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JEL: E32, F15, C51
Keywords: GVAR, Chinese integration, shock transmission, euro area debt crisis

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1 Introduction

The integration of China into the world economy has been one of the most spectacular events in recent economic history. In only three decades, China transformed from a closed and agricultural country to the second largest economy in the world, with a share of 15 percent of global GDP in PPPs. The industrialized world has benefitted from the evolution due to manufactured and intermediate products at lower costs and new markets. The country is already well integrated in the world economy. China absorbs more than 10 percent of the exports from the advanced countries, after 5.5 percent at the turn of the century. At the same time, concerns have risen in the industrialized world, as the manufacturing and labour intensive industries have gone under higher competition pressure, further intensified by a depreciation of the Renmimbi. These reservations became more relevant as unemployment increased in many countries during the last recession. Although the global imbalances have declined since then, they are still striking and will likely pick up again (Feldstein, 2011).

The rising economic power of China might affect the macroeconomic performance in industrial countries. For example, China absorbs more than 40 percent of the overall increase of Japanese exports over the past 5 years. The shares are 16 percent for the US and 8 percent for the euro area, respectively. The integration can contribute to a higher divergence of international business cycles, i.e. stronger decoupling in the world economy. In that case, the global economy could become more resistant against shocks arising from advanced economies. However, as the global financial crisis has shown, emerging markets are still highly vulnerable to the evolution of the advanced economies. After initial decoupling, economic activities became highly synchronized after the Lehman crash. The subsequent recovery has been characterized by a revival of the de-

coupling hypothesis, i.e. a strong increase in GDP in China and other emerging markets and modest growth in major industrial states. Currently, Chinese growth might be curtailed by the government debt crisis in the euro area, which is the most important export market.

The degree of comovement of economic activity across countries has been explored by several studies. However, the literature did not arrive at robust conclusions and the evidence is limited to the period before the financial crisis. Hence, the issue is still an open area of research. Most papers looked on business cycle dynamics across advanced countries or particular regions. Stock and Watson (2005) concluded from their analysis that output comovement for the G7 countries has fallen over the 1984–2002 period relative to 1960–83, most likely due to the absence of common shocks. According to Artis and Zhang (1997) and Artis, Krolzig and Toro (2004) a common component affects the cyclical development in the euro area countries. Sato and Zhang (2006) and Shin and Sohn (2006) reported evidence in favour of business cycle convergence in East Asia, probably caused by trade integration. International production chains are an important driver in this regard.

Only a few papers have extended the scope of the analysis to explore patterns between industrial and emerging markets. Following Kose, Otrok and Prasad (2008), business cycles have converged among the groups of advanced and emerging market economies, respectively. Since the weight of the global factor has declined, there is cyclical convergence within each group, but higher divergence between them. Globalization did not change the degree of the pattern of international synchronization because the joint contribution of the global and group-specific factors is rather stable over time. While common components play a larger role for business cycles in the group of advanced econo-

mies, country specific factors are more relevant for the emerging markets (Kose, Otrok and Whiteman, 2003). One rationale for this finding might be that many emerging countries have reached only intermediate levels of financial integration, i.e. they are not able to improve risk sharing opportunities (Kose, Prasad and Terrones, 2007). The high savings rate in China of almost 50 percent may be interpreted as an indication of poorly developed financial markets.

The Kose, Otrok and Prasad (2008) finding of a low correlation of business cycles between emerging and industrial countries is at odds with Frankel and Rose (1998). If trade linkages get tighter, business cycles can be more closely correlated across countries, at least in the absence of idiosyncratic shocks. But there is little evidence for comovement between industrial countries and China at the typical business cycle frequencies, as many correlations are even negative, see Fidrmuc, Korhonen and Bátorová (2008). The ties are positive only in the very short run, indicating strong relations between suppliers in China and final producers in developed countries. Vertical trade specialization is especially relevant for intermediate products. In a different vein, Pula and Peltonen (2009) emphasized that trade statistics overestimate the level of integration that actually takes place, because of multiple counting of products in largely fragmented production processes.

To explore the interdependencies acrosscountries, authors often looked on static and dynamic bivariate correlations of the cyclical components of output or on the ability of global or regional factors to explain individual business cycles. However, the directions of causality are not covered by this research (Chen and Chihying, 2008). This paper takes a different route and specifies a global VAR (GVAR) model to examine the impact of a Chinese shock on output growth and inflation in industrial countries, namely

the US, the euro area and Japan. Cesa-Bianchi, Pesaran, Rebucci and Xu (2011) have employed such a similar approach to investigate the impact of China on business cycles in Latin America. In the analysis presented below, the recent Chinese fiscal stimulus package serves as an example. For robustness, the results are compared to those obtained by leading structural macroeconometric models, such as NiGEM and OEF. The findings suggest that the Chinese impact on GDP growth and inflation in the advanced economies is substantial for the Asian region. The expansionary effects for the US and the euro area responses are much lower and decrease due to rising inflation pressure. As Chinese firms participate in international production chains, an increase in domestic inflation will cause spillovers to the rest of the world. The analysis also reveals that China is still highly vulnerable to shocks in industrial countries, including the government debt crisis in the euro area.

The rest of the paper is structured as follows. The next section (Section 2) presents the Chinese fiscal stimulus program as an illustration for a huge demand shock. Afterwards the econometric tools are reviewed. They include global VAR (Section 3) and structural macroeconometric models (Section 4). The empirical results are discussed in Section 5. Finally, Section 6 concludes.

2 China's fiscal stimulus package

Despite clear signals of a recession in industrial countries, China experienced high output growth in the first period of the financial crisis. However, after the collapse of the Lehman bank, GDP growth decreased markedly as major export markets deteriorated. Thousands of firms closed down especially in the export-oriented coastal areas and mil-

lions of workers lost their jobs from one day to the other. A deceleration of growth is a matter of concern for several reasons. According to many observers, an annual GDP growth rate of 8 percent is the minimum level to generate enough jobs to ensure a smoothed integration of labour migrants into the workforce and to avoid social unrest that could destabilize the country. Furthermore, high growth is a way of papering over existing weaknesses of the economy and provides one of the best instruments for solving structural problems (Prasad, 2007).

It is against this backround that the Chinese government decided to launch a fiscal stimulus package of 3.1 and 2.7 percentage points of GDP in 2009 and 2010, respectively. The package includes higher investment in infrastructure in rural areas and large scaled projects like railroads, roads and airports and to a minor extent measures to improve the livelihood of the people, such as a stronger social safety net, the construction of low rent housing, better quality of public healthcare and education. See Naughton (2009) for a breakdown of the individual expenditures.

The package may lead to a higher path of private consumption as the need of precautionary savings is reduced. The decrease of public social transfers is often seen as a factor behind the decline of the consumption to GDP ratio in the pre-crisis period. Private households had to save more to finance future expenditures on health, education and consumption in the retirement age (Baldacci, Callegari, Coady, Ding, Kumar, Tommasino and Woo, 2010). However, the stimulus package did not reverse the export- and investment led growth strategy (Xu, 2010). Strategic export oriented industries will be further supported in the next five year plan. But a more balanced path of output expansion is planned, putting higher weight on domestic demand and the production of non-

tradables and services. Eventually, China could become less vulnerable against global shocks.

The fiscal stimulus appears to be successful at first sight. Despite the marked break-down in export activities, the Chinese economy continued to increase at high rates. According to the input output analysis presented by He, Zhang and Zhang (2009) the fiscal multiplier is slightly about 0.8 in the short run and rises to 1.1 in the medium run. The package can generate up to 20 million new jobs in the non-farming sectors. Similarly, the simulation evidence provided by Cova, Pisani and Rebucci (2010) points to strong positive effects in the short run, as 2.5 percentage points of the recent growth experience might be attributed to the stimulus. Because of higher GDP growth Chinese imports will accelerate, implying international spillovers due to better export opportunities for the rest of the world. It should be noted, however, that the long run effects of the fiscal package are less clear. Especially public firms benefitted from the infrastructure projects and received further credit from the state owned banks. Competition pressures have declined, generating an obstacle for faster structural change towards a higher weight of private firms in the economy. Public debt increased in many regions to provide funding for projects.

3 Global VAR models

Global VAR (GVAR) models provide a convenient framework to explore international transmission mechanisms. The model is based on VARs for N+1 countries, see Pesaran, Schuermann and Weiner (2004) and Garratt, Lee, Pesaran and Shin (2006). The country specific models are linked as foreign variables are allowed to enter the equations. Due

to the low number of degrees of freedom, the latter are measured as aggregates. In the VARX(1,1) specification

$$(1) \qquad x_{it} = a_{i0} + a_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{i,t-1} + u_{it}$$

i is the country index and t denotes time. Furthermore x_{it} is a vector of k_i domestic variables, and x^*_{it} a vector with k^*_i country specific foreign variables, i.e. constructed by a weighting scheme relevant for the particular country. The system might be extended by common factors representing global variables such as oil prices. In addition, Φ_i is a k_ixk_i matrix of coefficients for the lagged domestic variables, and Λ_{i0} and Λ_{i1} are k_ixk^*_i matrices associated with the coefficients of the foreign variables in contemporaneous and lagged form. Deterministic components can include intercepts and linear time trends. Finally, u_{it} is a vector of k_i serially uncorrelated idiosyncratic shocks with zero mean and nonsingular covariance matrix. In case of autocorrelation patterns, further lags are added to the VARX. Shocks are allowed to be contemporaneously correlated, both across the equations for a specific country and across countries. International spillovers can arise because of a contemporaneous impact of the foreign on the domestic variables, through a dependence on global variables and through the contemporaneous correlation structure of the shocks.

The foreign variables are constructed using country-specific weighting schemes. In particular, weights are chosen in line with bilateral trade flows (Dees, Di Mauro, Pesaran and Smith, 2009). As an alternative, Vansteenkiste (2007) have proposed weights based on the distance between regions, and Hiebert and Vansteenkiste (2007) employed weights taken from input-output tables across sectors. The set of foreign specific variables for the ith country is

(2) $$x^{*}_{i,t} = \sum_{j=1}^{N} w_{i,j} x_{j,t}$$

where the weights $w_{i,j}$ add to unity and $w_{i,i}$ is equal to zero. The weights can be time-varying as long as they are predetermined. This is important in case of rapidly expanding emerging economies with fast changing trade relations to the rest of the world. Each VARX is consistently estimated on separate grounds, as the estimation of the whole system is not feasible. The foreign variables are treated as weakly exogeneous with respect to the parameters of interest. In the context of cointegrated models, the weak exogeneity assumption implies no long-run feedback from domestic to foreign variables, i.e. the error correction term is not significant for the latter series (Juselius, 2005). Lagged short-run feedback between the two sets of variables are allowed. The weak exogeneity restriction is tested in the context of individual models.

Once the VARXs have been estimated, the model is solved for all variables in a simultaneous way. By grouping the domestic and foreign variables, the individual country models can be stated as

(3) $$\mathrm{A}_i z_{i,t} = a_{i,0} + a_{i,1} t + \mathrm{B}_i z_{i,t-1} + u_{i,t}$$

where

$$\mathrm{A}_i = (\mathrm{I}_{k_i}, -\Lambda_{i,0}) \quad , \quad \mathrm{B}_i = (\Phi_i, \Lambda_{i,1}) \quad , \quad z_{it} = \begin{pmatrix} x_{it} \\ x^{*}_{it} \end{pmatrix}.$$

The kx1 global vector x_t

$$x_t = \left(x_{0t}', x_{1t}', \ldots, x_{Nt}' \right)' \quad , \quad k = \sum_{i=0}^{N} k_i$$

holds the variables gathered from all countries in the system. The model can be rewritten in terms of the *x*-vector by using the identity

(4) $$z_{i,t} = W_i x_t$$

where W_i is the $(k_i+k^*_i)$xk link matrix obtained from the country specific weights. The GVAR arises from the VARXs

$$A_i W_i x_t = a_{i,0} + a_{i,1} t + B_i W_i x_{t-1} + u_{i,t}$$

by stacking the individual models

(5) $$G x_t = a_0 + a_1 t + H x_{t-1} + u_t$$

$$G = \begin{pmatrix} A_0 W_0 \\ A_1 W_1 \\ \vdots \\ A_N W_N \end{pmatrix} \quad , \quad H = \begin{pmatrix} B_0 W_0 \\ B_1 W_1 \\ \vdots \\ B_N W_N \end{pmatrix} \quad , \quad a_0 = \begin{pmatrix} a_{00} \\ a_{01} \\ \vdots \\ a_{0N} \end{pmatrix} \quad , \quad a_1 = \begin{pmatrix} a_{10} \\ a_{11} \\ \vdots \\ a_{1N} \end{pmatrix} \quad , \quad u_t = \begin{pmatrix} u_{0t} \\ u_{1t} \\ \vdots \\ u_{Nt} \end{pmatrix}.$$

Given that G is nonsingular, the system (5) can be solved for x_t. The dynamics of the variables are investigated by impulse response analysis and variance decompositions. These tools are considered in generalized form, i.e. they are invariant to the ordering of variables and countries (Pesaran and Shin, 1998). Even if a suitable ordering of the variables in a VARX might be taken from economic theory, it is not clear how to order countries in the GVAR.

4 Structural macroeconometric models

Besides the GVAR, evidence is obtained on the grounds of two leading structural global macroeconometric models, the NiGEM (National Institute for Economic and Social Research, 2011) and the OEF model (Oxford Economic Forecasting, 2011). Although the models differ in detail, they share basic properties. Both are designed for forecasting and policy simulation. Because of the forecasting task, the equations are fitted to historical data. Individual country models are interlinked through several channels, like trade, commodity prices, asset holdings and associated income flows, exchange and interest rates. Forward looking agents are assumed in the financial markets, but this depends on the particular specification.

The general structure is similar across countries, more or less. Potential GDP is obtained from a Cobb Douglas or CES production function with labour augmenting technical progress. The latter is exogeneous for the advanced economies, but it might depand on FDI inflows for catching up economies. The production function constitutes the theoretical background for the specification of the factor demand equations for employment and capital. Firms bargain with workers over wages, and choose the extent of labour conditional to output and real wages. In the long run equilibrium, real wages move in line with productivity. A rise in unemployment (or an increase over the NAIRU) has a dampening effect on real wages, implying that they fall relative to their trend. Inflation is a monetary phenomenon in the long run. Monetary policy sets the short term interest rate to achieve its target. Interest rates move up if inflation is above the desired level and/or output is above potential. Actual GDP is equal to the sum of the demand components. Private consumption depends on real disposable income, real financial wealth, real interest rates and inflation. Investment of firms is affected by the capacity utilization and Tobins *q*. Taxes and allowances are taken into account to derive the opportuni-

ty costs. Exports are a function of foreign demand and the real exchange rate, where a world trade matrix ensures the fulfillment of adding-up constraints across countries. Imports are driven by real domestic demand and competitiveness, such as relative unit labour costs or relative prices. Disequilibria between supply and demand are temporary and are represented by the output gap, i.e. the difference between actual and potential GDP, expressed as a percentage of the latter. The output gap is relevant for the price adjustment, jointly with unit labour costs and import prices. Government spending and revenues depend on the state of the business cycle. For policy analysis, tax rates are treated as exogenous.

Due to the nonstationarity of most variables, the equations are often specified in error correction format with suitable dynamics around the long run. The long run is either specified on theoretical grounds or estimated in advance. Both model alternatives are implemented as simultaneous equation systems. To exclude spillovers arising from large errors in specific relationships, estimation is done equation by equation. An instrumental variable approach is used to control for endogeneous right hand side regressors. Interdependencies within a country and across countries are considered after estimation is done. Once the regression parameters are determined, the whole system is solved by simulation methods.

5 Business cycle spillovers in the global economy

The GVAR model comprises equations for real GDP and CPI inflation. To capture international spillovers arising through financial markets, real equity prices, real exchange rates, nominal short and long term interest rates are also embedded on a country-by-

country basis. In each equation, the domestic variable is explained by its own lags, lags of the other variables of the system and lags of the foreign variables. The latter enter as an aggregate, with weights reflecting the relevance of the individual countries as trading partner for the domestic economy. Provided that the series are nonstationary, the equations are specified for the differenced variables, including error correction terms for the level variables. All lag parameters are chosen in line with the Schwartz information criterion. The data are taken from the usual sources, such as the International Financial Statistics from the IMF and Datastream. Quarterly series are seasonally adjusted, and the observation period is from 1979Q1 to 2009Q4. Results are derived with the GVAR toolbox provided by Smith and Galesi (2011), version 1.1.

The fiscal stimulus (3.1 and 2.7 percent of GDP in the first and second year) is implemented by a respective shock. The expected effects are obtained by generalized impulse response analysis. In the structural models, the difference to the baseline, i.e. the development without any additional measures is investigated. See Table 1 for the impacts on GDP growth and Table 2 for the inflation response.

-Tables 1 and 2 about here-

The Chinese GDP is expected to rise as a response to the initial shock. Besides the national effect, business cycle spillovers can be substantial. According to the GVAR and NiGEM specification, the GDP response is relatively high in Asia. Output growth in Japan rises up to one percentage point, reflecting higher export opportuinities of Japanese firms. See also Figure 1 for the GVAR impulse responses. Therefore, China could

trigger economic growth in the region. Furthermore, the GVAR reveals some acceleration of GDP growth in the US and the euro area, especially in the second year. But this effect is not robust. The reactions will decrease in the NiGEM model, with a negative multiplier in the US.

-Figure 1 about here-

The latter reaction can be partially linked to differences in the inflation response. Due to the acceleration in demand, CPI inflation is affected. The estimates imply that a substantial part of the recent inflation experience in China can be attributed to domestic forces. While the rise in inflation is only minor in the US and the euro area in the GVAR, the reaction is more pronounced in the NiGEM specification. Private consumption will decline due to a reduction in the purchasing power of households. Global inflation increases because of higher prices of products imported from China. This size of this effect depends on the extent to which Chinese products can be substituted. The lower the respective elasticities, the higher the impact on inflation.

Further insights into the strenghts of business cycle spillovers can be obtained, if the analysis is carried out in the reversed direction, i.e. the Chinese reaction to shocks in the industrial countries is considered[2]. Currently, a shock stems from the euro area government debt crisis. It is assumed that the crisis will reduce euro area growth by 2 percentage points per annum, which is roughly equal to the difference between actual and potential output growth. Under this setting, GDP growth in China will drop by around 1

[2] Results are not explicity shown due to space limitations. The tables are available from the authors upon request.

percentage point per annum. The reaction is quite strong, as the euro area is among the most important export market. While its role as a new growth engine for the non Asian industrial economies is rather moderate, China remains highly vulnerable to shocks arising in these countries.

6 Conclusion

The integration of China into the global economy is one of the most spectacular events in economic history. In three decades, China transformed from an agricultural country to the second largest economy in the world, with a share of 15 percent of global GDP (PPP). This paper investigates to what extent this process affects output growth and inflation in the advanced countries. A GVAR model is specified to explore interdependencies between business cycles in China and industrial countries, including the US, the euro area and Japan. For robustness, the results are compared to those obtained from leading structural models, such as NiGEM and OEF. Evidence is based on the responses to a Chinese shock stemming from the recent fiscal stimulus package. The results indicate that the impact on GDP growth in the advanced economies is substantial for the Asian region. The expansionary effects to the US and the euro area responses are much lower and decrease due to rising inflation pressure. The analysis also reveals that China is still highly vulnerable to shocks in industrial countries, including the government debt crisis in the euro area.

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Table 1: Responses of real GDP to Chinese demand shock

	GVAR	NiGEM	OEF
China	3.4 | 3.7	3.0 | 2.7	3.1 | 2.9
Japan	0.6 | 0.7	0.9 | 0.4	0.0 | 0.0
US	0.4 | 0.7	0.2 | -0.3	0.0 | 0.0
Euro area	0.3 | 0.5	0.3 | 0.2	0.0 | 0.0

Note: Responses to the fiscal stimulus program in China. Left (right) entry: Cumulated response after the first (second) year. Differences expressed as percentage points from the baseline.

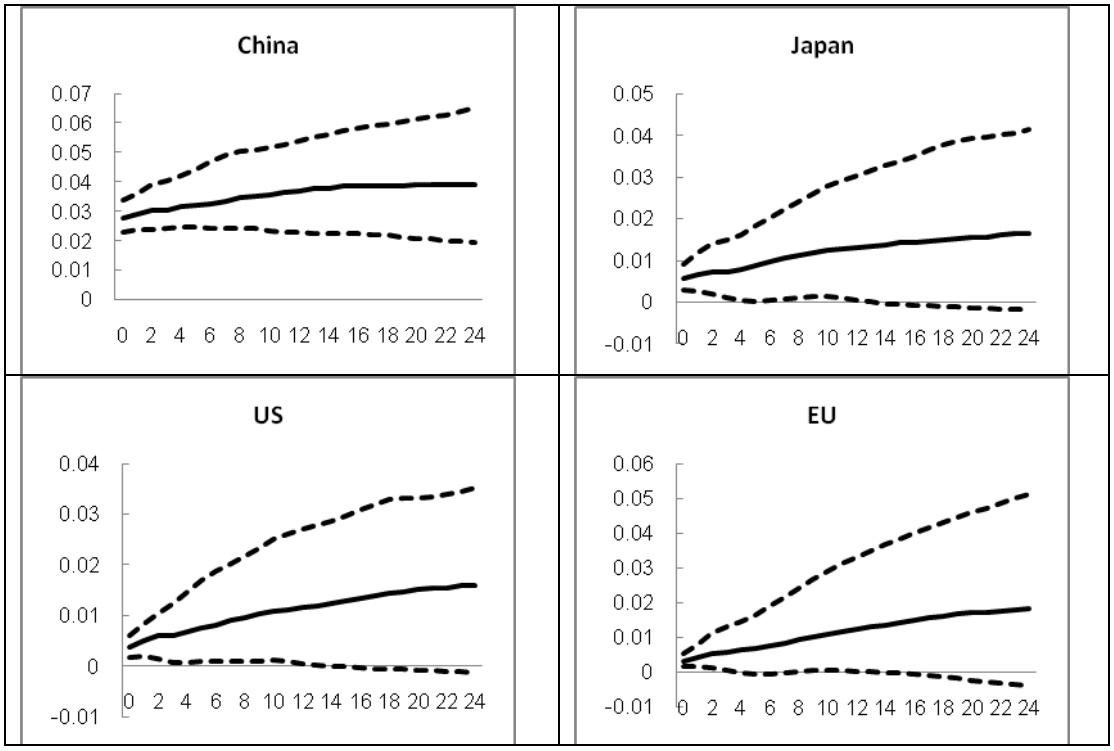
Table 2: Responses of inflation to Chinese demand shock

	GVAR	NiGEM	OEF
China	0.5 | 0.8	1.3 | 2.7	0.2 | 0.8
Japan	0.3 | 0.5	0.1 | 0.4	0.0 | 0.0
US	0.0 | 0.2	0.2 | 0.6	0.0 | 0.0
Euro area	0.0 | 0.1	0.2 | 0.5	0.0 | 0.0

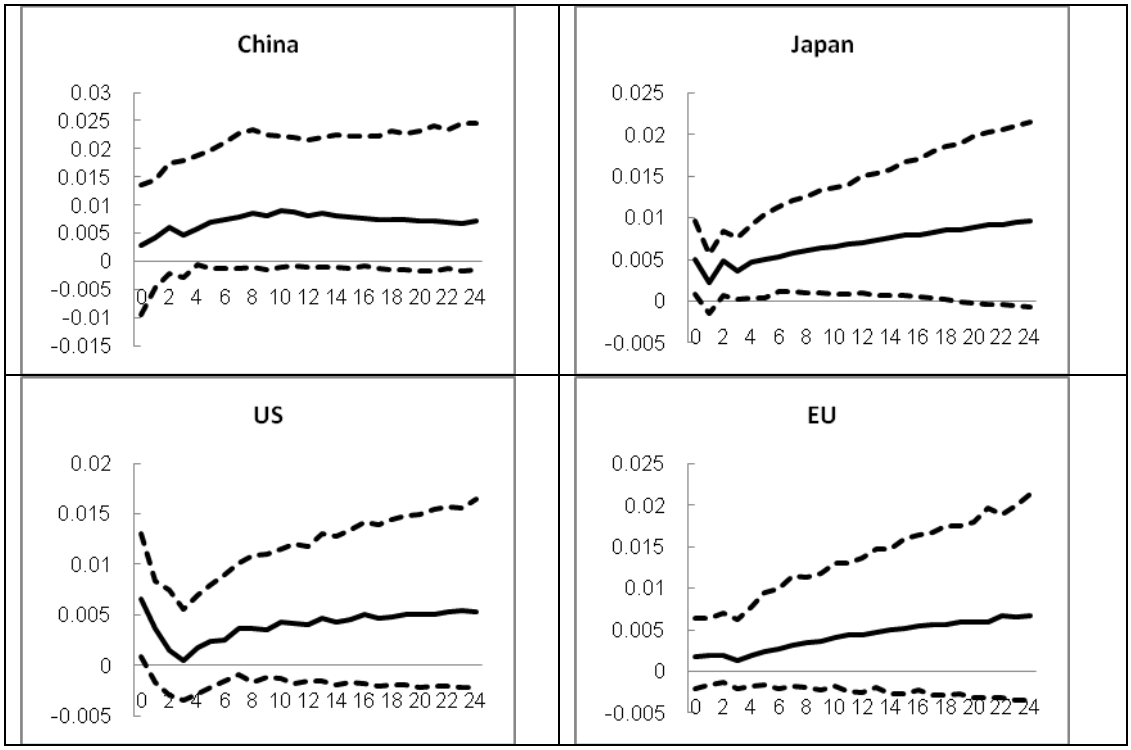
Note: Responses to the fiscal stimulus program in China. Left (right) entry: Cumulated response after the first (second) year. Differences expressed as percentage points from the baseline.

Figure 1: GVAR generalized impulse responses

GDP growth



CPI inflation



Note: Dotted lines denote 90 percent confidence bands.