EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 1480 / OCTOBER 2012

INTERDEPENDENCE AND CONTAGION IN GLOBAL ASSET MARKETS

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Acknowledgements
We are grateful for comments received at a presentation of the paper at the European Central Bank in October 2011, in particular from Alexander Chudik, Michael Ehrmann, Marcel Fratzscher, and Roland Straub, as well as an anonymous referee of the ECB Working Paper Series. We also acknowledge extremely useful comments received at a presentation of the paper at the INFINITI conference at Trinity College Dublin in June 2012. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the International Monetary Fund.

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ISSN 1725-2806 (online)

ABSTRACT

This paper provides an empirical assessment of interdependence and contagion across three asset classes (bonds, stocks, and currencies) for over 60 economies over the period 1998 to 2011. Using a global VAR, we test for changes in the transmission mechanism – both within and cross-market changes - during periods of turbulence in financial markets. Our results suggest that within-market effects over the sample period for each asset market are highly significant for advanced economies. For emerging economies, these within-market effects mostly apply to the equity market. Contagion effects within-market are most notable in Latin America and Emerging Asia for equities. Cross-market contagion is identified from global bonds to local stocks in Central and Eastern Europe, but from global stocks to domestic bonds in the case of advanced economies. Impulse responses indicate that in crisis times, the origin of the shock plays an important role on the nature of the global transmission. The evidence suggests that in times of financial crisis, shocks that emanate in the US, particularly equity shocks, lead to risk aversion by investors in equities and currencies globally and in some emerging market bonds. Euro area shocks tend to have the most significant effect within the bond market. Our results have implications for policymakers in terms of understanding financial exposures and vulnerabilities and for investors in relation to portfolio rebalancing and the construction of portfolio diversification strategies across asset classes in crisis and non-crisis times.

JEL Classification: F30, G15

Keywords: Asset markets, contagion, Global VAR

NON-TECHNICAL SUMMARY

This paper provides an assessment of interactions (interdependence and contagion) amongst asset classes (bonds, stocks, and currencies) across countries and regions, and examines whether these relationships change during a period of financial stress. Interdependence is defined as the relationship that exists between asset classes on average over the sample period. Contagion is defined as a change in the transmission mechanism between asset classes in crisis times. The paper is partly motivated by the fact that previous studies on contagion tended to focus on interactions and spillovers for a particular class of assets across countries, while other studies which examine interactions across asset markets tend to focus on these interactions in one state of the world, i.e. the non-crisis state. This paper aims at addressing the gap in the literature using a global VAR (GVAR) model. Focusing on the period from 1998 to 2011, we use the St. Louis Fed indicator of global financial market stress to determine changes in the transmission mechanism (i.e. shift contagion) across asset markets in periods of financial distress for over 60 economies. Overall our findings indicate that emerging economy equity markets are much more integrated to global equity markets than the integration of emerging bond markets with global bond markets and the integration of emerging currency market with global currency markets.

In line with previous literature, we find that interdependence is most notable across advanced and emerging economies in the case of the equity market. Indeed, our study affirms this more comprehensively as we have also controlled for interactions across other asset classes. Contagion effects within the stock market are most apparent in Latin America and Emerging Asia. Interestingly, however, we also find evidence of contagion from global bonds to regional stocks in Central and Eastern Europe and the Middle East and Africa. As regards the government bond market, interdependence within the bond market largely only applies to the advanced economies, although there are some cases of interdependence in emerging economies with relatively liquid bond markets (such as Hong Kong, Singapore, and South Africa for example). As regards bond market contagion, clear evidence of this is found for Mexico, Venezuela and the Philippines. Cross-market interdependence and contagion from global equities and global currencies to local bonds is not prevalent. That said, there is some evidence of cross-market contagion from global equities to local bonds in Mexico, Hong Kong, Russia and Poland, and from global currencies to local bonds in the case of Brazil.

As regards exchange rates (based on bilateral US dollar exchange rates), interdependence is a key feature of advanced economies. In the case of emerging economies, however, interdependence is more prevalent between global equities and local currencies than global currencies and local currencies. On contagion, domestic currencies in Hong Kong, Korea, Thailand, Slovakia and Australia appear to be susceptible to financial turbulence in global currency markets. The impulse response function analysis demonstrated that the relationship amongst asset classes differs in crisis times. The response to shocks is much higher in magnitude and also more persistent in crisis times. In addition, the response to shocks may differ depending on the origin of the disturbance. For example, a US equity market shock leads to a deterioration of all regional equity markets in crisis times. A euro area stock market shock in crisis times, however, boosts regional stock markets, although this effect is not significant. As a result, it appears that a US equity shock negatively affects investor confidence in the stock market generally, while this is not the case for a euro area equity shock. The response of regional equities to advanced economy bond shocks (US or euro area) are comparable however. The effect is not significant regardless of the origin of the shock, both on average and in a crisis period.

Responses by regional bond markets to advanced economy equity market shocks are more regionally heterogeneous than the reaction of regional equity markets. Our results indicate that an equity market shock originating in the US leads to a deterioration of the bond market (i.e. rising yields) in Latin America and Central and Eastern Europe. The same shock, however, reduces bond yields in Emerging Asia and other advanced economies, indicating that investors turn to these bond markets following a US equity market shock. Finally, US equity market shocks tend to lead to currency depreciations globally in times of financial distress. On the other hand, a euro area equity shock, however, leads to currency appreciations in other regions in crisis times, although this effect is not always significant. On advanced economy bond market shocks, these are transmitted largely similarly to other regional bond markets regardless of the origin of the shock. An interesting finding therefore is that in times of global financial distress, particular attention needs to be paid to asset market shocks that emanate in the US. Such shocks are transmitted globally and in a negative direction within-market in the case of US equity and bond shocks as well as cross-market from US equity shocks to global currencies and global bonds. On the other hand, the negative effects of euro area shocks mainly relate to bond market shocks and are largely confined to spillovers to advanced economy bond markets.

The analysis carried out has a number of implications of interest to policymakers. Our findings provide an insight into country-specific and region-specific financial vulnerabilities in times of global financial turbulence. In order to derive appropriate policy responses, it is crucial that policymakers understand the source and nature of financial exposures. The results from this paper may also have implications related to the construction of optimal portfolio diversification strategies at the country and regional levels.

1. INTRODUCTION

The current global financial crisis has been associated with turbulence in asset markets across advanced and emerging asset economies. This has generated an interest among investors, policymakers and academics on asset market linkages across countries in times of financial crisis and whether this is different compared to non-crisis times. We assess interactions (interdependence and contagion) amongst asset classes (bonds, stocks, and currencies) across countries and regions in alternative regimes over the period from 1998 to 2011. Interdependence is defined as the relationship that exists between asset classes on average over the sample period. Contagion is defined as a change in the transmission mechanism between asset classes in crisis times. There exists a dearth of academic work on asset market spillovers and contagion in non-crisis and crisis times. Previous studies on contagion tended to focus on interactions and spillovers for a particular class of asset across countries, while other studies which examine interactions across asset markets tended to focus on these interactions in one state of the world, i.e. the non-crisis state. This paper aims at addressing the gap in the literature using a global VAR (GVAR) model. Such an approach enables us to simultaneously estimate interdependence and contagion both within and across asset markets across over 60 economies. Our framework identifies turbulence in asset markets as being measured by the St. Louis Fed indicator of global financial market stress, enabling us to assess changes in the transmission mechanism (i.e. shift contagion) across asset markets in periods of financial distress. This helps to indicate vulnerabilities of particular economies or regions to contagion, and across asset classes.

Our findings indicate that there are differences in asset market linkages during a crisis, but also across advanced compared to emerging economies. First, across the sample period, while within-market effects are significant across all asset markets for advanced economies, in the case of emerging economies, within-market effects mainly apply to the equity market. Second, we find that cross-market effects are evident on average from global currencies to local stocks in the advanced economies and emerging economies in Asia and Central and Eastern Europe. Third, in crisis times, we find that contagion effects, i.e. a change in the transmission mechanism during a period of financial stress, within the stock market are most apparent in advanced economies and emerging economies in Asia and Latin America. Interestingly, we find only marginal evidence of within-market contagion for bonds and currencies across both advanced and emerging economies. Fourth, cross-market contagion is found from global bonds to local stocks in Central and Eastern Europe, but from global stocks to domestic bonds in the case of advanced economies.

Fifth, the response to shocks differs according to the origin of the disturbance. For example, a US equity market shock leads to a deterioration of all regional equity markets in crisis times. A euro area stock market shock in crisis times, however, boosts regional stock markets, although this effect is not significant. As a result, it appears that a US equity shock negatively affects investor confidence in the stock market generally, while this is not the case for a euro area equity shock. The response of regional equities to advanced economy bond shocks (US or euro area) are comparable however. The effect is not significant regardless of the origin of the shock, both on average and in a crisis period. Responses by regional bond markets to advanced economy equity market shocks are more regionally heterogeneous than the reaction of regional equity markets. Our results indicate that an equity market shock originating in the US leads to a deterioration of the bond market (i.e. rising yields) in Latin America and Central and Eastern Europe. The same shock, however, reduces bond yields in Emerging Asia and other advanced economies. Finally, US equity market shocks tend to lead to

currency depreciations globally in times of financial distress. On the other hand, a euro area equity shock, however, leads to currency appreciations in other regions in crisis times, although this effect is not always significant.

On advanced economy bond market shocks, these are transmitted largely similarly to other regional bond markets regardless of the origin of the shock. An interesting finding therefore is that in times of global financial distress, particular attention needs to be paid to asset market shocks that emanate in the US. Such shocks are transmitted globally and in a negative direction within-market in the case of US equity and bond shocks as well as cross-market from US equity shocks to global currencies and global bonds. On the other hand, the negative effects of euro area shocks mainly relate to bond market shocks and are largely confined to spillovers to advanced economy bond markets. Overall the evidence suggests that in times of financial crisis, shocks that emanate in the US, particularly equity shocks, lead to risk aversion by investors in equities and currencies globally and in some emerging market bonds.

Our results have obvious policy implications in terms of the degree to which insulating economies from the negative effects of a shock can be controlled by policy responses. The paper is organised as follows. Section 2 provides an overview of previous academic literature on asset market linkages and contagion. Section 3 provides details on the methodology employed. Section 4 describes the data used. Section 5 discusses the main empirical results. Section 6 summarises the main conclusions.

2. RELATED LITERATURE ON ASSET MARKET LINKAGES AND CONTAGION

This paper is closely related to a various strands of the literature on asset market interactions and contagion within and across asset markets. Firstly, there exists an abundant literature on asset market spillovers (e.g. Andersen, Bollerslev, Diebold, and Vega (2007), Ehrmann, Fratzscher, and Rigobon (2011)). However, our analysis differs from these previous studies in a number of respects. First, this literature fails to take into account the important role of emerging market economies. Our analysis considers a large sample of over 60 economies, whereby around two-thirds of the sample is made up of emerging economies. Second, while a vast number of studies have been carried out on contagion, this has largely focused on one particular asset class. Our paper examines three asset classes simultaneously. Third, this paper contributes from a methodological perspective to the growing literature on GVARs, which has recently been applied to studies of global spillovers (e.g. Pesaran et al. (2006), Pesaran et al. (2007)). In this paper, we construct a modified version of the standard GVAR framework that allows us to test for contagion as well as for interdependence.

2.1 Interactions between asset markets

One of the seminal papers that examine financial spillovers across countries (including those across bond, equity and exchange rate markets) was carried out by Dees et al (2007). Using a quarterly GVAR model for 26 countries for both macroeconomic and financial variables, spillovers and external shocks to the euro area are examined. They find that financial shocks are transmitted rapidly, particularly from the US to the euro area, and that the equity and bond markets are highly synchronous. In addition, it is found that euro area equity prices react quickly to a US equity market shock, though there may be some signs of an over-reaction. A GVAR approach was also employed by Galesi and Sgherri (2009), who find that equity markets are more synchronous than banking systems, and that asset prices are the main channel through which financial shocks are transmitted globally.

Andersen, Bollerslev, Diebold, and Vega (2007) examine the responses of German, US and British government bonds, stocks and exchange rates to US macroeconomic news in the period 1992-2002. The authors find the correlations between stocks and bonds are negative across the full sample and recession periods, but positive in the expansion period. When conditioning on the state of the economy, it is found that bond markets are most responsive to news, while equity and foreign exchange markets are equally responsive. Other earlier studies examining asset market linkages have tended to focus on the US, including Bernanke and Kuttner (2005), Ehrmann and Fratzscher (2004), Rigobon and Sack (2003a), and Rigobon and Sack (2003b).

Ehrmann, Fratzscher, and Rigobon (2011) investigate linkages between short-term interest rates, government bonds, equity markets, and exchange rates both within and between the US and the euro area in the period 1989-2004. They find that the US is the main driver of global financial markets. It is also found that while asset prices are particularly sensitive to other domestic asset price shocks, global spillovers within and across asset markets are apparent. Hakim and McAleer (2009) examine interactions across bonds, stocks, and exchange rates within and between Australia, Japan, New Zealand, Singapore, and the US in the period 1998-2006. Using the VARMA-AGARCH model of McAleer et al. (2009), Hakim and McAleer (2009) examine the relationships between asset market across two countries thus missing spillovers from other countries or regions. It was found that spillovers are largely explained by within-market interactions. Cross-market effects were found however coming from the US asset markets.

The period of the recent financial crisis is taken into account by Chudik and Fratzscher (2011a). Using a global VAR approach, these authors analyse the transmission of global liquidity shocks and shocks to investor risk appetite on equity and money markets. They find that liquidity shocks impact most notably on advanced economies, while declines in risk appetite affect emerging economies most severely. Chudik and Fratzscher (2011b) use an infinite-dimensional VAR methodology to examine changes in the transmission of liquidity and risk shocks on financial markets between the 2007-08 financial crisis and the 2010-11 sovereign debt crisis. The authors find fundamental differences between those two crises. Their results point to a stronger resilience of emerging economies to the sovereign debt crisis than to the financial crisis. In comparison to our paper, Chudik and Fratzscher (2011a, 2011b) have a similar methodology, although in their case the methodology is implemented separately across different states of the economy using data from 2007 for 28 countries. Differences in the transmission of shocks are then compared through examination of impulse responses across the various models estimated. On the other hand, our analysis uses data from 1998 across over 60 countries, and estimates the GVAR simultaneously for each country, allowing for a change in the transmission process during a crisis period using a dummy variable for global financial turbulence. Our analysis concentrates on the identification of interdependence and contagion across three asset markets for these countries, as well as examining changes in the transmission of shocks in crisis.

In relation to contagion in asset markets, the empirical literature has tended to focus on a particular type of asset market during a period of crisis; namely currency markets, equity markets, or fixed income markets. Although there have been some studies of contagion across asset markets, these have tended to be concentrated on a relatively low level of countries.

2.2 Currency market contagion

Crises in currency markets can take place under a range of scenarios. For example, currency market contagion in the Asian crisis was mostly associated with a banking system crisis, whereby pressure on exchange rates can lead to liquidity problems for banks. Such crises are often triggered by a large devaluation of the currency, which then spreads to other currencies due to both spillover effects and factors not directly associated with economic fundamentals. Currency market contagion is not confined to banking sector crises however. For example, portfolio flow reversals and surges play an important part in currency co-movements. The empirical literature on contagion is dominated by studies of how currency crises spread. For example, Cerra and Saxena (2002) explore the reasons behind the currency crisis in Indonesia in 1997. Using a Markov switching model, it was found that the crisis was caused by a combination of fundamental factors and contagion from speculative pressure in Thailand and Korea. An earlier study by Glick and Rose (1999) identified currency market contagion across five Asian countries, the cause of which was due to trade linkages. A similar result is found by Van Rijckeghem and Weder (2001), although they cite financial linkages between the countries as being the cause of the contagion. Currency market contagion studies of the Asian crisis have also been carried out by Panshikar (2000) and Baig and Goldfajn (1999). Early literature tended to find evidence of contagion in currency markets. However, more recent studies make use of more precise definitions of the issue and more sophisticated econometric testing procedures to show that contagion has not been prevalent in relation to currency crises. Typically, contagion in this regard is modelled as an increase in currency market interlinkages.[3] Debelle and Ellis (2005) and Dungey et al (2004) make the point that contagion in currency markets is much less prevalent in developed countries.

2.3 Equity market contagion

While not as prevalent as studies of contagion in currency markets, many of the studies carried out on equity market contagion have their roots in the stock market crash of October 1987. Using an ARCH framework, Hamao, Masulis and Ng (1990) assess the extent of price volatility between the New York, Tokyo and London stock markets following the 1987 crash. In addition, King and Wadhwani (1990) measure the changes in cross market correlation coefficients between the stock markets of the US, the UK and Japan. A further study by Lin, Engle and Ito (1994) uses a GARCH methodology to estimate the correlation between the returns and volatilities of stock market indices in New York and Tokyo. The empirical results of these early studies tended to find evidence of contagion across equity markets.[4] Forbes and Rigobon (2002) cast some doubt on the contagion results found in previous studies. Since cross-market correlation coefficients are conditional on market volatility, such estimates are likely to be biased upwards during a crisis (i.e. when markets are more volatile). When taking this into account, then changes into correlation coefficients during crises may be the result of natural economic linkages between regions as opposed to

[3] In assessing currency market contagion in Asian currencies, an important point was put forward by Dungey et al (2005) that although currencies were a significant driver of the crisis, testing for contagion in these markets is made difficult by the fact that fixed exchange rate regimes were largely in place prior to 1997 (thereby making it difficult to assess volatility in the pre-crisis period).

[4] There are two important caveats that need to be borne in mind, however, when considering results such as these. Firstly, the definition used to describe contagion in the early empirical literature tended to focus a more 'fundamentals-based' shock propagation. Secondly, independent of the definition issue, econometric measurement concerns in some of the early research were identified in the later literature.

contagion. There has been a range of other papers that focus on contagion in the equity market, e.g. Connolly and Wang (2003), Dungey et al (2003), Chan-Lau, Mathieson and Yao (2004), Corsetti, Pericoli and Sbracia (2005), Caporale, Cipollini and Spagnolo (2005), Baur and Schulze (2005), Baur and Fry (2005), Bond, Dungey and Fry (2005), Beirne et al (2009), and Bekaert et al (2011).

2.4 Fixed income market contagion

While the recent European sovereign debt crisis has led to number of recent papers on the contagion effects from peripheral euro area countries, e.g. Beirne and Fratzscher (2012), de Santis (2012), and, Arghyrou and Kontonikas (2011), previous papers on bond market contagion have tended to focus more on emerging economies. The sovereign bond market is a particularly important asset market for emerging economies given that such economies require greater relative support from the international financial community and sovereign bonds are closely linked with country risk. The market was largely stable until the Russian crisis in 1998 when there was a default on sovereign bond payments.[5] Dungey et al (2002) highlighted that the Russian crisis and the near-collapse of LTCM in 1998 constituted a financial crisis that marked a departure from other crises of the 1990s. In this case, the crisis was propagated beyond emerging markets, and developed economies also experienced some turbulence. The study highlights that Brazil, Bulgaria, the Netherlands and the United States were more proportionately affected by the Russian crisis than other countries.[6] Other previous work on bond market contagion in emerging economies was carried out by Baig and Goldfajn (1999), Lomakin and Paiz (1999), Rigobon (2000), and Gravelle, Kichian and Morley (2003).

2.5 Contagion across asset markets

As well as a crisis in a particular asset class transmitting to similar classes of assets elsewhere, the empirical literature on contagion also provides some evidence to show contagion across markets. The broader principles of the close relationship between asset markets of all types has been outlined in a seminal paper on crises by Kindelberger (1996). In relation to the Asian crisis, a recent study by Ito and Hashimoto (2005) looks at and finds contagion between the equity and currency markets. Dungey and Martin (2005) note that close links between equity and currency markets regarding contagion. The Forbes and Rigobon technique is applied by Bohl and Serwa (2005) to test whether European stock markets were affected by a range of crises, regardless of the nature of the crisis. The crises included in the analysis were the crises of Asia (1997), Russia (1998), Brazil (1999), Turkey (2000), the U.S. (2001), Argentina (2001) and the U.S. (2001). No contagion effects were identified. Rather, it was deemed that the transmission of shocks was due to interdependence. In relation to cross-market linkages, an insightful study was carried out by Dungey and Martin (2007) that models contagion between the equity and currency markets of Asian crisis countries. Their results show that currency market contagion (i.e. contagion originating in the currency markets) accounts for up to 11% of the volatility in the equity markets. By contrast, equity market contagion accounts for up to 36% of volatility in the currency markets. These results would clearly suggest that contagion from equity markets can have relatively more

[5] This excludes the bond market sell-off in 1994-95 (for example, the Mexican crisis had knock-on effects for Brady bonds in Argentina).

[6] The study was based on the following 12 countries: Argentina, Brazil, Mexico, Indonesia, Korea, Thailand, Bulgaria, Poland, Russia, the Netherlands, the United Kingdom, and the United States.

detrimental effects than contagion from currency markets. The literature appears to indicate that episodes of contagion are more likely in equity markets, followed by currency markets, and then bond markets.[7] Dungey et al (2005) note that this statement would appear to hold regardless of in which asset market the initial crisis occurred. The example cited is that the Russian crisis of 1998, which took place initially in the bond markets, had greater contagion effects for equity markets than bond markets.

3. METHODOLOGY

Our approach is based on the application of the GVAR model, first established by Pesaran, Schuerman and Weiner (2004). The advantage of the GVAR is that it can circumvent the "curse of dimensionality" and allows the estimation of models where the cross-sectional dimension *N* is high[8]. This enables us to have a sample with weekly data for 63 countries. For each country we have up to 3 variables: stock returns, government bond yields and exchange rate returns.[9] In the following we explain the methodology and how we identify interdependence and contagion in our GVAR model.

3.1 The Country Specific Models

Global VAR models are not estimated simultaneously, but on a country-by-country basis, our country-specific model for each country has the following specification[10]:

$$x_{it} = a_{i0} + \Phi_i x_{i,t-1} + \Lambda_{i0} x_{it}^{*} + \gamma_i d_t + \Gamma_{i0} d_t x_{it}^{*} + \varepsilon_{it}, \qquad (1)$$

where

$$x_{it} = (s_{it}, b_{it}, ex_{it})', \text{ for } i = 1,2,\ldots N, \; x_{it}^{*} = (s_{it}^{*}, b_{it}^{*}, ex_{it}^{*})' \text{ for } i = 0,1,\ldots N,$$

where

$$s_{it}^{*} = \sum_{j=0}^{N} w_{ij} s_{jt}, \qquad b_{it}^{*} = \sum_{j=0}^{N} w_{ij} b_{jt}, \qquad ex_{it}^{*} = \sum_{j=0}^{N} w_{ij} ex_{jt}, \qquad \sum_{j=0}^{N} w_{ij} = 1,$$

and $d_t = \begin{Bmatrix} 0 \forall GFS_t < 25 \\ 1 \forall GFS_t \geq 25 \end{Bmatrix}$,

[7] It is important to bear in mind that the literature on contagion for bond markets is much more limited than that for equity and currency markets, although a literature on bond market contagion has recently developed further owing to the European sovereign debt crisis.

[8] In particular, two features of the GVAR allow the management of such large data models. Firstly, the variables within the GVAR are distinguished between "domestic" and "foreign" variables. The domestic variables enter the model of one country in unrestricted form (the so called "country-specific model") whereas the foreign variables are weighted averages of the domestic variables of the other countries. Via the foreign variables each country-specific model is linked to the others. The key feature which reduces the parameters is the construction of the foreign variables as weighted averages. As a weighting scheme Pesaran et al (2004) use trade weights but other weights, such as financial weights, can be applied as well.

[9] All results are obtained using the GVAR Toolbox 1.0 from Smith and Galesi (2010) available on the following homepage http://www-cfap.jbs.cam.ac.uk/research/gvartoolbox/index.html. We have adjusted the toolbox for our purposes as our GVAR is non-standard, as explained in the remainder of this section.

[10] For the purpose of exposition we refrain from higher order lags notation.

s_{it} denotes the logarithm of stock returns of country *i* at time *t*, b_{it} denotes the first differences in government bond yields, ex_{it} is the logarithm of nominal exchange rate returns in terms of U.S. dollars, s^*_{it} denotes the weighted average of foreign logged stock returns specific to country *i* at time *t*, b^*_{it} is the weighted average of foreign government bond yields, and ex^*_{it} is the weighted average of foreign exchange rates returns, and d_t is a financial market turbulence dummy based on the St. Louis FED global financial stress (GFS) indicator.[11] For the U.S. the vector with the endogenous variables is $x_{0t} = (s_{0t}, b_{0t})'$, since the U.S. dollar is the numeraire exchange rate. Thus exchange rate returns for the U.S. are defined outside the U.S. model in terms of the other currencies, i.e. by the foreign exchange rate ex^*_{0t}. The weights w_{ij} are trade weights and reflect the economic importance of country *j* for country *i*. In particular, w_{ij} is the ratio of trade (exports plus imports divided by two) of country *j* in the total trade of country *i*. The matrix Φ_i is a $k_i \times k_i$ matrix of lagged coefficients ($k_i = 3$), Λ_{i0} is a $k_i \times k_i^*$ matrix of coefficients associated with the foreign-specific variables and captures impact elasticities of foreign-specific variables on domestic variables. γ_i is a $k_i \times 1$ vector of financial distress effects. Γ_{i0} is a $k_i \times k_i^*$ matrix which captures interaction effects between the financial turbulence dummy and the foreign-specific variables. ε_{it} is a $k_i \times 1$ vector of idiosyncratic country-specific shocks.

3.2 The global solution of the GVAR

The global solution in levels form can be obtained by re-writing the country-specific equation (1) as:

$$A_i z_{it} = a_{i0} + B_i z_{i,t-1} + \gamma_i d_t + \Gamma_{i1} d_t x^*_{it} + \varepsilon_{it} \tag{2}$$

where

$$z_{it} = (x_{it}, x^*_{it})' \tag{3}$$

and where

$A_i = (I_{ki}, -\Lambda_{i0})$, and $B_i = (\Phi_i, 0)$.

The matrices A_i and B_i are $k_i \times (k_i + k_i^*)$ matrices. From $\sum_{j=0}^{N} w_{ij} x_{it} = x^*_{it}$ and equation (3), it can be seen that, $z_{it} = W_i x_t$. W_i is a $(k_i + k_i^*) \times k_i$ "link" matrix which consist of ones and country specific weight w_{ij}.

By stacking Equation (4) across all *i*, the resultant "global" model can be re-written as

$$A_i W_i x_t = a_{i0} + B_i W_i x_{t-1} + \gamma_i d_t + \Gamma_{i1} d_t x^*_t + \varepsilon_{it}. \tag{4}$$

[11] Turbulence is defined as a period where the index is either at a very high level (higher than 25) or rising sharply (4-week moving average exceeding 52-week moving average by 30% or more).

By rewriting x_t^* as $x_t^* = W_i^* x_t$, where

$$W^* = \begin{pmatrix} W_0^* & 0 & 0 & 0 \\ 0 & W_1^* & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & W_N^* \end{pmatrix} \text{ and}$$

$$W_i^* = \begin{pmatrix} w_{i1} & 0 & 0 & w_{i2} & 0 & 0 & w_{i3} & 0 & 0 \\ 0 & w_{i1} & 0 & 0 & w_{i2} & 0 & 0 & w_{i3} & 0 \\ 0 & 0 & w_{i1} & 0 & 0 & w_{i2} & 0 & 0 & w_{i3} \end{pmatrix} \text{ for } i = 0,1,\ldots N,$$

we can rewrite Equation (4) as

$$A_i W_i x_t = a_{i0} + B_i W_i x_{t-1} + \gamma_i d_t + \Gamma_{i1} d_t W_i^* x_t + \varepsilon_{it}. \tag{5}$$

Stacking Equation (5) for each country yields the Global VAR model:

$$Gx_t = a_0 + Hx_{t-1} + \gamma_0 d_t + \Gamma_1 d_t W^* x_t + \varepsilon_t \tag{6}$$

where

$$G = \begin{pmatrix} A_0 W_0 \\ A_1 W_1 \\ \vdots \\ A_N W_N \end{pmatrix}, \; a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \vdots \\ a_{N0} \end{pmatrix}, \; H = \begin{pmatrix} B_0 W_0 \\ B_1 W_1 \\ \vdots \\ B_N W_N \end{pmatrix}, \; \gamma_0 = \begin{pmatrix} \gamma_{00} \\ \gamma_{10} \\ \vdots \\ \gamma_{N0} \end{pmatrix}, \text{and } \Gamma_1 = \begin{pmatrix} \Gamma_{01} & 0 & 0 & 0 \\ 0 & \Gamma_{11} & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \Gamma_{N1} \end{pmatrix}.$$

The matrix *G* is in general of full rank so that the global solution can be written as,

$$x_t = b_{0,t} + Fx_{t-1} + u_t \tag{7}$$

which is the reduced-form global model and where

$$b_{0,t} = (G - \Gamma_1 d_t W^*)^{-1}(a_0 + \gamma_0 d_t), \quad F = (G - \Gamma_1 d_t W^*)^{-1} H, \text{ and } u_t = (G - \Gamma_1 d_t W^*)^{-1} \varepsilon_t \tag{8}$$

3.3 Identification of Interdependence and Contagion

The novelty of our approach in comparison to other GVAR studies is that we apply the methodology to the study of both interdependence and contagion for three asset classes. By including interaction terms $d_t x_{it}^*$ into the country-specific VAR models (1), the impact of foreign variables on domestic variables is then given by:

$$\frac{\partial x_{it}}{\partial x_{it}^*} = \Lambda_{i0} + \Gamma_{i1} d_t,$$

Λ_{i0} captures the impact of foreign-variables throughout the whole sample period, whereas Γ_{i1} reflects the impact of foreign-variables in times of financial distress. From this we interpret Λ_{i0} as an indicator for interdependence. To us, interdependence means a significant relationship between financial variables throughout the whole sample period, whereas contagion is a significant association between financial variables in crisis times and is thus indicated by Γ_{i1}. We test the significance of coefficients in Λ_{i0} and Γ_{i1} and interpret results in the following way. If coefficients in Λ_{i0} and Γ_{i1} which represent the impact from the same foreign-asset class are both significant then we have interdependence and contagion. If the coefficient in Λ_{i0} is significant but the corresponding coefficient in Γ_{i1} is not, than we only have interdependence and no contagion and vice versa. To illustrate our methodology we give you an example. If we write equation (1) in matrix notation, where for the purpose of exposition we left out the constant and the matrix with lagged coefficients for x_{t-1}, the country-specific VAR model will look the following:

$$\begin{pmatrix} s_{it} \\ b_{it} \\ ex_{it} \end{pmatrix} = \cdots + \begin{pmatrix} \lambda_{i0,s,s^*} & \lambda_{i0,s,b^*} & \lambda_{i0,s,ex^*} \\ \lambda_{i0,b,s^*} & \lambda_{i0,b,b^*} & \lambda_{i0,b,ex^*} \\ \lambda_{i0,ex,s^*} & \lambda_{i0,ex,b^*} & \lambda_{i0,ex,ex^*} \end{pmatrix} \cdot \begin{pmatrix} s^*_{it} \\ b^*_{it} \\ ex^*_{it} \end{pmatrix} + \begin{pmatrix} \gamma_{i0,s,d_t} \\ \gamma_{i0,b,d_t} \\ \gamma_{i0,ex,d_t} \end{pmatrix} \cdot d_t + \begin{pmatrix} \gamma_{i1,s,s^*} & \gamma_{i1,s,b^*} & \gamma_{i1,s,ex^*} \\ \gamma_{i1,b,s^*} & \gamma_{i\,1,b,b^*} & \gamma_{i1,b,ex^*} \\ \gamma_{i1,ex,s^*} & \gamma_{i1,ex,b^*} & \gamma_{i1,ex,ex^*} \end{pmatrix} \cdot \begin{pmatrix} d_t \cdot s^*_{it} \\ d_t \cdot b^*_{it} \\ d_t \cdot ex^*_{it} \end{pmatrix} + \begin{pmatrix} e_{it,s} \\ e_{it,b} \\ e_{it,ex} \end{pmatrix}.$$

Isolating the equation for the domestic stock return in country *i* yields:

$$s_{it} = \cdots + \lambda_{i0,s,s^*} s^*_{it} + \lambda_{i0,s,b^*} b^*_{it} + \lambda_{i0,s,ex^*} ex^*_{it} + \gamma_{i0,s,d_t} d_t + \gamma_{i1,s,s^*} d_t \cdot s^*_{it} + \gamma_{i1,s,b^*} d_t \cdot b^*_{it} + \gamma_{i1,s,ex^*} d_t \cdot ex^*_{it} + e_{it,s}.$$

The effect of foreign stock returns on domestic stock returns in country *i* is given as:

$$\frac{\partial s_{it}}{\partial s^*_{it}} = \lambda_{i0,s,s^*} + \gamma_{i1,s,s^*} d_t$$

This relationship allows us to test two assumptions. Firstly, we test if foreign stocks have a significant contemporaneous impact on domestic stocks throughout the whole sample period, i.e. H0: $\lambda_{i0,s,s^*} = 0$ vs. H1: $\lambda_{i0,s,s^*} \neq 0$. If the H0 is rejected we interpret this result as an interdependence relationship between foreign stocks and domestic stocks. Then, we test if foreign stocks have a significant impact on domestic stocks in times of financial distress that is when $d_t = 1$. For this reason we test following hypothesis: H0: $\gamma_{i1,s,s^*} = 0$ vs. H1: $\gamma_{i1,s,s^*} \neq 0$. If we find γ_{i1,s,s^*} significantly different from zero than this is an indication for "Contagion" effects between foreign and domestic stocks. To test these both hypotheses, we follow Pesaran et al. (2004) and compute t-ratios. In order to account for possible heteroskedasticity we use Newey-West adjusted standard errors in our estimation.[12] Results from this hypothesis testing can be found in section 5.

[12] We also compute t-ratios with White-adjusted standard errors. Overall results do not change significantly and can be obtained from the authors upon request.

3.4 Impulse Response Analysis

To circumvent the complicated task of exact identification of shocks (which can be fraught with difficulty for such a high-dimensional VAR model) we refrain from using traditional orthogonalized impulse responses (OIR) as proposed by Sims (1980) and instead use generalized impulse response functions (GIRFs). GIRFs have the advantage that the impulse responses are invariant to the ordering of variables and countries, since only one element in u_t is shocked and the impact of other shocks is integrated out using the historically observed distribution of the errors. This approach goes back to Koop, Pesaran, and Potter (1996), Pesaran and Shin (1998), and Pesaran and Smith (1998). However, the disadvantage is that the shocks cannot be interpreted as structural shocks such as a demand, supply or monetary shock. In other words, GIRFs tell us how a shock say in variable *j* transmits throughout the whole model but we cannot interpret this shock economically, as different types of shock could have caused an increase in variable *j*. Thus GIRFs are useful tools when the focus of the analysis is on the transmission of shocks especially in the case of a Global VAR model. However, due to the reasons stated above we refrain to interpret our shocks economically.

The generalized impulse response to a one standard error shock to the *j*th variable in country *i* at time *t* on expected values of x at time *t+n* is given as,

$$GIRF_{x:u_{ij}}(n,\sqrt{\sigma_{ii,jj}},I_{t-1}) = E(x_{t+n}\left|u_{ijt}=\sqrt{\sigma_{ii,jj}},I_{t-1}\right.) - E(x_{t+n}\left|I_{t-1}\right.), \tag{9}$$

where $I_t = (x_t, x_{t-1},...)$ is the set of information at time *t*. The impact on x in period *n* when the variable *j* in country *i* is increased by one standard error, $\sqrt{\sigma_{ii,jj}}$,is given by

$$\eta\ (n) = \frac{1}{\sqrt{\sigma_{ii,jj}}} F^{n}(G - \Gamma_1 d_t W^{*})^{-1}\Sigma s_j, \quad n = 0,1,2,..., \tag{10}$$

where $F = (G - \Gamma_1 d_t W^{*})^{-1} H$, Σ is the $k \times k$ variance-covariance matrix of the errors ε_t, and s_j is a $k \times 1$selection vector with unity at its *j*th element. From Equations (10) and Equations (8) it is evident that GIRFs in our model are non-standard as they depend on the state of the economy, i.e. $d_t = 0$ or $d_t = 1$. Consequently, we have to estimate GIRF's twice.[13] In the first computation we set $d_t = 0$ and in the second d_t is equal to one. This allows us to compare if there are any differences in the transmission mechanism in countries (or regions) in different states of the economy. The results from the impulse response analysis can be found in section 5.

4. DATA

For our analysis we use weekly data on equity, government bond, and exchange rate returns. Compared to lower frequency data, it has the advantage that it captures better the relationships between variables, especially for financial assets. On the other hand, using data with a higher frequency is more difficult due to non-overlapping trading times across markets

[13] This implies that the total response to shocks during the crisis period is given by the sum of the overall effect and the change in the effect during the crisis.

in different countries. Our sample starts on the 10th of July 1998 and ends on the 10th of June 2011. In total, we have data for 63 advanced and emerging countries. These countries represent over 90% of world output. Foreign variables are constructed using annual trade flows as weights. These trade flows originate from the Direction of Trade statistics available at the IMF eLibrary. In our estimations we use fixed weights as opposed to time-varying weights. In particular, we average the annual trade flows over the years of 1998 till 2010. As well as conducting a country-specific analysis, we also implement a regional approach. Regions are constructed by weighting the time series data of countries in one region by its PPP-GDP share. Data on PPP-GDP weights was obtained from the World Development Indicator database of the World Bank. Details on the classification of regions and countries are given in Table 1.

[Table 1]

For most of the countries we have all three variables, however for some countries data on one or two asset classes were not available. This is notably the case in relation to government bond yields. All the data we use is collected in Datastream, Haver Analytics, and Global Financial Data. For government bonds, long maturities were used (mostly 10 years).

5. EMPIRICAL RESULTS

This section describes in the first instance the relationship between global asset markets and domestic stock, bond and currencies in crisis times in comparison to the whole sample period through an analysis of the contemporaneous elasticities of foreign on domestic variables, as described earlier in Section 3.1.[14]

5.1 Contemporaneous elasticities of global on domestic variables

Tables 2 to 4 present the results of the contemporaneous elasticities of global asset markets on domestic stock markets, domestic bond markets and domestic exchange rates. The average elasticities over the sample period as well as the change in the effect during the crisis are shown.[15] The tables also enable a determination to be made of both within-market and cross-market contagion effects.

[Tables 2 to 4]

When looking at the tables the results are ordered in the following way, Table 2 presents the impact of all three global markets (stocks, bonds, exchange rates) on domestic stock markets. Table 3 presents the impact elasticities of global markets on domestic bond markets, while Table 4 reports the results for the case of domestic exchange rate markets. In each table the first two columns - next to the countries – show the impact of the global stock market, columns 3 to 4 indicate the impact of the global bond markets, and the last two columns represent the influence of the global currency market on the respective domestic market. In

[14] Please note that region-specific results are provided in Tables A1 to A3 in the Appendix.
[15] Therefore, the total effect during the crisis is given by the sum of the average effect and the additional impact during the crisis.

each global market the two columns represent the results of the two hypotheses tested. The first column indicates an interdependence relationship, while the second tests for contagion.

Looking at the results as a whole, it is interesting to note at the outset that within-market effects on average are highly significant for all advanced economies in the sample. By contrast, in the case of emerging economies, within-market effects largely only apply to the equity market. In other words, emerging equity markets appear to be much more integrated at the global level compared to emerging bond or currency markets. As shown in Table 2, across the sample period as a whole, stock markets are highly interdependent. This is very much in line with expectations as stock markets in both advanced and emerging economies have become more financially integrated over the past decade or so. Across both advanced and emerging economies, local equity returns are closely linked with global stock market developments over the sample period. As regards cross-market effects, there is only sporadic evidence of interdependence between global bonds and local equities. By contrast, there appears to be more interdependence between global exchange rates and local stocks, particularly in Emerging Asia and the advanced euro area economies.

As regards contagion, Table 2 indicates evidence of within-market contagion effects in the cases of Latin America and Emerging Asia, implying that in times of financial turbulence, there is a change in the transmission mechanism beyond interdependence between global and local stock markets. Our results would suggest, however, that the scale of effect in crisis times may not be sufficient to lead to substantial equity market disruptions and financial stability risks. Our approach also enables an assessment to be made of cross-market contagion effects, i.e. shift contagion from one asset class to a different asset class. Our results indicate that there exists strong evidence of cross-market contagion from global bonds to regional stocks in Central and Eastern Europe and the Middle East and Africa, whereby the transmission mechanism between global bonds and emerging stock markets in these regions is only significant in crisis times. This applies to China, Singapore, the Czech Republic, Poland, Romania, Slovakia, Slovenia, Ukraine, Bahrain, Egypt, and Jordan. As a result, these emerging stock markets may be particularly vulnerable to global bond market developments. Finally, on the cross-market contagion effects, there is some evidence of a change in the transmission mechanism in crisis times as regards linkages between global exchange rates and EME domestic stocks in Korea, Thailand, Hungary, Slovenia, Ukraine, and Bahrain, although the magnitude of these effects is very low.

As the coefficients in Table 2 can be interpreted as impact elasticities between domestic and global asset markets, if these elasticities are above one, this implies that there is a more than proportionate effect by global stock market movements on local stocks. This is the case for major emerging markets in Latin America, as well as a number of euro area advanced economies. Where the elasticities are below one, this is an indication that local stock markets react less proportionately to changes in global stock markets. This is the case for economies in Emerging Asia, the Middle East, and major advanced economies outside of the euro area regions. This could be indicative of the autarky of some local stock markets. Ehrmann, Fratzscher, and Rigobon (2011) have previously found that the U.S. market is found to be a transmitter rather than a receiver of financial market spillovers. The cross-market elasticities between local stocks and global bonds and exchange rates are largely all below one. This reinforces our finding that local stock markets are less affected by movements coming from global bond and currency markets.

As regards the direction of the interdependence and contagion effects on local stock markets, we find that interdependence relationships are positive for both within-markets and cross-markets. Within-market contagion effects are mostly negative however. This implies that the change in the transmission mechanism from global stocks to local stocks dampens rather than amplifies the level of the overall effect. Also, where there exists an effect only in crisis times, the negative effect implies that global stock markets interact with local stock markets inversely in crisis times. These negative within-market coefficients are mostly apparent in emerging economies, implying that in times of crisis where global stock markets may experience negative shocks, local emerging stock markets may experience positive effects that may be related to investors searching for yield. The direction of the contagion cross-market effects, i.e. from global bond and currencies to local stocks, is much more heterogeneous across countries and regions. For global bonds to local stocks, the effect is mostly positive in the Central and Eastern Europe and Middle East and Africa regions. This may indicate that in times of financial turbulence in global bond markets (i.e. increases in yields), investors may prefer to diversify into other asset classes such as equity. Interestingly, the interdependence relationship between global currency markets and local stocks is in general positive. However, in the cases of France, Germany, Netherlands, Estonia, New Zealand, Sweden, and Switzerland it is negative. This means if the global currency basket depreciates these currencies tend to appreciate.

Turning to the assessment of the transmission mechanism between global asset markets and domestic government bond markets, Table 3 indicates that there is strong evidence of within-market interdependence for all advanced economy regions. As regards the emerging economies, within-market interdependence appears to be a feature of economies that have more liquid local bond markets, such as Hong Kong, Singapore, Poland, Slovakia and South Africa for example. Generally, the degree to which the local bond market is developed also drives the cross-market transmission mechanism. In the case of EMEs, there is only very marginal evidence of a transmission across the sample period from global stocks and currencies to local bonds. Turning to within-market contagion effects for the bond market, Table 3 shows that the transmission process only functions in crisis times for Mexico, Venezuela, and the Philippines, providing clear evidence of shift contagion for these EMEs. Some EME bond markets appear to be vulnerable to contagion from global equities and currencies, e.g. Mexico, Hong Kong, Russia and Poland in the former, and Brazil as regards the latter.

The within-market impact elasticities (i.e. between global bonds and local bonds) are usually above one, indicating a more than proportionate reaction of local bonds to global bond market changes. We also find cross-market elasticities (i.e. between global stocks and local bonds, and global currencies and local bonds) to be higher than one, especially between local bond returns and foreign exchange rate returns. The local bond markets in Ireland, Spain, the United States, and especially in Hong Kong and Russia tend to be extremely sensitive to changes in global currency markets.

The direction of the interdependence within-market effect is positive, as expected. Cross-market interdependence effects are negative however. Our results suggest therefore that, on average, investors prefer to diversify portfolios across bonds on the one hand, and equities and currencies on the other. Looking at contagion effects between global and domestic bonds, a negative coefficient would suggest that in times of financial distress in global bond markets, local bond yields are compressed, implying that bonds may be subject to safe haven flows in crisis times. Such negative coefficients are found across advanced economies in the

cases of Denmark, Japan, and the US. As regards cross-market contagion, a positive coefficient is found for the crisis-time interaction between global stocks and domestic bonds in the case of emerging economies, while the effect in largely negative in the case of advanced economies. Therefore, in times of financial stress in the case of global stock markets, emerging market bond yields fall while yields in advanced economies rise. That said, the effect is much more prevalent across countries for the advanced economies. This implication may be that stress in global stock markets spills over more to local advanced economy bonds than local emerging economy bonds, and the contemporaneous impact from global stocks is transmitted to local advanced economy bonds negatively. This suggests that advanced economy bonds are more susceptible than emerging economy bonds to investor risk aversion coming from stress in global stock markets. Cross-market contagion from global currencies to local bonds, as in the case of global currencies to local stocks, is predominantly absent and very low in terms of the magnitude of the effect.

Table 4 outlines the global effect on domestic exchange rates. Across all advanced economies except Iceland and across about half of emerging economies, a significant within-market (i.e. from global to domestic exchange rates) interdependence relationship can be seen. Interestingly, however, the transmission mechanism between global stock markets and domestic currencies is much more prevalent for emerging economies than the within-market interdependence. Therefore, , emerging market currencies appear on average to be more closely related to global stock market developments than global exchange rate developments. In relation to contagion, while there are very few cases of a change in the transmission mechanism in crisis times within the currency market, shift contagion is apparent from global to domestic currencies in the cases of Hong Kong, Korea, Thailand, Slovakia, and Australia, although the magnitudes are extremely small. As regards cross-market contagion from global stocks to domestic currency markets, this is not so prevalent across countries, although it is notable that the Korean exchange rate appears to be susceptible to contagion effects from global stocks. Contagion from global bonds to local currencies is more apparent than from global stocks to local currencies however, particularly in the Central and Eastern European and the Middle East and Africa regions.

Within-market interdependence (i.e. between global and local currencies) is positive, and in many cases close to one, implying full pass-through between global and local currencies in . As regards cross-market interdependence, global spillovers from stocks to local currencies in emerging markets exhibit positive effects, while in advanced economies negative coefficients are observed. This implies that rises in global stock market returns are associated with appreciating currencies in emerging economies but depreciating currencies in advanced economies. This may be related to equity flows into emerging economies, which can exert upward pressure on exchange rates. As regards the interaction between the global bond market and the local currency market, the relationship is most apparent for emerging economies and primarily negative. The explanation of this result may also be linked to capital flows, whereby compressed global bond yields push capital in the form of bond flows to emerging markets, leading to local currency appreciation. In relation to contagion effects from global bonds to local currencies, the direction of the effect is predominantly positive across both emerging and advanced economies. This suggest that in times of global financial stress, rises in global bond yields have depreciating effects on local currencies, perhaps related to rising risk aversion and bond outflows during periods of global financial tensions.

5.2 Impulse response function analysis

In this section, the GIRFs are presented to illustrate the effect of advanced economy asset market shocks on equity, bond and currency markets for a range of advanced and emerging economy regions. The results are presented at the regional level for clarity of exposition.[16] The impulse responses are shown over the sample period and for the change in the effect during the crisis period enabling an assessment to be made of differences in sensitivities of regional asset markets in alternative states of the world.[17] The main focus of the impulse response function analysis is to show how the transmission mechanism across asset classes and regions may change during a crisis period. To this end, we focus on shocks that emanate in advanced economies, in particular the US, which is consistent with the literature that financial market linkages globally are dominated by the US (e.g. see Ehrmann, Fratzscher, and Rigobon (2011)). We also examine how asset market shocks emanating in the euro area are transmitted globally.

In general our estimated GVAR model is stable. In all cases the eigenvalues are below one implying a stable system in crisis times and throughout the whole sample. When we apply the measure of overall persistence, such as that carried out in Chudik and Fratzscher (2011b) which is based on the estimated eigenvalues,

$$\mathrm{P}_{s,t} = \frac{1}{n_\lambda} \sum_{i=1}^{n_\lambda} (\hat{\lambda}_{s,i})^t, \qquad \text{for } t = 1,2,\dots, \tag{11}$$

where $s \in \{crisis, average\}$ denotes the state of the economy, t is the time horizon, $\hat{\lambda}_{s,i}$ is the i-th estimated eigenvalue and n_λ is the number of eigenvalues, we see that overall persistence is notably higher in crisis periods (see Fig. 1 and 2). Due to larger volatility of returns in crisis times we would expect stronger persistence in periods of financial distress.

[Fig. 1 to 2]

Turning our analysis to the impulse responses, in the first sub-section one can see the response of regional equities to shocks imposed on advanced economy asset markets. This is followed by an assessment, in turn, of the response of regional bonds and regional currencies to advanced economy asset market shocks.[18]

[Fig. 3 to 8]

5.2.1 Responses to advanced economy asset market shocks on regional equities

Overall, the results from the GIRFs indicate that regional financial markets are very notably more sensitive to a global shock during periods of financial distress, resulting in a much more amplified effect on regional equities, bonds and currencies. In the case of a shock originating

[16] Please note that the country-specific GIRFs are not presented for brevity reasons but are available from the authors upon request.
[17] We also provided confidence bands for the GIRFs based on 2000 bootstrapped estimations (25%-75% bounds).
[18] The results are presented in Fig. 3 to 8 for the GIRFs that are mostly statistically significant across regions, while a discussion is provided of the other impulse responses.

in the US equity market, the within-market (i.e. from the US equity market to regional equity markets) impulse response functions are greater in magnitude in crisis times by a factor of about four across regions (see Fig. 3). As can be seen from Fig. 3, the response of regional equities to a negative shock on the US equity market is notably more pronounced across all advanced and emerging economies during the crisis period.

That said, the reaction is different depending on whether the equity shock emanates from the US or the euro area. A US equity market shock leads to a deterioration across all regional stock markets. On the other hand, an equity market shock coming from advanced euro area economies negatively affects equity returns on average across the sample period, primarily in relation to the own-market effect. In the crisis period, a positive (but insignificant) effect on equity returns is found across all regions excluding the own-market effect. The lack of significance underlines the dominant global role played by the US equity market in affecting other regional equity markets as opposed to the euro area equity market. Turning to the response of regional equity markets to advanced economy bond yield shocks, a similar pattern in terms of the direction of the effect can be observed regardless of the source of the shock. In particular, across the sample as a whole, an advanced economy bond market shock (i.e. a rise in yields) leads to a fall in regional equity market returns. This may be related to general market uncertainty which can cause disruptions across all asset markets. However, in crisis times, such a shock increases equity returns across all other regions. The response in crisis times suggests that more pronounced market fears may be prevalent, leading to flight out of bonds and into other asset classes such as equity. However, this effect is not significant either for US or euro area bond market shocks.

5.2.2 Responses to advanced economy asset market shocks on regional bonds

The response of regional bond yields to a US equity market downturn is heterogeneous across regions (see Fig. 4). While there is no effect of a US stock market shock on regional bonds in the Middle East and Africa, a positive effect (i.e. rising bond yields) is found in the cases of Latin America and Central and Eastern Europe in all states of the world. The implication here is that US equity market downturns negatively affect the risk profile attached to bonds in Latin America and Central and Eastern Europe. By contrast, a negative US stock market shock increases the attractiveness of bonds in Emerging Asia and the advanced economies. This effect is particularly pronounced in times of global financial turbulence, suggesting that Emerging Asian and other advanced economy bonds may act as a safe haven for investors in periods of turbulence emanating in the US stock market. In the case of a shock emanating in the euro area equity market, the rise in yields is only passed on significantly in crisis times to Central and Eastern Europe. Euro area equity market shocks lead to no significant reaction in the bond markets of other advanced or emerging market regions.

A bond market shock emanating in either the US or the euro area leads to a similar response across regional bond markets, whereby the rise in yields is largely transmitted positively (see Fig. 5 and Fig. 6). There are some differences however. Euro area bond market shocks appear to mostly lead to rises in bond yields in advanced economies. Interestingly, however, bond yields in Central and Eastern Europe and Emerging Asia decline following a positive shock to euro area bond yields. For US bond yield shocks, this leads to rises in yields across all bond markets, excluding Emerging Asia. Our results for the euro area as a whole are consistent with those for a bond yield shock imposed on euro area countries facing sovereign debt pressures in the 2010-2011 period as regards the response by emerging market bonds

(see Fig. 7).[19] Overall, one implication is that an advanced economy bond market shock may lead to bond inflows to Central and Eastern Europe (for euro area shocks) and Emerging Asia (for US and euro area shocks) as investors rebalance their portfolios. The magnitude of the response is higher in crisis times by a factor of about two.

5.2.3 Responses to advanced economy asset market shocks on regional currencies

As regards the effect on regional currencies, a US stock market downturn leads to notable currency depreciations across advanced and emerging economy regions in times of global financial distress (see Fig. 8). This supports the view that negative shocks to the US stock market spillover to currencies across all regions. By contrast, a euro area stock market shock, a US bond market shock, and a euro area bond market shock lead to notable currency appreciations in crisis times across regions, though these effects are not always statistically significant. Nonetheless, this may tentatively suggest that portfolio rebalancing may be taking place in periods of crisis, whereby investors shift funds out of equities and into currencies (or bonds). In the case of the euro area stock market shock in crisis times, the response by regional currencies is to appreciate, and this may be related to equity outflows from the euro area in crisis times, whereby equity flows to other regions appreciate domestic currencies. Regional currencies react very similarly to bond shocks whether they originate in the US or the euro area, in both cases leading to currency appreciations.

6. CONCLUSIONS

Using a GVAR across over 60 economies over the period 1998 to 2011, this paper provides a comprehensive assessment of the interaction amongst asset classes (equities, bonds and currencies), in particular focusing on how the transmission mechanism between these assets may change during a crisis period. We have defined interdependence as the relationship that exists between asset classes on average over the sample period. Contagion is defined as a change in the transmission mechanism between asset classes in crisis times. Overall our findings indicate that emerging economy equity markets are much more integrated to global equity markets than the integration of emerging bond markets with global bond markets and the integration of emerging currency market with global currency markets.

In line with previous literature, we find that interdependence is most notable across advanced and emerging economies in the case of the equity market. Indeed, our study affirms this more comprehensively as we have also controlled for interactions across other asset classes. Contagion effects within the stock market are most apparent in Latin America and Emerging Asia. Interestingly, however, we also find evidence of contagion from global bonds to regional stocks in Central and Eastern Europe and the Middle East and Africa. As regards the government bond market, interdependence within the bond market largely only applies to the advanced economies, although there are some cases of interdependence in emerging economies with relatively liquid bond markets (such as Hong Kong, Singapore, and South Africa for example). As regards bond market contagion, clear evidence of this is found for Mexico, Venezuela and the Philippines. Cross-market interdependence and contagion from global equities and global currencies to local bonds is not prevalent. That said, there is some

[19] The euro area countries facing sovereign debt problems in our sample are Greece, Ireland, Portugal, Spain and Italy (GIPSI).

evidence of cross-market contagion from global equities to local bonds in Mexico, Hong Kong, Russia and Poland, and from global currencies to local bonds in the case of Brazil.

As regards exchange rates, interdependence is a key feature of advanced economies. In the case of emerging economies, however, interdependence is more prevalent between global equities and local currencies than global currencies and local currencies. On contagion, there is some evidence that domestic currencies in Hong Kong, Korea, Thailand, Slovakia and Australia may be susceptible to financial turbulence in global currency markets. The impulse response function analysis demonstrated that the relationship amongst asset classes differs in crisis times. The response to shocks is much higher in magnitude and also more persistent in crisis times. In addition, the response to shocks may differ depending on the origin of the disturbance. For example, a US equity market shock leads to a deterioration of all regional equity markets in crisis times. A euro area stock market shock in crisis times, however, boosts regional stock markets, although this effect is not significant. As a result, it appears that a US equity shock negatively affects investor confidence in the stock market generally, while this is not the case for a euro area equity shock. The response of regional equities to advanced economy bond shocks (US or euro area) are comparable however. The effect is not significant regardless of the origin of the shock, both on average and in a crisis period.

Responses by regional bond markets to advanced economy equity market shocks are more regionally heterogeneous than the reaction of regional equity markets. Our results indicate that an equity market shock originating in the US leads to a deterioration of the bond market (i.e. rising yields) in Latin America and Central and Eastern Europe. The same shock, however, reduces bond yields in Emerging Asia and other advanced economies. Finally, US equity market shocks tend to lead to currency depreciations globally in times of financial distress. On the other hand, a euro area equity shock, however, leads to currency appreciations in other regions in crisis times, although this effect is not always significant. On advanced economy bond market shocks, these are transmitted largely similarly to other regional bond markets regardless of the origin of the shock. An interesting finding therefore is that in times of global financial distress, particular attention needs to be paid to asset market shocks that emanate in the US. Such shocks are transmitted globally and in a negative direction within-market in the case of US equity and bond shocks as well as cross-market from US equity shocks to global currencies and global bonds. On the other hand, the negative effects of euro area shocks mainly relate to bond market shocks and are largely confined to spillovers to advanced economy bond markets.

The analysis carried out has a number of implications of interest to policymakers. Our findings provide an insight into country-specific and region-specific financial vulnerabilities in times of global financial turbulence. In order to derive appropriate policy responses, it is crucial that policymakers understand the source and nature of financial exposures. The results from this paper may also have implications for investors in relation to portfolio rebalancing and the construction of optimal portfolio diversification strategies at the country and regional levels.

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Table 1 Countries/Regions

Euro area Advanced	Other Advanced	Middle East & Africa	Central & Eastern Europe	Emerging Asia	Latin America
AUSTRIA	AUSTRALIA	BAHRAIN	BULGARIA	CHINA	ARGENTINA
BELGIUM	CANADA	EGYPT	CROATIA	HONG KONG	BRAZIL
FINLAND	DENMARK	IRAN	CZECH REP.	INDIA	CHILE
FRANCE	ICELAND	JORDAN	ESTONIA	INDONESIA	COLUMBIA
GERMANY	JAPAN	KUWAIT	HUNGARY	KOREA	ECUADOR
NETHERLANDS	NEW ZEALAND	LEBANON	POLAND	MALAYSIA	MEXICO
GREECE	NORWAY	OMAN	ROMANIA	PHILIPPINES	PERU
ITALY	SWEDEN	TUNISIA	SLOVAKIA	SINGAPORE	VENEZUELA
PORTUGAL	SWITZERLAND	ISRAEL	SLOVENIA	SRI LANKA	
SPAIN	UNITED KINGDOM	SOUTH AFRICA	TURKEY	THAILAND	
IRELAND	UNITED STATES		RUSSIA	PAKISTAN	
			UKRAINE		

Table 2 Global Asset Spillovers on Domestic Stocks

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Latin American economies						
Argentina	1.052 ***	-0.059 *	-0.004	0.208	0.375 **	0.004
Brazil	1.283 ***	-0.005	-0.037 **	-0.092	0.465 **	0.001
Chile	0.254 ***	-0.006	0.006	-0.181	-0.237	0.002
Colombia	0.193 **	-0.015	-0.014	-0.188	0.134	0.001
Ecuador	-0.063	-0.034 *	-0.020	0.085	0.026	0.000
Mexico	1.091 ***	-0.013 *	0.003	-0.149	0.134	-0.001
Peru	0.502 ***	-0.003	0.032 **	0.115	0.323	0.000
Venezuela	0.392 ***	-0.032 **	-0.006	0.122	0.169	-0.003
Emerging Asian economies						
China	-0.125	-0.001	-0.004	-0.588 *	0.655 **	-0.005
Hong Kong	0.168 **	-0.060 ***	0.038	0.069	1.342 ***	0.002
India	1.034 ***	-0.020	0.017	-0.030	0.521 ***	0.001
Indonesia	0.976 ***	-0.044	0.050	0.182	0.954 ***	0.000
Korea	1.296 ***	-0.031	0.018	0.007	0.498	0.005 **
Malaysia	0.720 ***	0.007	0.034	0.068	0.366	0.001
Philippines	0.884 ***	-0.020	0.026	0.071	0.374 ***	0.002
Singapore	1.001 ***	-0.021 *	0.009	0.398 **	0.061	0.002
Sri Lanka	0.017	-0.003	0.009	0.237	-0.125	0.004
Thailand	1.200 ***	-0.060 ***	0.015	0.072	0.558 **	0.004 **
Pakistan	0.176	0.034	-0.051	-0.349	0.179	0.000
Central and Eastern Europe						
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	0.434 **	0.032 *	0.017	0.375 **	-0.148	-0.003
Czech Republic	0.891 ***	-0.016	-0.005	-0.187 **	0.115	0.000
Estonia	0.422 ***	-0.015	0.031 **	0.122	-0.419 **	0.000
Hungary	1.165 ***	-0.001	-0.022	-0.056	0.384 ***	0.004 **
Poland	0.951 ***	-0.021	-0.006	-0.151 *	0.111	0.002
Romania	0.487 ***	-0.005	-0.035	0.245 *	0.377 ***	-0.006
Slovakia	0.066	-0.003	-0.008	0.189 *	-0.003	0.000
Slovenia	0.029	0.017	0.018	0.204 **	-0.059	-0.006 **
Turkey	1.562 ***	-0.038	-0.025	0.112	0.022	0.005
Russia	1.676 ***	-0.019	0.041	-0.062	0.411	0.001
Ukraine	0.114	-0.005	-0.014	0.415 ***	0.582 ***	-0.010 **
Middle East and Africa						
Bahrain	0.056	0.010	0.003	0.229 ***	-0.011	-0.003 **
Egypt	0.314 ***	0.009	-0.011	0.372 **	0.367 ***	-0.004
Iran	0.025	0.015	0.011	0.094	-0.109	0.001
Jordan	0.086	0.022	-0.002	0.450 **	0.082	-0.002
Kuwait	0.137 **	0.017	-0.004	0.125	-0.207	-0.002
Lebanon	n/a	n/a	n/a	n/a	n/a	n/a
Oman	0.042	0.026	-0.020	0.168	-0.116	-0.002
Tunisia	-0.012	0.018 **	0.018 **	0.050	-0.073	0.001
Israel	0.674 ***	0.015	-0.014	0.114	0.043	0.003
South Africa	1.062 ***	-0.016	0.014	-0.090	0.292 **	-0.001
Euro Area Advanced						
Austria	0.643 ***	-0.013	0.016	0.030	0.251 ***	-0.002
Belgium	0.753 ***	-0.018 **	-0.007	0.014	0.035	-0.002
Finland	1.321 ***	-0.004	-0.025 **	-0.304 **	0.158	0.003
France	1.188 ***	-0.002	-0.003	0.017	-0.097 **	0.000
Germany	1.215 ***	0.019 ***	0.008	-0.001	-0.149 **	0.000
Netherlands	1.087 ***	-0.008	0.019 ***	-0.081	-0.183 ***	-0.001
Greece	0.936 ***	0.032 *	-0.023	-0.125	0.433 ***	-0.002
Ireland	0.894 ***	-0.004	0.013	-0.166 *	0.011	-0.003
Portugal	0.702 ***	0.001	0.009	0.064	0.148 **	0.000
Spain	1.072 ***	0.000	-0.012	0.088	0.162	0.002
Italy	1.103 ***	-0.003	0.007	-0.040	-0.079	0.001
Other Advanced						
Australia	0.633 ***	0.008	0.003	-0.096	-0.026	0.000
Canada	0.011	-0.022 *	0.014	-0.497 *	0.121	-0.001
Denmark	0.723 ***	-0.015	-0.016	-0.129 **	0.022	-0.002
Iceland	0.206 ***	-0.030	0.001	-0.202	0.027	-0.011 **
Japan	0.840 ***	0.002	0.052 ***	0.214	0.187	-0.002
New Zealand	0.448 ***	-0.007	0.016	0.058	-0.224 **	0.000
Norway	1.007 ***	0.023 **	0.018	-0.155 **	0.222 **	-0.001
Sweden	1.321 ***	0.008	0.008	-0.114 *	-0.034	0.002
Switzerland	0.892 ***	0.003	0.014	-0.019	-0.095 ***	0.000
United Kingdom	0.931 ***	-0.011 *	0.001	0.009	0.008	0.001
United States	0.796 ***	0.014	-0.027	-0.134	0.331 **	0.002 *

Table 3 Global Asset Spillovers on Domestic Bonds

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Latin American economies						
Argentina	n/a	n/a	n/a	n/a	n/a	n/a
Brazil	-0.302 **	0.015	-0.005	0.123	-0.297	-0.006 *
Chile	n/a	n/a	n/a	n/a	n/a	n/a
Colombia	-0.208	0.130	0.003	-0.027	0.488	-0.003
Ecuador	n/a	n/a	n/a	n/a	n/a	n/a
Mexico	-0.201	0.046 ***	0.023	-0.539 **	0.518	-0.003
Peru	n/a	n/a	n/a	n/a	n/a	n/a
Venezuela	-0.110	0.038 *	0.016	0.462 **	-0.803 **	0.004
Emerging Asian economies						
China	n/a	n/a	n/a	n/a	n/a	n/a
Hong Kong	0.025	0.432 ***	0.718 ***	-0.640	-10.148 ***	0.009
India	-0.627	0.147	0.054	1.151	0.765	-0.023
Indonesia	n/a	n/a	n/a	n/a	n/a	n/a
Korea	n/a	n/a	n/a	n/a	n/a	n/a
Malaysia	n/a	n/a	n/a	n/a	n/a	n/a
Philippines	0.076	-0.205	0.068	3.191 *	3.121	-0.009
Singapore	0.066	0.022	0.129 ***	-0.065	-0.575 **	-0.005
Sri Lanka	n/a	n/a	n/a	n/a	n/a	n/a
Thailand	n/a	n/a	n/a	n/a	n/a	n/a
Pakistan	n/a	n/a	n/a	n/a	n/a	n/a
Central and Eastern Europe						
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a
Estonia	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	-0.272 ***	0.025	0.021	0.016	-0.346 ***	-0.001
Poland	-0.023	0.187 ***	0.065 ***	-0.313	0.162	0.005
Romania	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	-4.571 ***	1.060	1.475 ***	-2.677	14.255	-0.001
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a
Turkey	n/a	n/a	n/a	n/a	n/a	n/a
Russia	-1.134	0.650 ***	1.447	4.696	4.489 ***	-0.090
Ukraine	n/a	n/a	n/a	n/a	n/a	n/a
Middle East and Africa						
Bahrain	n/a	n/a	n/a	n/a	n/a	n/a
Egypt	n/a	n/a	n/a	n/a	n/a	n/a
Iran	n/a	n/a	n/a	n/a	n/a	n/a
Jordan	n/a	n/a	n/a	n/a	n/a	n/a
Kuwait	n/a	n/a	n/a	n/a	n/a	n/a
Lebanon	n/a	n/a	n/a	n/a	n/a	n/a
Oman	n/a	n/a	n/a	n/a	n/a	n/a
Tunisia	n/a	n/a	n/a	n/a	n/a	n/a
Israel	n/a	n/a	n/a	n/a	n/a	n/a
South Africa	-0.109 **	0.019 *	0.036 ***	0.098	-0.264 ***	0.000
Euro Area Advanced						
Austria	0.033	-0.082 ***	1.027 ***	-0.178	-0.439 **	0.001
Belgium	-0.046	-0.021	1.043 ***	0.054	-0.361 **	0.001
Finland	0.197	-0.092 **	0.575 ***	0.521 *	-0.686 **	0.001
France	0.077	0.073 ***	1.022 ***	-0.046	0.436 **	0.000
Germany	0.147	0.072 *	0.983 ***	0.243	0.153	0.001
Netherlands	-0.028	-0.107 ***	1.010 ***	-0.134	-0.261	0.003
Greece	-1.491 ***	0.055	0.862 ***	-0.048	-0.215	0.010
Ireland	-0.617	0.010	0.839 ***	0.424	-1.652	-0.006
Portugal	-0.195	0.026	1.149 ***	-0.523	0.688	0.005
Spain	-0.479 ***	-0.096 ***	1.087 ***	0.090	-1.395 ***	-0.003
Italy	-0.359 **	-0.105 ***	0.982 ***	-0.365	-0.684 ***	0.000
Other Advanced						
Australia	0.113	0.148 **	1.291 ***	0.310	-1.210	0.006
Canada	-0.374	-0.002	0.824 ***	0.113	-0.850 ***	-0.001
Denmark	-0.066	0.032	1.065 ***	-0.281 *	0.467 ***	0.002
Iceland	n/a	n/a	n/a	n/a	n/a	n/a
Japan	0.046	0.025	0.238 ***	-1.271 ***	0.491	-0.002
New Zealand	-0.265	0.133 ***	1.092 ***	0.326	-0.432	0.001
Norway	-0.581 **	-0.037	1.004 ***	0.046	0.046	-0.008
Sweden	-0.129	-0.016	1.107 ***	0.377 *	0.293	0.003
Switzerland	0.209 ***	0.028	0.660 ***	-0.047	-0.088	0.000
United Kingdom	0.091	-0.054	1.125 ***	0.065	0.148	0.004
United States	0.649 ***	-0.191 ***	1.766 ***	-0.845 *	-1.199 ***	0.012 **

Table 4 Global Asset Spillovers on Domestic Exchange Rates

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Latin American economies						
Argentina	0.066 ***	-0.002	-0.021	0.041	0.213 **	0.000
Brazil	0.456 ***	0.002	-0.006	0.017	0.699 ***	0.002
Chile	0.172 ***	-0.003	0.011	0.079	0.705	0.001
Colombia	0.188 ***	0.003	0.002	0.103	0.150	0.001
Ecuador	n/a	n/a	n/a	n/a	n/a	n/a
Mexico	0.236 ***	0.002	-0.002	-0.011	0.197 **	0.000
Peru	0.036 ***	-0.002	-0.003 **	0.079	0.045	0.000
Venezuela	0.086	0.000	-0.004	-0.084	-0.159	0.003
Emerging Asian economies						
China	0.005	0.001	-0.001	-0.008	0.055 **	0.000
Hong Kong	0.002	0.000	0.001	-0.010	0.042 ***	0.000 *
India	0.077 ***	0.001	0.007	0.085 *	0.276 ***	0.000
Indonesia	0.190 ***	0.001	0.020	0.291	1.077 ***	-0.001
Korea	0.152 ***	-0.020 *	0.014	0.097	0.774	-0.001 **
Malaysia	0.063 ***	-0.004	0.014	0.074	0.312	-0.003
Philippines	0.138 ***	-0.002	0.008	0.019	0.412 ***	0.001
Singapore	0.027	0.002	-0.003	0.016	0.808 ***	0.000
Sri Lanka	-0.018	0.003	-0.008 ***	0.050	0.057	0.000
Thailand	0.065 ***	-0.002	-0.003	0.039	0.581 **	0.000 **
Pakistan	0.038	-0.001	0.002	0.038	0.081	0.000
Central and Eastern Europe						
Bulgaria	-0.040	0.009	0.002	0.155 ***	0.835 ***	-0.001
Croatia	-0.031 **	0.010 *	-0.004	0.065 **	0.971	0.000
Czech Republic	0.029 ***	0.010	-0.009	-0.011	1.171	-0.001
Estonia	-0.039 ***	0.005	-0.002 **	0.146	0.606	0.000
Hungary	0.112 ***	0.004	-0.015 **	0.048	1.195 ***	0.000
Poland	0.235 ***	-0.001	-0.014 ***	0.009	0.969 ***	0.000
Romania	0.084 ***	-0.002	-0.001	0.059 *	0.721 ***	0.000
Slovakia	0.043	-0.006	0.005	0.054	1.025 ***	0.001 *
Slovenia	-0.045 ***	0.001	0.001	0.016 **	1.091	0.000
Turkey	0.372 ***	0.006	-0.016	0.163	0.506	0.004
Russia	0.266	-0.020	0.010	0.089	-0.086	0.002
Ukraine	n/a	n/a	n/a	n/a	n/a	n/a
Middle East and Africa						
Bahrain	-0.001	0.000	0.000	0.001 ***	0.001	0.000
Egypt	-0.004 ***	0.000	0.000	0.000 **	0.016 ***	-0.001
Iran	-0.023	-0.012	0.006	0.044	0.208	0.004
Jordan	0.005	0.001	-0.001 **	0.007 **	-0.010	0.000
Kuwait	-0.021 ***	0.001	0.001	0.023	0.182	0.000
Lebanon	0.002	0.000	0.001	-0.008	0.016 ***	0.000
Oman	n/a	n/a	n/a	n/a	n/a	n/a
Tunisia	-0.029 **	-0.006 **	0.000 **	0.011	0.494	0.000
Israel	-0.060 ***	-0.005	-0.003	-0.023	0.891	0.000
South Africa	0.205 ***	-0.017	0.015 ***	0.066	0.469 ***	-0.001
Euro Area Advanced						
Austria	-0.036 ***	0.002	0.000	-0.002	1.126 ***	0.000
Belgium	-0.043 ***	0.000	0.001	-0.011 *	1.267 ***	0.000
Finland	-0.019	0.014 *	-0.003	0.183 **	0.811 ***	0.000
France	-0.045 ***	0.001	0.001	-0.009	1.294 ***	0.000
Germany	-0.073 ***	0.003	-0.001	0.007	1.289 ***	0.000
Netherlands	-0.054 ***	0.001	0.000	0.005	1.313 ***	0.000
Greece	-0.031 ***	0.007 *	-0.002	0.059	1.132 ***	0.000
Ireland	0.143 ***	0.000	-0.013	-0.012	0.270 ***	0.000
Portugal	0.027 ***	0.004	0.002	-0.004	-0.668 ***	0.000
Spain	-0.061 ***	0.000	0.001	-0.011	1.463 ***	0.000
Italy	-0.062 ***	0.003	0.000	0.008	1.287 ***	0.000
Other Advanced						
Australia	0.173 ***	0.001	0.020 ***	0.169	1.394 ***	0.002 **
Canada	0.147 ***	-0.003	0.009 **	-0.060	0.668 ***	-0.001
Denmark	-0.066 ***	0.001	0.000	0.006	1.238 ***	0.000
Iceland	0.038 ***	-0.010	-0.007	-0.063	0.644	-0.002
Japan	-0.021	-0.002	-0.019	0.192	0.984 ***	0.000
New Zealand	0.060	0.007	0.011	0.161 **	1.441 ***	0.001
Norway	0.033	-0.003	0.005	-0.094 **	1.230 ***	0.000
Sweden	0.085 ***	0.003	0.002	-0.045	1.180 ***	0.000
Switzerland	-0.151 ***	0.000	0.003	0.042	1.158 ***	0.000
United Kingdom	-0.007	0.001	0.000	0.087 *	0.515 ***	-0.001

Fig. 1 Measure of overall persistence based on estimated eigenvalues for the GVAR model with regions

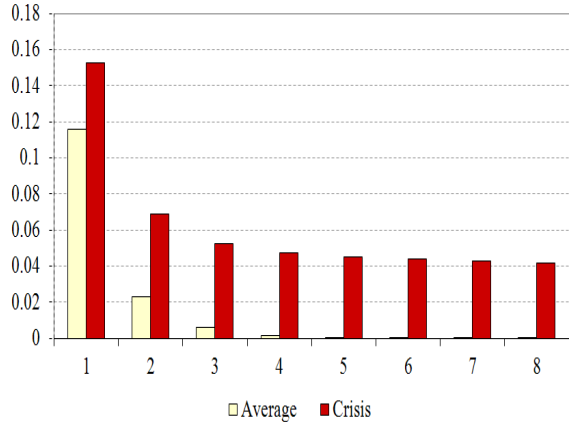


Fig. 2 Measure of overall persistence based on estimated eigenvalues for the country-by-country GVAR model

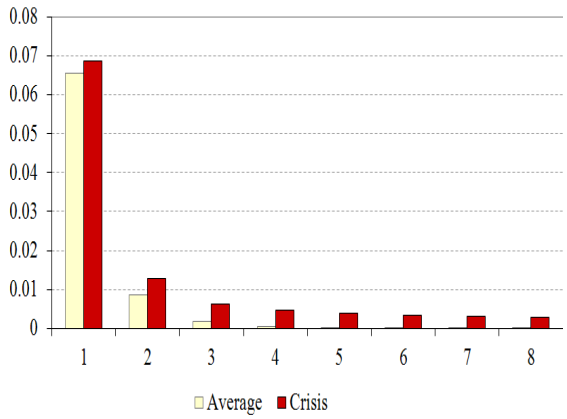


Fig. 3 Cumulative impact (four weeks) of a one standard deviation shock (negative) to US equity returns on regional equities

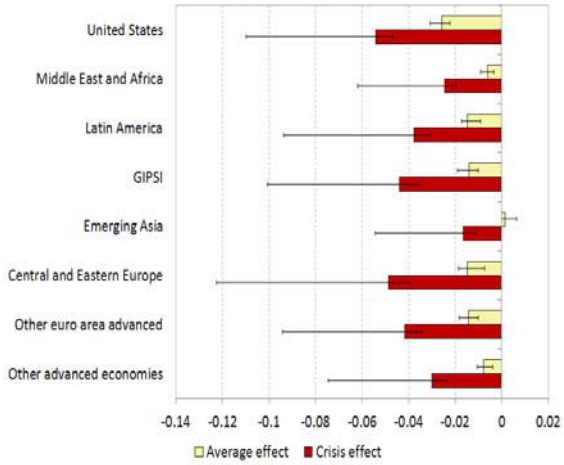


Fig. 4 Cumulative impact (four weeks) of a one standard deviation shock (negative) to US equity returns on regional bonds

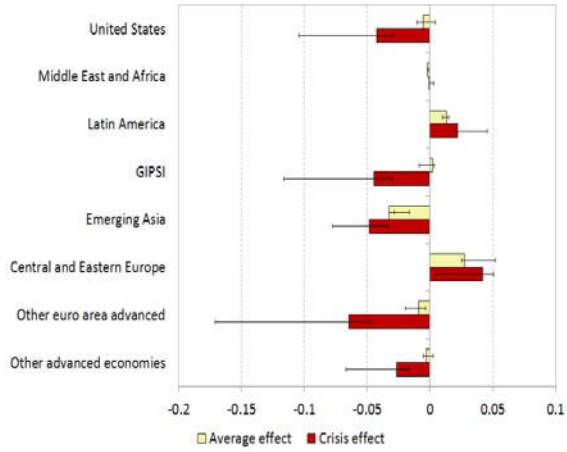


Fig. 5 Cumulative impact (four weeks) of a one standard deviation shock (positive) to US bond yields on regional bonds

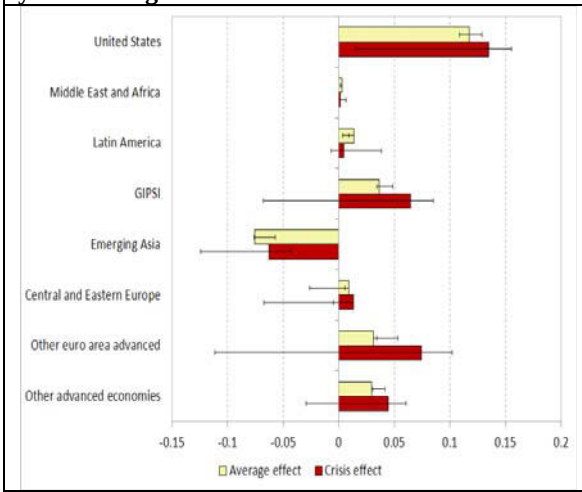


Fig. 6 Cumulative impact (four weeks) of a one standard deviation shock (positive) to euro area bond yields on regional bonds

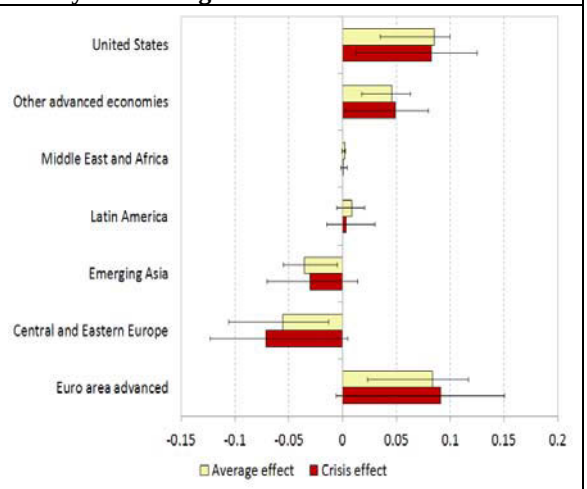


Fig. 7 Cumulative impact (four weeks) of a one standard deviation shock (positive) to GIPSI bond yields on regional bonds

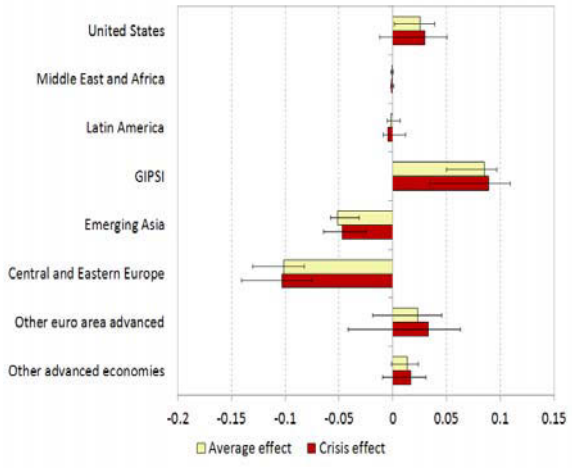
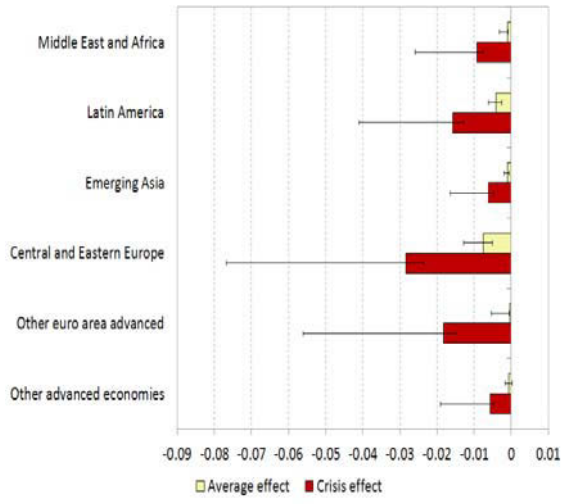


Fig. 8 Cumulative impact (four weeks) of a one standard deviation shock (negative) to US equity returns on regional currencies



APPENDIX

Contemporaneous elasticities of global on regional variables

Table A1 Global Asset Spillovers on Regional Stocks

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Advanced economies	0.777 ***	-0.004	0.022 **	0.024	-0.093	-0.001
Central and Eastern Europe	1.246 ***	-0.016	0.017	0.011	0.240	0.001
Emerging Asia	0.486 ***	-0.019	0.004	-0.151	0.488 ***	-0.002
Euro Area Advanced	0.886 ***	0.010	0.008	-0.139	0.271 **	0.000
Latin America	0.923 ***	-0.018 ***	-0.012	-0.028	0.059	0.001
Middle East and Africa	0.358 ***	0.011 *	0.003	0.141 **	0.116	0.000
USA	0.904 ***	0.021	-0.009	0.171	0.012	0.002

Table A2 Global Asset Spillovers on Regional Bonds

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Advanced economies	0.300 *	0.081 ***	0.418 ***	-0.645 **	-0.885 *	0.003
Central and Eastern Europe	0.199	0.506 ***	0.778	2.931	2.744	-0.060
Emerging Asia	-0.380	0.105	0.051	1.211	1.023	-0.022
Euro Area Advanced	0.341 *	-0.079	0.327 ***	0.029	-0.900 *	0.000
Latin America	-0.168 **	0.060 ***	0.017	0.291 *	-0.190	-0.004
Middle East and Africa	-0.097 **	0.009	0.028 ***	-0.002	-0.196 *	0.001
USA	1.774 ***	0.226 **	1.010 ***	-0.748	-3.358 ***	0.012

Table A3 Global Asset Spillovers on Regional Exchange Rates

	H1: Stock_average	*H2: Stock_crisis*	*H1: Bond_average*	*H2: Bond_crisis*	*H1: Exchange rate_average*	*H2: Exchange rate_crisis*
Advanced economies	0.006	-0.002	0.004	0.090 *	0.729 ***	0.000
Central and Eastern Europe	0.233 ***	-0.002	-0.034	0.034	0.453 **	0.001
Emerging Asia	0.062 ***	0.000	0.004 *	0.054 ***	0.168 ***	0.000
Euro Area Advanced	-0.018	0.014 **	-0.005	0.212 ***	0.603 **	0.000
Latin America	0.262 ***	0.002	-0.005	-0.003	0.234 ***	0.001
Middle East and Africa	0.050 ***	-0.002	0.002	0.016	0.303 ***	0.001