The role of financial conditions in transmitting external shocks ~~on~~to South Africa

Abstract: This paper analyses the spillover effects of external financial conditions onto South Africa using quarterly domestic and international data from 1996Q1 to 2014Q4. First, principal component analysis and vector autoregressive model are utilized to build financial conditions indices for South Africa and its main trading partners, namely, China, Germany, the United States, Japan, the United King, Netherlands, Italy, France and Belgium. Consistently across both methodologies, the financial conditions indices obtained track each other fairly well and capture the 2008/09 global financial crisis. Second, a Global Vector Autoregressive model comprised of financial indices and other macroeconomic variables is implemented to assess how international financial shocks spillover into South Africa. Our findings show that a sudden tightening of the US financial conditions has a significant but short lived effect on the South Africa's real GDP growth while the spillover effects from other trading partners appear to be of negligible impact throughout the sample period.

Keywords: Financial Conditions Index, Global Vector Autoregressive Model, Spillover Effects.

1. Introduction

The recent financial crisis has emphasized the importance and the effects of global economic and financial connectedness.[1] Kose & Prasad (2010), note that the 2008/09 global financial crisis has vividly thought us that financial markets around the world are closely tied together and shocks in one part of the global financial system can and often do have a large and immediate effects on other parts. Furthermore, they argue that crisis has been a bitter reminder that, for all their benefits, deeper trade and financial linkages can serve as a mechanism for magnifying shocks and intensifying their effects on the real side of the economy. It is therefore important for policymakers in South Africa (SA) to understand how external shocks from trading partners[2], particularly financial shocks, influence South Africa's macroeconomic variables.

Data from the International Monetary Fund (IMF) direction of trade statistics shows that South Africa's trade with its trading partners, namely, the Euro Area[3], China, the United States, Japan and the United Kingdom has increased over time. This data is plotted in Figures A1 and A2 in Appendix A and illustrates, firstly, that South Africa's trade with the Euro Area remain high compared to other trading partners albeit as a share of total trade has somehow slowed. Secondly and most notably is the increasing trade trend between South Africa and China which has materially surpassed that of the United States, Japan and the United Kingdom and now accounts for just above 30% of total trade. Figures A1 and A2 also demonstrate that even though in value terms South Africa's trade trend with the United States, Japan and the United Kingdom remain above 1998 levels, it has proportionally slowed.

As shown in figures A3 to A6 in the Appendix A, South Africa is also undeniably connected to the global economy through financial linkages arising from capital movements. Figure A3 indicates that total stock of both foreign liabilities and assets in South Africa has increased over time relative to GDP; reaching above 100% of GDP since 2010. The South African foreign assets stock also recently increased above 100% of GDP in 2013 and 2014. Figure A4 shows that post 1994, total net incurrence of liabilities increased significantly as a share of GDP reaching 10% and 11.3% of GDP in 1999 and 2006, respectively, before dropping to 2.2% of GDP in 2008 due to the 2008/09 crisis. It then stabilized around 5.8% of GDP between 2009 and 2015. Notably, these inflows are mainly

[1] The 2008 financial crisis which originated from the United States strongly affected emerging economies including South Africa. Since the 2008 financial crisis, SA growth contracted by 1.5 per cent in 2009 after growing by an average 4.2 per cent from 2000 to 2008. Five years after the 2009 recession, the South African economy has been struggling to grow at pre-crisis level, only growing at an average 2.4 per cent (calculations using South African Reserve Bank GDP data show).

[2] The analysis includes the main trading partners with leading currencies as the focus is on the financial transmission shocks.

3 For the Euro Area we have used data for five countries only; namely;, Germany, Netherlands, Belgium, Italy and France

driven by short term portfolio inflows searching for higher yields.[4] A similar trend emerges with net acquisitions of financial assets in Figure A5 where outflows are mainly driven by portfolio outflows. Figure A6 shows that the balance between net incurrence of liabilities and acquisition of assets has generally increased over time relative to GDP.

In light of the above it is apparent therefore that South Africa's degree of trade and financial openness has increased overtime and this motivates an investigation of the vulnerability of the South African economy to external shocks. If there is some degree of trade and financial linkages between South Africa and the rest of the world, then logically external shocks, both real and financial, would somehow be transmitted into South Africa. Enlightening examples are to be found during financial crises that emanate from the United States and propagate to the rest of the world including South Africa. For instance, as a result of the 2008/09 global financial crisis, South Africa's GDP growth contracted by 1.5% in 2009.

Several empirical studies, adopting different methodologies, have assessed the transmission of global financial shocks into South Africa. Ncube et al. (2012) apply a structural VAR model to assess how abrupt United States bond yield increases, monetary stimulus and federal funds rate tightening shocks spill over into South Africa. Fink & Schuler (2013) also employ a structural VAR model to evaluate international transmission of United States financial stress shocks to emerging market economies including South Africa. Akinci (2013) implements a panel structural VAR to investigate the extent to which United States global financial conditions (i.e. global risk free interest rate and global financial risk) and country spreads contribute to macroeconomic fluctuations in emerging markets, including South Africa.

Through acknowledging South Africa's increasing degree of trade and financial linkages, this paper attempts to examine how foreign financial shocks are transmitted into South Africa. To this end, we consider financial shocks as unexpected changes in Financial Conditions Index (FCI hereafter) of the aforementioned South Africa's trading partners. FCI is defined by Hatzius, et al. (2010) as the current state of financial variables that influence economic behavior and (thereby) the future state of the economy. In other words FCI is an aggregate measure of financial variables which can be used to assess current and future economic activity. Differently from previous studies on financial transmission shocks to South Africa, this paper considers a composite measure of financial conditions rather than narrowly defined financial measures such as interest rates, yields and credits (Ncube et al., 2012). A few exception includes Akinci (2013) who however makes use of a PVAR methodology which can only enable the study of the average cross-country response to external shocks. Unlike this set up, our methodology helps isolate the

[4] A closer look at the data showed that these inflows are mainly from the private non-banking sector with only a small share from the banking sector in a form of short term loans and deposits.

response of a single country to shocks emanating from a specific trading partner; hence allowing country specific policy implications..

Following a two-step procedure, we the first construct the FCI for South Africa and its trading partners based on the commonly used methodologies, the Vector Autoregressive (VAR) model and the Principal Component Analysis (PCA). In the second step, a Global Vector Autoregressive (GVAR) in the constructed FCI and other macroeconomic variables is used to assess the extent to which foreign financial shocks spill over into South Africa. Unlike standard VAR models, GVAR approach is able to deal with curse of data dimensionality while representing a resourceful tool for analyzing global macroeconomic and financial linkages through various channels.

Our findings show that a sudden tightening of the United States financial conditions has a significant but short lived effect on the South Africa's real GDP growth while the spillover effects from other trading partners appear to be of negligible impact throughout the sample period. Particularly, South Africa's real GDP growth falls for eight quarters, reaching the largest impact (-0.15) by the fourth quarter. Even though, in this paper, we focus on a broader measure of financial conditions instead of narrow measures of financial conditions such as short term interest rates, credit and yields, our results are more in line with findings of existing literature on financial spillovers from the United States to South Africa and are consistent with what happened during the 2008/09 global financial crisis. In terms of magnitude, South Africa's and China's response to the United States financial stress appear to be less than that of developed countries; possibly suggesting a strong contagion effect between developed countries.

The rest of this paper is structured as follows. Section 2 reviews the literature on global financial spillovers. Section 3 describes the data and methodologies applied for both the construction of the FCI and the analysis of global financial spillovers. Section 4 discusses the empirical results and the last section provides some concluding remarks and policy recommendations.

2. Literature review

Several empirical studies have contributed to the investigation of global financial spillovers. Eickmeier, et al. (2011) apply a time-varying factor-augmented vector autoregressive (FAVAR) model and assess how United States financial shocks (FCI shocks) are transmitted to nine major advanced economies (G7 countries as well as Australia and Spain). They find that positive United States financial shocks have a significant positive impact on growth in all the nine advanced economies.

Fink & Schuler (2013) implement a structural VAR model on monthly data in order to evaluate international transmission of the United States financial stress shocks to emerging market economies including South Africa. In their paper United States financial stress shocks are identified as unexpected changes in the FCI of the Federal Reserve

Bank of Chicago. They find that emerging markets experience similar negative effects as the United States economy in response to unexpected changes in United States financial conditions. In addition, transmission through international financial linkages is found to be more paramount than transmission through trade linkages.

Even though Park & Mercado (2013) do not focus on the overall financial conditions (i.e. they do not focus on the FCI), they construct Financial Stress Indices (FSIs) for a group of emerging markets and advanced markets, and assess the cross-country shocks transmission. They define FSI as episodes when the financial system is under strain and its ability to intermediate is impaired. Their results show, among other things, that financial stress shocks originating from an emerging economy is likely to significantly affect the financial stress condition of other emerging market economies.

Several other studies have only focused on narrowly defined measures of financial shocks, such as interest rates shocks, asset price shocks, credit or exchange rate shocks. A recent study by Akinci (2013) analyses how United States global financial conditions (i.e. global risk free interest rate and global financial risk) and country spread contribute to macroeconomic fluctuations in a panel of emerging markets including South Africa Using a panel VAR approach, Akinci(2013) finds that global financial risk shocks explain about 20 percent of movements in both emerging markets country spread and economic activity and that country spread shocks explain roughly 15 percent of the business cycles in emerging economies.

Canales-Kriljenko et al. (2014) investigate global financial transmission into Sub-Saharan Africa using a GVAR model and found that the effect of global uncertainty (CBOE volatility index) is more pervasive in exports, while the impact of economic and lending activities was mixed. Adler & Tovar (2012) identifies two main channels, the trade channel and the financial channel, through which global financial shocks have been transmitted to emerging market and small advanced economies. Using the S&P 500 Chicago Board Options Exchange Volatility Index (VIX) to measure global financial shocks, they find that, episodes of global financial shocks have been accompanied by a slump in commodity prices through the trade channel while these episodes are associated with sizable re-pricing of sovereign risk through the financial channel,.

Galesi & Sgherri (2009) apply a GVAR model to investigate regional spillovers across Europe and provide evidence that asset prices are the main channel through which short run financial shocks are propagated internationally while the cost and quantity of credit only become significant over longer horizon. Chudik and Fratzscher (2011) apply a GVAR model in identifying global transmission of the 2008/09 financial crisis and find that while liquidity shocks have had severe impact on advanced economies, it is mainly the decline in risk appetite that affect emerging market economies (EMEs). Jo (2014) analyses the transmission of United States' bank financial shocks to EMEs and finds that during the 2008/09 global financial crisis, United States financial shocks were transmitted to EMEs through the international lending activities of United States banks.

Ehrmann et al. (2011) assess the financial transmission between money, bond and equity markets and exchange rates within and between United States and the Euro Area and they find that asset prices react strongly to other domestic asset price shocks. Their findings also indicate that there are substantial spillovers both within and across asset classes. For example, United States markets appear to be the main driver of global financial markets, explaining on average around 30 percent of movements in the Euro Area financial markets whereas the Euro Area markets account only for about 6% of United States asset price changes.

Ncube et al. (2012) study the transmission of abrupt United States bond yield increases, monetary stimulus and federal funds rate tightening shocks into South Africa. They find three interesting results based on structural VAR. Firstly, United States monetary stimulus leads to weak consumer price inflation, rand dollar appreciation, real stock price revaluation, decline in bond yields, decline in monetary aggregates and real interest rates in South Africa. Secondly, in line with portfolio balance exchange rate model, United States medium-term bond yield shock results in rand-dollar depreciation and increasing bond yields. Thirdly, abrupt Federal funds rate tightening results in increased South African bond yields, rand-dollar depreciation, and a delayed inflation.

3. FCI and GVAR methodology

3.1 The FCI methodology

While several studies have contributed to the construction of the FCI based on different methodologies, the use of PCA has become standard for such exercise. Recent examples include Angelopoulou et al. (2012) who select a wide range of prices, quantities, spreads and survey data to build FCI for selected countries in the Euro Area. Hatzius et al. (2010) also use similar approach to build a FCI for OECD countries from a group of 45 financial variables. Similarly, Gomez et al. (2011) construct a FCI for Colombia from a group of standardized financial variables While Vonen (2011) focuses on Norway and extracts a FCI from a group of 13 financial variables representing stock market, money market, bond market and foreign exchange market.

In the South Africa context, Gumata et al. (2012) propose a FCI obtained from a dual approach (PCA and Kalman filter) while Thompson et al. (2015) exploit the full-sample and rolling window PCA to develop an index based on a set of 16 financial variables including variables that measure the state of international financial markets, asset prices, interest rate spreads, stock market yield and volatility, bond market volatility, and monetary aggregates.

Besides the PCA approach, the empirical literature on FCI has equally emphasized the use of VAR models. Selected recent studies on VAR based FCI include Guihuan & Yu (2014); Koop & Korobilis (2013); Matheson (2011); Osorio et al. (2011); Shinkai (2010); Swiston (2008) and Goodhart & Hofmann (2001), among others. Starting with the PCA

and borrowing from Vonen (2011), common factor(s) from a set of variables can be expressed mathematically as follows:

Let N be the number of financial variables x_i, i = 1,……..N, and T be the number of time period observations included in the analysis, t = 1,…….T. The time t observation of a given variable x_i can then be expressed as:

$$x_{it} = \lambda_i F_t + e_{it}$$

$$= C_{it} + e_{it} \quad (1)$$

F is the underlying factor. The relationship between a given factor and an observable financial variable is given by factor loadings, λ_i. These loadings generally differ between the variables, and for each variable there is only one factor loading associated with each of the underlying factors. $C_{it} = \lambda_i F_t$ is referred to as the common component of the model. e_{it} is the idiosyncratic or variable specific component reflecting part of the variation in a series which is not common to all the included variables. In this study for each country different financial variables are selected and included in the PCA (See Table A7 in the Appendix)[5]. All variables are in real terms and are standardized as follows: $z_{it} = \frac{x_{it}-\mu}{\sigma}$ where x_{it} is each variable at time t, μ mean over the entire sample period and σ is the corresponding standard deviation. In PCA analysis, standardization of variables is necessary in order to ensure that the extracted underlying components are not unduly influenced by the measurement units and relative magnitude of the candidate variables.

The second approach adopted in this study to construct the FCI is the VAR model. Borrowing from Swiston (2008) and Osorio et al. (2011), we present our VAR model as follows:

$$X_t = A_0 + \sum_{i=1}^{m} A_i X_{t-i} + BY_i + \varepsilon_t \quad (2)$$

Where, X_t is a vector of endogenous variables, Y_i is a vector of exogenous variables, A_i and B are vectors of coefficients, and ε_t is a vector of error terms. The weights of each variable in the FCI are then derived from generalized impulse response functions (i.e. the response of the output gap to other endogenous variables in the system after shocking the error term). The VAR-based FCI is therefore calculated as follows:

$$FCI_t = \sum_{j=1}^{n} w_j (x_{j,t} - \tilde{x}_j) \quad (3)$$

Where, w_j is the weight attached to the financial variable x_j, obtained as the average response (between 1-12 quarters) of GDP growth to one-unit shock to the variable x_j, and $\tilde{x}_j$ is an average or long term trend of x_j over the entire sample period. Before estimating the VAR model all variables are tested for unit root and transformed to be

[5] The number of financial variables used in the FCI construction varies from 5 to 16 depending on the country availability of the data and are selected based on the existing literature. Though the use of a broader set of financial variables is thought to improve the predict ability of the composite financial index (Hatzius et al., 2010), relying on a restricted set of variables has a limited impact on the results as our FCIs are able to capture historical financial events, namely the recent global financial crisis.

stationary where necessary by de-trending the data using Hodrick-Prescott (HP) filter with a smoothing parameter set at 1600, in line with what is recommended in literature when using quarterly data. For example, in estimating the FCI for Canada, Gauthier, et al. (2004) apply both the HP filter and the first-difference operator to deal with non-stationarity. They point out that the HP filter is a popular method of deriving a time-varying trend and that he advantage of deriving a long term trend is that a positive deviation of the FCI from its equilibrium value can be interpreted as a relatively accommodative stance, and vice versa.[6] All nominal variables, for each individual country were deflated by their respective domestic consumer price index or inflation to convert them into real variables.

3.2 GVAR methodology

This study employs the GVAR model originally proposed and implemented by Pesaran, et al. (2004) and further extended by Dees et al. (2007) and is now applied in several existing studies. Based on the VAR models of individual countries, it is an ingenious tool to study inter-country dynamics. Unlike individual country VAR models, the GVAR model has the ability to combine individual country-specific models into a global framework, and allow for analysis of spill over effects. The country-specific model is linked with the rest of the countries through country-specific foreign variables, in such a way that a shock in one country could be propagated to the rest of the world. According to Sun et al. (2013), the main benefit of a GVAR model compared to individual country specific VAR model is that it allows full interactions of every country in the studied group to be captured explicitly, and in two aspects.[7]

Application of a GVAR model has become increasingly popular, having been applied in most recent studies covering different countries and regions. For example, Emilie & Bonga-Bonga (2015) have recently applied a GVAR model to study trade linkages and shock transmission between Africa and its main trading partners, namely China, Europe and the United States. Canales-Kriljenko et al. (2014) investigate global financial transmission into Sub-Saharan Africa using GVAR and find that the effect of global uncertainty is more pervasive in exports, while the impacts of economic and lending activities are mixed.

Likewise, Ncube and Gurara (2013), examine the effect of global economic spillovers into Africa based on GVAR model whileGalesi & Sgherri (2009) explore regional spillovers across Europe. They provide evidence that asset prices are the main channel through which short run financial shocks are propagated internationally while the cost and quantity of credit only becomes significant over longer horizon. Chudik & Fratzscher (2011) also apply a GVAR in attempting to identify global transmission of the 2008/09 financial crisis

[6] Gauthier, et al. (2004) also highlight that this interpretation is particularly important if a policy-maker wants to use the FCI as an operational target.

[7] Firstly, the interactions among countries through trade, finance, or other channels are reflected in the construction of foreign variables specific to each individual country. Secondly, the estimation of a single, often fairly large, VAR model based on individual VAR models makes it possible to demonstrate how shocks specific to an individual country affect other countries, as the model is estimated globally at the group level.

and find that in the aftermath of the crisis, liquidity shocks had severe impact on advanced economies whereas it was mainly the decline in risk appetite that affected EMEs.

There are two fundamental steps involved in the application of the GVAR. The first step involves modelling each country individually by estimating a country-specific vector error-correction model (VECM) in which domestic macroeconomic variables are related to corresponding foreign variables constructed using bilateral trade weights or financial linkage weights reflecting the relative importance of each country's trade partner or financial partner, respectively.[8] Observed global factors, such as oil prices, are also included in each country-specific VECM and assumed to be weakly exogenous (or long-run forcing).

In the second step, country-specific models for all countries estimated in the first step are stacked, one on top of the other, to yield a global model that is able to provide a solution which can be used for a variety of purposes, including the analysis of spill over effects and forecasting. Our GVAR[9] model covers a total of 10 countries namely, South Africa, China, the United States, Japan, the United Kingdom, Germany, Netherlands, Belgium, Italy and France. It is important to emphasise that the studied group of countries are chosen based on their trade relationship with South Africa and hence their influence for South Africa's economic growth and policy making. We use quarterly data and the sample period spans from 1996Q1 to 2014Q4.

For each country, the variables considered in the estimation are as follows: real GDP growth, real equity price growth, nominal short term interest rates[10], real exchange rate, financial conditions index (the variable of interest) and oil price growth.[11] Specifically, $x_{it} = (y_{it}, eq_{it}, \rho_{it}, rer_{it}, fci_{it})$ are country-specific domestic variable and $x_{it}^{*} = (y_{it}^{*}, eq_{it}^{*}, oilp_{it})$ are foreign variables for country $i = 1,2,3 \dots \dots \dots N$. Important to note and in line with literature is the oil price which is treated as an exogenous variable for all the countries in the global system except the reference country, which is the United States in this study.

Because the United States represents the reference country, its equation is different from that of other countries in the system. Formally, it is given by:

$x_{0t} = (y_{0t}, eq_{0t}, \rho_{0t}, oilp_{0t}, fci_{0t})$ and $x_{it}^{*} = (y_{0t}^{*}, rer_{0t}^{*})$

Due to the importance of the United States as a reference country in the system, the oil price enters the United States model endogenously. The real exchange rate is treated in

[8] The application of financial weights to construct foreign variables in the GVAR literature was first suggested by Galesi & Sgherri (2009)
[9] The reader may refer to Appendix B for more details on how the GVAR is conducted.
[10] Short term nominal interest rate are measured as policy rate

[11] See Table A1 in the appendix for more details on each variable formula and data source

the United States model as weakly exogenous, because in practice the real value of the United States dollar is determined outside the United States model.[12]

Foreign variables are computed using fixed trade weights (ω_{ij}). These weights are based on average annual trade flows fixed over the period 2009-2011. Following Pesaran et al. (2004), we measure ω_{ij} as total trade between country i and country j divided by the total trade of country i with all of its trading partners, where $\omega_{ii} = 0$ for all i. Table 7 below illustrates our computed 10x10 trade weights matrix for all countries in the study such that each column, but not row, sums to 1.

Table 1: Trade weight matrix based on fixed weights, period (2009-2011)

Country	BELGIUM	CHINA	FRANCE	GERMANY	ITALY	JAPAN	NETHERLANDS	SOUTH AFRICA	UNITED KINGDOM	USA
BELGIUM	0.00	0.02	0.16	0.11	0.07	0.01	0.17	0.03	0.09	0.04
CHINA	0.05	0.00	0.08	0.13	0.12	0.52	0.11	0.28	0.14	0.43
FRANCE	0.21	0.04	0.00	0.18	0.21	0.03	0.11	0.04	0.12	0.06
GERMANY	0.25	0.13	0.31	0.00	0.31	0.06	0.33	0.18	0.21	0.12
ITALY	0.06	0.04	0.14	0.12	0.00	0.02	0.05	0.04	0.06	0.04
JAPAN	0.02	0.28	0.02	0.03	0.03	0.00	0.03	0.12	0.04	0.16
NETHERLANDS	0.23	0.05	0.10	0.19	0.08	0.03	0.00	0.05	0.13	0.05
SOUTH AFRICA	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.03	0.01
UNITED KINGDOM	0.09	0.05	0.10	0.11	0.08	0.03	0.11	0.08	0.00	0.09
USA	0.08	0.36	0.09	0.11	0.10	0.28	0.08	0.16	0.18	0.00

Note: *Trade weights are displayed in columns by country/region. Each column, but not row, sums to 1.*
Source: Direction of trade statistics IMF, 2009-2011

4. Empirical results

In this section, there are two sub-sections. The first sub-section discusses results of the constructed FCIs and the second sub-section discusses results of the GVAR model.

4.1 FCI results

In this section, we discuss results of the FCIs constructed using both PCA and VAR methodologies. The purpose for building these indices is to have some reasonable measure of broader financial conditions in each of the countries selected for this study, which will then be incorporated in the GVAR for further analysis of global financial spillovers.

Figures 1 to 10 below provide a graphical representation of our PCA and VAR based FCIs for all countries considered in this study. Movement below the horizontal zero line can be interpreted as tightening of financial conditions and movement above the zero line can be interpreted as loosening of financial conditions. Interestingly, our FCIs, albeit constructed using different methodologies, appear to show consistency and track each other fairly well. For example, these FCIs capture very well the 2008/09 global financial crisis indicating that financial conditions deteriorated much stronger in all our sample countries during the 2008/09 crisis. Notably, our FCIs also capture the late 1990s to early 2000s crisis known as the dot-com bubble which was preceded by a bull rush into the technology and internet related stocks.

[12] See Pesaran et al. (2004) & Dees et al. (2007)

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Figure 1: SA Financial Conditions Index

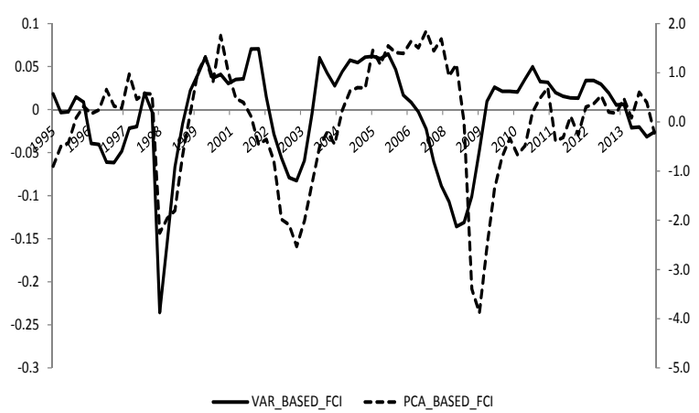


Figure 2: China Financial Conditions Index

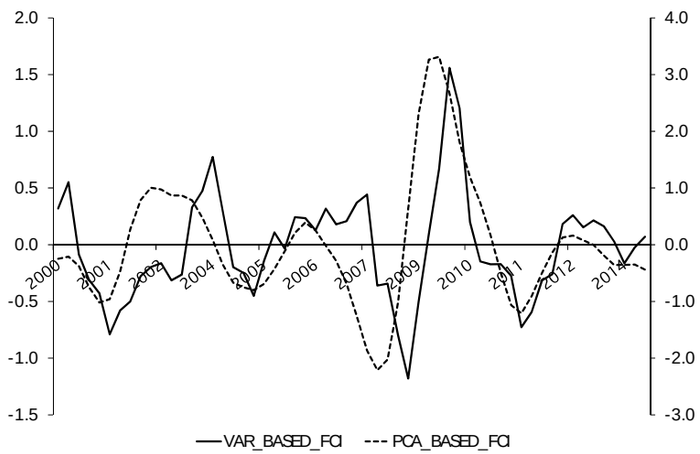


Figure 3: US Financial Conditions Index

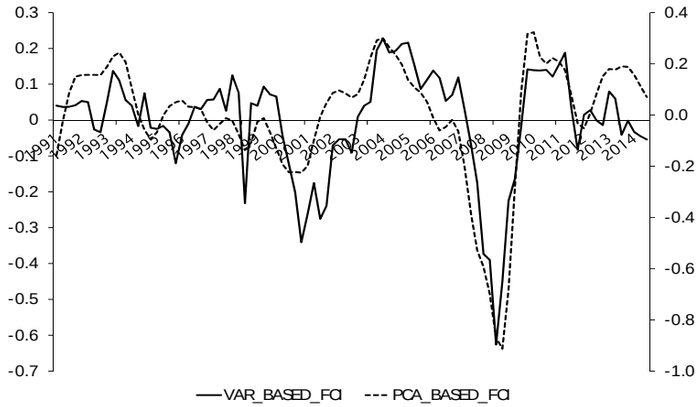


Figure 4: Germany Financial Conditions Index

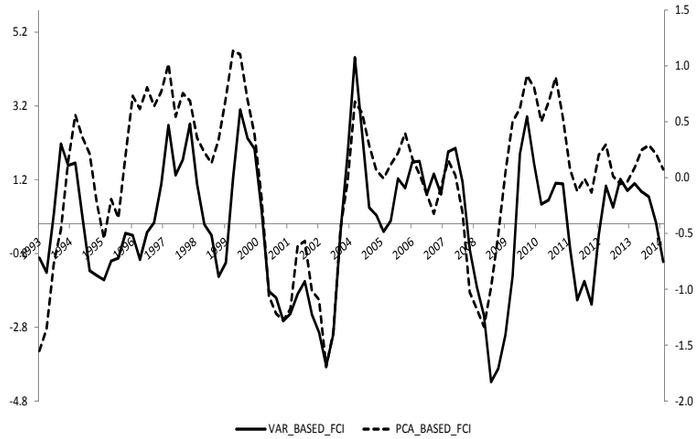


Figure 5: Japan Financial Conditions Index

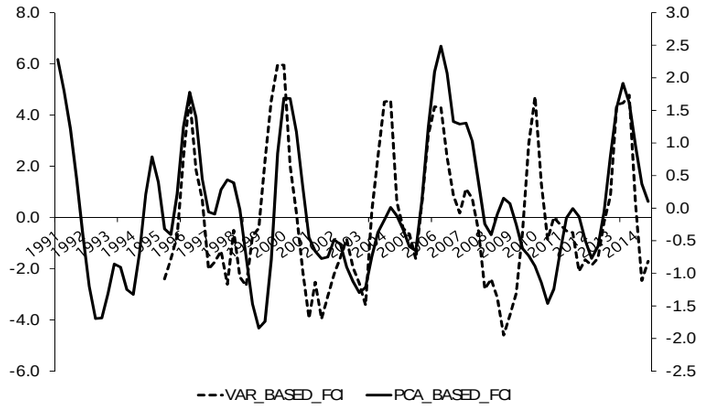


Figure 6: UK Financial Conditions Index

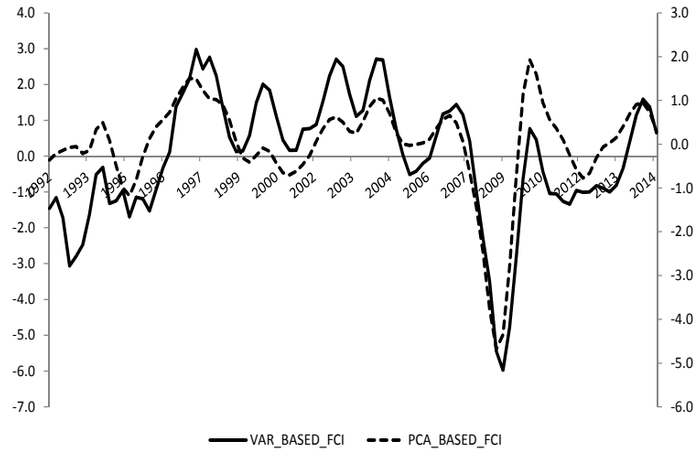


Figure 7: Netherlands Financial Conditions Index

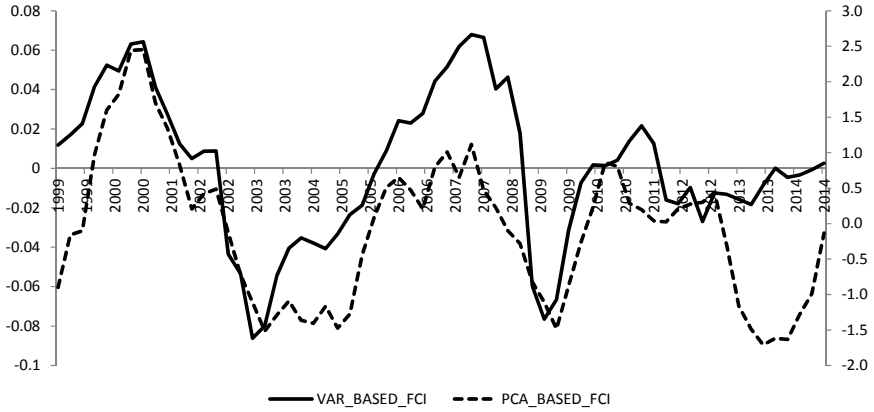


Figure 8: Italy Financial Conditions Index

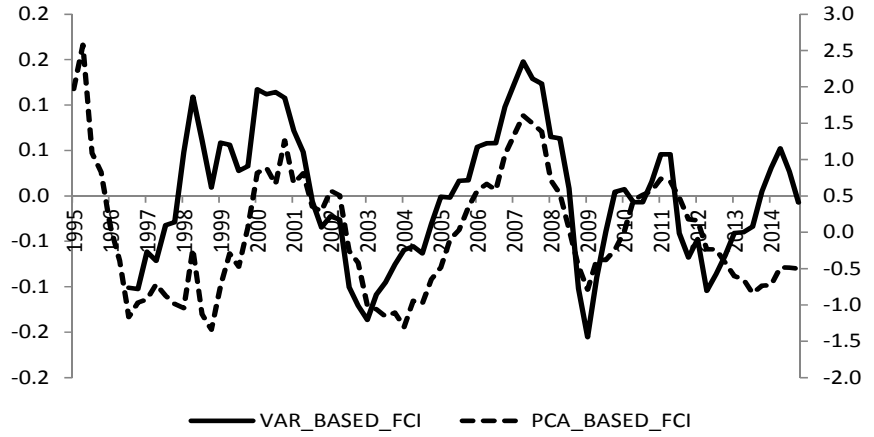


Figure 9: France Financial Conditions Index

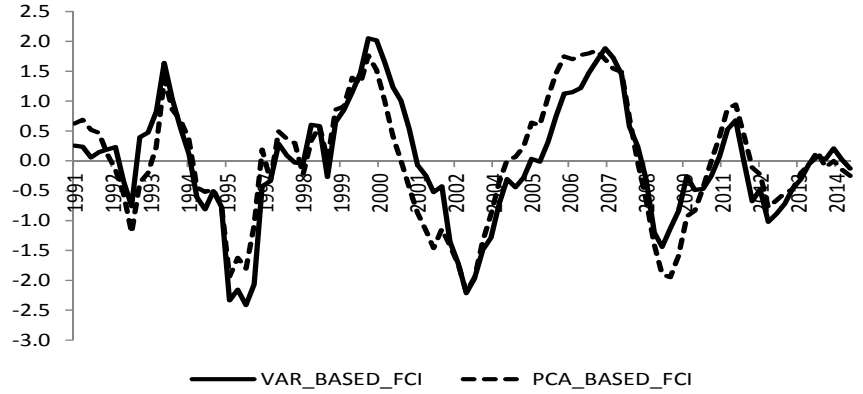
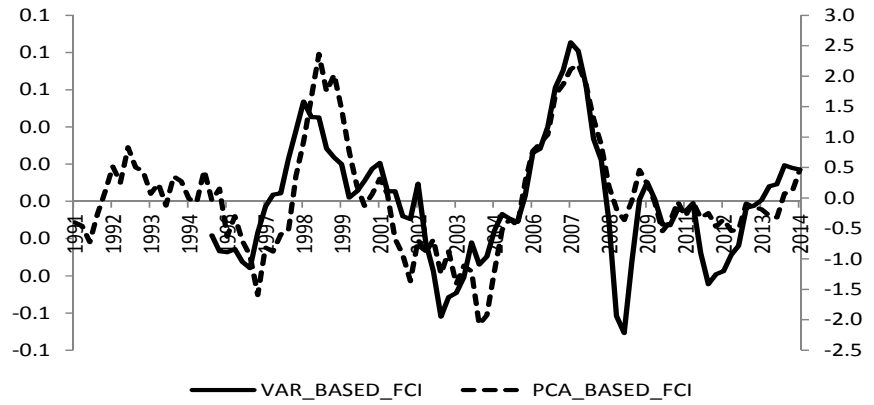


Figure 10: Belgium Financial Conditions Index



4.2 GVAR results and interpretation

4.2.1 Data and preliminary analysis

Firstly, in order to show that the system will return to its long-run equilibrium after a system-wide shock, we looked at the persistence profiles of selected co-integrating vector for each country in our GVAR model Persistence profiles are plotted in Figure A7 in appendix A and converge to zero over a long term horizon which is an indication that the system is stable and will revert back to its long-run equilibrium following a system-wide shock.[13] Furthermore we have exactly 32 eigenvalues lying on the unit cycle and 58 with moduli less than 1. Based on these two properties (convergence of persistence profiles and eigenvalues), GVAR model appears to be stable.

Unit root and weak exogeneity tests results are also provided in appendix A (Tables A2 to A5). Unit root tests results reported are based on the conventional augmented Dicky-Fuller (ADF) test with t-statistics based on weighted symmetric estimation of ADF. Unit root test results indicate that the global variable (Dpoil) is stationary (Table A3), while the foreign variables are all stationary at first difference (Table A4). Likewise, Table A5 shows that real GDP growth (Dy) which are the endogenous variables and the real equity price growth are stationary for all countries. Similar result is reported for the FCI[14] in all countries with the exception of Germany.

One of the key assumptions of the GVAR model, as explained in DdPS, is that foreign variables are weakly exogenous with respect to the long-run parameters of the error correction model. A weakly exogenous variable can be defined as a variable whose value is independent of the contemporaneous values of the endogenous variables, but may depend on lagged values of these variables. The test results of weak exogeneity for foreign variables reported in Table A2 could not reject this assumption except for South Africa's FCI.

[13] Non converging persistent profiles are said to be caused by some misspecification in the model (Smith, 2011)
[14] We have used the PCA based FCI as the VAR based FCI was not providing significant results

4.2.2 Contemporaneous Effects of Foreign Variables on their Domestic Counterparts

Table 2 below presents the contemporaneous effects of foreign variables on their domestic counterparts. Heteroskedastic t-ratios are reported in round brackets and standard t-ratios in square brackets. According to Dees et al. (2007) these estimates can be interpreted as impact elasticities between domestic and foreign variables.[15] Most of these elasticities are highly significant and have the expected sign. Looking at these estimates for South Africa we pick up that the elasticity on South Africa's domestic real GDP growth is 0.41percent meaning that a 1 percent increase in foreign real GDP growth in any given quarter leads to a 0.41 percent increase in South Africa's real GDP growth within the same quarter.

Notably, the elasticity on domestic real equity growth is 0.14 percent, lower than that of GDP growth. Of importance to note as well is the impact elasticity of 0.47 percent on South Africa's financial conditions index. In other words, for every one percent increase in foreign financial conditions in any given time, South Africa's financial conditions will increased by 0.47 percent.

Table 2: Contemporaneous effects of foreign variables on their domestic counterparts

[15] According to Dees, et al. (2007)These elasticities are informative as regards the international linkages between the domestic and foreign variables

Country	y	eq	ep	r	fci
BELGIUM	0.33	1.15			0.25
	(2.16)	(0.43)			(1.11)
	[2.38]	[0.25]			[1.12]
CHINA	0.29	0.05		0.63	-0.03
	(2.46)	(0.73)		(3.89)	(-0.42)
	[2.91]	[1.15]		[3.20]	[-0.41]
FRANCE	0.90	0.01		0.58	0.44
	(10.51)	(0.91)		(8.35)	(2.31)
	[13.81]	[1.32]		[8.18]	[2.16]
GERMANY	1.10	0.00		0.65	0.89
	(5.87)	(0.28)		(6.88)	(5.52)
	[5.35]	[0.33]		[6.97]	[6.29]
ITALY	0.78	1.50			0.06
	(8.07)	(1.41)			(4.27)
	[8.90]	[0.58]			[4.04]
JAPAN	0.79	-0.05		0.90	0.41
	(2.43)	(-0.68)		(6.26)	(3.08)
	[2.36]	[-0.57]		[6.00]	[3.12]
NETHERLANDS	0.79	0.02			0.06
	(8.04)	(0.72)			(0.30)
	[8.61]	[0.66]			[0.34]
SOUTH AFRICA	0.41	0.14			0.47
	(3.99)	(0.92)			(4.25)
	[3.62]	[1.69]			[4.67]
UNITED KINGDOM	0.48	0.02			0.46
	(2.97)	(1.15)			(5.42)
	[2.95]	[1.33]			[4.82]
USA	0.41				
	(2.22)				
	[2.08]				

Note: White's heteroskedastic robust t-ratios are reported in round brackets, Standard t-ratios are in given square brackets

4.2.3 Dynamic analysis based on GIRFs of the GVAR

In this section we present empirical results of the GIFRs of our GVAR model. particularly, we investigate how negative financial conditions shocks originating from any one country in the GVAR system, propagate, most importantly to South Africa, but also to the rest of the countries in the model. We examine GIRFs computed over a

time horizon of 40 quarters. Nevertheless, the interpretation focuses on the first eight quarters, which is a reasonable time frame for making inferences about short-term macro-economic dynamics. The GIRFs results reported below include the confidence interval at the 95 percent significance level, calculated using the bootstrap technique with 100 replications. We consider negative financial conditions shocks as opposed to positive shocks because as evidenced in the past, periods of tighter financial conditions are more pronounced and at times more severe than periods of looser financial conditions.[16]

4.2.4 Spillover of financial conditions shocks

The GIRFs associated to a one standard deviation negative shock to financial conditions are illustrated through Figures 11 to13 below. As demonstrated in Figure 11, a shock in the United States financial conditions significantly affects all the countries in our model.[17] However, China is the less affected, suggesting its fast tendency to recover from external shocks. China's financial conditions index in Figure 2 above also shows us that during the 2008/09 global financial crisis, its financial conditions deteriorated only marginally and recovered strongly and immediately from the fourth quarter of 2008. Important to note as well is that even though China's output slowed during the global crisis, China did not go into recession, which might explain the sluggish response of China to United States financial shocks.

Particularly, South Africa's real GDP growth falls for eight quarters, reaching the largest impact (-0.15) by the fourth quarter. Even though, in this paper, we use a broader measure of financial conditions, our results are not only consistent with the experience of the 2008/09 financial crisis, but are also in line with the empirical literature on emerging economies that mainly relies on single financial measures. This

[16] One of the less prominent but most important findings of the literature on FCIs is the asymmetry apparent between their peaks and troughs (Hansen, 2006). Periods of heightened financial stress are more pronounced than periods of loose financial conditions. This finding is consistent with the empirical evidence from the financial accelerator literature, according to which financial market imperfections matter most in periods of negative shocks to economic activity (Angelopoulou, et al., 2012).

[17] We only present the effect of a shock in US financial conditions on the rest of the countries in our model simply because these were the most statistically significant empirical results. Other results not presented in this paper are available on request.

includes Chudik and Fratzscher (2011) who show that liquidity shocks caused by global financial conditions affect emerging economies through the decline in the risk appetite; Adler & Tovar (2012) who substantiate that global financial shocks proxied by the VIX impact emerging economies through the slump in commodity prices and the re-pricing of sovereign risk; Akinci (2013) who find that global financial condition measured by the global financial risk explain about 20 percent of the business cycle in the emerging market economies.

In terms of magnitude, South Africa's and China's responses to the United States financial stress appear to be less than that of developed countries; possibly suggesting that there is a strong contagion effect between developed countries.

More importantly, Figure 12 shows that South Africa responds insignificantly to financial shocks emanating from its trading partners, except Netherlands. This possibly indicates the existence of other channels through which South Africa's real GDP may be affected by unexpected financial changes in these countries given their relatively strong bilateral trade linkages. This might also be attributed to the inability of the GVAR to capture complex dynamics as pointed out (Pagan, 2003; Pesaran et al., 2003). In fact, De Waal & Van Eyden (2013) use a GVAR to investigate the impact of world economic shocks on South Africa and show that following a positive shock on China's GDP, South Africa's GDP increased systematically and substantially since 1995; confirming that China's business cycle matters for South Africa's economic activity. This is further illustrated by the significant response of South Africa's GDP to a negative equity shock from China (Figure 14).

We observe in Figure 13 that following a shock in South Africa's financial conditions, real GDP declines instantaneously and persistently over the entire horizon. However in the fourth quarter real GDP begins to decline significantly reaching a maximum decline of 10 basis points by the fifth quarter. On average South Africa's financial shocks subtract 1 percent from GDP over a year. This is in line with a contraction of 1.5 percent of GDP we observed during 2009 following the global financial crisis, which according to our FCI plotted in figure 1 above, was the worse period of South Africa's financial deterioration between 1991 and 2014.

Interestingly for South Africa, a shock to the United States financial conditions, although short lived, matters more for the business cycle than a shock to South Africa domestic financial conditions. This is understandable given the greater exposure of emerging economies and South Africa particularly to external shocks led by the United States. However, differently from the domestic financial condition shocks with permanent impact, the immediate response to the United States financial conditions does not last long; suggesting that contagion based recession is more likely to be resorbed than recession caused by internal factors.

Finally, due to its size, South Africa's financial conditions shocks did not unsurprisingly have any significant effect on the rest of the countries in our model; confirming the vulnerabilities of small open economies to external shocks and not the opposite.

Furthermore, with the exception of China and the United States, it emerges from Figure 14 that South Africa's GDP growth does not respond to a negative shock in real equity prices from its trading partners. Unlike china, South Africa's GDP responds positively to a negative shock in the United States real equity prices. This is expected as South Africa is likely to be a destination country for the United States investors during financial crisis.

Figure 11: Response of the real GDP growth to a one standard deviation negative shock from USA financial conditions

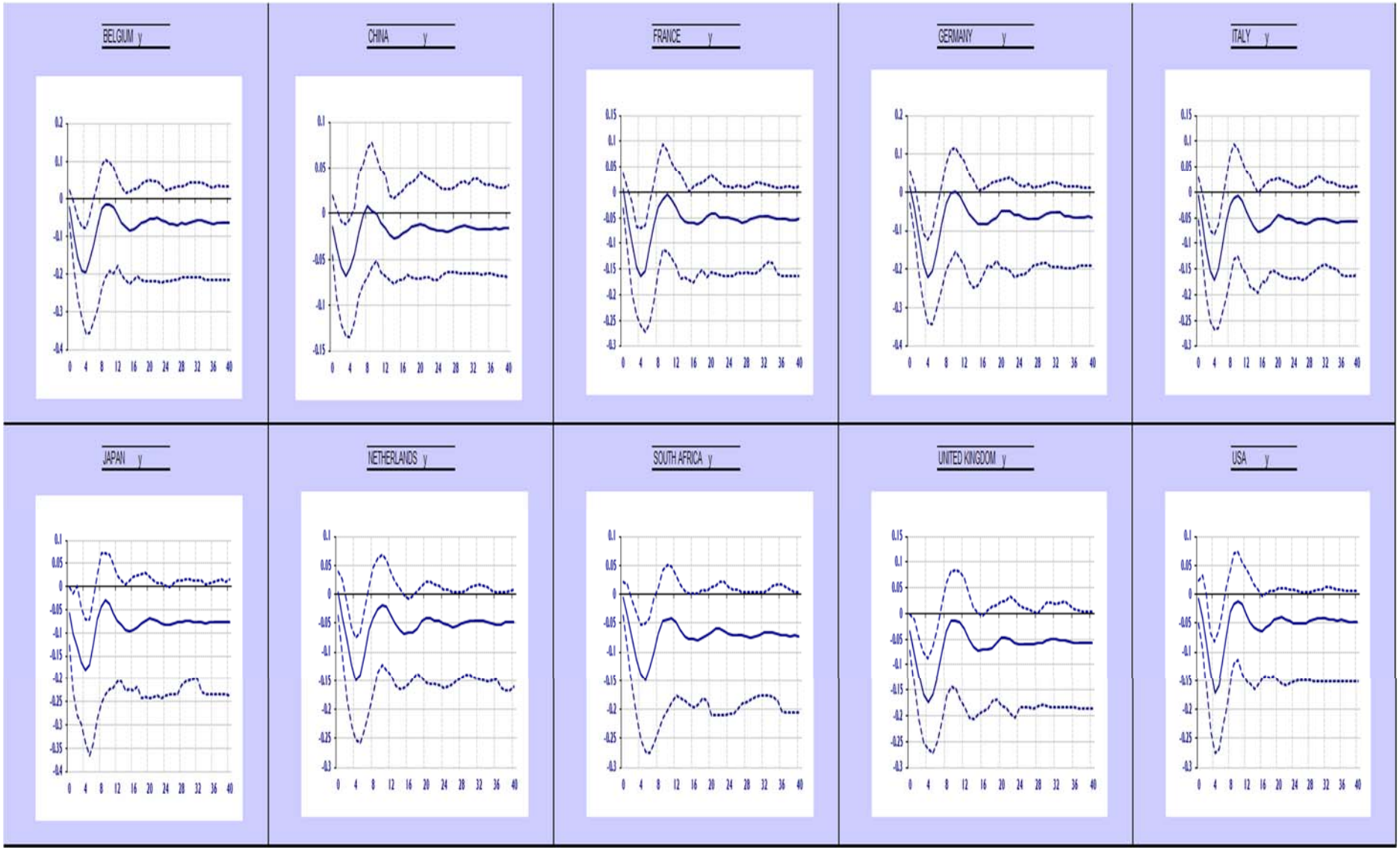


Figure 12: Response of the SA real GDP growth to a one standard deviation negative shock from other countries financial conditions except the USA

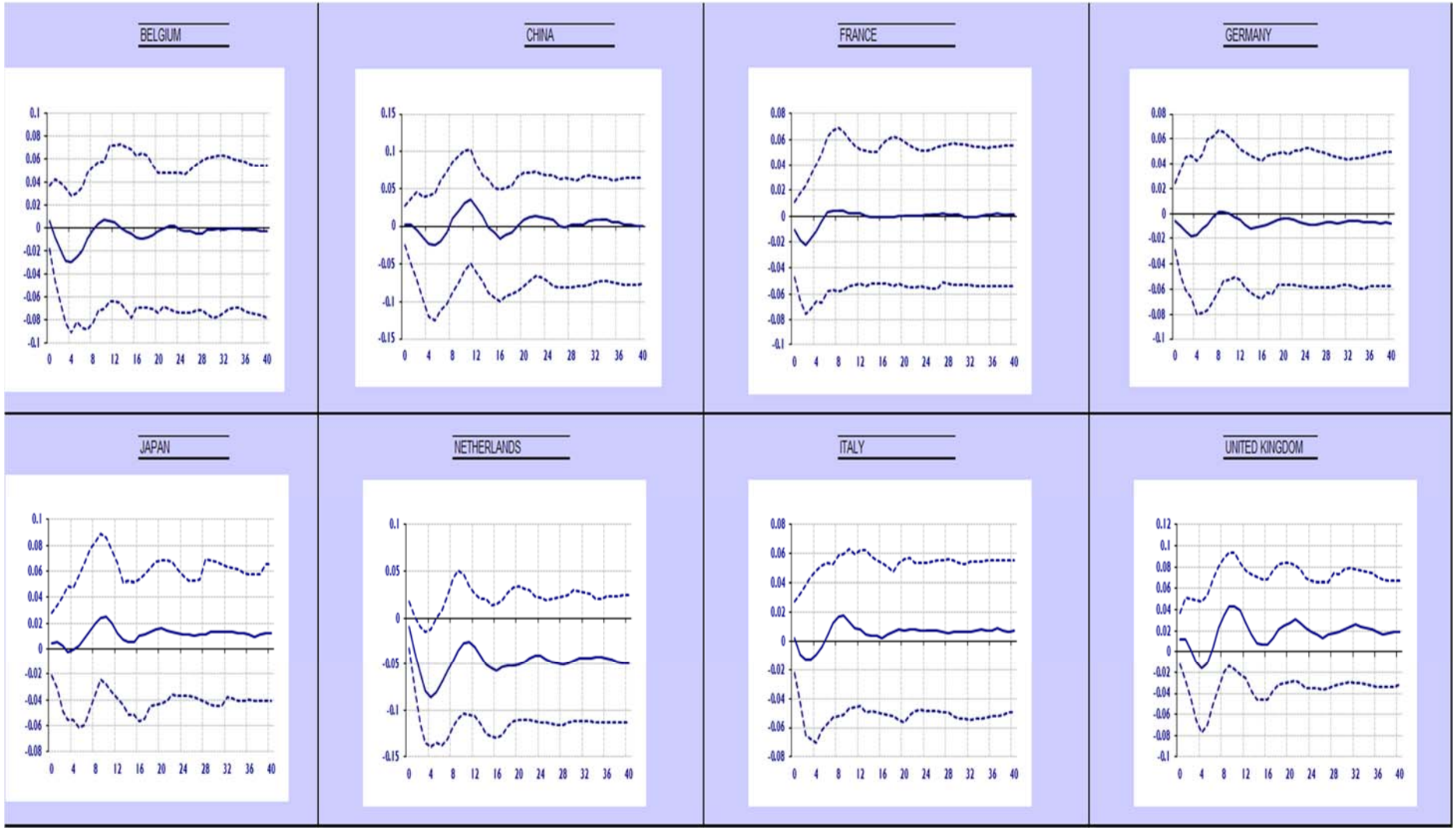


Figure 13: Response of the real GDP growth to a one standard deviation negative shock from SA financial conditions

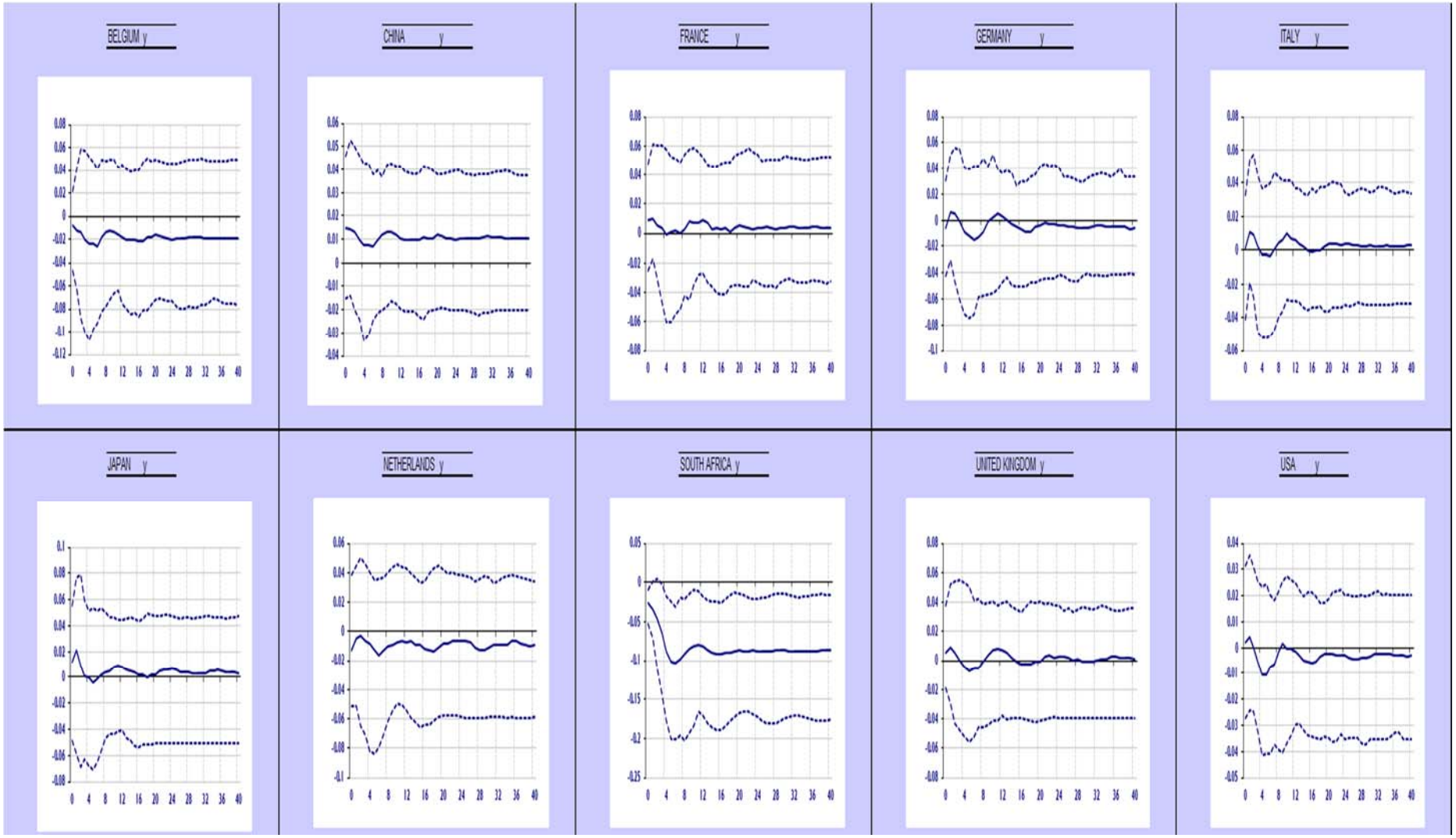
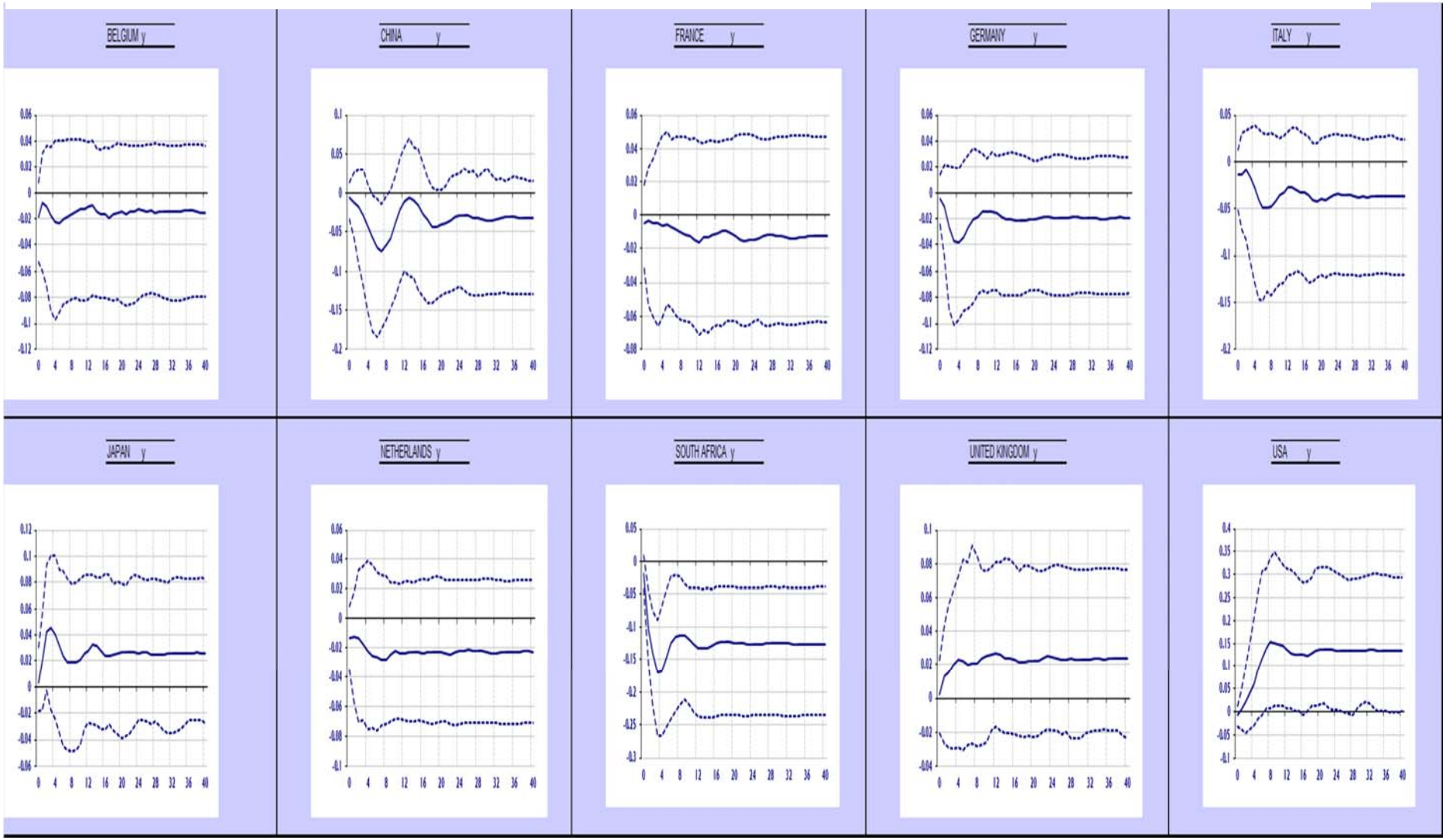


Figure 14: Response of the SA real GDP growth to a one standard deviation negative shock to real equity growth



5. Conclusion and recommendation

This paper investigates the spillover effect of external financial conditions shocks onto South Africa. To achieve this goal, the paper first constructs financial conditions indices for South Africa and its main trading partners, namely, China, Germany, the United States, Japan, the United King, Netherlands, Italy, France and Belgium, applying both the Principal Component Analysis and the Vector Autoregressive model. In the second step, the paper implements the GVAR methodology comprised of the financial conditions indices and selected macroeconomic variables to assess spillovers effects of international financial conditions.

Generalized impulse response functions show that a sudden tightening of the United States financial conditions has a significant but short lived effect on the South Africa's real GDP growth while the spillover effects from other trading partners are found to be of negligible impact throughout the sample period. This possibly suggests the existence of other channels through which South Africa's real GDP may be affected by unexpected financial changes from these countries

Unsurprisingly, we find that the impact of an unexpected tightening of South Africa's financial conditions on its trading partners was statistically insignificant confirming the vulnerabilities of small open economies to external shocks and not the opposite. We also find that following a shock to South Africa's financial conditions, real GDP declines instantaneously and persistently over the entire horizon. On average South Africa's financial shocks subtract 1 percent from GDP over a year. This is in line with a contraction of 1.5 percent of GDP we observed during 2009 following the global financial crisis.

More interestingly is the finding that for South Africa, the United States financial conditions, though short lived, matter more than domestic financial conditions. This substantiates the vulnerability of the South African's domestic markets to foreign markets, particularly the United States. In addition, the United States appear to be the most influential country in the model despite the increasing trade linkages between South Africa and China. While our results might be driven by the linearity assumption; hence, adopting a non-linear framework to analyse the joint dynamics of international financial time series is likely to provide further insight on international spillovers, which

is however not empirically supported by the GVAR set up. Moreover, the expansion of the sample countries, both emerging and developed and/or the use of different weighting scheme such as financial weights may also shed further light on the financial contagion in South Africa.

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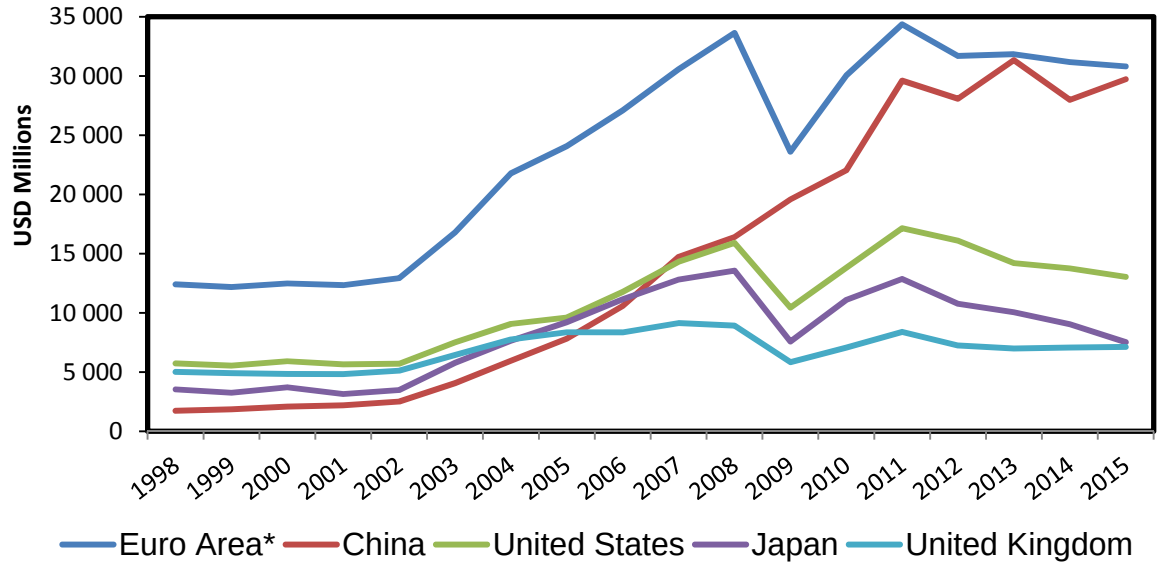
Appendix A. Supplementary materials

Figure A1: South Africa's total trade (exports plus imports) with its trading partners



**the Euro Area in this paper is made up of Germany, Netherlands, Belgium, Italy and France*

Figure A2: Trade share between South Africa and its trading partners from 1998 to 2015

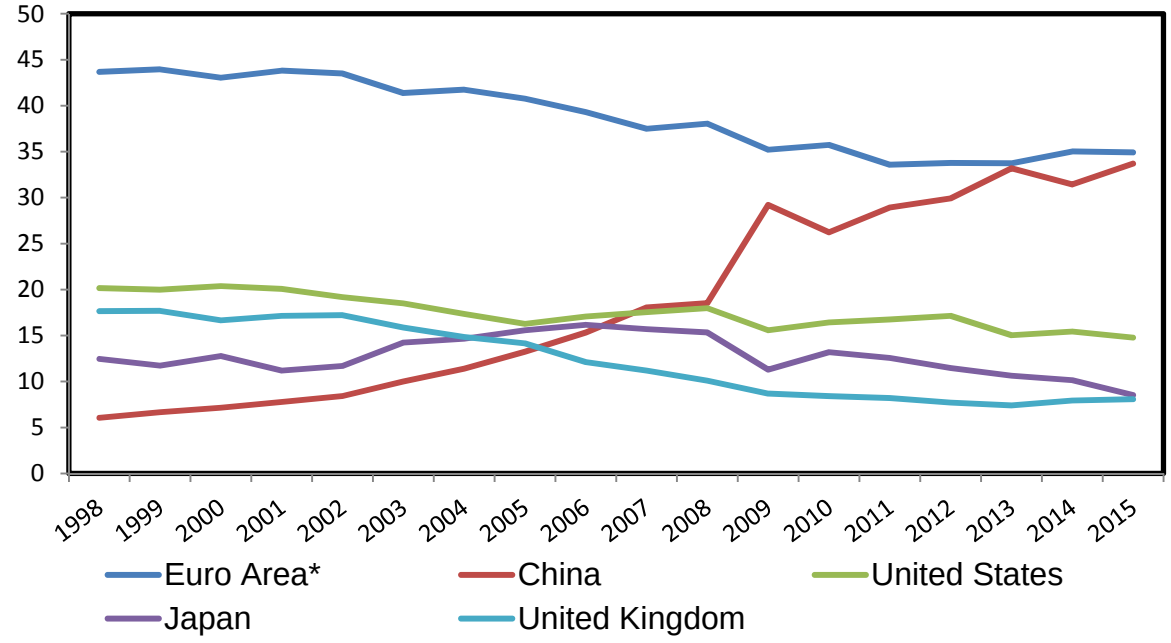


Figure A3: Total foreign liabilities and assets of South Africa as a percentage of Gross Domestic Product

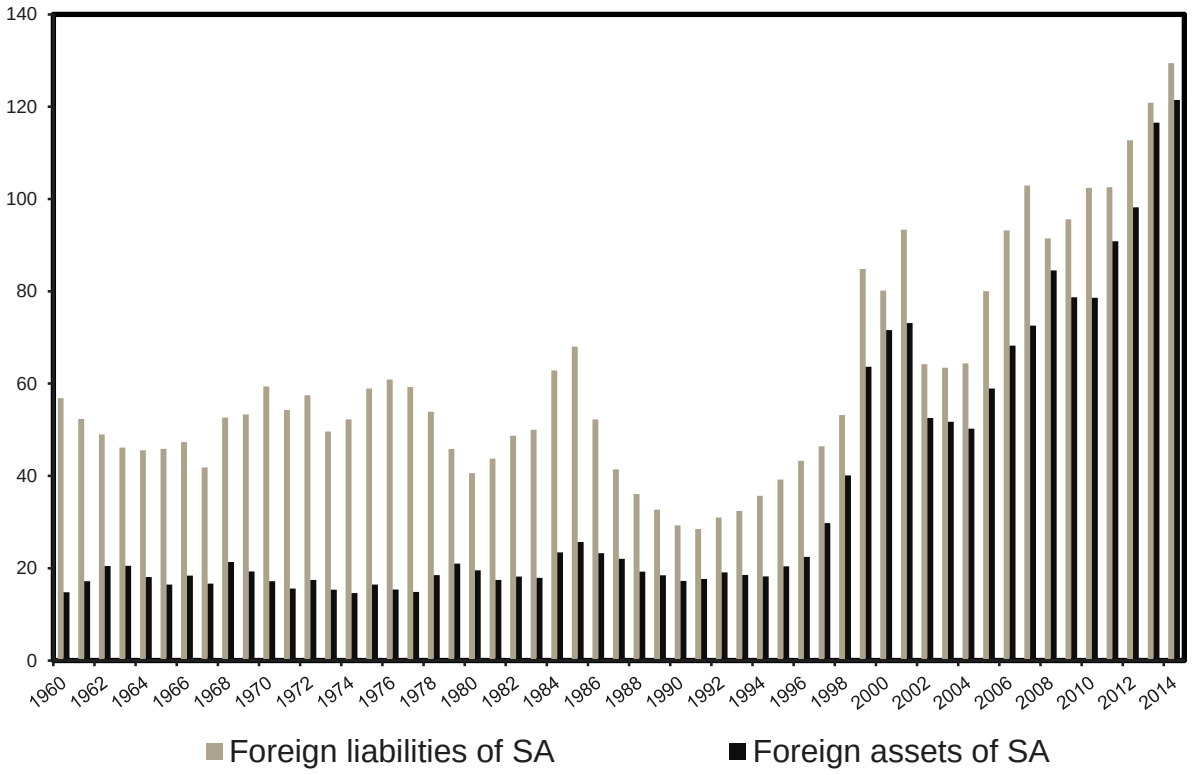


Figure A4: Capital movements: net incurrence of liabilities (% of GDP)

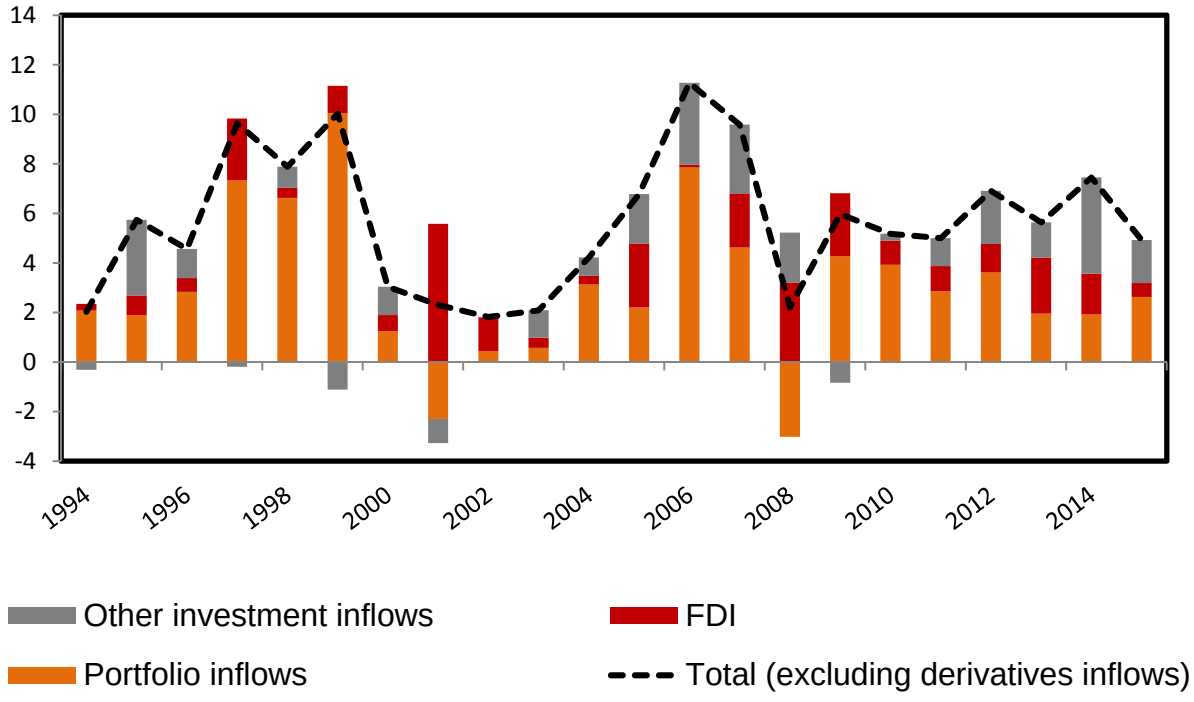


Figure A5: Capital movements: net acquisition of financial assets (% of GDP)

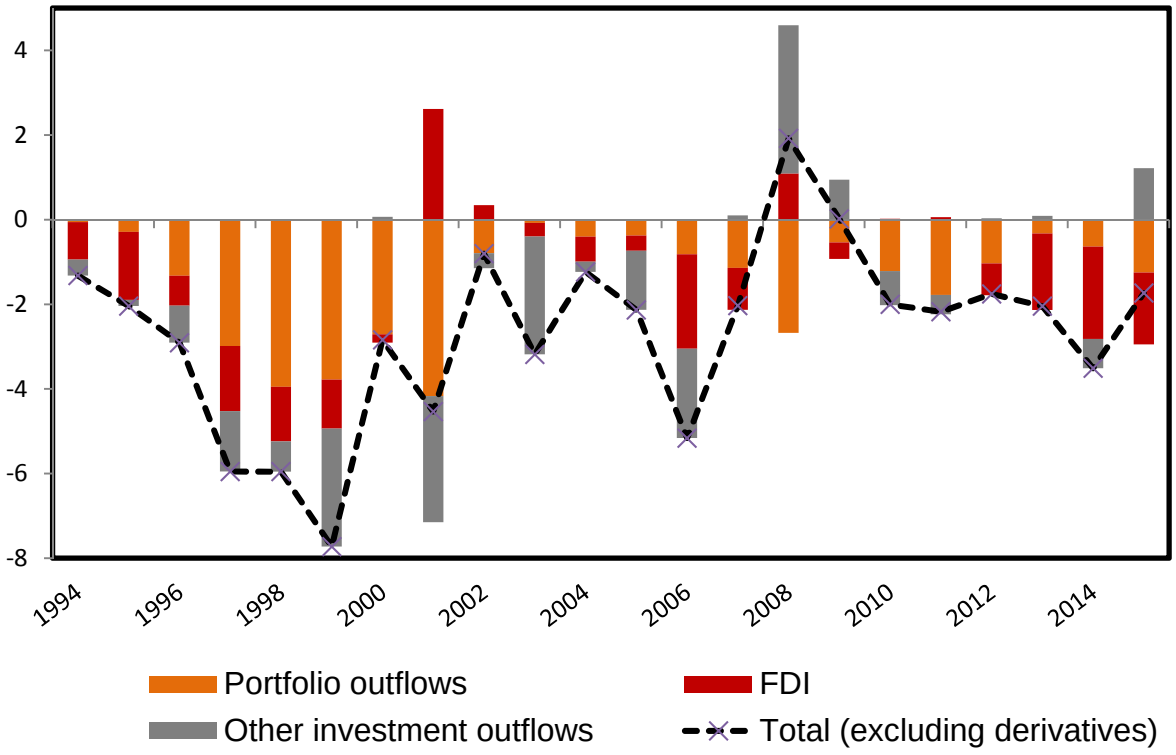
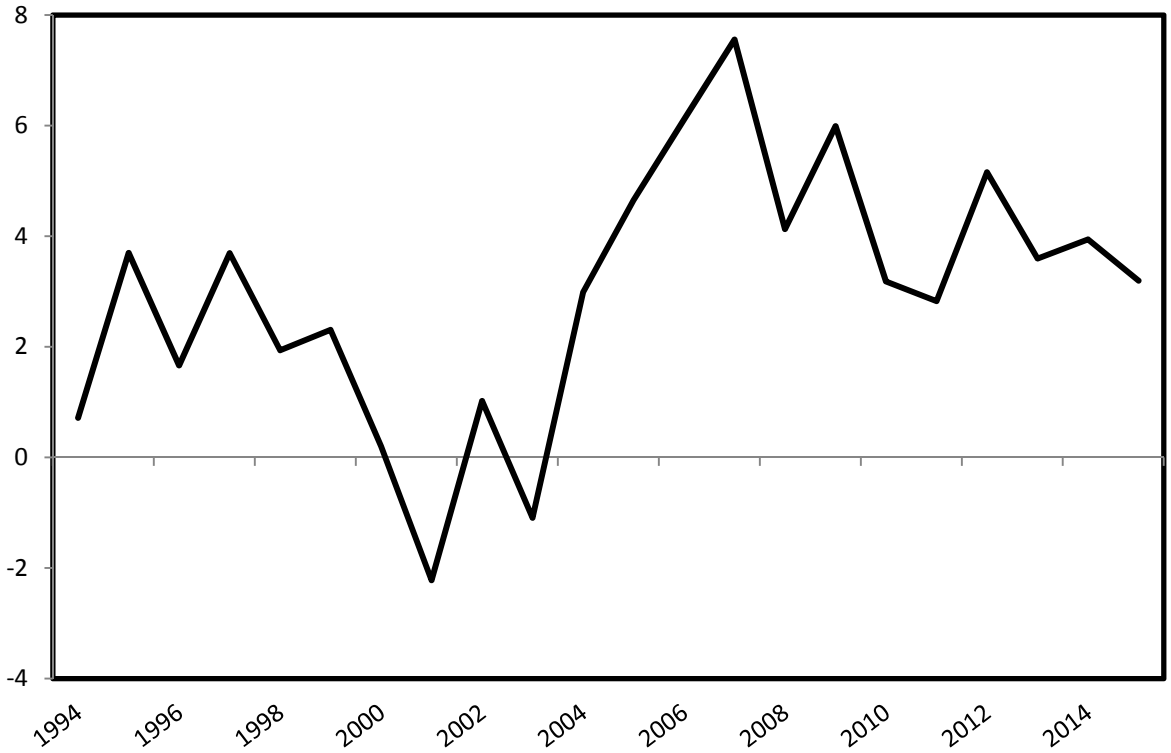


Figure A6: Net capital flows (% of GDP)



Appendix

Table A1: Variables, code and transformation

Variable	Short Name	Formula
Real GDP growth	y_{it}	$y_{it} = ln\left(\frac{gdp_{it}}{gdp_{it-4}}\right)$ x100
Real equity price growth	eq_{it}	$eq_{it} = ln\left(\frac{eq_{it}}{eq_{it-4}}\right)$ x100
Interest rates	ρ_{it}	$\rho_{it} = 0.25 * ln\left(\frac{1 + R_{it}}{100}\right)$
Oil price growth	$oilp_{it}$	$oilp_{it} = ln(Oil\ Price_{it})$
Real exchange rate growth	rer_{it}	$rer_{it} = ln\left(\frac{E_{it}}{E_{it-4}}\right)$ x100
Financial conditions index	fci_{it}	PCA based FCI

Table A2: Weak exogeneity test of the country-specific foreign variables and oil prices

Country	F test	Critical value	ys	eqs	eps	rs	fcis	poil
BELGIUM	F(0,54)							
CHINA	F(1,62)	4.00	0.04	0.13		1.46	0.01	1.54
FRANCE	F(1,51)	4.03	0.10	0.09		0.03	0.70	5.70
GERMANY	F(3,60)	2.76	0.77	1.10		1.10	1.00	0.23
ITALY	F(1,63)	3.99	0.03	0.87		0.11	0.17	2.30
JAPAN	F(2,61)	3.15	2.09	0.26		0.45	0.05	1.22
NETHERLANDS	F(0,64)							
SOUTH AFRICA	F(1,63)	3.99	0.36	0.47		0.03	8.80	0.08
UNITED KINGDOM	F(1,63)	3.99	0.07	2.14		0.81	0.00	3.71
USA	F(3,63)	2.75	0.76		0.52			

***Note**: critical values are at the 5% significance level, * denoted statistical significance at 5% level*

Table A3: Unit root test for the global variable at the 5% significance level

Global Variables	Test	Critical Value	Statistic
poil (with trend)	ADF	-3.45	-2.82
poil (with trend)	WS	-3.24	-3.09
poil (no trend)	ADF	-2.89	-2.85
poil (no trend)	WS	-2.55	-3.09
Dpoil	ADF	-2.89	-4.56
Dpoil	WS	-2.55	-4.83
DDpoil	ADF	-2.89	-7.00
Dpoil	WS	-2.55	-7.48

Table A4: Unit root test for the foreign variables at the 5% significance level

Foreign Variables	Statistic	Critical Value	BELGIUM	CHINA	FRANCE	GERMANY	ITALY	JAPAN	NETHERLANDS	SOUTH AFRICA	UNITED KINGDOM	USA
ys (with trend)	ADF	-3.45	-4.86	-5.51	-5.45	-5.58	-4.95	-3.99	-5.34	-5.24	-5.32	-4.41
ys (with trend)	WS	-3.24	-5.00	-5.72	-5.61	-5.73	-5.10	-4.20	-5.50	-5.45	-5.48	-4.61
ys (no trend)	ADF	-2.89	-4.33	-5.13	-5.03	-4.63	-4.57	-3.79	-5.00	-4.98	-4.80	-4.31
ys (no trend)	WS	-2.55	-4.54	-5.31	-5.23	-4.83	-4.77	-3.96	-5.21	-5.17	-5.01	-4.49
Dys	ADF	-2.89	-5.66	-4.15	-5.48	-5.48	-5.62	-5.34	-5.48	-5.53	-5.35	-5.47
Dys	WS	-2.55	-5.96	-4.32	-5.65	-5.69	-5.91	-5.60	-5.76	-5.81	-5.61	-5.77
DDys	ADF	-2.89	-6.70	-7.66	-7.03	-6.70	-6.63	-6.37	-6.88	-6.67	-6.70	-6.61
DDys	WS	-2.55	-7.03	-7.94	-7.37	-7.01	-6.95	-6.68	-7.21	-7.00	-7.03	-6.93
eqs (with trend)	ADF	-3.45	-2.70	-2.27	-2.18	-2.11	-2.30	-2.81	-2.54	-2.24	-2.22	-2.24
eqs (with trend)	WS	-3.24	-2.91	-2.48	-2.36	-2.30	-2.40	-3.05	-2.68	-2.41	-2.39	-2.41
eqs (no trend)	ADF	-2.89	-2.74	-1.90	-2.06	-2.02	-1.74	-1.82	-2.29	-1.91	-2.03	-1.89
eqs (no trend)	WS	-2.55	-2.92	-2.16	-2.30	-2.25	-2.04	-2.00	-2.54	-2.18	-2.28	-2.16
Deqs	ADF	-2.89	-7.43	-6.88	-7.28	-7.11	-9.67	-4.75	-8.48	-7.26	-7.62	-7.75
Deqs	WS	-2.55	-7.65	-7.10	-7.50	-7.32	-9.92	-4.98	-8.72	-7.48	-7.84	-7.97
DDeqs	ADF	-2.89	-6.84	-9.02	-9.11	-8.84	-11.19	-15.06	-10.44	-8.66	-9.35	-8.87
DDeqs	WS	-2.55	-7.14	-9.34	-9.43	-9.15	-11.56	-15.42	-10.79	-8.97	-9.68	-9.19
eps (with trend)	ADF	-3.45	-2.11	-1.44	-2.04	-1.92	-2.10	-1.84	-2.09	-2.16	-2.00	-2.14
eps (with trend)	WS	-3.24	-1.92	-1.71	-1.74	-1.85	-1.95	-2.12	-1.91	-2.33	-1.77	-2.40
eps (no trend)	ADF	-2.89	-0.80	-0.88	-0.56	-0.56	-0.80	-1.13	-0.72	-0.88	-0.57	-1.00
eps (no trend)	WS	-2.55	-1.06	-0.30	-0.91	-0.80	-0.95	-0.67	-0.92	-0.57	-0.88	-0.47
Deps	ADF	-2.89	-5.26	-3.23	-5.04	-5.42	-5.35	-5.33	-5.12	-3.33	-5.28	-3.33
Deps	WS	-2.55	-5.28	-3.26	-5.09	-5.41	-5.37	-5.45	-5.17	-3.41	-5.30	-3.40
DDeps	ADF	-2.89	-10.00	-10.57	-10.28	-8.01	-10.23	-7.31	-10.15	-10.93	-7.82	-11.03
DDeps	WS	-2.55	-10.15	-10.78	-10.43	-8.30	-10.44	-7.63	-10.35	-11.13	-8.10	-11.26
rs (with trend)	ADF	-3.45	-3.22	-3.01	-3.49	-3.62	-3.36	-3.72	-3.44	-3.78	-2.97	-3.54
rs (with trend)	WS	-3.24	-1.94	-2.41	-1.80	-2.35	-1.86	-1.79	-1.82	-1.54	-1.74	-1.27
rs (no trend)	ADF	-2.89	-0.58	-0.56	-0.86	-0.72	-0.49	-0.57	-0.87	-0.64	-0.36	-0.41
rs (no trend)	WS	-2.55	-1.03	-1.07	-1.32	-1.19	-0.96	-1.03	-1.32	-1.13	-0.89	-0.77
Drs	ADF	-2.89	-4.05	-3.94	-3.84	-3.74	-4.10	-4.18	-3.71	-3.86	-4.14	-3.86
Drs	WS	-2.55	-3.39	-3.56	-2.94	-3.25	-3.44	-3.76	-2.97	-3.20	-3.49	-3.65
DDrs	ADF	-2.89	-9.24	-6.22	-5.89	-9.84	-9.26	-10.43	-5.67	-9.91	-5.76	-10.43
DDrs	WS	-2.55	-9.46	-6.47	-5.99	-10.08	-9.47	-10.68	-5.77	-10.10	-5.78	-10.63
fcis (with trend)	ADF	-3.45	-4.91	-3.19	-5.29	-5.21	-4.89	-3.65	-4.78	-3.63	-5.63	-4.76
fcis (with trend)	WS	-3.24	-5.12	-3.42	-5.46	-5.41	-5.09	-3.90	-4.98	-3.88	-5.83	-4.88
fcis (no trend)	ADF	-2.89	-4.89	-3.17	-5.34	-5.20	-4.90	-3.66	-4.81	-3.66	-5.67	-4.71
fcis (no trend)	WS	-2.55	-5.07	-3.43	-5.49	-5.40	-5.11	-3.92	-5.02	-3.91	-5.87	-4.88
Dfcis	ADF	-2.89	-5.44	-3.24	-5.53	-4.70	-5.10	-6.40	-5.63	-5.85	-4.87	-6.19
Dfcis	WS	-2.55	-5.71	-3.49	-5.74	-4.88	-5.37	-6.60	-5.79	-6.05	-5.09	-6.39
DDfcis	ADF	-2.89	-6.14	-4.14	-6.72	-5.57	-5.99	-6.28	-6.52	-7.04	-6.55	-7.03
DDfcis	WS	-2.55	-6.49	-4.42	-7.04	-5.76	-6.40	-6.42	-6.79	-7.34	-6.78	-7.28

Table A5: Unit root tests for the domestic variables at the 5% significance level

Domestic Variables	Statistic	Critical Va	BELGIUM	CHINA	FRANCE	GERMANY	ITALY	JAPAN	NETHERLANDS	SOUTH AFRICA	UNITED KINGDOM	USA
y (with trend)	ADF	-3.45	-6.24	-2.31	-2.99	-4.55	-4.92	-3.22	-3.49	-4.36	-2.60	-3.60
y (with trend)	WS	-3.24	-6.34	-2.53	-2.91	-4.75	-5.05	-3.09	-3.63	-4.55	-2.84	-3.78
y (no trend)	ADF	-2.89	-5.39	-2.34	-2.10	-4.56	-3.19	-3.27	-2.90	-4.37	-2.33	-1.98
y (no trend)	WS	-2.55	-5.60	-2.55	-2.37	-4.78	-3.34	-3.08	-3.10	-4.58	-2.60	-2.23
Dy	ADF	-2.89	-3.93	-5.54	-6.07	-5.79	-5.32	-7.70	-5.36	-5.57	-6.15	-5.81
Dy	WS	-2.55	-3.80	-5.83	-6.35	-6.06	-5.52	-8.05	-5.57	-5.83	-6.41	-5.96
DDy	ADF	-2.89	-5.04	-6.82	-6.76	-6.15	-6.96	-7.58	-6.09	-6.44	-7.37	-6.49
DDy	WS	-2.55	-5.22	-6.94	-6.98	-6.49	-7.26	-7.71	-6.41	-6.28	-7.64	-6.69
eq (with trend)	ADF	-3.45	-2.29	-4.05	-3.80	-1.87	-2.02	-3.43	-3.22	-4.43	-3.28	-1.82
eq (with trend)	WS	-3.24	-2.43	-4.23	-3.88	-2.16	-2.36	-3.65	-3.52	-4.38	-3.01	-1.82
eq (no trend)	ADF	-2.89	-2.02	-1.78	-2.18	-1.36	-2.17	-2.08	-2.42	-3.22	-1.44	-2.00
eq (no trend)	WS	-2.55	-2.30	-1.55	-2.31	-1.37	-2.37	-1.88	-2.53	-2.30	-1.66	-0.15
Deq	ADF	-2.89	-9.43	-9.76	-9.90	-6.97	-7.00	-7.41	-4.99	-8.12	-6.39	-8.06
Deq	WS	-2.55	-9.68	-9.99	-9.67	-6.56	-7.28	-7.67	-5.27	-8.34	-5.47	-7.91
DDeq	ADF	-2.89	-11.25	-7.93	-8.69	-7.66	-10.68	-7.50	-6.76	-14.34	-7.75	-7.33
DDeq	WS	-2.55	-11.63	-8.34	-8.83	-7.68	-11.05	-7.28	-7.10	-14.63	-7.39	-8.10
ep (with trend)	ADF	-3.45	-1.88	-2.02	-2.05	-2.16	-2.13	-1.86	-1.68	-1.76	-1.50	
ep (with trend)	WS	-3.24	-1.83	-2.28	-2.02	-1.76	-1.99	-1.92	-1.85	-2.08	-1.82	
ep (no trend)	ADF	-2.89	-0.97	-1.48	-0.92	-0.88	-0.58	-1.94	-2.05	-1.36	-1.45	
ep (no trend)	WS	-2.55	-1.36	-0.71	-0.84	-1.21	-0.83	-0.57	-1.49	-1.69	-0.86	
Dep	ADF	-2.89	-5.61	-5.56	-5.15	-5.03	-4.02	-1.97	-5.63	-5.05	-3.55	
Dep	WS	-2.55	-5.75	-5.73	-5.16	-5.14	-4.15	-2.11	-5.79	-5.13	-3.61	
DDep	ADF	-2.89	-10.96	-7.77	-9.69	-10.21	-6.90	-13.44	-8.19	-9.33	-10.76	
DDep	WS	-2.55	-11.24	-8.08	-9.85	-10.42	-7.20	-13.66	-8.48	-9.51	-11.01	
r (with trend)	ADF	-3.45		-2.93	-3.02	-3.04		-3.86				-2.89
r (with trend)	WS	-3.24		-1.08	-2.97	-1.88		-2.27				-2.07
r (no trend)	ADF	-2.89		-0.50	-1.47	-1.07		-0.99				-0.61
r (no trend)	WS	-2.55		-0.79	-1.78	-1.45		-1.39				-1.13
Dr	ADF	-2.89		-3.87	-3.74	-3.87		-4.42				-4.10
Dr	WS	-2.55		-3.99	-3.51	-3.08		-4.46				-3.33
DDr	ADF	-2.89		-11.21	-9.99	-5.42		-6.45				-6.36
DDr	WS	-2.55		-11.47	-10.25	-5.47		-6.69				-6.37
fci (with trend)	ADF	-3.45	-2.96	-4.32	-3.52	-2.03	-2.99	-2.53	-4.40	-3.48	-3.06	-2.65
fci (with trend)	WS	-3.24	-3.12	-4.59	-3.78	-2.30	-2.76	-2.72	-4.45	-3.74	-3.29	-2.92
fci (no trend)	ADF	-2.89	-2.98	-4.35	-3.57	-2.07	-3.14	-2.49	-3.36	-3.51	-3.05	-2.63
fci (no trend)	WS	-2.55	-3.12	-4.62	-3.81	-2.30	-3.18	-2.72	-3.11	-3.77	-3.12	-2.92
Dfci	ADF	-2.89	-4.37	-6.40	-4.14	-4.27	-6.01	-8.68	-4.21	-3.04	-5.06	-4.29
Dfci	WS	-2.55	-4.58	-6.58	-4.10	-4.32	-6.20	-8.90	-4.32	-3.29	-5.30	-4.49
DDfci	ADF	-2.89	-6.70	-6.61	-6.02	-7.72	-7.92	-7.97	-6.26	-4.31	-5.46	-3.66
DDfci	WS	-2.55	-6.98	-6.67	-6.24	-8.02	-8.19	-8.21	-6.63	-4.55	-5.76	-3.84

Table A6: VARX order of Individual models and Cointegrating Relations

	p	q	# of Cointegrating relations
BELGIUM	2	1	0
CHINA	2	1	1
FRANCE	1	1	1
GERMANY	2	1	3
ITALY	1	1	1
JAPAN	2	1	2
NETHERLANDS	1	1	0
SOUTH AFRICA	2	1	1
UNITED KINGDOM	2	1	1
USA	2	1	3

Note: P=lag order of domestic variables, q=lag order of foreign variables
Source: Authors' estimation

Figure A7: persistence profiles for selected cointegrating vectors

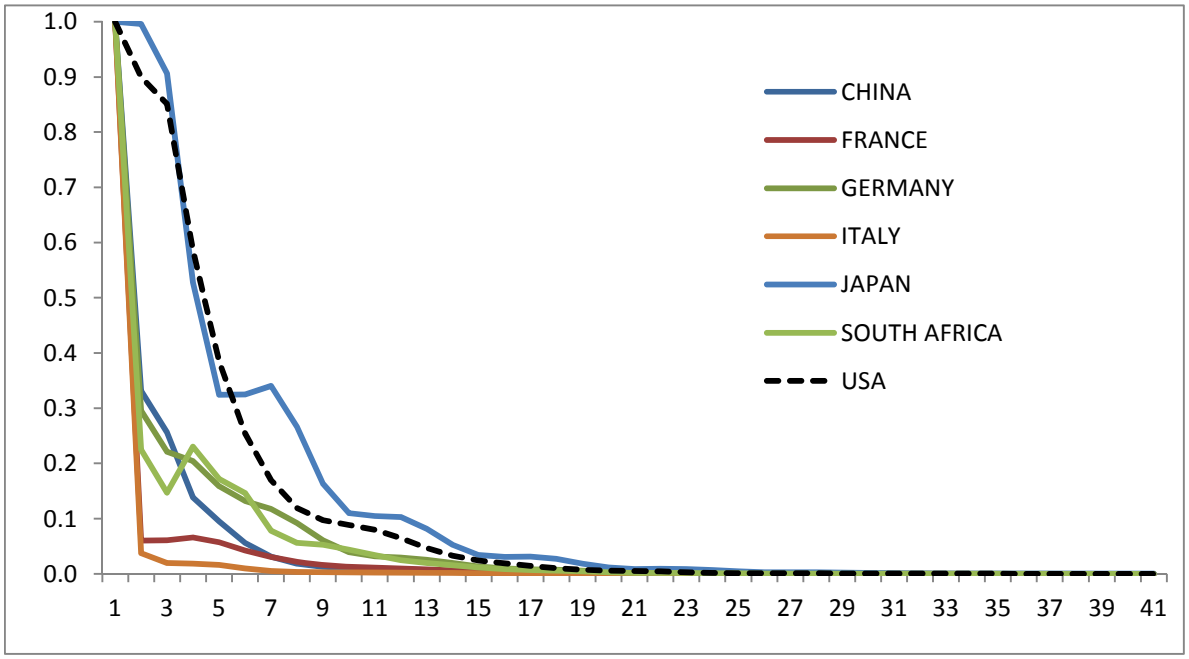


Table A7: Variables used for FCI construction

BELGIUM	CHINA	FRANCE	GERMANY	ITALY	JAPAN	NETHERLANDS	SOUTH AFRICA	UNITED KINGDOM	USA
Real equity price index	Real equity price index	Real equity price index	Real equity price index	Real equity price index	Real equity price index	Real equity price index	Real equity price index	Real FTSE100 stock index	Real S&P500 stock index
Real house prices	Effective Exchange Rate	Real house prices	Real Household credit	Real Household credit	Real house prices	Nominal Effective exchange rate	ABSA Real house prices	Real house prices	Real house prices
Effective Exchange rate	Real Money Supply (M2)	Real Household credit	Real house prices	Real house prices	Real Household credit	Real household credit	Negotiable certificate of deposits	Nominal Effective exchange rate	Commercial paper/3-month treasury bill spread
Treasury bill rate	5 year swap rate	Real Corporate credit	Effective Exchange Rate	Effective Exchange Rate	Real Corporate credit	Real corporate credit	Total loans and advances	Money market interest rate	Business and consumer credit
Consumer Price Index	CBOC policy rate	Effective Exchange Rate	3 month overnight rate	Treasury bill rate	5 year generic government bond	Real house prices	Nominal effective exchange rate	10 year bond/3 year bond spread	Federal funds rate
Real household credit	Private credit extension	Treasury bill rate			Treasury bill rate		Eskom/government bond spread	3-month libor/3-month treasury bill	US 10-year government bond yield/3-month treasury bill spread
	TED spread				Lending rate /3-month libor spread		10 year government bond/3-month treasury bill		3-month libor
							Lending spread		Prime rate/libor spread
							Prime lending rate		3-month libor/3-month treasury bill
							S&P500 stock index		Real money supply (M1 & M2)
							VIX index		SLOOS
							TED spread		5 year swap rate
							Oil price		VIX index
									Real Effective Exchange rate
									NASDAQ composite index
									Oil price

Note: data represented in table A7 is sourced from different data sources including: BIS, IMF, and Bloomberg

Appendix B. Country specific models

Assuming a set of *N+1* countries indexed by $i = 0,1,2 \ldots\ldots\ldots\ldots N$, with country 0 taken as the reference country, which is the US in this study due to its economic size, we estimate a VARX* model of the following form:

$$x_{it} = a_{i0} + a_{i1}t + \phi_i x_{i,t-1} + \Lambda_{i0} x_{it}^{*} + \Lambda_{i1} x_{i,t-1}^{*} + \Gamma_{i0} d_t + \Gamma_{i1} d_{t-1} + \varepsilon_{it} \quad (5)$$

Where $t = 1, \ldots\ldots, T$, x_{it} is a (k_i x 1) vector of endogenous variables in country i at time t. ϕ_i denotes the (k_i x k_i) matrix of coefficients associated with the lagged domestic variables, Λ_{i0} and Λ_{i1} are (k_i x k_i^*) matrices of parameters related to contemporaneous and lagged foreign variables respectively. a_{i0} is a (k_i x 1) vector of fixed intercepts, a_{i1} is a (k_i x 1) vector of coefficients of the deterministic time trend, d_t denotes a set of observed global factors assumed to be weakly exogenous to the global economy but should be endogenous to the reference country (the United States). Γ_{i0} and Γ_{i1} are matrices of fixed parameters. Furthermore, ε_{it} is a (k_i x 1) vector of idiosyncratic, serially uncorrelated, country specific shocks, where $\varepsilon_{it} \sim i.i.d\ (0, \sum_{ii})$. Finally, x_{it}^{*} is a (k_i^* x 1) vector of country-specific foreign variables constructed as a weighted average of their cross-country counterparts, as follows:

$$x_{it}^{*} = \sum_{j \neq i}^{N} \omega_{ij} x_{jt} \quad (6)$$

Where ω_{ij} denotes the weights corresponding to the pair of country i and country j, and shows the degree to which one country depends on the remaining countries in the global system. Specifically, ω_{ij} can be constructed as the total trade between country i and country j divided by the total trade of country i with all of its trading partners, where $\omega_{ii} = 0$, $\forall i = 0,1,2 \ldots\ldots\ldots\ldots$N and $\sum_{j \neq i}^{N} \omega_{ij} = 1\ \forall j = 0,1,2 \ldots\ldots\ldots\ldots$N. Importantly, country-specific foreign variables x_{it}^{*} are treated as weakly exogenous, which implies that each country, with the exception of the reference country (US), is a small open economy.[18]

[18] In other words, its domestic macroeconomic developments cannot affect the whole set of the 'rest of the world' countries, at least in the long-run, though allowing for short-run feedbacks between these two set of variables (See Galesi & Sgherri ,2009).

GVAR model specification

After VARX* models are estimated, the construction of a GVAR model becomes simple and straightforward. We re-write the VARX* model in equation 5 above without the global variables as follow:

$$x_{it} = a_{i1} + a_{i1}t + \phi_i x_{i,t-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{i,t-1} + \varepsilon_{it} \quad (7)$$

We then group together both domestic and foreign variables defined by (k_i + k_i^*) x 1 vector

$$z_{it} = \begin{pmatrix} x_{it} \\ x^*_{it} \end{pmatrix} \quad (8)$$

Equation 7 can then be rewritten as

$$A_i z_{it} = a_{i0} + a_{i1}t + B_i z_{i,t-1} + \varepsilon_{it} \quad (9)$$

where $A_i = (I_{ki,} - \Lambda_{i0})$ and $B_i = (\phi_i, \Lambda_{i1})$

The dimensions of A_i and B_i are k_i x (k_{it} + k_i^*), and A_i has a full row rank, meaning $rank\ (A_i) = k_i$. To create the global vector $x_t = (x'_{ot}, x'_{it}, x'_{2t} \dots\dots\dots x'_{Nt})'$ we collect all country specific domestic variables with dimension (k_i x 1) where $k = \sum_{i=0}^{N} k_i$ denotes the total number of endogenous variables in the global system. We make an assumption that all country-specific variables are endogenously determined and therefore country-specific variables can now be written in terms of x_t in order to yield the following important identity:

$$Z_{it} = M_i\, x_t \quad \forall i = 0,1,2 \dots\dots\dots\dots N \quad (10)$$

where M_i is a (k_i + k_i^*) x k_i matrix of trade weights ω_{ij} $\forall i, j = 0,1,2 \dots\dots\dots\dots N$ and can be viewed as the link matrix that allows the country-specific models to be expressed in terms of global variable vector, x_t. Accordingly, combining equations (10) and (9) leads to the following expression:

$$A_i M_i x_t = a_{i0} + a_{i1}t + B_i M_i x_{i,t-1} + \varepsilon_{it} \quad (11)$$

where $A_i M_i$ and $B_i M_i$ are both (k x k) dimensional matrices. Lastly, we stack each country-specific model, one on top of the other, in expression (11) in order to obtain

the global VAR for all the endogenous variables in the global system x_t in the following way

$$Gx_t = a_0 + a_1 t + Hx_{t-1} + \varepsilon_t \quad (12)$$

With $G = A_i M_i$ and $H = B_i M_i$,

where

$$G = \begin{pmatrix} A_0 M_0 \\ A_1 M_1 \\ \cdots \\ \cdots \\ A_N M_N \end{pmatrix}, \quad H = \begin{pmatrix} B_0 M_0 \\ B_1 M_1 \\ \cdots \\ \cdots \\ B_N M_N \end{pmatrix} \quad (13)$$

and

$$a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \cdots \\ \cdots \\ a_{N0} \end{pmatrix}, \; a_1 = \begin{pmatrix} a_{01} \\ a_{11} \\ \cdots \\ \cdots \\ a_{N1} \end{pmatrix}, \quad \varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ \cdots \\ \cdots \\ \varepsilon_{Nt} \end{pmatrix} \quad (14)$$

Matrix G is of dimension $(k \text{ x } k)$ with full rank and hence non-singular. Consequently, G can be inverted to get the global VAR in its reduced form as follows:

$$x_t = G^{-1} a_0 + G^{-1} a_1 t + G^{-1} H x_{t-1} + G^{-1} \varepsilon_t \quad (15)$$

Equation 15, which is our GVAR model, can then be solved recursively and the dynamic properties of the model are analysed using GIRFs.