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Global and regional business cycles. Shocks and propagations

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Global and regional business cycles. Shocks and propagations*

Leif Anders Thorsrud†

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Abstract

We study the synchronization of real and nominal variables across four different regions of the world, Asia, Europe, North and South America, covering 32 different countries. Employing a FAVAR framework, we distinguish between global and regional demand and supply shocks and document the relative contributions of these shocks to explaining macroeconomic fluctuations and synchronization. Our results support the decoupling hypothesis advanced in recent business cycle studies and yields new insights regarding the causes of business cycle synchronization. In particular, global supply shocks cause more severe activity fluctuations in European and North American economies than in Asian and South American economies, whereas global demand shocks shift activity in the different regions in opposite directions at longer horizons. Furthermore, demand shocks play a larger role than that found in related studies. Finally, only innovations to the Asian activity and price factors have significant spillover effects on shared global factors, demonstrating the growing importance of Asia in the global economy.

JEL-codes: C11, C38, F41, F44
Keywords: Business cycles, Factor model, Globalization, International macro

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1 Introduction

The goal of this paper is to distinguish common global from regional business cycle components in real and nominal variables and study their interaction in a dynamic model. In particular, we answer two related questions: How important are common global and regional business cycle components to activity and prices across nations and regions, and what are the primary forces driving these business cycles components? To answer the last question, we distinguish between global and regional demand and supply shocks and study the relative contributions of these shocks to explaining macroeconomic fluctuations and synchronization.

The paper is motivated by recent findings in the business cycle synchronization literature. First, globalization, a term describing the increasingly integrated and interdependent world economy, has had pronounced effects on the synchronization of real and nominal variables across nations and regions. The findings in Kose et al. (2003), a seminal contribution to the business cycle synchronization literature, exemplify this. They study co-movement among real variables across 60 countries, covering a sample period from 1960 to 1990, and find that one common world business cycle factor explains the cross sectional data well.[1] Two decades after this period, every country is a member of one or more regional trade agreements, and over one-third of world trade takes place within such arrangements, giving rise to what is popularly labeled regionalism.[2] Accordingly, recent evidence in the business cycle literature supports a decoupling hypothesis as advanced in, e.g., Kose et al. (2012) and Mumtaz et al. (2011), thus emphasizing the regional aspect of international business cycles, rather than a global one.

However, studies in the international business cycle synchronization literature almost exclusively study the co-movement among real and nominal variables separately. This distinction overlooks the potential interaction between real and nominal factors in determining international business cycle fluctuations and impedes the identification of the common sources of macroeconomic fluctuations. Towards this end, our paper contributes to the literature by analyzing this interaction explicitly. In the spirit of Burns and Mitchell (1946), our study also contributes to the literature documenting business cycle facts. The degree of business cycle synchronization, and understanding how demand- and supply-side spillovers affect countries and regions, has important implications for macro economic policy and should inform the development of economic theory, which offers ambiguous answers to our two questions.[3]

[1] The theory and empirics of business cycle synchronization, or co-movement, have a long history. Other important contributions in the literature are, e.g., Backus and Kehoe (1992), Backus et al. (1995), Ambler et al. (2002), Baxter and Kouparitsas (2005), Stock and Watson (2005) and Kose and Yi (2006). While most of the research concerning international business cycle synchronization has focused on real activity measures, a few recent papers, see, e.g., Mumtaz and Surico (2008), Ciccarelli and Mojon (2010) and Monacelli and Sala (2009), document that national inflation rates contain a large global component and that fluctuations in nominal variables are actually more synchronized across countries than cyclical fluctuations in real output (see Henriksen et al. (forthcoming)).

[2] See, e.g., di Mauro et al. (2009).

[3] In theory, three channels that affect co-movement among real variables are often considered: trade integration, specialization and financial integration (see, e.g., Frankel and Rose (1998) and Imbs (2004)). Here, intense bilateral trade will lead to a high degree of business cycle correlation in a wide range of theoretical models with, for example, technology or monetary shocks, while specialized patterns of production, combined with industry-specific shocks, would reduce business cycle correlation. The effect of

The model we employ is a factor augmented vector autoregression (FAVAR). An advantage of our framework over many previous studies of international synchronization is that we can preserve the parsimonious representation of the data offered by factor modeling techniques while identifying structurally important shocks driving common business cycle components. Our quarterly data set covers the sample period 1992-2011 and includes a large panel of 32 countries from four different regions of the world: Asia, Europe, North America and South America. Common global and regional demand and supply shocks are identified using a combination of zero and sign restrictions.

As such, this study complements two recent papers by Crucini et al. (2011) and Mumtaz et al. (2011). As in both of these studies, we employ a factor model approach that considers a large set of countries and estimate common factors. However, in contrast to Crucini et al. (2011), who focus exclusively on real variables, we investigate the interaction between common real and nominal factors simultaneously in an international context, and in contrast to Mumtaz et al. (2011) we identify the shocks driving the common business cycle components. Furthermore, our study is conducted using quarterly data, while the above mentioned studies consider yearly observations that are less informative for business cycle analysis.[4]

We have four main findings. The first two confirm and elaborate on existing evidence in the business cycle literature,[5] and the last two are unique to this study.

First, we find significant evidence for regional, real and nominal, business cycle components in Asia, North America and South America. Thus, our results support the decoupling hypothesis advanced in, e.g., Kose et al. (2012) and Mumtaz et al. (2011) and are consistent with interpretations where industry specialization at the regional level is important, or where a number of countries have established important trade agreements at the regional level. As in Kose et al. (2003), we find only weak evidence of a common European business cycle. Accordingly, business cycles in European countries are primarily driven by shocks to common global factors or large idiosyncratic disturbances.

Second, aggregate supply shocks explain most of the business cycle variation in the activity measures in the long run. In the short run, aggregate demand shocks are more important. Thus, our results may provide further nuance regarding the findings reported in, e.g., Crucini et al. (2011), where common shocks to productivity typically account for more of the variation in output than the other candidates combined. For prices, the main driving forces are demand shocks at all horizons. This finding agrees with that in Ciccarelli and Mojon (2010), where global inflation dynamics are strongly linked to (global) monetary developments at longer horizons, but our results differ slightly, as we find that both global and regional demand shocks are important.

Third, the transmission mechanisms for common global shocks differ across regions.

financial integration could be twofold, as the contagion and income insurance effects may have opposing effects on business cycle co-movement. Less attention has been devoted to nominal variables. One theoretical contribution is Henriksen et al. (forthcoming), who advanced a theory of international co-movements in inflation and nominal interest rates based on technology spillovers, while Rogoff (2003) and Bean (2007) propose a theory of inflation synchronization based on increased competition among economies.

[4]Another closely related FAVAR study is Bagliano and Morana (2010), but they do not consider regional factors and restrict their analysis to the US, UK, Canada, Japan and the Euro area.

[5]Which is interesting in its own right because our data set and methodology differ from previous studies investigating business cycle synchronization.

This finding has not previously been documented in an international synchronization study but lends further support to the decoupling hypothesis discussed above and challenges the scope for international policy coordination. The responses of activity measures in European and North American countries exhibit a particularly clear boom and bust pattern following common global demand shocks. In other countries, the same shock has a stronger initial response but then dies out (Asian countries) or remains positive for a prolonged period (South American countries). Furthermore, positive supply shocks cause a much more persistent and significant response in activity measures in European and North American countries than in Asian and South American countries.

Fourth, only shocks to the Asian activity and inflation factors have significant spillovers to the common global factors, highlighting the growing importance of Asia in the world economy.

The remainder of this paper is organized as follows: Section 2 and 3 present our data and the structural factor model. Section 4 reports the empirical results, while section 5 concludes.

2 Data and correlations

Our data set consists of data for activity and prices from 32 countries: USA, Canada, Japan, India, South Korea, Malaysia, Taiwan, Singapore, Hong Kong, China, Thailand, Australia, New Zealand, Indonesia, Brazil, Peru, Chile, Argentina, Mexico, Belgium, Denmark, France, Germany, the Netherlands, Spain, Switzerland, Sweden, the UK, Norway, Italy, Finland and Portugal. Overall, these countries were responsible for approximately 80 percent of world GDP as of 2009 and span four regions of the world; Asia, Europe and North and South America.

Because both inflation and activity variables are measured with noise, we use real quarterly gross domestic product (GDP) and industrial production (IP) to measure overall activity and quarterly headline consumer price indexes (CPI) and producer prices (PPI) to measure inflation. This increases the size of the panel of data, and as described in section 3, also facilitates the factor model framework we employ. Due to data availability, some variables are missing for some of the countries. Thus, our data set contains a total of 116 observable variables. See appendix A for details.

All variables are log differentiated, and variables affected by seasonality are seasonally adjusted either by the original source or using the X12 ARIMA procedure.[6]

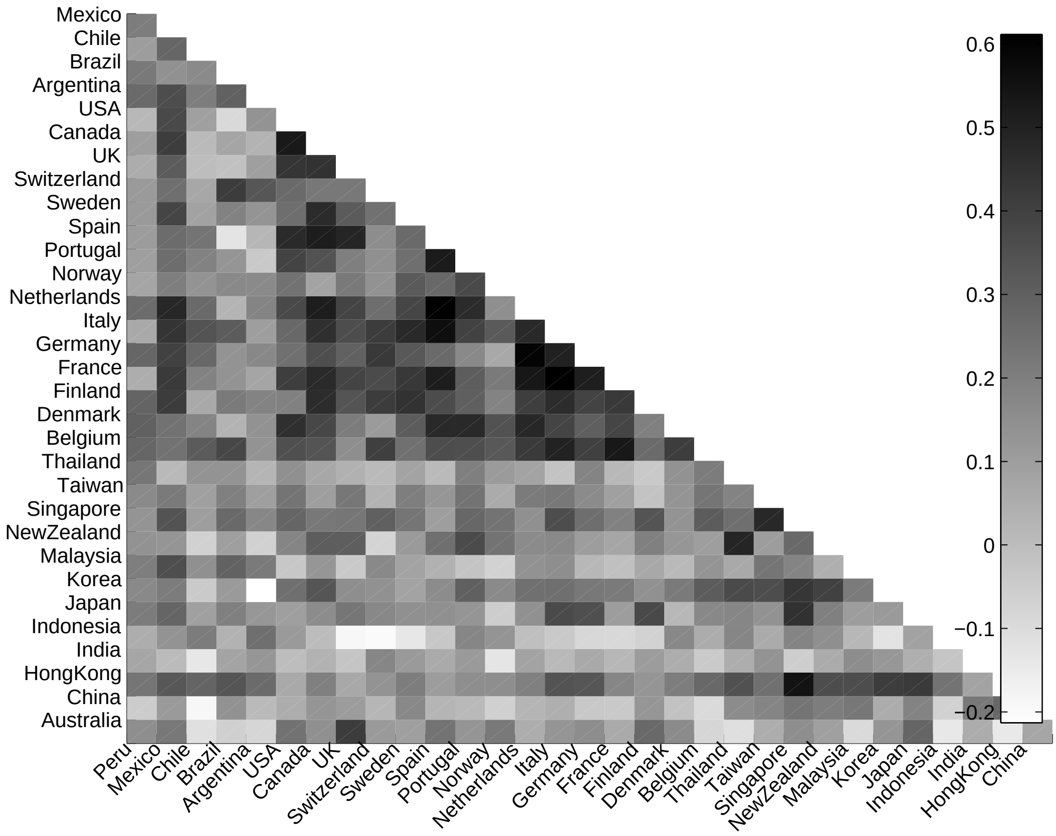
Studies that investigate business cycle synchronization typically employ some type of filtered measure (e.g., the Hodrick-Prescott filter, Band-pass filter, or simple moving averages) of an individual country's activity or price measure to uncover the unobserved business cycle properties of the series. In this analysis, we do not pre-filter the variables. Instead, we extract the underlying unobserved business cycle variables based on the covariance matrix of the appropriate data sets.

As such, figure 1 displays the simple pairwise correlations between the quarterly log difference in GDP (panel 1a) and CPI (panel 1b) for the 32 countries in our sample. The estimation period is from 1992.01 to 2011.04.

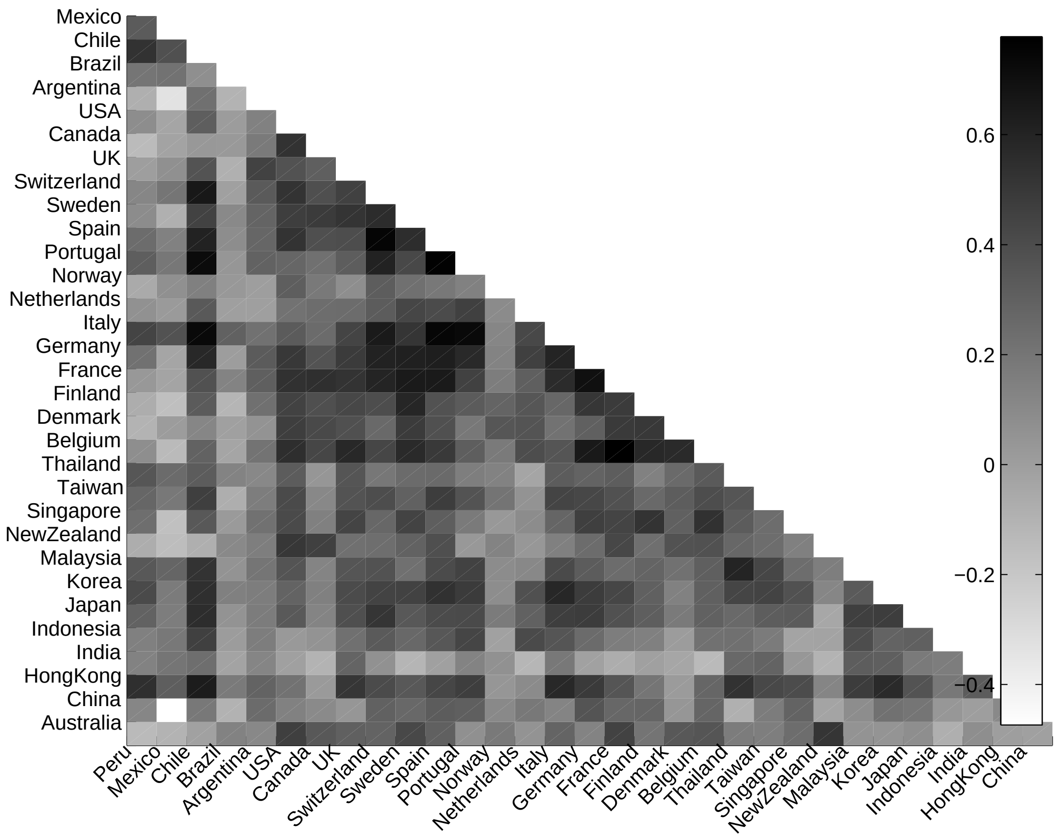
[6]For China and Hong Kong, the observable variables are quarterly growth rates.

Figure 1: **Correlations**

(a) Activity



(b) Inflation



Note: The figure displays the lower triangular part of the correlations matrix between activity (upper panel) and inflation (lower panel) for the 32 countries in the sample. Squares with shading towards the black end of the "color" spectrum indicate higher correlation.

The clustered color shadings along the diagonals indicate that there are strong regional correlations. This is especially evident in panel 1a, and the correlation between the European countries is particularly clear. Moreover, there also seems to be significant correlation across countries in different regions. For example, most activity measures in the European countries are highly correlated with those of the US and Canada, and to a lesser extent, with some of the Asian countries. The same patterns can be observed for inflation in panel 1b. However, compared to the correlation patterns obtained for the activity measures, the inter-regional correlations in inflation seem to be stronger. Most notably, the correlation between some of the South American countries and the Asian, European, and North American countries is much stronger for inflation than for activity. Overall, in our sample, the average bivariate correlations in activity and inflation are 0.20 and 0.27, respectively.

3 The model

Based on the data presented in the previous section, we estimate common global and regional business cycle components. As these components are generally unobserved, the factor augmented vector autoregression (FAVAR) methodology, introduced by Bernanke et al. (2005), is well suited to the problem at hand.

It is instructive to represent the model in a state space form. Here, the transition equation is specified as follows:

$$\begin{bmatrix} W_t \\ R_t^m \end{bmatrix} = \beta(L)^m \begin{bmatrix} W_{t-1} \\ R_{t-1}^m \end{bmatrix} + u_t^m, \tag{1}$$

where $W_t = \begin{bmatrix} W_{t,y} & W_{t,\pi} \end{bmatrix}'$ and $R_t^m = \begin{bmatrix} R_{t,y}^m & R_{t,\pi}^m \end{bmatrix}'$ are a set of unobserved world and regional factors. The y and π subscripts denote activity and inflation, respectively. The parameter $\beta(L)^m$ is a conformable lag polynomial of order p, and u_t^m is the 4×1 vector of reduced form residuals. The structural disturbances follow $u_t^m = \Omega^{1/2}\varepsilon_t^m$, with $\varepsilon \sim N(0, 1)$ and $\Omega^m = A_0(A_0)'$, where Ω is the covariance of the reduced form residuals. We specify one FAVAR model for each of the four regions we study, thus $m = \{1, 2, 3, 4\}$. The world factors are the same in all m model specifications, while the regional factors vary.

The observation equation of the system is:

$$\begin{bmatrix} X_{t,a,i}^m \\ X_{t,p,i}^m \end{bmatrix} = \begin{bmatrix} \Lambda_{W,a,i}^m & 0 & \Lambda_{R,a,i}^m & 0 \\ 0 & \Lambda_{W,p,i}^m & 0 & \Lambda_{R,p,i}^m \end{bmatrix} \begin{bmatrix} W_{y,t} \\ W_{\pi,t} \\ R_{y,t}^m \\ R_{\pi,t}^m \end{bmatrix} + \begin{bmatrix} e_{t,a,i}^m \\ e_{t,p,i}^m \end{bmatrix} \tag{2}$$

where $X_{t,a,i}^m = \begin{bmatrix} X_{t,a_1,i}^m & X_{t,a_2,i}^m \end{bmatrix}'$ is a $2N^m \times 1$ vector of activity numbers with $i = 1, 2, ..., N^m$, N^m is the number of countries in the specific region (m) under study, and a_1 and a_2 are the two observable measures of economic activity we employ (see section 2). Similarly, $X_{t,p,i}^m = \begin{bmatrix} X_{t,p_1,i}^m & X_{t,p_2,i}^m \end{bmatrix}'$ defines a $2N^m \times 1$ vector of inflation measures. Parameters $\Lambda_{W,s,i}^m$, $\Lambda_{R,s,i}^m$ and $e_{t,s,i}^m$, where $s = \{a, p\}$, are $2N^m \times 1$ vectors of corresponding factor loadings and idiosyncratic, zero mean disturbances.

Generally, restricting the factor loadings in equation 2 ensures the identification of the factors, while restrictions on the ordering of the factors in equation 1 and A_0 identifies structural shocks, ε_t. The identification of the factors and the structural shocks can be demanding, and in section 3.1 we discuss our approach in greater detail.

The system of equations 1 and 2 is estimated in a three step procedure: First, the unobserved world and regional factors are estimated and identified. These identified factors are used to estimate the restricted factor loading matrix in equation 2 in a second estimation step. This is achieved through ordinary least squares, for each variable in the X_t vector. Finally, the estimated and identified factors are used as observed variables in a standard VAR framework.

We estimate the transition equation of the system using maximum likelihood. Based on AIC information criteria, we set the lag length to three, and the VAR residuals pass standard diagnostic tests. To construct distributions for the impulse response functions, and accurately account for the problem of generated regressors in the third estimation step, we employ a residual bootstrap procedure to the whole system, with 5000 replications.[7]

3.1 Identification

The structure of the transition equation is a natural extension of small open economy VARs, where world variables are ordered above domestic variables. However, in our model, the regional factors do not represent small open economies. Thus, we do not impose exclusion restrictions on the parameters in the transition equation but do order the regional factors below the world factors based on exogeneity assumptions that are consistent with our approach to factor identification. We discuss the approach and our methodology for identifying the structural shocks that represent demand and supply in greater detail below.

3.1.1 Identifying the factors

The $X^m_{t,a,i}$ ($X^m_{t,p,i}$) vector in equation 2 consists of $2N^m$ activity (inflation) measures for each of the m regions we study. As is standard in many business synchronization studies (see, e.g., Kose et al. (2003)), we cluster countries into four regions based on geographical definitions, i.e., Asia, Europe, North America, and South America.[8] Based on these categorizations, we estimate and identify the unobserved factors.

To estimate and identify the world factors, we augment the $X^m_{t,s,i}$ vectors across regions and countries, i.e., $X_{t,s} = \left[X^1_{t,s,1}, ..., X^1_{t,s,2N^1}, ..., X^M_{t,s,1}, ..., X^M_{t,s,2N^M}\right]'$, where $M = 4$. From

[7] Bai and Ng (2006) show that the least squares estimates obtained from factor-augmented regressions are $\sqrt{T}$ consistent and asymptotically normal if $\sqrt{T}/N \rightarrow 0$. In our sample, this is clearly not the case, and bootstrap methods are thus a potential alternative to the normal approximation, see, e.g., Goncalves and Perron (2011).

[8] New Zealand, Australia and Mexico are exceptions. Geographically, they belong to "Oceania" and North America, but we merge them with Asia and South America. Categorization based on geography is natural given our main research questions, but we acknowledge that other clustering approaches (other than by geography) could be informative. For example, countries where trade is highly dependent on raw materials and emerging economies could all be expected to share important business cycle properties, despite not being in the same region. Nevertheless, the results presented in section 4 indicate that our categorization has content.

$X_{t,s}$ we then estimate one world activity factor ($s = a$) and one world inflation factor ($s = p$). The unobserved factors are estimated by principal components. To avoid the rotational indeterminacy problem associated with principal component analysis, we use the standard normalization implicit in the literature and restrict $C'C/T = I$, where $C(\cdot)$ represents the common space spanned by the factors of $X_{t,s}$ in each block of data. The signs of the factors are identified by restricting the factors to load positively on one of the countries in the sample. For the world factors, we used US activity and inflation. Finally, to make the estimation of the factors invariant to scale, all variables are standardized prior to estimation.[9]

Given the estimates of the world inflation and activity factors, we estimate and identify the regional activity and inflation factors. This is consists of two steps: First, the world activity (inflation) factor is regressed on the component of the $X^m_{t,s}$ vector containing the activity (inflation) variables associated with a particular region. Second, the residuals from this regression are used to estimate a regional activity (inflation) factor, using the same principal components procedure described above. For the regional activity and inflation factors, we have restricted the sign of the factor loadings such that Germany, Japan, Brazil, and the US load positively on the European, Asian, South American and North American factors, respectively.[10]

The identification and estimation procedure ensures that the world and regional activity (inflation) factors are orthogonal.

3.1.2 Identifying the shocks

To identify the structural innovations as demand and supply shocks, we employ a combination of short run and sign restrictions. In particular, we restrict A_0, defined in section 3, as follows:

$$\begin{bmatrix} u^{W,y} \\ u^{W,\pi} \\ u^{R,y} \\ u^{R,\pi} \end{bmatrix} = \begin{bmatrix} + & + & 0 & 0 \\ + & - & 0 & 0 \\ x & x & + & + \\ x & x & + & - \end{bmatrix} \begin{bmatrix} \varepsilon^{W,demand} \\ \varepsilon^{W,supply} \\ \varepsilon^{R,demand} \\ \varepsilon^{R,supply} \end{bmatrix} \tag{3}$$

where a $+$ indicates that the effect of the shock must be positive, a $-$ restricts the effect to be negative, x leaves the effect unrestricted, and finally, a 0 imposes zero contemporaneous restrictions.

Under this identification scheme, a positive world (regional) demand shock increases world (regional) activity and inflation. A positive world (regional) supply shock increases world (regional) activity but has a negative impact on world (regional) inflation. The zero restrictions ensure that spillovers from regional shocks only affect the world with a

[9] As all variables are in log differences and standardized, all countries are a-priori given equal weight in the factor estimation. Some would argue that greater weight should be given to larger countries, as innovations in these countries could have a more substantial effect on global and regional business cycles. This is of course a valid objection. However, if this were indeed the case, it should be reflected in the correlation structures of the data, and thus reflected in our factor estimates.

[10] For both the world and regional estimates, the results are robust to alternative plausible restrictions. In our model, the decision to estimate four factors is motivated by the economic question we ask. However, the information criteria discussed in Bai and Ng (2002) also suggest that four factors are appropriate for our data set.

lag.[11] A combination of zero and sign restrictions to identify supply and demand shocks is also used in, e.g., Mumtaz and Surico (2009). The decomposition into world and regional shocks is novel to our study.

With minor modifications, the sign restrictions are implemented following the procedure outlined in Rubio-Ramirez and Zha (2009). Specifically, we implement the following algorithm for each draw of the reduced form covariance matrix Ω:

1. Let $\Omega = PP'$ be the Cholesky decomposition of the VAR covariance matrix Ω, and $\tilde{A}_0 = P$.

2. Draw an independent standard normal n x k matrix J, where n is the size of the block (e.g., world or regional block) and k is the number of shocks affecting that block according to the block exogenous structure outlined in equation 3. Let $J = QR$ be the "economy size" QR decomposition of J with the diagonal of R normalized to be positive.

3. Compute a candidate structural impact matrix $A_0 = \tilde{A}_0 \cdot \tilde{Q}$, where $\tilde{Q}$ is a N x N identity matrix with Q' in the n x k block associated with either the world or regional block in equation 3.

4. Repeat steps 1-3 for the next block of data.

If the candidate matrix satisfies the sign restrictions, we retain it. Otherwise, the procedure above is repeated. The restrictions are only enforced on the impact multiplier.[12]

4 Empirical results

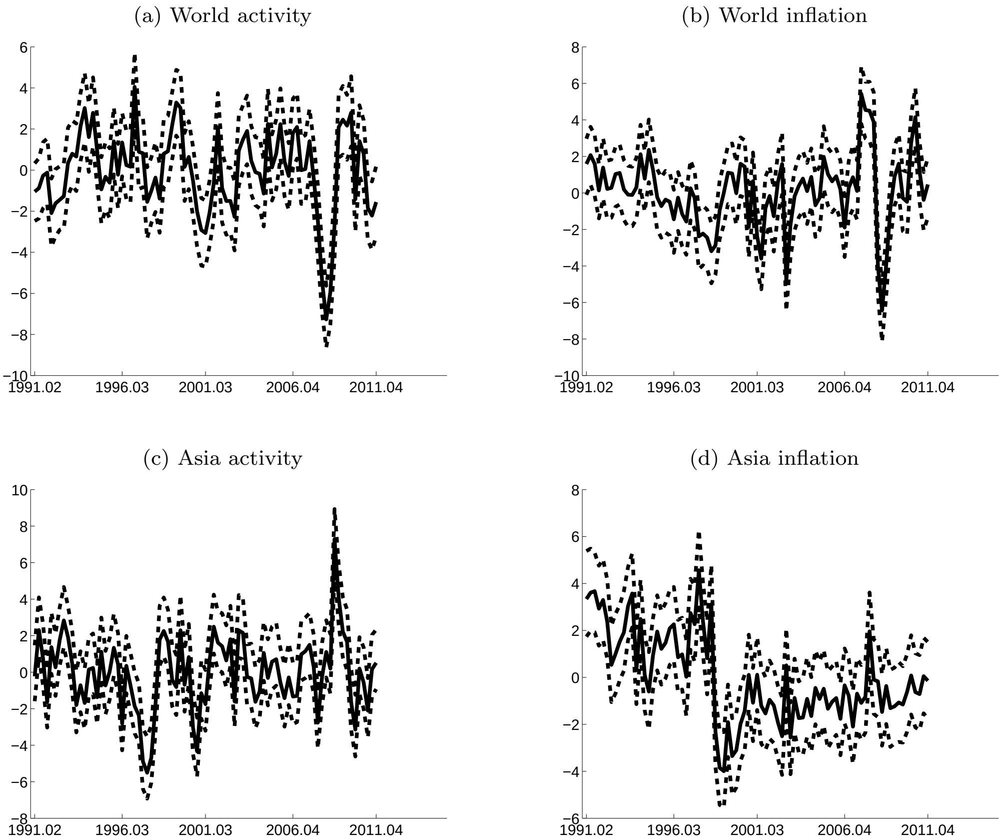
The goal of this paper is to distinguish common global from regional business cycle components in real and nominal variables and study their interaction in a dynamic model. As such, we divide the results section into two different, but closely related parts. First, in sections 4.1 and 4.1.1, we present and discuss the identified world and regional activity and price factors and analyze their relevance. These results identify the synchronization patterns observed in the data given our structural model.[13] Second, in section 4.2, we examine the driving forces of the international and regional business cycles in terms of

[11] We have also run the model with a combination of short and long run restrictions such that the world factors are not affected by regional shocks on impact, and global and regional demand shocks do not have permanent effects on the world and regional activity factors, respectively. Irrespective of whether we use these restrictions or sign restrictions to identify the structural innovations, the results presented in section 4 are very similar.

[12] As emphasized by, e.g., Fry and Pagan (2011), the sign restrictions methodology will identify (median) impulse response functions that potentially represent responses to shocks from different models. Accordingly, an analysis of the variance decompositions might be meaningless because the structural shocks considered are not orthogonal. To avoid this problem, we adopt the following strategy: For each set of reduced form parameters, we compute the median impulse response function across 1000 accepted candidates and calculate the mean squared error between all of the candidate functions and this median impulse response function. The impulse response function with the lowest score is stored. As such, the structural shocks identified for each set of parameter estimates will be orthogonal.

[13] This part of the analysis is also comparable to studies conducted previously by, e.g., Kose et al. (2003) and Mumtaz et al. (2011).

Figure 2: **Identified factors**



Note: See next page.

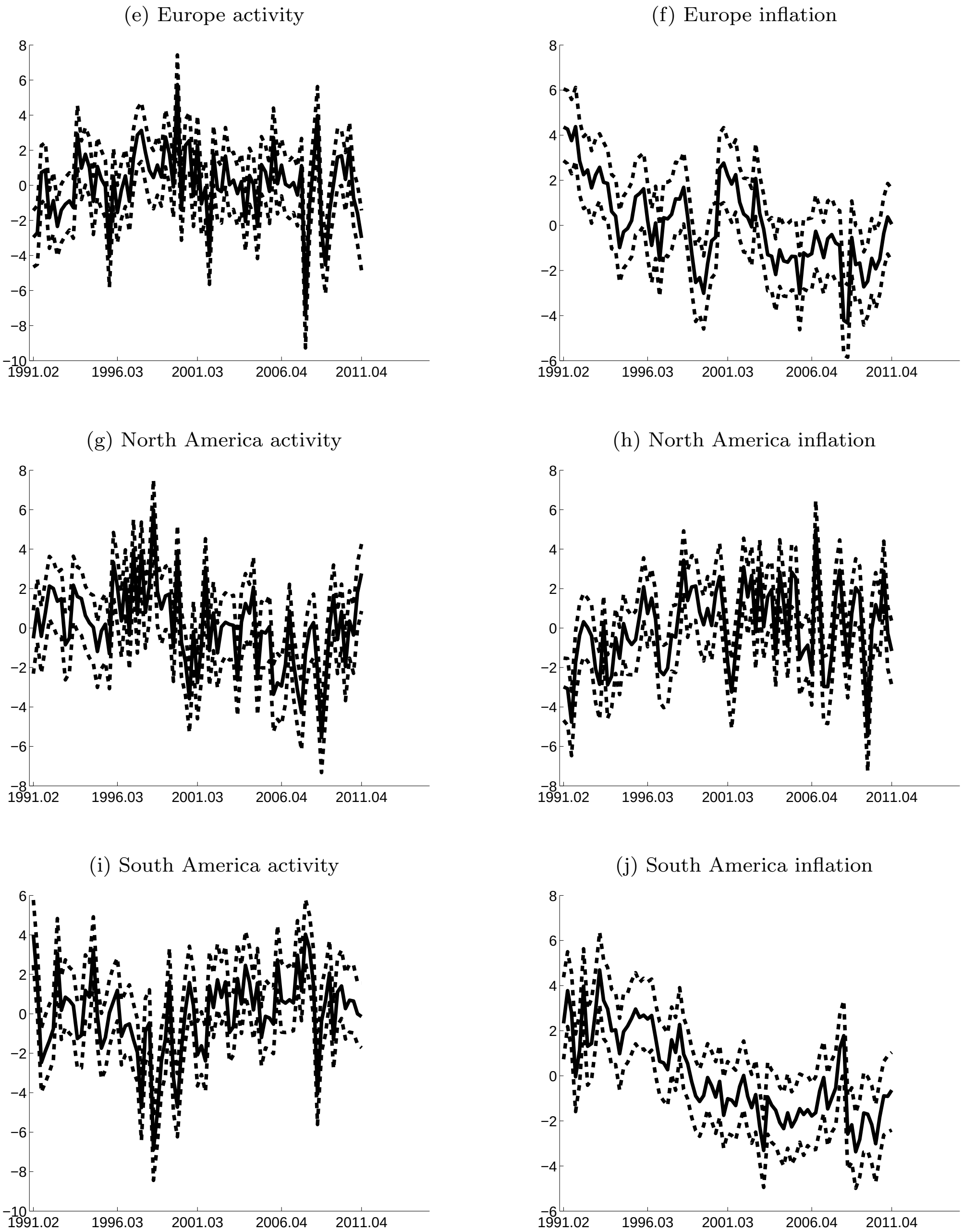
structural shocks. Finally, in section 4.3, we examine the spillovers from different regional shocks to the world factors.

4.1 Global and regional business cycles

Figure 2 displays the activity and inflation factors identified by the model.

The international activity and inflation factors in figures 2a and 2b capture features commonly associated with world business cycles over the last 20 years. Both the booms and busts predating and following the Asian crisis near the end of the 1990's and the dot com bubble around 2001 are evident. Compared to the substantial decline in activity following the financial crisis in the late 2000's, these downturns are however very modest. The increased volatility in the world inflation factor towards the end of the sample is particularly striking and likely reflects the hike in commodity prices just prior to the 2008 financial crisis and the ensuing fall and rise in these prices.

Figure 2: – **continued from previous page**



Note: Estimated factors. Sample 1991.02 to 2011.04. The regional activity (inflation) factors are by construction orthogonal to the world activity (inflation) factor. The solid lines are median estimates, and the dotted lines are 90 percent confidence intervals based on residual bootstraps adjusted using Hall's percentile interval (see Hall (1992)).

The regional activity and inflation factors capture the dynamics that are specific to the particular region. Not all developments in the regional factors are easily explained, but some events stand out and are well known. From figure 2c, we observe that the downturn in the Asian activity factor following the Asian crisis towards the end of the 1990's is much more pronounced compared to the downturn in the world activity factor. Perhaps because of the relatively large trade linkage between the South American countries and Asia (see table 4 in appendix B), the South American activity factor, see figure 2i, was clearly also in a downturn during this period. Interestingly, neither the European nor the North American activity factors, figure 2e and 2g, were severely affected by the Asian crisis, but both were substantially affected by the bust of the dot com bubble. Furthermore, for Asian specific activity, the impact of the latest financial crisis is very small, and by the end of 2011, the Asian activity factor had recovered to a greater extent than the world activity factor and to a much larger extent than, for example, the European activity factor. It is also interesting to note how the Asian, European and South American inflation factors in figures 2d, 2f and 2j share periods of disinflation. At the beginning of the 1990's, many countries in our sample experienced periods of high inflation rates. In the latter part of the sample, a common feature is that these periods have become less frequent (at least at the regional level). Finally, we note that the European activity and inflation factors seem to rise and fall around the same time as the introduction of the Euro, a period when inflation specific to Asia also declined significantly.

4.1.1 Factor statistics

How important are the common global and regional business cycle components for activity and inflation across nations and regions? As we show in table 1, they are very important. World and regional factors are statistically significant for nearly all countries in our sample, and the average variance explained (across countries within a region) by the factors is as high as 70 percent.

Generally, the total R^2 is higher for economies in Europe and North America than for the more volatile economies in Asia and South America. However, the average total R^2 for the activity figures in Asia seems particularly low. Country details, reported in table 6 in appendix B, show that this value is driven down by a very low R^2 in three of the Asian countries. If these countries are removed from the sample, the total variance explained (R^2) also increases considerably for the Asian region, while the factor estimates themselves do not change substantially.[14] Importantly, overall, only a few countries within regions are anomalies in terms of the variance explained, significance and the signs of the factor loadings (see table 6 for details).[15]

Returning to one of our focal questions, we see from table 1 that for countries in Asia, North and South America, the contributions of the world and regional factors to total R^2 is nearly equal, thus emphasizing the regional aspect of international business cycles. For inflation measures, the contribution of the regional factors to total R^2 is particularly high in South America, where as much as 74 percent of the total variance explained is attributed to the regional inflation factor. This is not surprising given the periods of

[14] This is not shown, but further results are available on request.

[15] Generally, the commonality of the "outlier" countries is that they share one or more of these features: not truly a core regional country (e.g., Australia), highly dependent on raw materials (e.g., Norway, which is a net oil exporter), or affected by some substantial, idiosyncratic shocks (e.g., Argentina, which experienced a period of significant macro economic volatility during the early 1990's). Additionally, the raw data is likely to be rather poorly measured for some of the countries. This might contaminate the individual country regressions but argues for the use of factor modeling techniques to uncover aggregated variables.

Table 1: **Average signifcance and R^2**

		Activity World	Regional	R^2	Inflation World	Regional	R^2
Asia	R^2	0.51	0.49	0.26	0.51	0.49	0.41
	Sign.	0.83	0.75		0.83	0.83	
Europe	R^2	0.82	0.18	0.40	0.73	0.27	0.54
	Sign.	1.00	0.62		1.00	0.69	
North America	R^2	0.47	0.53	0.69	0.64	0.36	0.70
	Sign.	1.00	1.00		1.00	1.00	
South America	R^2	0.54	0.46	0.37	0.26	0.74	0.40
	Sign.	1.00	1.00		0.60	0.80	

Note: The table displays for each region summary statistics for activity (3nd to 5th column) and inflation (6th to 8th column) after running the regressions:

$$X^m_{t,r,i} = \Lambda^m_{W,r,i} W_{r,t} + \Lambda^m_{R,r,i} R^m_{r,t} \tag{4}$$

where $r = \{y, \pi\}$, and the rest of the notation follows from section 3. The first row for each region displays the average (across countries within a region) contribution to total R^2 for each factor as well as total R^2. The second row reports the fraction of significant factor loadings for each region and factor based on residual bootstraps of the whole system (see section 3). All test statistics are calculated at the 10 percent significance level. A more detailed table with individual country statistics can be found in table 6 in appendix B.

particularly high inflation during the 1990's in many South American countries. In Asia, the results are similar to those for activity, and approximately 50 percent of the explained variance is attributed to the regional factors. For Europe and North America, the world inflation factor dominates. Across activity and inflation measures, the large difference in regional importance between Europe and the other regions is noteworthy, as the world factors account for substantially more of the explained variance than the regional factors in this region. In particular, of an average R^2 of 40 percent, 82 percent is explained by the world activity factor. We discuss this discrepancy in greater detail in section 4.2.2.

A natural question is: How regionally specific are our estimated regional factors? To be able to shed some light on the questions at hand, we regress each set of regional activity (inflation) data on all of the activity (inflation) factors we have identified, i.e., world, Asian, European, North American and South American factors. The results are presented in table 2. Columns 3 to 6 report the fraction of significant coefficients within each region. First, compared to the results in table 1, we observe that the fraction of significant factor loadings for the relevant geographical factor is very stable.[16] However, as indicated by the non zero numbers off the diagonal in columns 3 to 6, there are significant correlations between activity and inflation measures in different countries and the different regional factors. This result suggests that the global factors are not able to capture all

[16] The significance of the world factors do not change. This is as expected, as the world factors are orthogonal to the regional factors by construction. However, the estimation and identification procedures for the regional factors do not ensure that the regional factors will be orthogonal between regions.

Table 2: **Cross regional factor regressions**

	World	Asia	Europe	North America	South America	F-test
Panel a: Activity						
Asia	0.75	0.75	0.08	0.00	0.00	0.83
Europe	1.00	0.54	0.54	0.15	0.23	0.62
North America	1.00	0.00	0.00	1.00	0.00	1.00
South America	1.00	0.20	0.00	0.00	0.80	1.00
Panel b: Inflation						
Asia	0.83	0.75	0.42	0.25	0.00	0.50
Europe	1.00	0.31	0.69	0.00	0.15	0.77
North America	1.00	0.00	0.50	1.00	0.50	0.50
South America	0.60	0.00	0.40	0.20	1.00	0.40

Note: Each row reports the fraction (within a region) of significant coefficients when we regress the individual regional variables on a world factor and all the regional factors:

$$X^m_{t,r,i} = \Lambda^m_{W,r,i} W_{r,t} + \sum_m^M \Lambda^m_{m,r,i} R^m_{r,t} \tag{5}$$

where $r = \{y, \pi\}$, and the rest of the notation follows from section 3. Panel a reports the results for regional activity variables, while panel b reports the results for regional inflation variables. The last column in each panel shows the fraction of F statistics in favor of our standard model. All test statistics are calculated at the 10 percent significance level and are based on residual bootstraps of equation 5.

of the common cross country correlations in the data, or that our geographical clustering might be improved upon. However, by testing the hypothesis that all non-corresponding geographical factor loading coefficients are zero, see the last column, we find that the loss of fit is not significant in most cases. In particular, for the activity measures, we cannot reject the hypothesis that our standard model is appropriate for all countries in North and South America, while for a few countries in Asia and Europe this is not the case. For the inflation measures, there is somewhat more variability. In sum, as a few outliers within each region could easily drag down these averages, we believe that the results confirm the appropriateness of our model.

The conventional view has been that increased trade and financial integration following globalization would cause business cycles across the globe to become more synchronized, see e.g., Kose et al. (2003) and Ciccarelli and Mojon (2010). However, recent evidence in the literature highlights the increased importance of region-specific business cycles and has led to the notion of decoupling, as documented in, e.g., Kose et al. (2012) and Mumtaz et al. (2011). Our results support this decoupling hypothesis, and the results are consistent with an interpretation where industry specialization at the regional level is important, or where a number of countries concluded important trade agreements at a regional level.[17]

[17] Indeed, a comparison of the intra- and inter-regional goods trade, see table 4, reveals that most regions act as nearly closed economies.

Our estimates are at the lower end of the results presented in Mumtaz et al. (2011), where regional factors account for between 40 and 80 percent of the explained variance in activity and prices. There are two important differences between our study and theirs: We use quarterly data, and potentially more important, our sample includes the financial crisis.[18] When we estimate our model over the sample period 1992.02 to 2007.04, i.e., excluding the effects of the financial crisis, the importance of the regional factors generally increase, see table 9 in section B. Specifically, compared to the results presented in table 1, the contributions of the regional activity and inflation factors to total R^2 increase substantially for countries in Asia and North America. In Europe, the regional factors explain more of the total R^2 than in table 1, but the contribution of the world factors continues to dominate.

As such, the importance of common regional business cycle factors relative to common world factors is substantially affected by the frequency and magnitude of truly global shocks to the business cycle.[19] One could argue that, in the future, if global shocks of the magnitude experienced during the financial crisis were dominant, the degree of decoupling could rapidly become much less pronounced. However, this statement implicitly assumes that countries in different regions react homogenously to all types of common global shocks. As we show in the next sections, this might not be the case.

4.2 Shocks and propagations

In this section, we answer the question: What are the primary forces driving common business cycles? As described in section 3.1.2, the structural shocks are identified using sign restrictions, which enables us to categorize them as either world or regional demand and supply shocks. The world shocks are common to all countries in the model. The regional shocks are by definition only common to a particular region. Within our framework, it is natural to interpret the common world shocks as fast moving, as they may affect all countries in the same quarter, whereas the regional shocks can only affect countries in the rest of the world with a lag.

4.2.1 Impulse responses

World shocks: Figure 3 displays the impulse responses for the activity and price variables, measured by GDP and CPI, in the different regions of the world to a common world demand and supply shock. A one percent increase in world demand on impact leads to a considerable positive response in activity and prices in nearly all countries, see figures 3a and 3b. For the activity measures, however, the propagation of the world demand shock is very different in Europe and North America compared to the effects in Asia and South America. Specifically, activity levels in Europe and North America decline and become negative after 8 quarters, thus following a typical boom and bust pattern. In Asia the effect is generally not significantly different from zero at the 2 year horizon,

[18] We estimate the model over the period 1992 to 2011. The most comparable sample to our own, studied in Mumtaz et al. (2011), runs from 1985 to 2007.

[19] A similar argument is advanced in Stock and Watson (2005), who investigate business cycles across G7 economies and conclude that co-movement declined in the 1984-2002 period relative to 1960-1983 due to the diminished importance of common (G7) shocks.

while in South American countries, a positive demand shock tends to also have a positive contribution at a longer horizon.

The heterogeneous responses to aggregate world demand shocks across regions lends further support to the decoupling hypothesis discussed in the previous section and may be due to a number of factors, e.g., labor market flexibility, the composition of the aggregate demand shock, policy interventions, and the effect on wages and prices. Therefore, we have investigated whether the differences in impulse responses between countries within and across regions can be understood by comparing the estimated responses to country specific data on economic structure.[20] Although our list of potential indicators is far from exhaustive, we find significant correlations between the heterogeneous responses between Asia and South America and Europe and North America after a world demand shock and measures of exports attributed to high skilled and technologically intensive manufactures and the share of services and agriculture in GDP. Most of the other indicators we examined were not significant. This evidence is in accordance with the fact that many emerging economies in Asia and South America have followed an export led growth strategy in recent decades and experienced higher income growth than countries in, e.g., Europe and North America. The results are also in line with findings in, e.g., Imbs (2004), where the effects of economic specialization (in production patterns) play an important role in business cycle synchronization.

A one percent reduction in the world price factor, interpreted as a positive world supply shock, leads to a long lasting and significant increase in activity in nearly all countries in Europe and North America, as seen in figure 3c. Interestingly, the activity responses in Asia and South America are either more muted or are insignificant. Again, this is consistent with the decoupling hypothesis alluded to above.

Finally, figure 3d indicates that a global supply shock has an immediate and negative effect on prices in most countries. However, after 8 quarters, the positive effect on the activity measures leads to higher price levels across the world, although these effects are not significant.[21]

Regional shocks: Figure 4 displays the responses for all regional activity and price variables, measured by GDP and CPI, after a demand or supply shock in their respective regions.

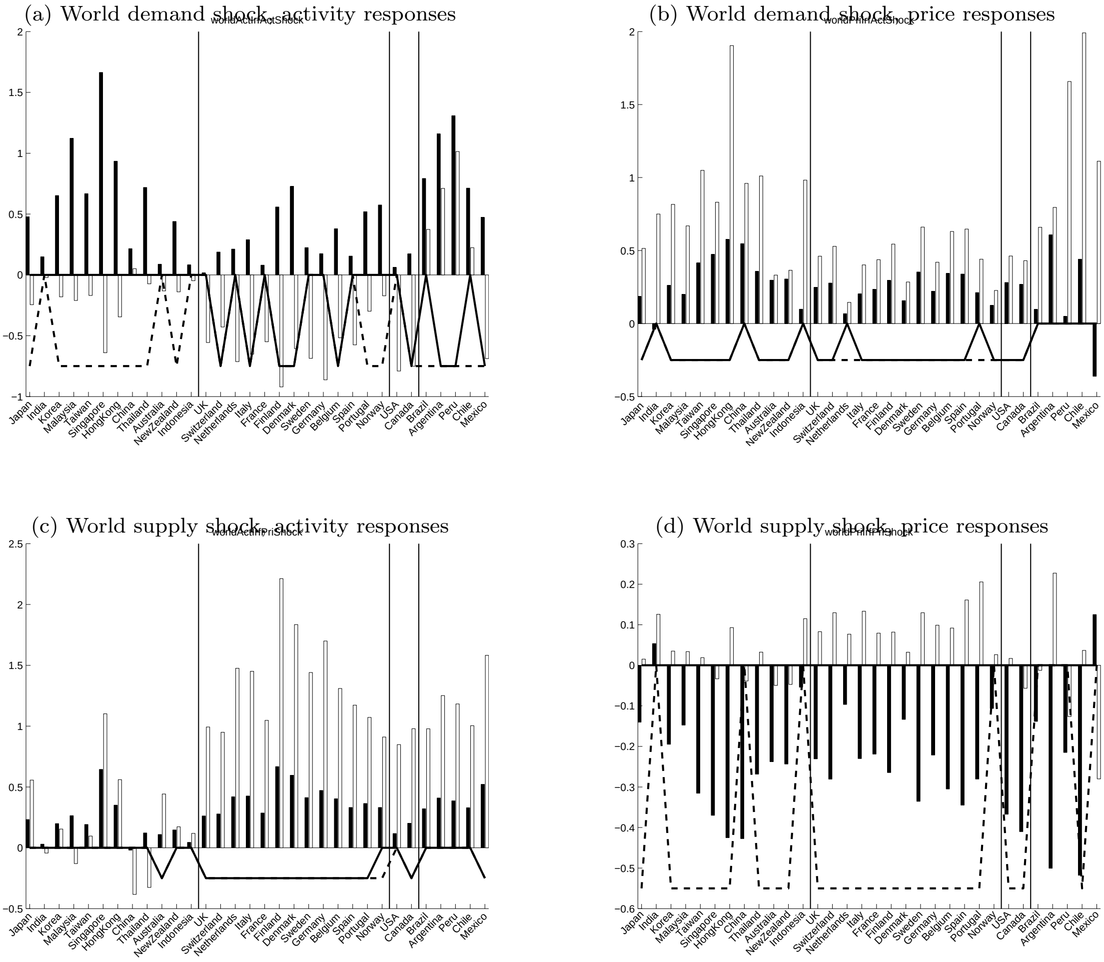
For most countries and regions, the impulse responses follow the expected patterns following demand and supply shocks: Activity and prices both rise in response to regional demand shocks, while activity and prices move in opposite directions following regional supply shocks.[22] However, regional shocks in Asia and South America cause larger and

[20] The data were collected form the World Bank and UNCTAD and include (all as share of GDP and computed as the mean value over the sample period): agriculture, services and industry fractions, openness (exports plus imports), foreign direct investment and merchandise trade in minerals and fuels, crude materials and high skilled and technology intensity manufactures.

[21] The consistency in price responses across countries and regions following global demand and supply shocks might reflect the wave of central banks adopting inflation targeting policies that began near the end of the 1980s, and thus a synchronization of monetary policy. However, the policy trade offs faced by policy makers in different regions of the world become evident given the heterogeneous responses in activity after global shocks and raise questions regarding the prospects for international policy coordination, see e.g., Obstfeld and Rogoff (2002).

[22] Some countries do not fit into the general picture presented in figures 3 and 4 above. As the impulse responses are a function of the factor loadings, it is not surprising that the "outlier" countries documented

Figure 3: **Impulse responses: World shocks**



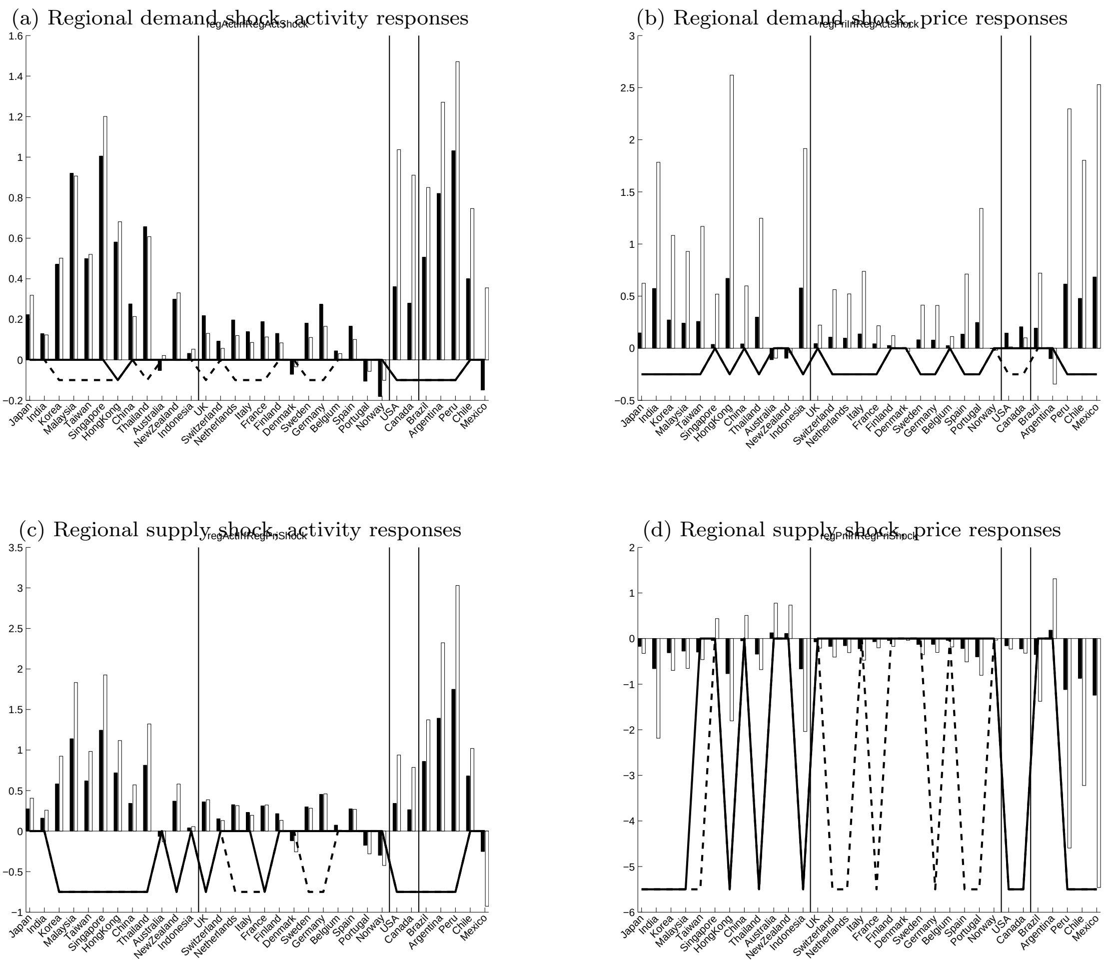
Note: The figures display the responses of all the countries in the four different regions to a world demand and supply shock. The responses are transformed to levels, and the initial shock is normalized to one percent. The black and white bars are point estimates for respectively horizons 1 and 8 quarters ahead. The responses are ordered from left to right starting with countries in Asia, Europe, North America and finally South America. The horizontal lines report which responses are significantly different from zero at the 10 percent significance level. A point on the line different from zero indicates that the response is significant. The dotted line represent horizon 1, and the solid line represent both horizon 1 and 8. E.g. in panel 3b the impulse responses are significantly different from zero at both horizons in Norway, but only at horizon 1 in Portugal.

more persistent effects compared to regional shocks in Europe and North America. This holds for demand and supply shocks and activity and price variables.

To the extent that regional shocks are an important driver of business cycles, regional shocks in Asia and South America would cause the business cycles in these regions to become more volatile relative to economies in other regions. Differences in the variability of business cycles have also been observed in other studies. Crucini (1997) argues that the

in section 4.1.1 are also "outliers" here.

Figure 4: **Impulse responses: Regional shocks**



Note: See figure 3.

result is a general feature of stochastic competitive general equilibrium models involving trade between countries of different sizes. An alternative explanation, which may be more compatible with our findings, is advanced by Mumtaz et al. (2011). They find that business cycles are more volatile in countries where the variance explained by international factors is lower and argue that one possible interpretation is that countries that are internationally less related also have less opportunities for risk sharing, thus experiencing more severe fluctuations.

In summary, our findings indicate that activity levels in different regions of the world react quite differently to global demand and supply shocks. This is a novel result in the business cycle literature, but the finding is consistent with the decoupling hypothesis advanced here and in related studies. In terms of prices, countries in different regions of the world react much more homogenously to global shocks. This finding is consistent with the "stylized facts" documented in Henriksen et al. (forthcoming), where fluctuations in nominal variables are found to be more synchronized across countries than cyclical fluctuations in real output. Finally, regional shocks seem to increase variability in activity and inflation in countries in Asia and South America to a greater extent than in Europe and North America.

As shown in figures 7 and 8 in appendix B, and described in section 3.1.2, these results are robust to imposing alternative long run identification restrictions. Furthermore, one might question whether the response patterns are completely driven by the recent financial crisis, after which the European and North American countries experienced a deeper and more prolonged recession than many countries in Asia and South America. However, when we estimate the model over a sample period running from 1992.02 to 2007.04, i.e., excluding the financial crisis, the heterogeneity in the response to global shocks across countries persists.[23]

Now, the impulse responses must also be seen in relation to how important the different shocks are in explaining the variances of the individual activity and price measures. We turn to this next.

4.2.2 Variance decompositions

Table 3 provides a broad overview of the variance decompositions, while figure 6 in appendix B reports country details. We focus our discussion on three main findings:

First, our results clearly show that common demand shocks are important. In the short run, world and regional demand shocks account for approximately 50 percent of the variance in activity and price measures across regions. At longer horizons, supply shocks explain most of the variation in activity measures, while prices are still primarily explained by demand shocks. This is particularly the case for global shocks but also, although to a lesser extent, for regional shocks.

As mentioned in section 1, our main research questions are closely related to those in Crucini et al. (2011). Interestingly, our results may provide additional nuance regarding the findings reported there. Crucini et al. (2011) show that productivity typically accounts for more of the variation in output than fiscal and monetary policy shocks, oil price shocks and shocks to the terms of trade combined. Interpreting productivity shocks as supply shocks, we show that this might hold in the long run, but at shorter horizons, aggregate demand shocks explain more of the variation in output than supply shocks.[24] Furthermore, our finding that aggregate demand shocks explain most of the variance in prices at longer horizons might indicate the presence of common monetary developments, a point made by, e.g., Ciccarelli and Mojon (2010).

We have identified global and regional demand and supply shocks, but we cannot determine the precise channels through which these shocks are transmitted to the domestic economies: through trade, consumer sentiments, the diffusion of technology, etc. Nevertheless, the global shocks still explain a considerable share of the variation in activity and price measures in the short run. Thus, given the relatively small inter-regional component in trade flows, see table 4 in appendix B, it is difficult to believe that the transmission of

[23] These results are not shown but are available on request.

[24] As such, our results challenge the conventional wisdom from many theoretical real business cycle models, where supply shocks have generally been modeled as the main driving force of business cycles, but are in line with a large body of empirical research documenting the importance of (aggregate) demand shocks, see e.g., Blanchard and Quah (1989), Clarida and Gali (1994), Bjørnland (2000) and Canova and de Nicolo (2003).

Table 3: **Average variance decompositions: Demand and supply shocks**

	Horizon	World Demand	World Supply	Regional Demand	Regional Supply	Sum Demand	Sum Supply
Panel a: Activity							
Asia	1	0.40	0.10	0.17	0.33	0.57	0.43
	8	0.07	0.26	0.15	0.53	0.21	0.79
Europe	1	0.34	0.42	0.13	0.12	0.47	0.53
	8	0.13	0.82	0.02	0.03	0.14	0.86
North America	1	0.07	0.08	0.44	0.42	0.50	0.50
	8	0.10	0.26	0.32	0.32	0.43	0.57
South America	1	0.48	0.12	0.23	0.17	0.70	0.30
	8	0.27	0.31	0.21	0.21	0.47	0.53
Mean	1	0.32	0.18	0.24	0.26	0.56	0.44
	8	0.14	0.41	0.17	0.27	0.31	0.69
Panel b: Prices							
Asia	1	0.32	0.22	0.17	0.29	0.49	0.51
	8	0.41	0.03	0.23	0.33	0.64	0.36
Europe	1	0.50	0.34	0.09	0.07	0.59	0.41
	8	0.64	0.04	0.26	0.06	0.90	0.10
North America	1	0.28	0.40	0.14	0.18	0.42	0.58
	8	0.64	0.08	0.02	0.26	0.67	0.33
South America	1	0.21	0.14	0.35	0.30	0.56	0.44
	8	0.33	0.02	0.30	0.35	0.63	0.37
Mean	1	0.33	0.28	0.19	0.21	0.51	0.49
	8	0.51	0.04	0.20	0.25	0.71	0.29

Note: Panel a reports, for activity variables (measured by GDP), the average variance (within regions) explained by the the four shocks in the model. The world activity and inflation factors are the same for each region, while the regional factors are regional specific. Panel b reports the same decompositions for price variables (measured by CPI). In each panel the row labeled mean report average variance decompositions across regions. Figure 6, in appendix B, reports country details.

common global shocks works through trade alone. For global demand shocks, this means that changes in consumer sentiments and other rapidly changing components of demand are potential candidates. On the supply side, a balance sheet channel, introduced by Krugman (2008) under the notion of a international financial multiplier, and formalized by, e.g., Devereux and Yetman (2010), conforms to our findings. Here, a negative productivity shock is spread across countries through interconnected portfolios. Devereux and Yetman (2010) show that in the presence of leverage constraints, this gives rise to a separate financial transmission mechanism for business cycle shocks that is independent of trade linkages.[25]

[25] Bjørnland et al. (2011) study how four small open economies are affected by innovations to world and regional factors in detail using a similar setup as here, but augment the model with domestic factors. As such, at the expense of the generality of this study, their analysis is better suited to analyze the precise channels through which international shocks affect domestic economies.

Second, regional shocks matter. On average across regions, regional shocks explain 50 and 45 percent of the variance in activity measures at horizons 1 and 8, respectively, and 40 and 45 percent of the variance in price measures. Many studies of international business cycles do not consider regional factors, or restrict the analysis to a small number of countries. As we have shown in a relatively large cross sectional panel of countries, regional factors are important, and not taking these into account may underestimate the importance of international developments in country specific variables, as well as incorrectly support the presence of common transmission mechanisms across countries in different regions.

Third, the results in table 3 also reveal the heterogeneity between regions, and the difference between South America and Europe is particularly clear. In South America, as much as 70 percent of the short run variation in activity is driven by demand shocks, while in Europe as much as 90 percent of the long run variation in prices is driven by demand shocks. One possible explanation for this discrepancy is that many South American countries are major exporters of raw materials and food, the increased demand for such commodities in recent decades and the common monetary framework employed in many European countries. However, as in, e.g., Kose et al. (2003) and Canova et al. (2007), we only find a very modest regional contribution in Europe. On average, regional demand and supply shocks explain 5 and 31 percent, respectively, of the variation in activity and prices after 8 quarters in this region. Thus, as shown in table 1 in section 4.1.1 and in table 3 above, there is only weak evidence of a common European business cycle. Accordingly, business cycles in Europe are primarily driven by shocks to common world factors, or large idiosyncratic disturbances.

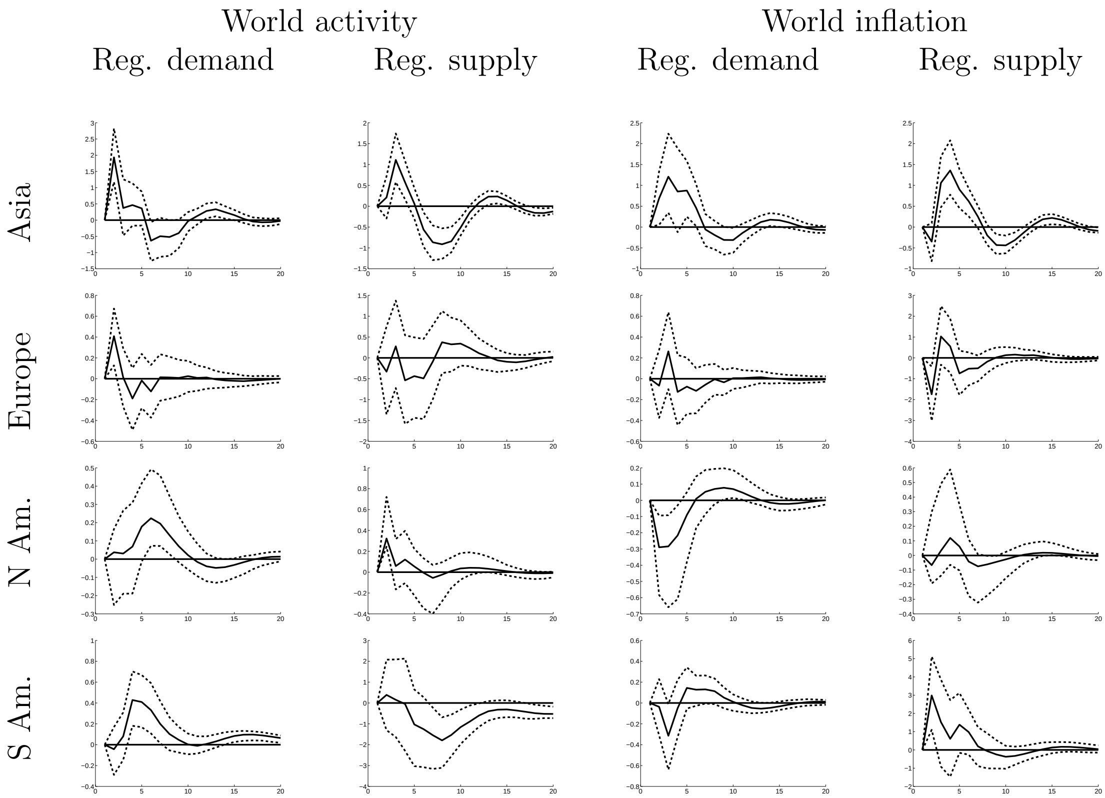
4.3 Spillovers

In the previous sections, we have studied how shocks to international and regional business cycles affect activity and prices across regions and individual countries. In this final section, we perform an additional exercise and analyze the spillovers from common shocks in one region to the world economy. If the spillovers were large and significant, this would of course question the finding of decoupling emphasized in much of this paper. However, such spillovers might provide a different perspective on the different regions' importance in the world economy than that offered by the factor statistics in table 1.

Figure 5 reports the responses of world activity growth and inflation following regional demand and supply shocks. Generally, the responses are significant for one or more of the regional shocks, but we only find significant effect on both world activity and inflation for the Asian model (region). Here, world activity growth increases temporarily after a positive regional demand and supply shock. Moreover, world inflation increase after a positive Asian demand shock, while it falls initially (although not significantly) after a positive supply shock. After 3 to 5 quarters, world inflation increases significantly. This is probably due to the stimulating effects the positive Asian supply shock has on world activity growth. The results are more mixed for the other regional shocks, and the spillovers are not always easy to interpret. However, as we show in table 7 in appendix B, only regional shocks in Asia, and to some extent North America, explain a non-negligible fraction of the total variance in world activity growth and inflation.

Do these results question the findings regarding decoupling? We do not believe so. As

Figure 5: **Regional spillovers**



Note: Column 1 (3) and 2 (4) report the median responses, with 90 percent confidence bands, of the world activity (inflation) factor after a one percent innovation in respectively regional demand and supply. Each row correspond to a particular region.

seen in table 7, the most dominant regional shock is the regional supply shock in Asia, which explains less than 15 percent of the variance in the world inflation factor.

It might seem surprising that innovations to the North American factors are not more important. For example, Bui and Bayoumi (2010) argue that the international business cycle is largely driven by US financial shocks and innovations to commodity prices. Our results do not necessarily contradict such an interpretation.[26] As we documented in section 4.2, the world factors affect all of the countries in our sample significantly, and the American economy is certainly an important contributor to these world factors.[27] Instead, our results show that only the purely Asian business cycle shocks affect both world factors significantly, while the results for the purely North American shocks are more mixed. As such, our results are in line with a large number of statistics indicating the growing importance of Asia in the global economy.

[26] In fact, given the discussion of our results presented in previous sections, such an interpretation may agree with our findings.

[27] The world factors by construction load positively on US output and inflation. Thus, to the extent that other countries also load positively on the world factors, what is good for America is also good for the world.

5 Conclusion

In this paper, we have answered two related questions: How important are common global and regional business cycle components to activity and prices across nations and regions, and what are the primary driving forces of these business cycle components? To answer the last question, we distinguished between global and regional demand and supply shocks and studied the relative contributions of these shocks in explaining macroeconomic fluctuations and synchronization. Our empirical strategy employed a FAVAR model that considered real and nominal variables across four different regions, Asia, Europe, North and South America, covering 32 different countries.

Our main findings can be summarized as follows: First, we find significant evidence for regional business cycle components in real and nominal variables in Asia, North America and South America. In Europe, the global factors are dominant, and the regional factors and shocks explain only a small share of the variance among European countries. Thus, with the exception of Europe, these results support the decoupling hypothesis proposed in recent business cycle synchronization studies. Second, in the short run, aggregate demand shocks explain a larger share of the business cycle variation in activity measures than supply shocks. In the long run, aggregate supply shocks are more important. For prices, the main driving forces are demand shocks at all horizons. Third, the transmission mechanisms for the activity measures following common global shocks differ across regions. This finding is unique to our study and lends further support to the decoupling hypothesis. Finally, only innovations to the Asian activity and price factors have significant spillover effects on the common world factors, indicating the growing importance of Asia in the global economy.

To the best of our knowledge, this paper is the first to analyze the presence of global and regional business cycles and their driving forces simultaneously in a structural VAR setting. As such, new insights have been unveiled regarding common shocks and propagations. Importantly, depending on the country and region considered, common global shocks may or may not cause more business cycle synchronization. In the future, a deeper examination of the channels through which global (and regional) shocks are transmitted to domestic economies would be helpful for understanding the causes of business cycle synchronization in particular and business cycle variation in general.

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Appendices

Appendix A Data

The data set contains observations covering the period 1991.01 to 2011.04 and is collected from Datastream.

Some of the series we include in the model contain missing observations. In cases where fewer than 4 years of observations are missing, we elected to retain the countries and variables in the data set and use the EM algorithm described in Stock and Watson (2002) to construct the missing observations. Our results are robust to the exclusion of these variables. For variables where more than 4 years of observations are missing, we have excluded the series altogether. Thus, for Australia, Belgium, France, India, Malaysia, and Mexico we lack producer prices (PPI), and for Belgium, Denmark, India, Indonesia, Portugal and Thailand we lack industrial production (IP).

Finally, the IP series are for the manufacturing sector, with a few exceptions: For Argentina, China, and New Zealand the IP series are for total production. Again, this is due to data availability.

In sum, the data coverage is 88, 90, 100, and 95 percent for the regions of Asia, Europe, North America and South America, respectively.[28]

Appendix B Region and country specific statistics

Table 4: **Regional trade shares: 2008**

	Asia	**Europe**	**North Am.**	**South Am.**
Asia	65 (8)	16 (-2)	16 (-6)	2 (0)
Europe	9 (-1)	80 (0)	9 (1)	1 (0)
North Am.	14 (-3)	14 (1)	69 (1)	3 (1)
South Am.	28 (4)	30 (-4)	22 (2)	19 (-2)

Note: Each row displays a region's share of export with the other respective regions. In parenthesis are the differences between the export shares in 1995 and 2008. The numbers are calculated based on the countries used in this analysis. Source and raw data: UNCTRAD, merchandise exports in thousands of dollars, annual.

[28] I.e., with respect to the region as defined in this paper.

Table 5: **Individual country regional trade shares: 2008, and standard deviations of activity and price measures**

	Trade shares				Standard deviations	
	Asia	**Europe**	**NA**	**SA**	**Activity**	**Inflation**
Australia	79	12	7	1	0.54	0.41
China	48	24	25	3	0.55	1.51
Hong Kong	69	15	15	1	1.31	1.19
India	39	34	21	4	1.31	1.18
Indonesia	74	13	12	1	0.67	1.23
Japan	58	16	24	2	0.94	0.34
Korea	63	15	19	3	0.99	0.48
Malaysia	70	13	16	1	2.29	0.46
New Zealand	67	16	15	1	0.94	0.40
Singapore	78	12	10	1	2.14	0.59
Taiwan	71	12	15	2	1.14	0.74
Thailand	64	17	16	2	1.52	0.74
Belgium	6	86	7	1	0.68	0.40
Denmark	9	82	8	1	1.18	0.23
Finland	13	74	10	2	1.07	0.40
France	11	78	9	2	0.40	0.27
Germany	12	75	11	2	0.67	0.29
Italy	11	76	11	2	0.55	0.34
Netherlands	6	87	6	1	0.61	0.26
Norway	5	87	7	0	1.17	0.35
Portugal	6	87	6	1	0.84	0.51
Spain	6	84	8	2	0.58	0.44
Sweden	10	78	9	1	0.70	0.42
Switzerland	17	67	13	2	0.53	0.35
United Kingdom	13	66	19	1	0.45	0.33
Argentina	20	26	14	38	1.92	1.38
Brazil	26	33	23	17	1.11	1.85
Chile	41	28	20	11	1.27	1.00
Peru	27	32	30	11	1.74	1.47
Canada	8	8	82	1	0.54	0.44
Mexico	3	6	88	3	0.87	1.86
United States	29	27	38	5	0.55	0.34

Note: Each row displays a country's share of export with the other respective regions. The numbers are calculated based on the countries used in this analysis. Source and raw data: UNCTRAD, merchandise exports in thousands of dollars, annual. The standard deviations are calculated for the sample period 1992:01 to 2011.04, using quarterly data and the transformations described in section 2, times 100. Here Activity is measured by GDP (growth), while prices are measured by CPI (inflation).

Table 6: **Factor loadings and statistics**

	Activity World	Regional	R^2	Inflation World	Regional	R^2
Panel a: Asia						
Japan	0.74	0.26	0.22	0.48	0.52	0.44
	0.22	0.05		0.29	0.31	
	(0.00)	(0.02)		(0.00)	(0.00)	
India	0.33	0.67	0.03	0.00	1.00	0.31
	-0.12	-0.06		-0.14	0.36	
	(0.34)	(0.17)		(0.77)	(0.00)	
Korea	0.47	0.53	0.44	0.36	0.64	0.60
	0.29	0.31		0.33	0.48	
	(0.00)	(0.00)		(0.00)	(0.00)	
Malaysia	0.38	0.62	0.25	0.31	0.69	0.53
	0.12	0.21		0.25	0.46	
	(0.00)	(0.00)		(0.00)	(0.00)	
Taiwan	0.44	0.56	0.34	0.59	0.41	0.40
	0.22	0.26		0.32	0.23	
	(0.00)	(0.00)		(0.00)	(0.00)	
Singapore	0.59	0.41	0.57	0.99	0.01	0.43
	0.44	0.33		0.50	-0.10	
	(0.00)	(0.00)		(0.00)	(0.39)	
HongKong	0.58	0.42	0.48	0.32	0.68	0.60
	0.37	0.29		0.29	0.50	
	(0.00)	(0.00)		(0.00)	(0.00)	
China	0.10	0.90	0.28	0.99	0.01	0.09
	-0.02	0.31		0.10	-0.18	
	(0.08)	(0.00)		(0.01)	(0.76)	
Thailand	0.30	0.70	0.27	0.46	0.54	0.41
	0.10	0.23		0.27	0.31	
	(0.01)	(0.00)		(0.00)	(0.00)	
Australia	0.82	0.18	0.05	0.75	0.25	0.40
	-0.01	-0.31		0.37	-0.48	
	(0.06)	(0.39)		(0.00)	(0.00)	
NewZealand	0.51	0.49	0.22	0.81	0.19	0.40
	0.16	0.14		0.41	-0.44	
	(0.00)	(0.00)		(0.00)	(0.00)	
Indonesia	0.82	0.18	0.01	0.04	0.96	0.31
	-0.11	-0.16		-0.05	0.36	
	(0.37)	(0.69)		(0.18)	(0.00)	
Summary:						
R^2	0.5	0.5	0.3	0.5	0.5	0.4
Significance	0.8	0.8		0.8	0.8	
Panel b: Europe						
UK	0.47	0.53	0.40	0.90	0.10	0.44
	0.26	0.29		0.47	0.05	
	(0.00)	(0.00)		(0.00)	(0.02)	
Switzerland	0.89	0.11	0.27	0.69	0.31	0.64
	0.31	-0.02		0.52	0.32	
	(0.00)	(0.08)		(0.00)	(0.00)	

See end of table for notes

Table 6 – continued from previous page

	Activity World	Regional	R^2	Inflation World	Regional	R^2
Netherlands	0.79 0.46 (0.00)	0.21 0.18 (0.00)	0.49	0.18 0.10 (0.00)	0.82 0.40 (0.00)	0.39
Italy	0.90 0.62 (0.00)	0.10 0.12 (0.00)	0.61	0.44 0.42 (0.00)	0.56 0.48 (0.00)	0.67
France	0.62 0.47 (0.00)	0.38 0.33 (0.00)	0.59	0.90 0.66 (0.00)	0.10 0.14 (0.00)	0.68
Finland	0.96 0.43 (0.00)	0.04 -0.05 (0.18)	0.38	0.97 0.49 (0.00)	0.03 -0.05 (0.19)	0.42
Denmark	0.99 0.38 (0.00)	0.01 -0.24 (0.54)	0.33	1.00 0.41 (0.00)	0.00 -0.20 (0.78)	0.35
Sweden	0.81 0.37 (0.00)	0.19 0.08 (0.00)	0.36	0.85 0.57 (0.00)	0.15 0.16 (0.00)	0.59
Germany	0.69 0.46 (0.00)	0.31 0.26 (0.00)	0.54	0.72 0.55 (0.00)	0.28 0.28 (0.00)	0.65
Belgium	0.99 0.45 (0.00)	0.01 -0.09 (0.47)	0.39	0.98 0.64 (0.00)	0.02 -0.03 (0.14)	0.60
Norway	0.84 0.18 (0.00)	0.16 -0.34 (0.11)	0.16	1.00 0.10 (0.00)	0.00 -0.22 (0.94)	0.10
Spain	0.76 0.33 (0.00)	0.24 0.11 (0.00)	0.35	0.67 0.57 (0.00)	0.33 0.37 (0.00)	0.72
Portugal	0.94 0.32 (0.00)	0.06 -0.32 (0.17)	0.28	0.24 0.29 (0.00)	0.76 0.63 (0.00)	0.71
Summary:						
R^2	0.8	0.2	0.4	0.7	0.3	0.5
Significance	1.0	0.6		1.0	0.7	

Panel c: North America

	Activity World	Regional	R^2	Inflation World	Regional	R^2
USA	0.36 0.38 (0.00)	0.64 0.55 (0.00)	0.70	0.72 0.66 (0.00)	0.28 0.38 (0.00)	0.80
Canada	0.59 0.50 (0.00)	0.41 0.41 (0.00)	0.67	0.55 0.44 (0.00)	0.45 0.39 (0.00)	0.61
Summary:						
R^2	0.5	0.5	0.7	0.6	0.4	0.7
Significance	1.0	1.0		1.0	1.0	

See end of table for notes

Table 6 – continued from previous page

	Activity World	Regional	R^2	Inflation World	Regional	R^2
Panel d: South America						
Brazil	0.48	0.52	0.40	0.12	0.88	0.04
	0.26	0.29		-0.13	-0.02	
	(0.00)	(0.00)		(0.49)	(0.07)	
Argentina	0.39	0.61	0.30	0.88	0.12	0.15
	0.15	0.23		0.14	-0.34	
	(0.00)	(0.00)		(0.00)	(0.21)	
Peru	0.30	0.70	0.47	0.03	0.97	0.63
	0.22	0.42		0.00	0.64	
	(0.00)	(0.00)		(0.06)	(0.00)	
Chile	0.58	0.42	0.21	0.24	0.76	0.75
	0.16	0.12		0.32	0.63	
	(0.00)	(0.00)		(0.00)	(0.00)	
Mexico	0.93	0.07	0.45	0.02	0.98	0.46
	0.49	-0.34		-0.25	0.50	
	(0.00)	(0.05)		(0.31)	(0.00)	
Summary:						
R^2	0.5	0.5	0.4	0.3	0.7	0.4
Significance	1.0	1.0		0.6	0.8	

Note: The table displays for each country and region summary statistics for activity (2nd to 4th column) and inflation (5th to 7th column) variables. The first row for each country displays the contribution to total R^2 for each factor as well as total R^2. The second and third row reports factor loadings and p-values (in parenthesis). The activity numbers load only on the activity factors, and the inflation numbers load only on the inflation factors. Activity is measured by GDP numbers, while inflation are measured by CPI numbers. The summary statistics at the bottom of each panel are the mean values of the contributions and the R^2 values in the respective columns, and the fraction of significant factor loadings for each region and factor. See also table 1

Table 7: **Variance decomposition: Regional spillovers**

	World activity		World inflation	
	Reg. demand	Reg. supply	Reg. demand	Reg. supply
Asia	0.08	0.08	0.04	0.13
Europe	0.02	0.00	0.01	0.03
North Am.	0.00	0.05	0.07	0.01
South Am.	0.03	0.00	0.01	0.02

Note: Column 2 (4) and 3 (5) report the variance explained of the world activity (inflation) factor after an innovation in respectively regional demand and supply. Each row correspond to a particular region. The horizon is 4 quarters ahead.

Table 8: **Average variance decompositions: World and region**

Horizon	Asia		Europe		North America		South America		Mean	
	World	Reg.	World	Reg.	World	Reg.	World	Reg.	World	Reg.
Panel a: Activity										
1	0.50	0.50	0.75	0.25	0.14	0.86	0.60	0.40	0.50	0.50
8	0.32	0.68	0.95	0.05	0.36	0.64	0.58	0.42	0.55	0.45
Panel b: Prices										
1	0.54	0.46	0.84	0.16	0.69	0.31	0.35	0.65	0.60	0.40
8	0.43	0.57	0.69	0.31	0.72	0.28	0.36	0.64	0.55	0.45

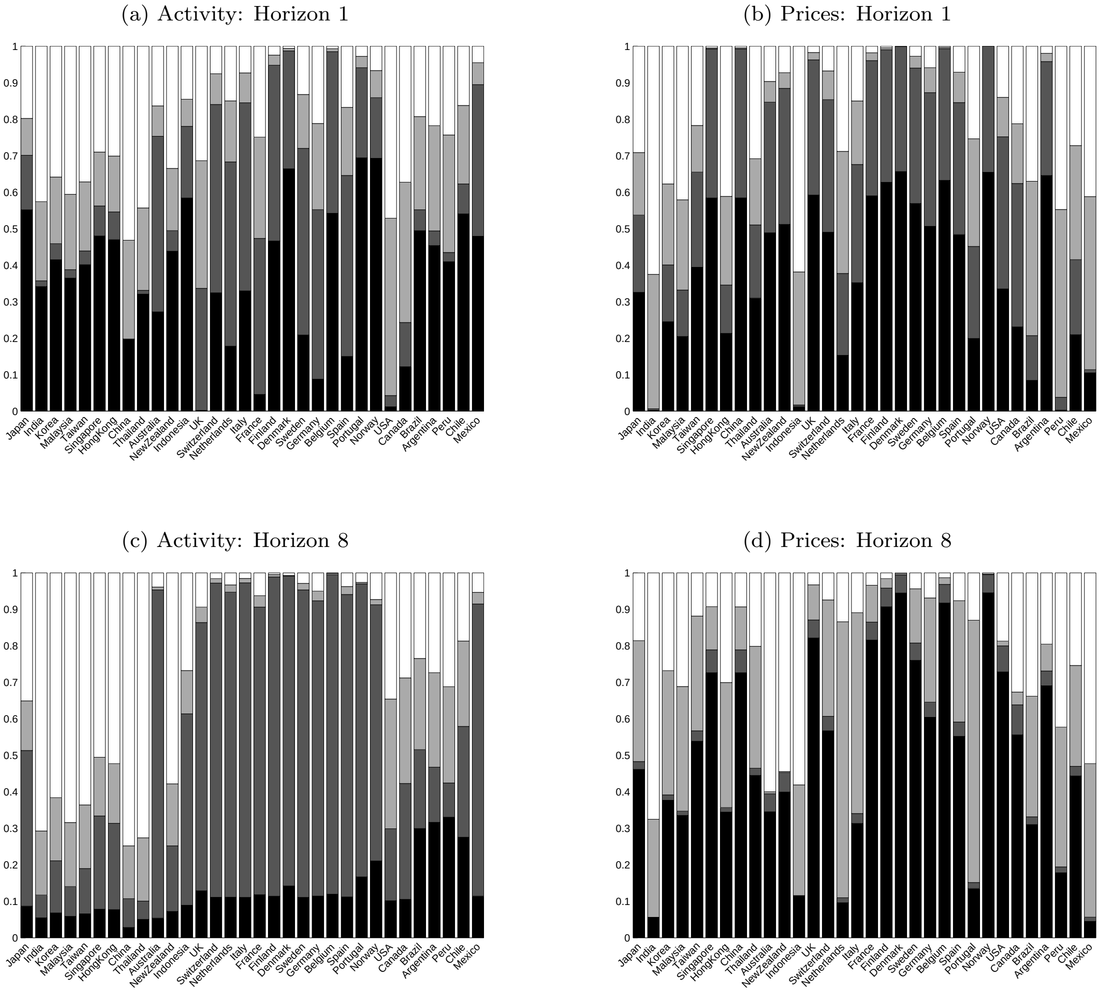
Note: Panel a reports, for activity variables (measured by GDP), the average variance explained (across countries within regions) by the the four factors in the model. The world activity and inflation factors are the same for each region, while the regional factors are regional specific. Panel b reports the same decompositions for price variables (measured by CPI). See also table 3.

Table 9: **Sample: 1992.Q1 - 2007.Q4. Average significance and** R^2

		Activity World	Regional	R^2	Inflation World	Regional	R^2
Asia	R^2	0.24	0.76	0.25	0.42	0.58	0.39
	Sign.	0.50	0.75		0.83	0.92	
Europe	R^2	0.79	0.21	0.33	0.63	0.37	0.48
	Sign.	1.00	0.62		0.92	0.77	
North America	R^2	0.31	0.69	0.67	0.55	0.45	0.70
	Sign.	1.00	1.00		1.00	1.00	
South America	R^2	0.52	0.48	0.36	0.35	0.65	0.36
	Sign.	0.80	0.80		0.40	0.60	

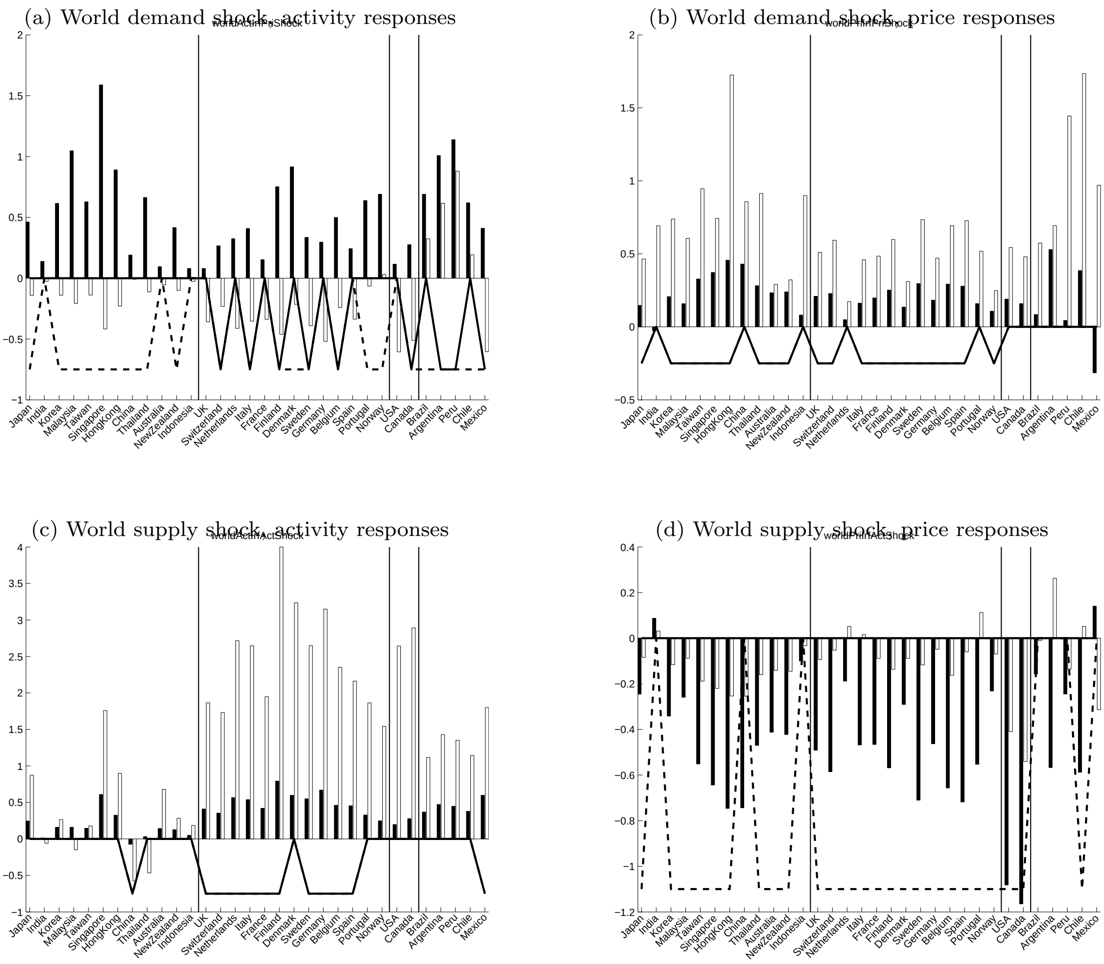
Note: See table 1.

Figure 6: **Variance decompositions**



Note: The figures display variance decompositions for GDP and Prices for all the countries in the four different regions to world and regional shocks. Starting at zero on the y-axis are the contribution from world demand shocks (black), world supply shocks, regional demand shocks and finally regional supply shocks (white). The variance decompositions are ordered from left to right, starting with countries in Asia, Europe, North America and finally South America.

Figure 7: **Longrun restrictions. Impulse responses: World shocks**



(a) World demand shock, activity responses

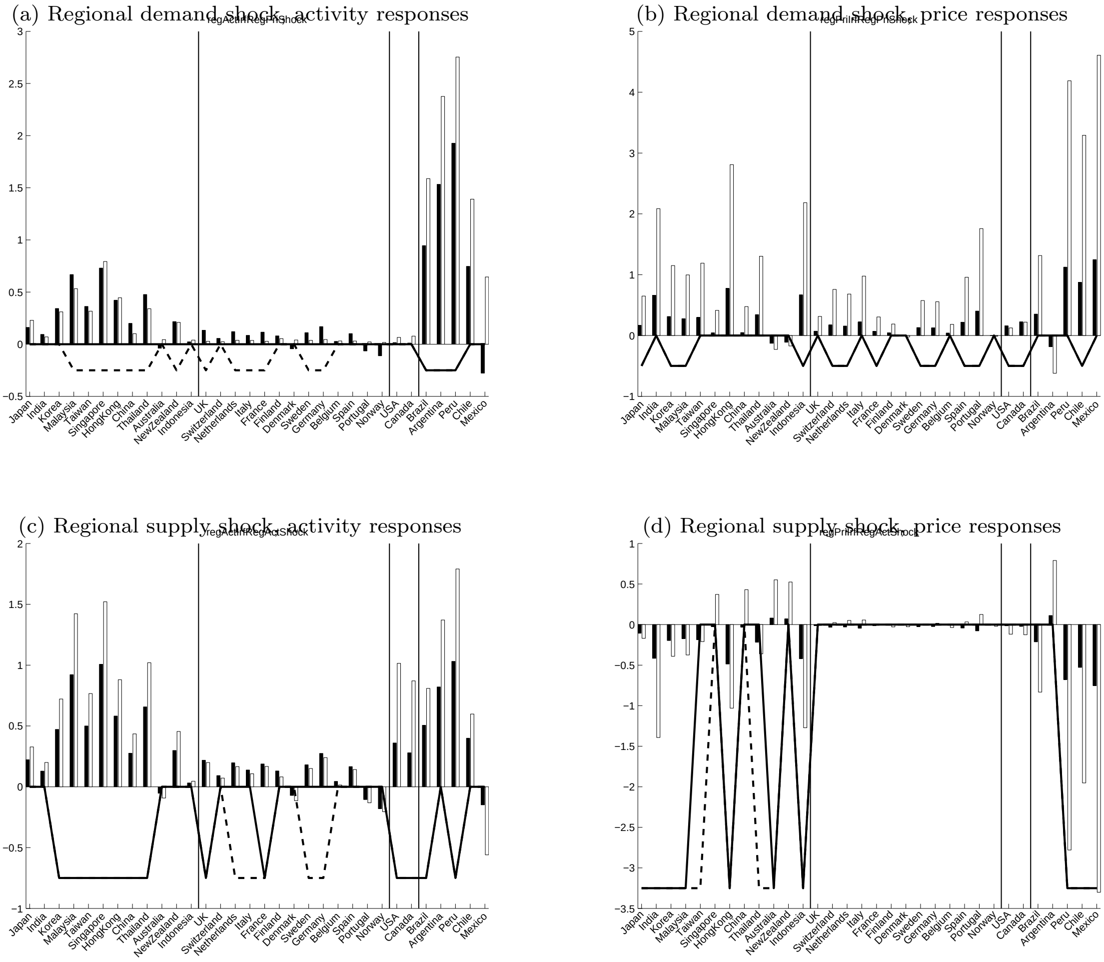
(b) World demand shock, price responses

(c) World supply shock, activity responses

(d) World supply shock, price responses

Note: See figure 3.

Figure 8: **Longrun restrictions. Impulse responses: Regional shocks**



(a) Regional demand shock, activity responses

(b) Regional demand shock, price responses

(c) Regional supply shock, activity responses

(d) Regional supply shock, price responses

Note: See figure 3.