0.33 | 0.09 | -0.14 | -0.19 | 0.05 | 0.33 | 1.00 |

Source: Derived from table 7.1.8ased on Euro stat. data. Time period: Jan 2002 –Jun 2009
CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania,

**Table 7.1.11: Correlations of conditional volatility of inflation from 1996-2009**

| | BG | CZ | EE | HU | LT | LV | PL | RO | SK | SI | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BLVH | 1.00 | | | | | | | | | | |
| CRVH | -0.01 | 1.00 | | | | | | | | | |
| ESVH | -0.01 | -0.01 | 1.00 | | | | | | | | |
| HUVH | 0.12 | 0.40 | 0.15 | 1.00 | | | | | | | |
| LIVH | 0.23 | 0.20 | 0.34 | 0.13 | 1.00 | | | | | | |
| LVVH | 0.14 | 0.13 | 0.28 | 0.20 | 0.46 | 1.00 | | | | | |
| POVH | 0.19 | 0.19 | 0.28 | 0.64 | 0.20 | 0.14 | 1.00 | | | | |
| RMVH | 0.23 | 0.18 | 0.25 | 0.10 | 0.08 | -0.08 | 0.14 | 1.00 | | | |
| SRVH | -0.03 | 0.15 | 0.07 | 0.21 | 0.07 | 0.01 | 0.28 | -0.04 | 1.00 | | |
| SLVH | -0.02 | 0.05 | 0.15 | 0.14 | 0.11 | 0.21 | 0.11 | 0.06 | 0.08 | 1.00 | |
| EAVH | -0.04 | 0.08 | 0.09 | 0.02 | 0.22 | 0.08 | -0.07 | -0.10 | 0.04 | 0.31 | 1.00 |

Source: Derived from table 7.1.8sed on Euro stat. data. Time period: Jan 1996 –Jun 2009. For some countries data series for 1996 was not available
CR Czech Republic, HU Hungary. PO Poland' SL Slovenia, SR Slovak Rep, ES Estonia, LI Lithuania, LV Latvia, BL Bulgaria, RM Romania,

## *7.2 Multivariate GARCH*

### 7.2.1 Equity prices

The above work has estimated simple univariate GARCH and enabled us to compare the conditional variance of share prices and other forms of volatility across NMS. However, to derive consistent estimates of conditional covariances which are indicative of the degree of contagion, we need to estimate multivariate GARCH. What we considered useful for the Commission analysts is a method that is easily updated and provide illustration of the degree of covariance between the relevant market, the rest of the Eastern European country markets (currently based on simple averages) and the EU index as a whole (i.e. the Western European stock markets).

The VECH model of Bollerslev, Engle and Wooldridge (1988) which we use for estimation is a multivariate generalisation of the basic GARCH model. It is defined as follows: let $H_t$ define an N*N conditional variance covariance matrix, and $RESID_t$ an N*1 vector of innovations/residuals, $H_{t-1}$ is the GARCH term, while $Y_t$ represents the information set at time t-1, then the following shows the unrestricted variance covariance equations of the unrestricted VECH (where the term VECH refers to the VECH column stacking operator applied to the upper triangle of the symmetric matrix).:

$$VECH(H_t) = M + A1*VECH(RESID_{t-1}\ RESID'_{t-1}) + B1*VECH(H_{t-1}),\ E_t|y_{t-1} \sim N(0,H_t) \qquad (3)$$

M is the (N(N+1)/2) * 1 vector of intercepts in the conditional variance and covariance equations and A1 and B1 are (N(N+1)/2) * (N(N+1)/2) matrices on lagged disturbance squares or cross products and on the lagged variance and covariances respectively. As regards method, we considered it best to use the diagonal VECH, as that method saves parameters compared to the unrestricted VECH model for which a trivariate system requires 78 parameters. In the diagonal VECH the A and B matrices are forced to be diagonal, reducing the number of parameters for a trivariate estimate to 18. The program then verifies that the Ht is positive definite for all values of the disturbances, which is needed for the multivariate GARCH to be plausible. Full rank matrices were estimated for the sets of coefficients constant (M), ARCH (A) and GARCH(B).

Accordingly, we have estimated trivariate GARCH using the diagonal VECH approach, over the period 1995-2009. The term 1 refers to the log first difference of home country equity prices, the term 2 refers to the log first difference of EU equity prices and the term 3 refers to the log first difference of the weighted average of all other NMS equity prices, using weights based on market capitalisation. To interpret the results the following representations show what equations have been estimated:

GARCH1 = M(1,1) + A1(1,1)*RESID1(t-1)^2 + B1(1,1)*GARCH1(t-1) (4)

GARCH2 = M(2,2) + A1(2,2)*RESID2(t-1)^2 + B1(2,2)*GARCH2(t-1) (5)

GARCH3 = M(3,3) + A1(3,3)*RESID3(t-1)^2 + B1(3,3)*GARCH3(t-1) (6)

COV1_2 = M(1,2) + A1(1,2)*RESID1(t-1)*RESID2(t-1) + B1(1,2)*COV1_2(t-1) (7)

COV1_3 = M(1,3) + A1(1,3)*RESID1(t-1)*RESID3(t-1) + B1(1,3)*COV1_3(t-1) (8)

COV2_3 = M(2,3) + A1(2,3)*RESID2(t-1)*RESID3(t-1) + B1(2,3)*COV2_3(t-1) (9)

In other words, the first three are the standard GARCH equations for the three variables, home share price change, EMU share price change and other CEE share price change. Then there are three covariance equations for the cross relationships between these three variables.

The results are shown in Table 7.2.1 below. The equations are generally stable in that the sum of the A and B terms is less than 1. Bear in mind that (1) refers to the home market, (2) refers to EMU and (3) to the other CEE markets. The covariance subcomponents ((1,2) (1,3) and (2,3)) as well as the variance equations ((1,1), (2,2) and (3,3)) are significant in all cases. As is to be expected, the (2,2) sets are quite similar as they refer to the EMU market in each case. The A (ARCH) coefficients are typically significant and between 0.05 and 0.1, while the B (GARCH) coefficients are highly significant and are between 0.85 and 0.95 for the most part.

The output of interest is less in terms of the coefficients per se and more in the charts which can be generated of the development of the conditional variances and covariances. We first show the development of the conditional covariances over time, splitting the sample in 2001 as above. It is evident from Figure 7.2.1 that there is a marked increase in covariance on average since 2001, compared with the earlier period. This suggests heightened integration of equity markets and scope for contagion. Similar increases in conditional covariance are shown in Figure 7.2.2 for Western Europe.

**Table 7.2.1: VECH equity estimates**

| | BULGARIA | | CZECH REPUBLIC | | ESTONIA | | HUNGARY | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic |
| M(1,1) | 2.00E-06 | 6.1 | 6.78E-06 | 8.2 | 3.37E-06 | 13.6 | 1.30E-05 | 14.6 |
| M(1,2) | 1.00E-06 | 2.2 | 1.66E-06 | 6.5 | 1.02E-06 | 3.4 | 2.45E-06 | 7.5 |
| M(1,3) | 1.30E-06 | 2.7 | 3.32E-06 | 7.6 | 1.68E-06 | 4.8 | 4.50E-06 | 9.6 |
| M(2,2) | 1.84E-06 | 5.2 | 1.74E-06 | 7.3 | 1.43E-06 | 5.9 | 1.47E-06 | 7.3 |
| M(2,3) | 1.87E-06 | 5.4 | 2.03E-06 | 8.0 | 1.42E-06 | 6.1 | 1.45E-06 | 7.3 |
| M(3,3) | 3.42E-06 | 5.4 | 6.03E-06 | 9.9 | 2.95E-06 | 7.2 | 3.27E-06 | 7.7 |
| A1(1,1) | 0.050525 | 20.7 | 0.089754 | 14.2 | 0.095723 | 26.1 | 0.115653 | 24.3 |
| A1(1,2) | 0.046082 | 5.9 | 0.075083 | 13.0 | 0.055274 | 7.7 | 0.083232 | 15.8 |
| A1(1,3) | 0.04636 | 7.8 | 0.082731 | 15.2 | 0.057302 | 8.6 | 0.077506 | 16.4 |
| A1(2,2) | 0.078389 | 11.8 | 0.079667 | 16.0 | 0.069715 | 15.2 | 0.07117 | 16.4 |
| A1(2,3) | 0.069129 | 11.4 | 0.076979 | 17.7 | 0.062596 | 14.3 | 0.060084 | 15.0 |
| A1(3,3) | 0.070198 | 10.9 | 0.092638 | 24.9 | 0.066908 | 16.2 | 0.065317 | 14.8 |
| B1(1,1) | 0.951311 | 543.8 | 0.875757 | 97.9 | 0.901174 | 360.9 | 0.848671 | 174.2 |
| B1(1,2) | 0.915846 | 45.3 | 0.889751 | 104.8 | 0.901143 | 61.2 | 0.880321 | 119.5 |
| B1(1,3) | 0.917323 | 57.2 | 0.876117 | 105.5 | 0.897695 | 68.7 | 0.879172 | 124.3 |
| B1(2,2) | 0.907633 | 109.6 | 0.905036 | 160.8 | 0.919003 | 175.7 | 0.915368 | 186.6 |
| B1(2,3) | 0.907772 | 104.2 | 0.891014 | 145.1 | 0.916912 | 150.9 | 0.913957 | 153.2 |
| B1(3,3) | 0.907977 | 99.5 | 0.877231 | 164.7 | 0.914936 | 175.2 | 0.912569 | 155.6 |
| | | | | | | | | |
| Range | 3/10/2000-30/6/2009 | | 2/1/1995-30/6/2009 | | 3/6/1996-30/6/2009 | | 2/1/1995-30/6/2009 | |
| Log likelihood | | 20485.01 | | 35419.16 | | 31591.52 | | 35141.96 |
| Avg. log likelihood | | 2.993572 | | 3.121731 | | 3.086315 | | 3.097299 |
| Akaike info criterion | | -17.94302 | | -18.71928 | | -18.5056 | | -18.57269 |
| Schwarz criterion | | -17.89024 | | -18.68464 | | -18.4678 | | -18.53805 |
| Hannan-Quinn criter. | | -17.92377 | | -18.70697 | | -18.4921 | | -18.56038 |

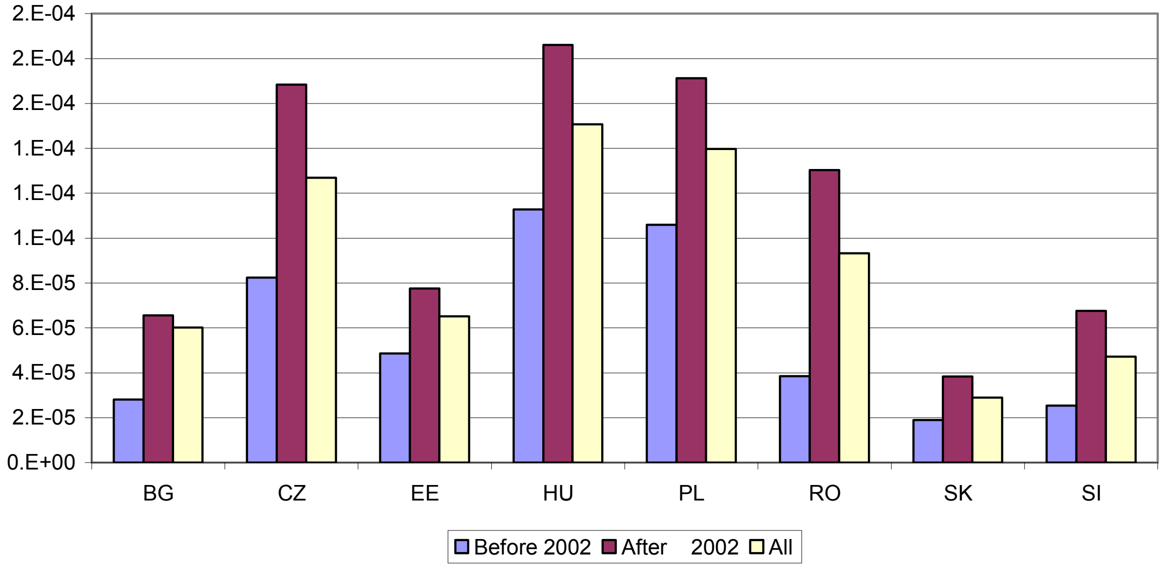
Source: Derived from Data Stream data.

**Table 7.2.2: VECH equity estimates**

| | POLAND | | ROMANIA | | SLOVAKIA | | SLOVENIA | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic |
| M(1,1) | 5.72E-06 | 7.4 | 2.84E-05 | 16.8 | 1.41E-06 | 8.3 | 5.69E-06 | 11.0 |
| M(1,2) | 1.74E-06 | 6.7 | 2.68E-06 | 4.0 | 5.49E-07 | 3.4 | 1.20E-06 | 5.3 |
| M(1,3) | 2.76E-06 | 8.0 | 3.87E-06 | 5.0 | 8.55E-07 | 3.3 | 1.80E-06 | 6.0 |
| M(2,2) | 1.40E-06 | 7.1 | 1.89E-06 | 6.0 | 1.15E-06 | 6.5 | 1.27E-06 | 7.1 |
| M(2,3) | 1.28E-06 | 7.1 | 2.01E-06 | 6.5 | 1.14E-06 | 6.6 | 1.25E-06 | 6.9 |
| M(3,3) | 3.30E-06 | 8.8 | 4.10E-06 | 7.3 | 2.73E-06 | 7.8 | 3.03E-06 | 7.8 |
| A1(1,1) | 0.063056 | 16.0 | 0.239245 | 45.0 | 0.037159 | 16.0 | 0.126457 | 18.5 |
| A1(1,2) | 0.056503 | 15.1 | 0.088236 | 8.2 | 0.043546 | 7.6 | 0.068145 | 12.2 |
| A1(1,3) | 0.062669 | 17.0 | 0.104797 | 12.6 | 0.041597 | 6.7 | 0.067374 | 11.5 |
| A1(2,2) | 0.067527 | 15.9 | 0.070415 | 14.7 | 0.068837 | 16.4 | 0.067955 | 16.4 |
| A1(2,3) | 0.065501 | 15.4 | 0.063346 | 13.4 | 0.063117 | 15.5 | 0.061787 | 15.3 |
| A1(3,3) | 0.076651 | 16.1 | 0.070823 | 14.7 | 0.067327 | 17.3 | 0.066433 | 15.8 |
| B1(1,1) | 0.918655 | 176.0 | 0.752962 | 126.2 | 0.957887 | 390.6 | 0.839127 | 123.0 |
| B1(1,2) | 0.91906 | 162.7 | 0.825597 | 35.8 | 0.927549 | 91.2 | 0.874025 | 66.8 |
| B1(1,3) | 0.908926 | 163.6 | 0.821427 | 48.8 | 0.923121 | 70.1 | 0.869832 | 66.0 |
| B1(2,2) | 0.919466 | 185.9 | 0.915065 | 154.9 | 0.921741 | 198.5 | 0.920404 | 202.8 |
| B1(2,3) | 0.909327 | 148.1 | 0.910437 | 129.4 | 0.918923 | 169.3 | 0.917068 | 165.8 |
| B1(3,3) | 0.899301 | 146.2 | 0.905832 | 140.9 | 0.916217 | 190.7 | 0.913858 | 164.5 |
| Range | 2/1/1995-30/6/2009 | | 6/12/1996-30/6/2009 | | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | |
| Log likelihood | | 35319.82 | | 28714.81 | | 35298.53 | | 36104.42 |
| Avg. log likelihood | | 3.112976 | | 2.919952 | | 3.111099 | | 3.182128 |
| Akaike info criterion | | -18.66675 | | -17.5069 | | -18.6555 | | -19.08166 |
| Schwarz criterion | | -18.63211 | | -17.46786 | | -18.6209 | | -19.04702 |
| Hannan-Quinn criter. | | -18.65444 | | -17.49292 | | -18.6432 | | -19.06935 |

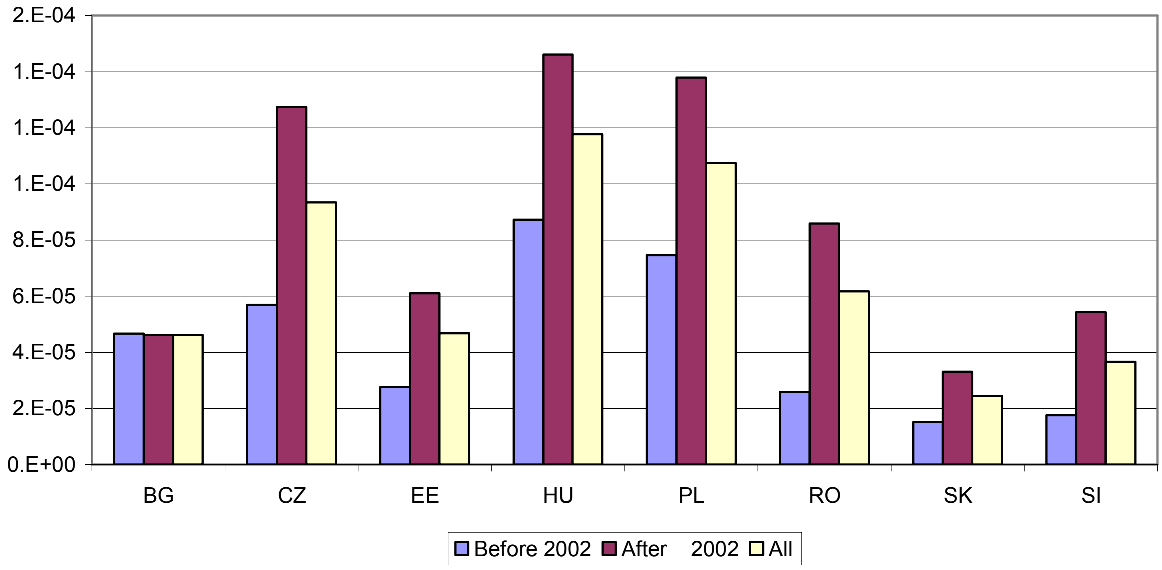
Source: Derived from Data Stream data.

**Figure 7.2.1: Conditional covariances with other NMS markets before and after 1/1/2002**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

**Figure 7.2.2: Conditional covariances with EMU (Western European) markets before and after 1/1/2002**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

However, of greater interest in terms of contagion is the development of conditional volatility and covariance over time. Higher covariance implies that the country is more vulnerable to contagion. Using the example of Hungary, we show in Figure 7.2.3 the covariance of the Hungarian market with EMU and other NMS over the full data sample. It is evident that the periods of heightened covariance were the respective financial crises in 1998 (Russia/LTCM) and 2008, with the latter showing a much larger degree of contagion. It is also apparent that the absolute level of contagion in these crises was higher for other NMS markets than for EMU markets. In normal times they were more comparable. Other NMS patterns are broadly comparable to Hungary's. Meanwhile Figure 7.2.4 illustrates that the conditional variance for Hungary is much higher than that of EMU and the "basket" of other NMS markets, perhaps unsurprisingly. Comparing with Figure 7.2.5 shows how the peaks in variance and covariance coincide.

**Figure 7.2.3: Conditional covariances for Hungary**

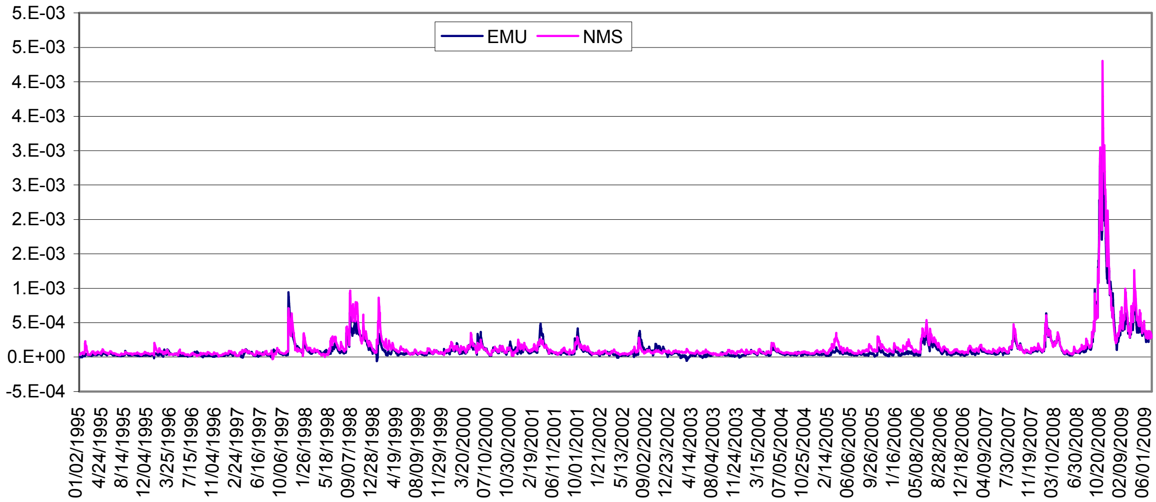
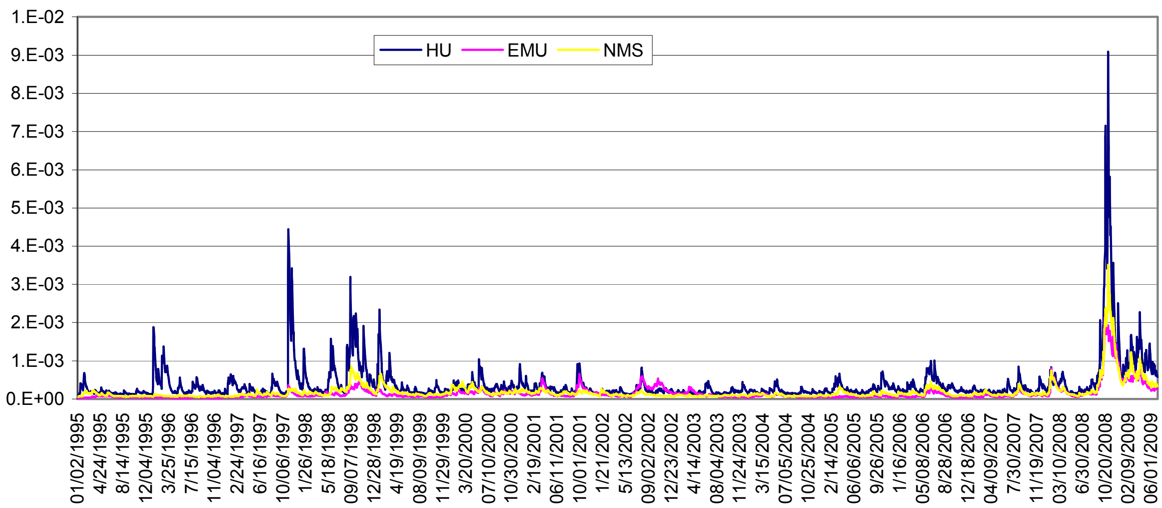


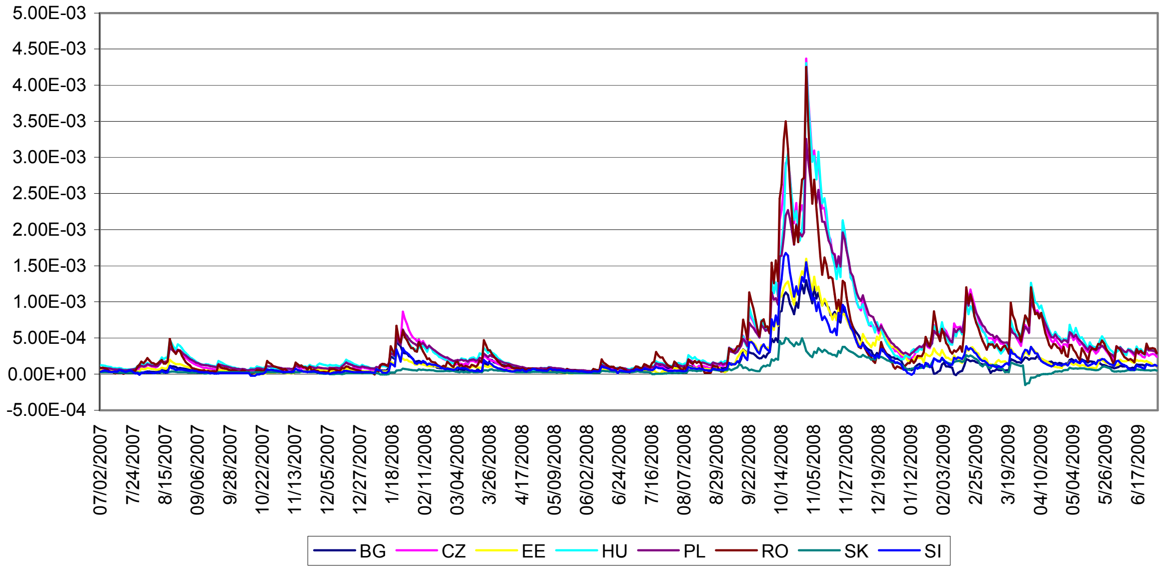

**Figure 7.2.4: Conditional variances for Hungary**




HU: Hungary, EMU: EMU members, NMS: Other NMS

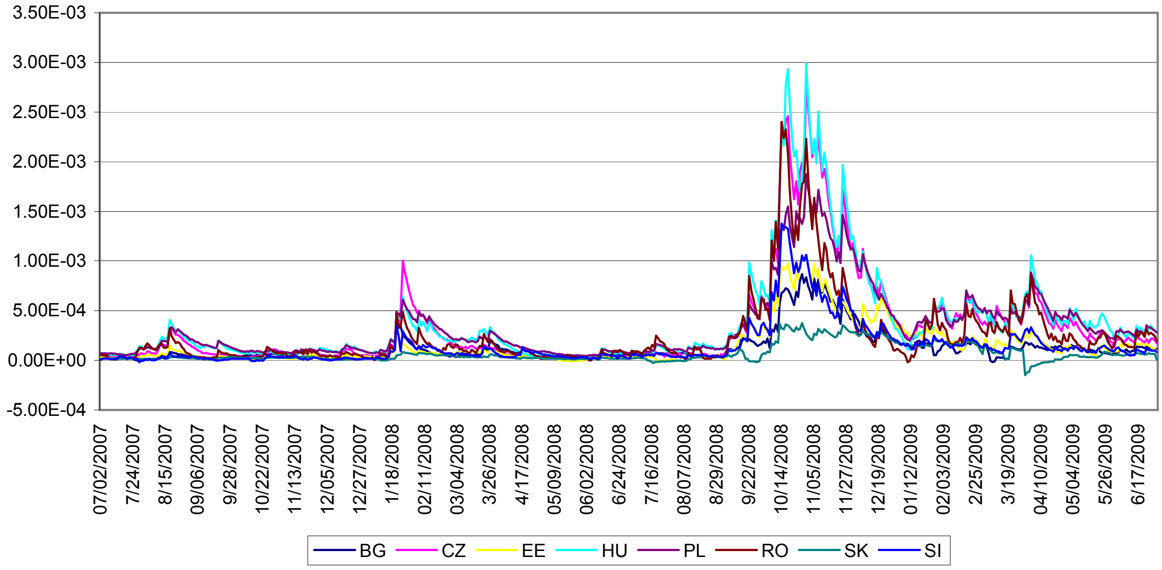
There can also be a useful focus on cross country comparisons at times of crisis. We show in Figures 7.2.5-7.2.6 the patterns for the 2008 crisis for conditional covariances with other NMS and EMU, respectively. The pattern shows low covariance after Lehman's collapse in Slovakia, Bulgaria, Slovenia and Estonia, while there is high covariance in Hungary, Romania, the Czech Republic and to a lesser extent Poland. This pattern was foreshadowed in the lesser period of tension in January and February 2008.

**Figure 7.2.5: Conditional covariances with other NMS markets in the 2007-9 period**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

**Figure 7.2.6: Conditional covariances with EMU markets in the 2007-9 period**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

## 7.2.2 Exchange rates

Similar VECH estimation was undertaken for the exchange rates of the CEE countries. Results of the estimations are incorporated below in Table 7.2.7 and 7.2.8. Similar comments apply to the coefficients and cross effects, bearing in mind in this case that the first term refers to the home effective exchange rate, the second to the volatility of the EMU exchange rate and the third to the volatility of the GDP-weighted basket of other effective exchange rates for the NMS. The covariance subcomponents ((1,2) (1,3) and (2,3)) as well as the variance equations ((1,1), (2,2) and (3,3)) are significant in all cases. As is to be expected, the (2,2) sets are quite similar as they refer to the EMU market in each case. The A (ARCH) coefficients are typically significant and between 0.05 and 0.1, while the B (GARCH) coefficients are highly significant and are between 0.85 and 0.95 for the most part.

**Table 7.2.7: VECH effective exchange rate estimates**

| | BULGARIA | | CZECH REPUBLIC | | HUNGARY | | POLAND | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic |
| | | | | | | | | |
| M(1,1) | 2.39E-08 | 3.9 | 1.76E-07 | 8.7 | **1.58E-06** | 19.3 | 8.63E-07 | 17.7 |
| M(1,2) | 2.98E-08 | 5.5 | 1.38E-08 | 1.5 | -3.70E-08 | -1.5 | -7.83E-08 | -3.6 |
| M(1,3) | 1.47E-07 | 7.5 | 1.03E-07 | 3.8 | 9.37E-07 | 11.3 | 2.84E-07 | 6.2 |
| M(2,2) | 3.75E-08 | 0.3 | 6.26E-08 | 4.4 | 1.22E-07 | 5.7 | 5.06E-08 | 3.7 |
| M(2,3) | 1.84E-07 | 0.4 | -1.61E-07 | -4.3 | -3.82E-07 | -5.7 | -1.73E-09 | -0.1 |
| M(3,3) | 9.07E-07 | 3.1 | 5.24E-07 | 4.4 | 1.63E-06 | 15.4 | 1.31E-07 | 6.0 |
| A1(1,1) | 0.111732 | 40.5 | 0.066133 | 17.7 | 0.22215 | 30.4 | 0.105509 | 26.2 |
| A1(1,2) | 0.058618 | 19.8 | 0.039577 | 8.1 | 0.09201 | 10.9 | 0.066457 | 12.5 |
| A1(1,3) | 0.242683 | 40.1 | 0.165457 | 20.3 | 0.444768 | 29.9 | 0.274961 | 38.5 |
| A1(2,2) | 0.030754 | 13.7 | 0.032372 | 10.7 | 0.040655 | 10.5 | 0.043562 | 11.5 |
| A1(2,3) | 0.127321 | 16.4 | 0.100611 | 13.9 | 0.173369 | 22.5 | 0.161888 | 26.0 |
| A1(3,3) | 0.527112 | 25.7 | 0.437858 | 22.4 | 1.013729 | 39.7 | 0.876553 | 48.5 |
| B1(1,1) | 0.902362 | 450.8 | 0.931708 | 249.8 | 0.779768 | 94.4 | 0.880931 | 233.5 |
| B1(1,2) | 0.934507 | 357.0 | 0.94501 | 137.2 | 0.861102 | 68.6 | 0.912839 | 117.5 |
| B1(1,3) | 0.78846 | 125.8 | 0.841703 | 85.5 | 0.643413 | 53.8 | 0.75165 | 77.6 |
| B1(2,2) | 0.967798 | 412.5 | 0.963402 | 281.9 | 0.950926 | 215.2 | 0.954281 | 258.3 |
| B1(2,3) | 0.816548 | 76.6 | 0.861261 | 74.2 | 0.710555 | 39.6 | 0.786268 | 61.7 |
| B1(3,3) | 0.688937 | 73.1 | 0.772183 | 93.0 | 0.531044 | 57.7 | 0.647865 | 90.0 |
| | | | | | | | | |
| Range | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | |
| Log likelihood | | 47370.63 | | 46341.29 | | 46478.69 | | 46669.72 |
| Avg. log likelihood | | 4.176199 | | 4.085453 | | 4.097566 | | 4.114407 |
| Akaike info criterion | | -25.04609 | | -24.50161 | | -24.5743 | | -24.67534 |
| Schwarz criterion | | -25.01144 | | -24.46696 | | -24.5396 | | -24.64069 |
| Hannan-Quinn criter. | | -25.03377 | | -24.48929 | | -24.562 | | -24.66302 |

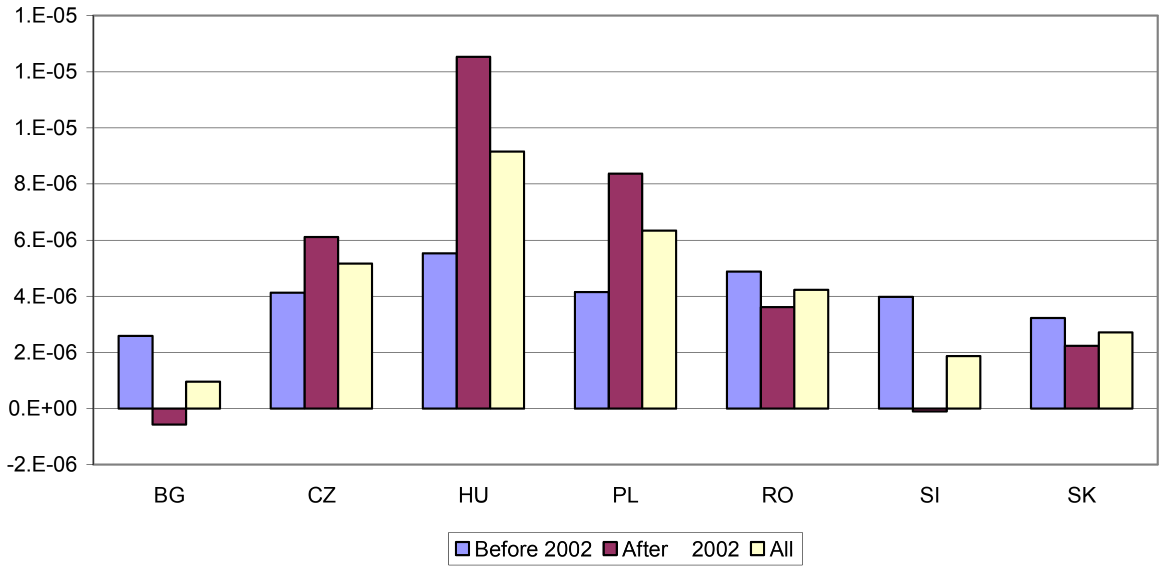
**Table 7.2.8: VECH effective exchange rate estimates**

| | ROMANIA | | SLOVAKIA | | SLOVENIA | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | Coefficient | z-Statistic | Coefficient | z-Statistic | Coefficient | z-Statistic |
| | | | | | | |
| M(1,1) | 2.99E-07 | 11.6 | 2.88E-08 | 8.6 | 4.31E-07 | 21.7 |
| M(1,2) | 9.91E-09 | 0.8 | 3.28E-08 | 5.6 | 1.27E-07 | 8.5 |
| M(1,3) | 3.38E-08 | 1.4 | 1.72E-07 | 13.1 | 5.25E-07 | 19.1 |
| M(2,2) | 7.58E-08 | 4.7 | 3.72E-08 | 1.5 | 3.73E-08 | 0.4 |
| M(2,3) | -2.76E-08 | -2.6 | 1.95E-07 | 2.1 | 1.54E-07 | 0.8 |
| M(3,3) | 2.81E-07 | 9.4 | 1.02E-06 | 0.9 | 6.39E-07 | 3.7 |
| A1(1,1) | 0.107682 | 34.9 | 0.142785 | 43.3 | 0.101147 | 30.8 |
| A1(1,2) | 0.069923 | 22.7 | 0.066258 | 24.5 | 0.055775 | 14.4 |
| A1(1,3) | 0.065874 | 9.7 | 0.274978 | 33.4 | 0.213888 | 27.5 |
| A1(2,2) | 0.048805 | 15.8 | 0.030747 | 14.6 | 0.030757 | 11.7 |
| A1(2,3) | 0.05328 | 11.6 | 0.127602 | 20.6 | 0.117944 | 16.7 |
| A1(3,3) | 0.072748 | 17.5 | 0.529559 | 24.6 | 0.452294 | 21.0 |
| B1(1,1) | 0.909137 | 692.6 | 0.873983 | 688.6 | 0.878862 | 307.2 |
| B1(1,2) | 0.928035 | 355.5 | 0.919696 | 305.9 | 0.922262 | 166.1 |
| B1(1,3) | 0.908665 | 84.1 | 0.770324 | 107.5 | 0.808293 | 162.3 |
| B1(2,2) | 0.947325 | 195.8 | 0.9678 | 477.6 | 0.967806 | 349.6 |
| B1(2,3) | 0.927553 | 74.0 | 0.810616 | 69.6 | 0.848209 | 93.0 |
| B1(3,3) | 0.908194 | 155.8 | 0.678962 | 66.5 | 0.743392 | 114.0 |
| | | | | | | |
| Range | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | | 2/1/1995-30/6/2009 | |
| Log likelihood | | 46654.8 | | 49311.55 | | 46171.73 |
| Avg. log likelihood | | 4.113091 | | 4.347311 | | 4.070504 |
| Akaike info criterion | | -24.66744 | | -26.07276 | | -24.4119 |
| Schwarz criterion | | -24.6328 | | -26.03812 | | -24.3773 |
| Hannan-Quinn criter. | | -24.65512 | | -26.06044 | | -24.3996 |

Source: Derived from DataStream data.

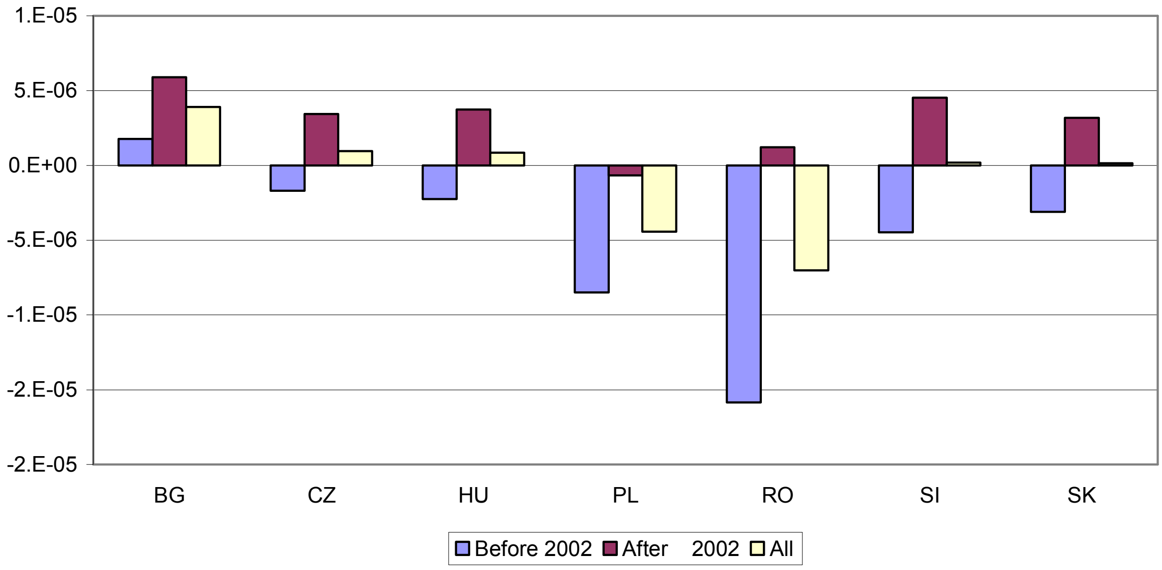
We show similar charts to the equity price result below. Figure 7.2.7 shows no consistent pattern for the covariances within the region. In Hungary and Poland the covariance rose while elsewhere it fell since 2002. We note that prior to 2002 the covariance with the currencies forming the EMU basket was often negative, which may of course be explicable in terms of offsetting trade weights. This affected the result for the earlier period. Since 2002 the covariance with the Euro is positive for all of the countries except Poland and Romania. Figure 7.2.8 shows higher conditional covariance for the Hungarian effective rate with the basket of other NMS effective rates Euro than with the euro in most periods, and especially in the crisis of 2008. In other words it is intra regional currency contagion rather than speculation in the Euro rate that the chart depicts. Again to be expected is that the conditional variance of the Hungarian effective rate is much greater than that of the Euro or basket (Figure 7.2.9).

**Figure 7.2.7: Conditional covariances with other NMS effective exchange rates before and after 1/1/2002**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

**Figure 7.2.8: Conditional covariances with Euro effective exchange rate before and after 1/1/2002**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

Again, we show in Figures 7.2.9-7.2.10 the patterns for the 2008 crisis for conditional covariances with other NMS and Euro effective rates, respectively. The pattern show low covariance after Lehman's collapse in Slovakia and Slovenia, as is to be expected given they are tied to the euro for this period, and also for Bulgaria with its currency board peg to the euro. The highest covariance is in Hungary, followed by Poland, the Czech Republic and Romania. For the Euro rate the pattern is more diverse with

Romania initially most strongly covarying, followed later by Hungary. As for equity prices, these charts underline the usefulness of the VECH approach for exchange rate and currency market contagion.

**Figure 7.2.9: Conditional covariances Hungary**

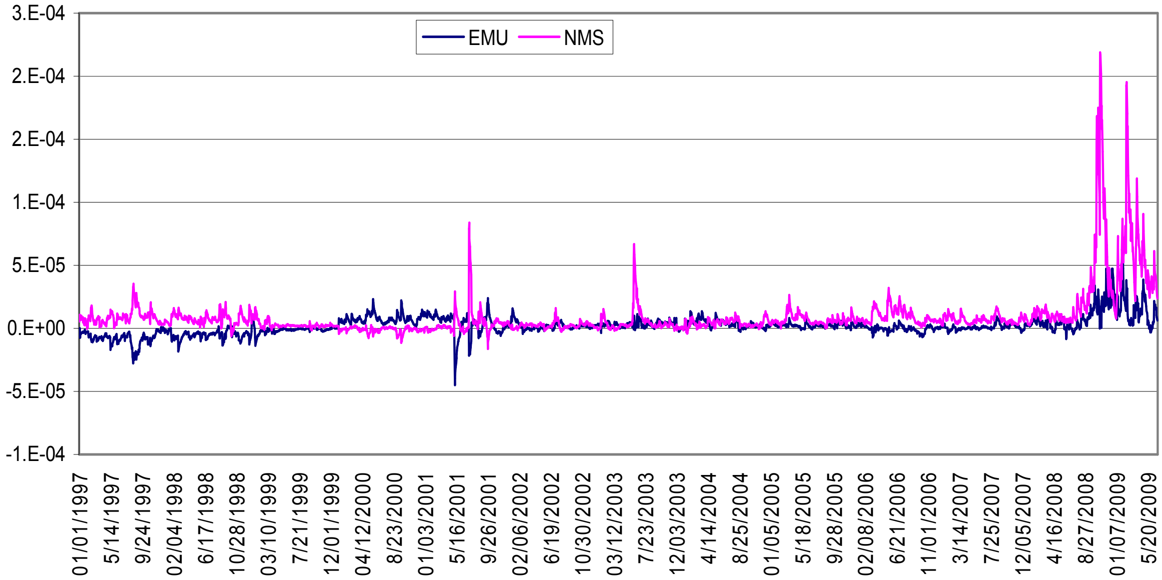
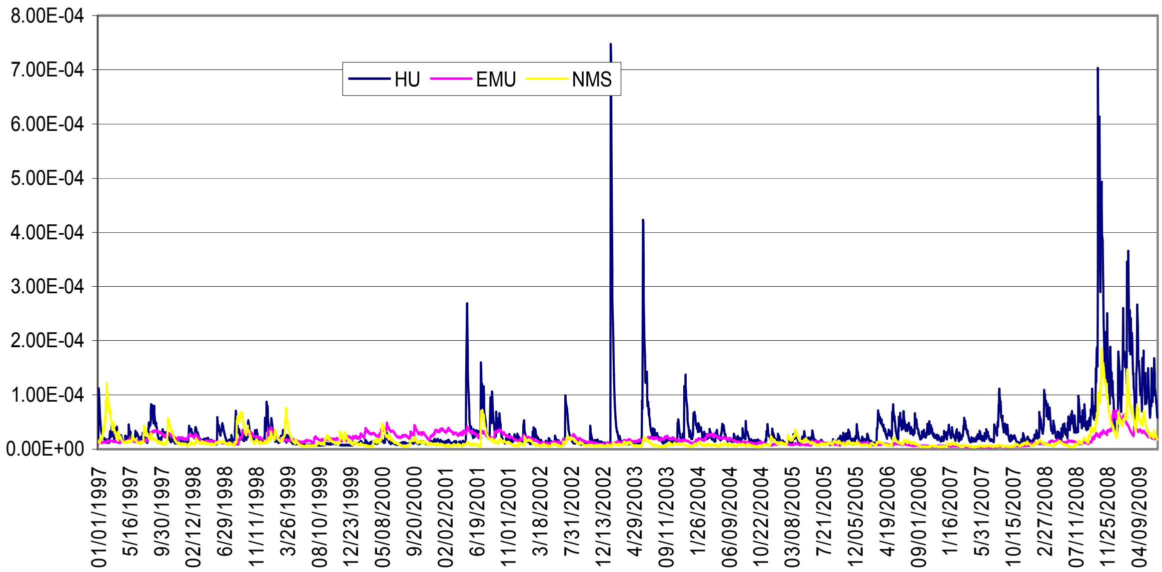
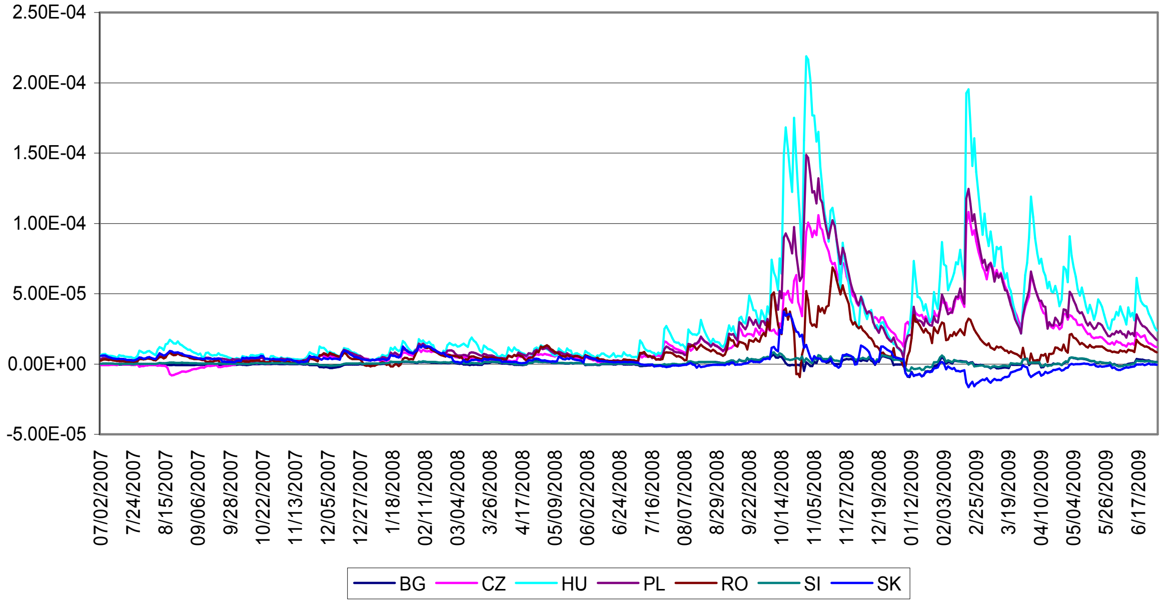



**Figure 7.2.10: Conditional variances for Hungary**



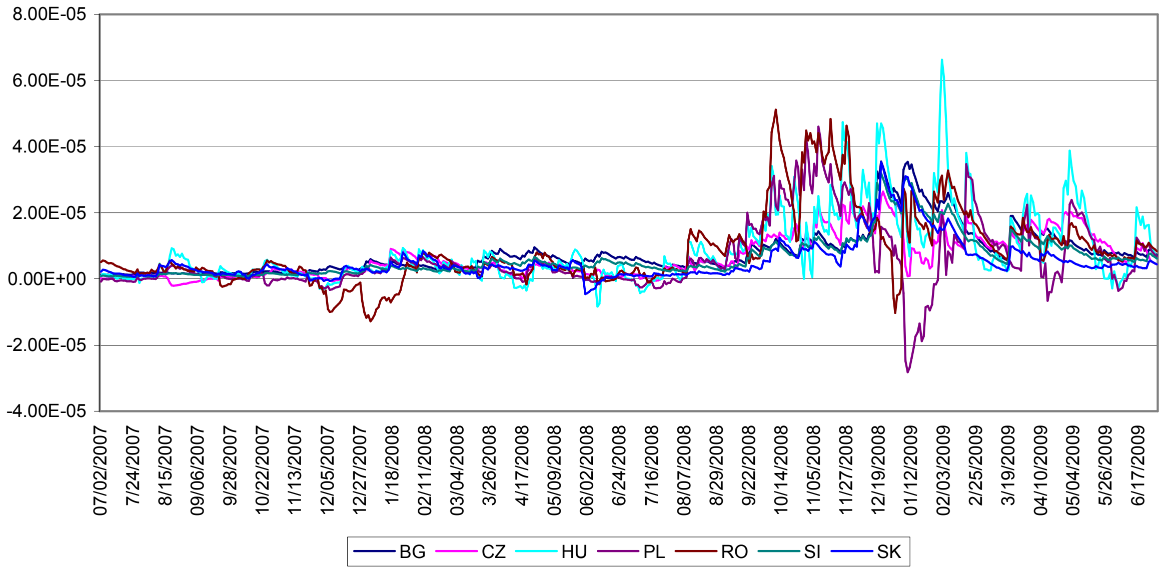

HU: Hungary, EMU: EMU members, NMS: Other NMS

**Figure 7.2.10: Conditional covariances with other NMS effective rates in the 2007-9 period**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

**Figure 7.2.11: Conditional covariances with Euro effective rates in the 2007-9 period**




BG: Bulgaria, HU: Hungary, CZ: Czech Republic, PL: Poland, RO: Romania, SL: Slovenia, SK: Slovakia

The overall recommendation for the VECH as well as the univariate GARCH is that it should be treated as a diagnostic toolkit and run once a month to assess the latest developments in financial markets for risks of contagion.

## *7.3 Panels for volatility estimation*

As a third exercise to be part of the toolkit, we undertook simple panel estimation for the macro and structural determinants of volatility as measured by estimates of conditional volatility from the univariate GARCH equations. This follows earlier work by Davis and Pomerantz (2009) which estimated the impact of EMU on real exchange rate volatility of EU countries.

Accordingly, 7-country panels were estimated for the determinants of equity market and exchange market volatility. The additional variables used to capture correlatives of volatility were the quarterly change in GDP (DGDP), the quarterly inflation rate (DHCP), the current balance/GDP ratio (CBR), the government deficit/GDP ratio (GBR), the intervention interest rate (INT) and dummies for EMU and financial crises (Russia-LTCM 1998Q2-Q4 and the subprime crisis 2008Q3-2009Q2 - CRISES). In the equity price equation we also added market structure variables market capitalisation (MCAP) and quarterly return (QRET). All equations were estimated with cross section fixed effects and White cross-section standard errors.

**Table 7.3.1: Equity price volatility panel (1995Q1-2009Q2) - unrestricted**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 8.78E-05 | 0.000191 | 0.458974 | 0.6466 |
| DGDP | -0.000672 | 0.001867 | -0.360024 | 0.7191 |
| DHCP | 0.002506 | 0.001603 | 1.563197 | 0.1190 |
| INT | 5.07E-06 | 7.35E-06 | 0.689522 | 0.4910 |
| CBR | 8.43E-06 | 7.64E-06 | 1.104317 | 0.2703 |
| GBR | -5.94E-06 | 7.47E-06 | -0.794911 | 0.4273 |
| EMU | 0.000142 | 8.40E-05 | 1.694070 | 0.0912 |
| CRISIS | 0.000224 | 0.000125 | 1.795539 | 0.0735 |
| MCAP | 9.44E-10 | 6.29E-10 | 1.501354 | 0.1342 |
| QRET | -3.36E-06 | 2.64E-06 | -1.274164 | 0.2035 |
| Fixed Effects (Cross) | | | | |
| BL—C | 0.000395 | | | |
| CR—C | -6.43E-05 | | | |
| HU—C | -2.52E-05 | | | |
| PO—C | -6.10E-05 | | | |
| RM—C | 9.26E-05 | | | |
| SL—C | -0.000155 | | | |
| SR—C | -5.86E-05 | | | |
| | Effects Specification | | | |
| Cross-section fixed (dummy variables) | | | | |
| R-squared | 0.208831 | Mean dependent var | | 0.000308 |
| Adjusted R-squared | 0.171745 | S.D. dependent var | | 0.000484 |
| S.E. of regression | 0.000440 | Akaike info criterion | | -12.57194 |
| Sum squared resid | 6.20E-05 | Schwarz criterion | | -12.39017 |
| Log likelihood | 2128.085 | Hannan-Quinn criter. | | -12.49948 |
| F-statistic | 5.630988 | Durbin-Watson stat | | 2.034804 |

**Table 7.3.2: Equity price volatility panel (1995Q1-2009Q2) - restricted**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000102 | 6.60E-05 | 1.553245 | 0.1213 |
| DHCP | 0.003696 | 0.001049 | 3.521860 | 0.0005 |
| EMU | 0.000124 | 5.37E-05 | 2.315703 | 0.0211 |
| CRISES | 0.000402 | 0.000113 | 3.571043 | 0.0004 |
| Fixed Effects (Cross) | | | | |
| BL—C | 0.000219 | | | |
| CR—C | -5.14E-05 | | | |
| HU—C | 1.35E-05 | | | |
| PO—C | -6.36E-06 | | | |
| RM—C | 0.000141 | | | |
| SL—C | -0.000133 | | | |
| SR—C | -8.14E-05 | | | |
| | Effects Specification | | | |
| Cross-section fixed (dummy variables) | | | | |
| R-squared | 0.198487 | Mean dependent var | | 0.000323 |
| Adjusted R-squared | 0.178109 | S.D. dependent var | | 0.000486 |
| S.E. of regression | 0.000441 | Akaike info criterion | | -12.58802 |
| Sum squared resid | 6.88E-05 | Schwarz criterion | | -12.48095 |
| Log likelihood | 2301.019 | Hannan-Quinn criter. | | -12.54546 |
| F-statistic | 9.740516 | Durbin-Watson stat | | 1.990465 |

What is evident from Table 7.3.1 and 7.3.2 as compared to 7.3.3 is that the exchange rate is much more predictable with current macro variables than the equity price. The conditional volatility of the equity price is largely idiosyncratic with only global developments captured by dummies (EMU and crises) being significant at any acceptable level, as well as domestic inflation. The EMU effect may of course indicate heightened volatility in the second part of the sample rather than a direct EMU effect. Meanwhile, market structure factors (market capitalisation and quarterly return on shares) were insignificant in determining equity price volatility.

Meanwhile, Table 7.3.3 and the restricted equation in Table 7.3.4 show that there are a number of factors which help to explain exchange rate volatility. These include again EMU which led to higher volatility in CEE countries after 1999 than before. This is an interesting contrast with the results of Davis and Pomerantz (2009) which showed for Western European countries, including Sweden and Denmark but not Germany, Belgium, the Netherlands and the UK, EMU reduced (real) exchange rate volatility, Equally, higher interest rates are associated with higher volatility in these countries, as might be expected due to defence of a parity or band. Volatility also tends to be related to lower inflation and a more positive fiscal balance as fiscal policy is tightened and/or economic growth is high. The interest rate and inflation results combined can be seen as entailing a positive impact of real interest rates on volatility. Note that since we have fixed effects these are not merely capturing the different average levels of volatility in the different countries.

**Table 7.3.3: Exchange rate volatility panel (1995Q1-2009Q2): unrestricted**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -9.17E-05 | 4.72E-05 | -1.941557 | 0.0530 |
| DGDP | -0.000698 | 0.000505 | -1.383941 | 0.1672 |
| DHCP | -0.001977 | 0.000222 | -8.909328 | 0.0000 |
| INT | 1.07E-05 | 2.68E-06 | 3.979981 | 0.0001 |
| CBR | -4.72E-07 | 9.25E-07 | -0.510550 | 0.6100 |
| GBR | 3.21E-06 | 1.80E-06 | 1.783404 | 0.0754 |
| EMU | 6.22E-05 | 3.02E-05 | 2.059734 | 0.0402 |
| CRISES | -1.39E-05 | 1.69E-05 | -0.821084 | 0.4121 |
| Fixed Effects (Cross) | | | | |
| BL--C | 6.20E-05 | | | |
| CR--C | 4.32E-05 | | | |
| HU--C | -5.38E-06 | | | |
| PO--C | -6.57E-06 | | | |
| RM--C | -0.000124 | | | |
| SL--C | 1.77E-05 | | | |
| SR--C | 2.09E-05 | | | |
| | Effects Specification | | | |
| Cross-section fixed (dummy variables) | | | | |
| R-squared | 0.642535 | Mean dependent var | | 3.65E-05 |
| Adjusted R-squared | 0.629482 | S.D. dependent var | | 0.000171 |
| S.E. of regression | 0.000104 | Akaike info criterion | | -15.46353 |
| Sum squared resid | 3.86E-06 | Schwarz criterion | | -15.31545 |
| Log likelihood | 2874.753 | F-statistic | | 49.22324 |
| Durbin-Watson stat | 1.381262 | Prob(F-statistic) | | 0.000000 |

**Table 7.3.4: Exchange rate volatility panel (1995Q1-2009Q2): restricted**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000103 | 5.19E-05 | -1.993098 | 0.0470 |
| DHCP | -0.002025 | 0.000247 | -8.195299 | 0.0000 |
| INT | 1.09E-05 | 2.81E-06 | 3.864271 | 0.0001 |
| GBR | 2.77E-06 | 1.61E-06 | 1.720124 | 0.0863 |
| EMU | 6.59E-05 | 3.10E-05 | 2.124564 | 0.0343 |
| Fixed Effects (Cross) | | | | |
| BL--C | 6.42E-05 | | | |
| CR--C | 4.50E-05 | | | |
| HU--C | -4.87E-06 | | | |
| PO--C | -8.66E-06 | | | |
| RM--C | -0.000124 | | | |
| SL--C | 1.71E-05 | | | |
| SR--C | 1.91E-05 | | | |
| | Effects Specification | | | |
| Cross-section fixed (dummy variables) | | | | |
| R-squared | 0.637097 | Mean dependent var | | 3.65E-05 |
| Adjusted R-squared | 0.626988 | S.D. dependent var | | 0.000171 |
| S.E. of regression | 0.000105 | Akaike info criterion | | -15.46465 |
| Sum squared resid | 3.92E-06 | Schwarz criterion | | -15.34830 |
| Log likelihood | 2871.960 | Hannan-Quinn criter. | | -15.41843 |
| F-statistic | 63.02448 | Durbin-Watson stat | | 1.399479 |

## 7.4 Conclusions

We contend that the univariate GARCH is a key tool for analysis, and the equations should be re-estimated regularly and conditional variances derived for consideration. The estimation for equity markets show a pattern of declining conditional volatility which was interrupted by the 2008 crisis. 2008 also saw a rise in dispersion of volatility, but much less than in 1998, indicating higher integration and hence scope for contagion. Correlations of volatility have also increased, consistent with this conclusion.

Univariate effective exchange rate GARCH estimates show that the 2008 crisis is more severe than that of 1998. For most countries correlation of variance increased after 2002 compared with 1995-2002. Comparing conditional volatility of equities and the effective exchange rate, there are strong correlations of the series, albeit at different levels. This is also true within individual countries.

GARCH is also a useful tool for analysing the real economy. Conditional volatility of retail sales is lower and more stable than that of industrial production, which was markedly increased by the crisis of 2008. The correlation of the two series is less marked than for equities and the exchange rate. Price level conditional volatility has declined over time but is higher in Bulgaria and Romania than elsewhere in the NMS. Countries adopting the euro or currency boards have close correlation with the eurozone volatility.

Multivariate GARCH permits the derivation of conditional covariance as well as variances. Higher covariance is an indicator of contagion risk. The recommended tool is the VECH model estimable in Eviews and it is recommended to re-estimate and assess charts regularly as part of the toolkit. The VECH estimates show that equity market covariances have increased both vis a vis other NMS markets and the eurozone during 1995-2009. In crises, variance and covariance typically increase together. Nevertheless there are marked differences in the level of covariance, with Hungary, Romania and the Czech Republic being relatively high in the 2008-9 period. Exchange rate covariances have not followed a consistent pattern in the two halves of the sample. In the 2007-8 crisis it was again Hungary, Poland and Czech that most strongly covaried with other NMS rates, while for the euro rates there was less of a consistent pattern.

Finally, panel estimation for determinants of conditional volatility in equities and exchange rates shows that macroeconomic variables have little consistent impact for equities, while for exchange rates, significant effects of real interest rates and the fiscal balance can be detected, as well as EMU which raised volatility in NMS currency rates.

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# Appendices

## *A.1 Appendix I: Practical Guide to Early Warning Systems*

See Attached files.

## *A.2 Appendix II: Practical Guide to GARCH Models in EViews*

See attached files.

## *A.3a Appendix IIIa: Equity Risk Premia*

See attached files.

## A.3b Appendix IIIb: Interest Rate Volatility

See attached files.

## A.3c Appendix IIIc: Exchange Rate Risk Premia

See attached files.

## A.4 Appendix IV: The role of Swedish banks in the Baltic countries