On the Asymmetry of Global Spillovers

Emerging Markets vs. Advanced Economies

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Abstract

This paper examines growth spillovers between emerging markets (EMs) and advanced economies (AEs). The empirical results based on a two-block set-up and covering the period 1991 to 2015 are twofold. First, the paper shows that the size of the spillovers running from EMs to AEs is about a fifth of these running from AEs to EMs. Second, results point to spillovers from EMs to AEs having increased over the second half of the sample period. The paper presents suggestive evidence that the (evolving) structure of interdependencies play an important role in explaining the existence of "asymmetrical spillovers" between these similar sized blocks.

On the (Changing) Asymmetry of Global Spillovers: Emerging Markets vs. Advanced Economies

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I. INTRODUCTION

Emerging markets (EMs) represent a relatively large and rising share of world GDP. Taken together, EMs now constitute the largest block in the world economy and contribute the most to global growth (Figures 1 and 2). From a trade standpoint, advanced economies (AEs)' imports are sourced in large part from EMs (about 50 percent) and EMs have also become important destinations for AE's exports (Figure 3 and 4).[2] EMs are as a block the world's largest consumer of commodity including metals and energy (Figures 5 and 6). The EM block is thus expected to be a large source of (cyclical) spillovers to the rest the world. To date, however, little is known about these spillovers. Indeed, the spillover literature has focused mostly on spillovers from AEs.[3] While AEs were arguably the most important sources of spillover for most of the second half of the 20th century, it is high time to consider the EM block as not just the destination of these spillover effects but also the origin—considering the growing importance of EMs. Some

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[2] It should be noted however that trade data used in the analysis are on a gross basis and thus double or multiple-count vertical trade or flows in intermediates. Trade flows in gross basis may overestimate the extent of trade links between AEs and EMs. That said, to the extent that supply chains are at least in part regional in nature the issue of double counting when considering trade links between AEs and EMs is less prevalent. Trade in value added allows incorporating the specificity of the new business model on which global manufacturing is based. Due to limited country coverage of value-added trade data we are however unable to use such data in our analysis.

[3] See for example Österholm et al. (2007) and Utlaut et al. (2010) for studies of spillover from AEs to Latin America and to Emerging Asia respectively. See also Erten (2012) for a study of spillover emanating from the Eurozone to emerging markets.

recent studies have attempted to study spillovers from EMs but focusing on individual EMs mainly China (Hsieh and Ossa, 2011).[4] The present paper attempts to fill the gap.

The main contribution of our paper is to document empirically that global spillovers are asymmetrical. Our empirical results based on a two-block set-up and covering the period 1991 to 2015 are twofold. First, we show that the size of the spillovers running from EMs to AEs is about a fifth of these running from AEs to EMs. Second, results point to spillovers from EMs to AEs having increased over the second half of the sample period. We present suggestive evidence that the (evolving) structure of interdependencies play an important role in explaining the existence of asymmetrical spillovers between these similar sized blocks.

A casual look at data on trade and capital flows between AEs and EMs suggest that global spillover may indeed be asymmetrical and changing. Figure 7 shows that the EM block depends relatively more on external demand suggesting that spillovers from AEs to EMs are expected to be large. AE's dependence on external demand is increasing suggesting that spillovers from EMs maybe increasing (see Table 1). Figure 8 also shows that the EM block depends more on capital inflow suggesting that spillovers from AEs maybe large. AE's dependence on capital flows is increasing suggesting spillovers from EMs are expected to increase (see Table 2). In this paper we use state of the art Vector Autogressive (VAR) techniques to systematically document the asymmetrical nature of global spillovers.

In explaining the origins of spillovers, there are three strands of theoretical literature namely the "fundamental", "financial", and "coordination failure" explanations (see survey by Rigobon, 2018; Arezki and Yang, 2019 and references therein). The fundamental explanation of spillovers between countries rely on real channels. The related set of papers focus on bilateral trade, trade

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[4] Also see Ashvin, and Nabar (2012) for a study of the global spillovers from China's investment-led growth.

of similar goods with a common market, and monetary policy coordination and macro similarities.[5] The financial explanation of spillovers relies on the constraints and inefficiencies in banking sectors and international equity markets. Imperfections in the financial system are exacerbated during a crisis, and such imperfections limit the extent in which financial services can be provided to different countries.[6]

The new theories of financial spillovers are based on the existence of bank networks as channels of propagation.[7] Empirically, Rey (2013) provides evidence of a "global financial cycle" in capital flows, asset prices and in credit growth. This cycle co-moves with the VIX, a measure of uncertainty and risk aversion of the markets.[8] [9]

The third explanation is based on coordination failure. Existing theories include explanations where spillovers are due to multiple equilibria, herding, learning, and political contagion. The transmission of shocks is related to informational problem that can drive market participants to make decision affecting many countries at once. In addition to investors facing informational challenge, policy makers also often follow each other and often adopt similar macroeconomic policy response. Even when countries have little in common, the behaviors of investors and

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[5] See Gerlach and Smets (1995), Corsetti, Pesenti, Roubini, and Tille (1998), Corsetti, Pericoli, and Stracia, (2003), and Basu, (1998).

[6] See Goldstein, Kaminsky, and Reinhart (2000) and Kaminsky and Reinhart (2002) for explanations based on common lender and banking and Calvo (2002) for explanation based on financial intermediaries.

[7] See Allen and Gale (2000) and Elliott, Golub, and Jackson (2014).

[8] Further Rey (2013) shows that asset markets in countries with more credit inflows are more sensitive to the global cycle—the latter is not aligned with countries' specific macroeconomic conditions. The VAR analysis suggests that one of the determinants of the global financial cycle is monetary policy in the center country, which affects leverage of global banks, capital flows and credit growth in the international financial system. Whenever capital is freely mobile, the global financial cycle constrains national monetary policies.

[9] See also Bruno and Shin (2013) for evidence of global financial cycle.

policy makers influence the transmission of shocks between countries.[10] In this paper, our empirical framework contribute to the literature by allowing to distinguish the different channels of transmission of shocks between regional blocks.

For the purpose of allowing the reader to grasp the importance of our empirical findings on the asymmetrical nature of global spillovers, it is useful to make a detour by explaining how existing theoretical frameworks used to study the international transmission of business cycle treat EMs. There are essentially two schools of "modelling". The first school relies on the small economy assumption (see Schmitt-Grohe & Uribe, 2003; Aguiar and Gopinath, 2007; Garcia-Cicco et al. 2010). Clearly, that small open economy assumption has been justified for the most part of the second half of the second 20th century but as EMs have become a large if not the largest economic block—with a large share of manufacturing activities in AEs having moved to EMs— it seems important to explore whether this assumption is still valid.[11] Indeed, EMs growth may potentially exercise large spillovers through direct trade linkages, commodity and asset prices. The second school of modelling employs a two-country framework. Specifically, the Backus et al. (1992) framework henceforth BKK model is a two-blocks set-up assuming symmetry and correlated shocks. These assumptions are reasonable when considering spillovers between AEs. However, these assumptions seem less appropriate when considering spillovers between AEs and EMs that are not symmetrical in terms of the structure of their economies. The BKK also does not account for the evolving structure of interdependencies.

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[10] See Calvo and Mendoza (2000) and Chari and Kehoe (1999) for application of herding information cascade to capital flows.

[11] For evidence of volatility spillover being different between large and small countries see Colacito et al. (2015).

One challenge in documenting empirically spillovers between EMs and AEs is the choice of the identification strategy. In our benchmark VAR model we assume that AE shocks spillover to EMs contemporaneously within a quarter but that EM shocks do not spillover to AE within that time frame. That assumption relies on the nature of linkage between EMs and AEs. Specifically, considering that EMs rely more exclusively on export-led growth models, growth shocks in AEs more directly spill over to EMs growth. Only then would the latter "spill back" onto AEs. It is likely that the speed of spillovers from AEs to EMs trump the speed of spillovers running from EMs to AEs. Relying on that timing restriction however imposes that a large part of co-movement between growth in EMs and AEs is attributed to AE shocks. In turn, this could lead to overestimating the magnitude of the spillovers originating from AEs onto EMs. We thus also explore different avenues including arguably exogenous variables to test whether our results are sensitive to the choice of decomposition. Specifically, we use fiscal shocks and damages from natural disasters to isolate growth shocks that are exogenous to other blocks. Fiscal news are constructed using the so-called narrative approach to isolate exogenous components of policy changes from endogenous policy responses. The fiscal shocks are defined as exogenous that are not driven by current and future developments on the real side of economy. These shocks are exogenous with respect to the state of the real economy. We exploit the arguably exogenous shock stemming from damage caused by large natural disasters. We rely on the fact that the timing natural disasters is exogenous. In addition, we also explore the spillovers from monetary and geopolitical shocks. Results using these identification strategies confirm the existence of the asymmetrical spillover from AEs to EMs.

The rest of the paper is organized as followed. Section II lays out the data and empirical strategy. Section III presents our main empirical results. Section IV discusses results using an alternative identification strategy. Section V concludes.

II.   DATA AND EMPIRICAL STRATEGY

A.   Data

The sample includes 19 emerging market economies and 21 advanced economies.[12] Our

classification is based on the core lists of countries that the International Monetary Fund and

other organizations such as the World Bank define as AEs and EMs. The main results presented

in this paper are robust to using different classifications.[13] The sample period runs from 1991Q1

to 2015Q4. The data are at the quarterly frequency. The economic growth series for the two

economic blocks namely EM and AE blocks are based on purchasing power parity (PPP)

weighted average of local currency real GDP growth from IMF's World Economic Outlook live

database. For the purpose of checking whether our main results are robust to different country

grouping we use smaller country groupings including the Group of Seven represent the world's

largest industrialized economies (G-7), a group composed of Brazil, Russia, India, China

(BRIC), and China alone.

The data also include control variables that capture the main channels of transmission (trade,

finance, and commodities). To control for trade, we use imports over total trade constructed

using bilateral data from IMF's Direction of Trade Statistics. To control for the financial

channel, we construct a spread measure based on the MSCI Emerging Index over the MSCI

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[12] The EM block is comprised of: Argentina, Brazil, Chile, China, Czech, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Russia, Taiwan Province of China, Turkey, Thailand and South Africa. The AE block is comprised of: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Luxembosurg, Netherland, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

[13] Due to the lack of quarterly frequency GDP data, we omit controlling for growth in the residual group of countries composed of developing countries.

World Index. To control for the commodity channel, we use the Bloomberg's commodity price index.

Last, we also use data on fiscal expenditure and tax event in the United States and natural disasters as source of arguably exogenous variation to identify growth shocks in both AEs and EMs. US spending news data are the narrative military expenditure shock obtained from Ramey (2011). US tax news are the narrative tax shock obtained from Romer and Romer (2012). AE and EM natural disaster shocks are the damage stemming from large natural disasters (larger than one billion US dollars) in the relevant country group over the group GDP. The data are originally from the online version of the International Disaster Database (EM-DAT).[14]

B. Empirical Approach

We exploit VAR techniques to capture the interrelationships between AEs and EMs growth and quantify the dynamic spillovers between these blocks. Our VAR model specification is as follows:

$$y_t = \Phi' x_t + u_t, u_t \sim N(0, \Sigma)$$

where $x_t = [y_{t-1}, \dots, y_{t-p}, z_t]$

We first use a parsimonious model that simply employ bivariate model including GDP growth of EMs and AEs. [15] Second, we augment the model with various other control (endogenous) variables such as the main financial and trade variables, commodity prices. Last, we augment our bivariate model with exogenous variables to explore a different identification strategy.

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[14] See URL link to the natural disasters database: http://www.emdat.be/database
[15] A dummy is also included to control for the period covering the global recession that is from 2007Q3 to 2009Q3.

We estimate the model from a Bayesian perspective. Unlike traditional approach, we optimally choose the informativeness of our prior belief. The priors are treated as hyper-parameters to maximize the marginal likelihood of the data. For illustrative purposes, take the case where one estimates an autoregressive process of order one, *AR(1),* with an unknown persistence, ρ. Instead of setting the prior associated with the persistence of the *AR(1)* process to follow a normal distribution as follows, $\rho \sim N(0.3, 1)$, we set the distribution to be as follows, *N(0.3, s)* and treat *s*, the "tightness of our prior" as a parameter we aim to maximize the marginal data density (equivalently the out-of-sample prediction power). The estimated value of *s* determines what approach we choose to pursue. If the estimated *s* is large, we have a loose prior and go back to using ordinary least square results. If instead *s* is small, we have in effect a tight prior and use that prior in our estimation. This approach is theoretically grounded and reduces the subjective choices in the setting of the prior. This approach is superior as it performs well both in out-of-sample prediction and accuracy in the estimation of impulse response functions (see Giannone et al. 2015). More details about the estimation strategy are presented in Appendix II.

III. EMPIRICAL RESULTS

We now turn to our empirical results. In the first sub-section, we present the results using our parsimonious specification. In the second sub-section, we explore how our results change across various samples. In the last sub-section, we present results using an augmented specification with the various channels of transmission.

A. Basic Results

Results obtained from our parsimonious specification taking the form of a bi-variate VAR show that the spillover between AEs and EMs are asymmetrical.[16] The impulse response function are reported in Figure 9. The left hand-side panel show the impulse responses stemming from an AE growth shock while the right hand-side show the impulse responses from an EM growth shock. The impulses are based on one standard deviation of GDP growth in AEs and EMs respectively. It should be noted that the standard deviation of growth of the original impulse is much higher for EMs than it is for AEs reflecting the more volatile growth process in the former. That said, when comparing the relative importance of the spillover originating from AEs onto EMs to the opposite direction of the causality, the impulse responses clearly show that the former direction of causality yields much larger spillovers.

To further illustrate the asymmetrical spillover between AEs and EMs we construct an "elasticity" of the spillover as the ratio between cumulative impulse responses over a year horizon. The elasticity of the spillover running from EMs to AEs is less than a fifth of the elasticity of the spillover in the other direction of the causality (see Table 3). These elasticities are statistically significant. These results confirm the intuitive view that AEs spillover to EMs are much more potent. Indeed, the facts presented earlier show the relatively high reliance of EMs on external demand and capital flows from AEs.

Results also show that the spillover from EMs to AEs have been growing. To show this, we simply split the sample in sub-period running from 1991 to 2002 and 2003 to 2015. The impulse responses are shown in Figure 10. We normalize the shock in the block of origin to be 1 on

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[16] The VAR specification uses one lag. Using several lags yield qualitatively and quantitatively comparable results.

impact for ease of comparison. Figure 10 clearly show that the spillover from EMs to AEs jump in the second period compared to the first. There is much less difference between the two sub-periods when considering the impulse responses capturing the spillovers running AEs to EMs. To illustrate further illustrate these results, we again construct the elasticity of the spillover from EMs to AEs. The elasticity associated with that direction of the causality jumps from 0.06 to 0.37 between the two sub-periods (see Table 4). Instead the elasticity associated with spillovers running from AEs to EMs is relatively high in both sub-samples and only increasing moderately. The ratio of elasticity between the two directions of causality is about a third for the second sub-period while it was less than a fifth using the overall sample.

These results confirm the intuitive view that the linkage between EMs and AEs have deepened in that a growing share of exports from AEs are destined to EMs and that commodity prices are increasingly driven by growth in EMs. While the spillovers from EMs to AEs have been increasing, they remain much smaller than spillovers originating from AEs.

B. Results using Different Country Groupings

Results using different country groupings confirm the existence of global asymmetrical spillovers. To explore that we unpack the various country groupings for both the destination and origin of spillovers (see Table 5). While the results using G7 instead of EMs are comparable, the elasticity drop (increase) when we instead consider US, Japan and Germany as source (destination) of the spillover. When using BRIC instead of the EM grouping results are comparable for both direction of the causality suggesting that these four countries drive the spillovers. However, when using China instead of the EM grouping, the elasticity of the spillover running from AE to China become much smaller and not significant. China's spillover onto

Germany and Japan appear however high in line with China important trade links with these two countries. These results confirm that global spillovers are asymmetrical but that the geography of trade can help explain some of the heterogeneity in the spillover effects between sub-groups. We explore the relative importance of these channels in more details in the following sub-section.

C. Channels of Transmission

Results controlling for the various channels of transmission confirm the existence of asymmetrical spillover between EMs and AEs. To explore the importance of controlling for the various channels we augment our benchmark specification with variables capturing trade, financial and commodity channels. Table 6 shows that our main results are virtually unchanged when incorporating these channels.

In order to explore the relative importance of these channels in explaining the transmission of these spillovers, we conduct a decomposition exercise. Specifically, we "distribute" the spillover to AE and EM growth between the three channels we have identified (see Table 6). Using variance decomposition, we compute the ratio between the variance from spillover and the total variance. AE shocks account for 10.5 percent of EM variance 1-year ahead. To control for the trade channel, we augment the VAR with a measure of trade and rank the latter first. In this system, the identified growth shock has no impact on trade. The variance of the spillover from the AE shock controlling for trade is 8.2 percent. Taking the difference, we attribute 2.3 percent to the trade channel. We perform the same calculation for finance and commodity. The relative share of trade, finance and commodity over total spillover are respectively21.8, 66.6 and 62.3 percent . Similarly, we investigate the respective importance of these channels for the spillovers stemming EMs to AEs. We find that trade finance and commodity account respectively for 22.2,

50.8 and 40.8 percent.[17] Results suggest that finance and commodities are important channels of propations of shocks between the two blocks namely AEs and EMs. These results are consistent with Rey (2013) work on the existence of global financial cycle in asset prices, capital flows and credit growth—over and above domestic macroeconomic conditions.

IV. ALTERNATIVE IDENTIFICATION SCHEMES

As mentioned earlier, the ordering of the decomposition is chosen such as AEs are ordered first, AEs are thus deemed "more exogenous" than EMs. In other words, we impose that EMs growth shocks do not *contemporaneously* affect AEs growth. One could argue that while there is a strong case for such choice decomposition, our results may be overly reliant on that identification strategy. In this sub-section, we present impulse responses using arguably exogenous US fiscal news (both spending and tax) and damage from natural disasters for both EMs and AEs as a source of exogenous variation for growth shocks. To generate these impulse responses, we simply augment our benchmark bi-variate VAR with either the US fiscal news or the damage from EM/AE natural disasters. Fiscal news and natural disasters are ordered first considering their arguably exogenous nature.

Results using spending and tax news in the US confirm that the spillover running AEs to EMs is (very) large. Figure 11 show on the left hand-side panel the impulse response from an US spending news based on the narrative military expenditure shock from Ramey (2011) on AE and EM growth. The impulse response confirms that the spillover from an US spending shock is very large. The elasticity of spillovers after a year running from the US (spending shock) to EM

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[17] Note that the channels are not exclusive and interact. Therefore, the sum of the relative shares is larger than one.

(growth) is over one that is larger than the elasticity from our benchmark specification. The right hand-side panel in Figure 11 shows the impulse response from a tax shock using the narrative tax shock from Romer and Romer (2010). While Romer and Romer (2010) find that tax news shocks have a strong effect on US growth, we find that the effect on AE growth overall is negative but not statistically significant. That is perhaps due to the shorter sample period used in this paper but also perhaps because when considering AE as a whole a tax hike in the US may also lead to an increase in capital flows to AE therefore counterbalancing the negative growth effect from higher tax in the US. That said, the impulse response from a US tax news shocks show a negative and statistically significant response suggesting that the spillover from US tax news shock to EM is large. The elasticity of the spillover from US to EM is also above one.

Thus far, we have validated only one of our main results that is the spillover from AE/US spillover to EMs are large using a different identification strategy. To also explore whether the other direction of the causality running from EMs to AEs is much smaller we use arguably exogenous variation from natural disaster shocks measured as the damage from large natural disasters (larger than one billion USD) in the relevant group over the total group GDP. Natural disasters have significant consequences. EM-DAT report that the direct economic damage from natural disasters between 1991–2015 is estimated at around $2.5 trillion and led to 1.75 million deaths. In theory, the impact of natural disasters on GDP is unclear (Strömberg, 2007). On the one hand, the loss of productive physical and human capital may reduce GDP. On the other hand, the disaster may provide a positive contribution to measured GDP as reconstruction efforts and humanitarian aid. The net effect of natural disaster is thus an empirical matter.

Impulse responses presented in Figure 12 confirm that a natural disaster shock in AEs have a negative and significant effect on GDP growth in AEs. The results also show that AE natural

disaster shocks spillover onto EM growth. The spillover effect from AE to EM is larger than one.

The impulse response on the right hand-side show the effect of a EM natural disaster on EM

growth is negative and statistically significant. The spillover from an EM natural disaster on AE

growth is not different from zero suggesting that the spillover from EM to AE is small.

In addition, we also explore the spillover effect of monetary and geopolitical shocks.

We first investigate spillovers from monetary policy in the United States. The first shock we

consider is the change in the 3-month Fed funds futures rate (see Bernanke and Kuttner, 2005).

We augment our main VAR specification with the monetary shock and order it first. The

elasticity of monetary spillovers is larger than 1 as shown in Figure 13. Alternatively, we use the

monetary policy shock as in Nakamura and Steinsson (2018). It is a composite measure of rate

changes at different maturities spanning the first year of the term structure, which captures the

effects of "forward guidance." The results are less significant, but the point estimate of the

elasticity of the spillovers from that forward guidance shock is consistent with the Fed funds

futures rate shock as shown in Figure 14.

For other countries, the identification relies on Cholesky ordering. We added Euro and China

monetary policy rate shocks to the baseline VAR and order these shocks after the growth rates.

The impulse response of the Euro monetary policy shock is large and has strong spillovers. In

contrast, the China monetary policy shock has smaller spillovers on AEs, albeit the effect is large

on EM growth. These confirms our main results that spillover from AEs to EMs are much larger

than the reverse.

To study the effect of geopolitics, we consider a classic spatial autoregressive (SAR) model (see LeSage and Pace, 2009) as follows:

$$y = \rho y W + u \,,$$

where y is a N-by-1 vector that contains growth shocks in N countries. ρ captures the importance of spatial dependence. W is a N-by-N spatial weight matrix that captures the distance between countries. We measure the spatial interdependence using geographical distance. The diagonal elements are zero. The off-diagonal elements are the inverse of the distance between country capitals. Next, the weight matrix is standardized so that the sum of row is unity.

To ensure a balanced sample, we use G7 countries in the AE block, and Brazil, China and Russia in the EM block. We estimate the growth shocks y by filtering the growth rates using an AR(1) model. The SAR model is then estimated using maximum-likelihood estimation. The estimates of ρ is 0.125 and is highly significant with a p value of 0.004. The evidence thus suggests the existence of spatial dependence. To measure the spatial effect, we rewrite the model as $y = (1 - \rho W)^{-1} u$. The effect from the innovation u is magnified through the spatial multiplier $(1 - \rho W)^{-1}$. Table 7 reports the spatial multiplier matrix. A shock affects the home country by more than unity because of the "spillback". Generally, the spillover is around 0.02. For neighboring countries, this effect could be much larger. For example, China has a spillover of 0.045 on Japan. Overall, the spillover from geopolitics are relatively small in comparison to the aggregate spillover documented earlier.

The spatial model only captures time-invariant geopolitical shocks. There could however be time-varying geopolitical conditions capturing the corresponding risks. Does an increase in geopolitical risk in one country spillover over to growth in other countries? To study the issue, we rely on the measure of Caldara and Iacoviello (2017). In the paper, the authors construct geopolitical risk indices based on textual analysis of newspaper articles. We obtain the EM geopolitical shock by averaging the eight EM countries in their sample. As shown in Figure 15, the results point to geopolitical risks having contractionary effects on the own bloc, but the spillover effects being relatively small.

Spillovers from monetary and geopolitical shocks originating from AEs to EMs are much larger than from EMs to AEs. All in all, the use of alternative identification strategy confirms the asymmetrical nature of growth spillovers between AEs and EMs.

V. CONCLUSIONS

The paper documented the existence of asymmetrical spillover between AEs and EMs. In particular, results showed that the size of the spillovers running from EMs to AEs is about a fifth of that running from AEs to EMs. Results also pointed to spillovers from EMs to AEs having increased over the second half of the sample. We also presented suggestive evidence that the (evolving) *structure* of interdependencies play an important role in explaining the existence of asymmetrical spillovers between these similar sized blocs. Our results suggest that while quantitatively the small open economy assumption associated with EMs might still seem appropriate, more research need to be done to model how the evolving structure of interdependencies between EMs and AEs matter for the global economy and welfare. Our empirical findings provide useful moments to calibrate theoretical models aimed at exploring welfare implications of these spillovers.

These results have also important implications for policies with respect to spillover effects. The asymmetric nature of spillover between EMs and AEs imply the former are in need of policy buffers to help stabilize their economies and macro-prudential to safeguard welfare. Amongst the existing literature, Brunnermeier and Sannikov (2015) provide a useful theoretical framework to think about externalities from interdependencies. Their model is a dynamic two-country growth model with incomplete markets. They show that short-term credit flows can be excessive and

reverse suddenly. The equilibrium outcome is constrained inefficient. The authors provide a full characterization of the endogenous volatility dynamics and welfare. They find that imposing capital controls or other domestic macro-prudential policy measures that limit short-term borrowing can improve welfare.

Looking forward, the spillover between AEs and EMs will tend to become more symmetric as EMs especially China continue to rebalance away from external demand and toward internal demand. However, as EMs continue to grow in size, it is unclear how global asset and commodity prices and EM's portfolio allocations will be affected and hence how AEs will be affected indirectly.

References

Aguiar Mark & Gita Gopinath, (2007). "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, University of Chicago Press, vol. 115, pages 69-102.

Ahuja, Ashvin, and Malhar Nabar, (2012), "Investment-Led Growth in China: Global Spillovers," IMF Working Paper No. 12/267 (Washington: International Monetary Fund).

Allen, F., and D. Gale (2000): "Bubbles and Crises," *Economic Journal*, 110, 236–255.

Arezki, Rabah & Yang Liu (2019). " International Spillovers: A Survey", World Bank, Washington DC, mimeo.

Backus, D.P., P. Kehoe, and F. Kydland (1992) "International Real Business Cycles," *Journal of Political Economy* 101, 745-775.

Basu, R. (1998): "Contagion Crises: The Investor's Logic," University of California, Los Angeles, mimeo.

Bernanke Ben S. & Kenneth N. Kuttner (2005). "What Explains the Stock Market's Reaction to Federal Reserve Policy?," *Journal of Finance*, American Finance Association, vol. 60(3), pages 1221-1257, June.

Bluedorn, John C, Rupa Duttagupta, Jaime Guajardo, Petia Topalova, 2011, " Capital Flows are Fickle: Anytime, Anywhere", IMF Working Paper No. 13/183.

Brunnermeier, Markus K, and Yuliy Sannikov (2015). "International Credit Flows and Pecuniary Externalities". American Economic Journal: Macroeconomics 71: , 7, 1, 297-338.

Bruno, Valentina, and Hyun Song Shin (2013). "Capital Flows and the Risk-Taking Channel of Monetary Policy," NBER Working Paper Series 18942. Cambridge, Mass.: National Bureau of Economic Research, April.

Caldara, Dario & Matteo Iacoviello, 2018. "Measuring Geopolitical Risk," International Finance Discussion Papers 1222, Board of Governors of the Federal Reserve System (U.S.).

Calvo, G. (2002): "Contagion in Emerging Markets: When Wall Street is a Carrier," Proceedings from the International Economic Association Congress, vol. 3, Buenos Aires, Argentina 2002.

Calvo, G., and E. Mendoza (2000): "Rational Contagion and the Globalization of Security Markets," *Journal of International Economics*, 51, 79–113.

Chari, V., and P. Kehoe (1999): "Herds of Hot Money," Federal Reserve Bank of Minneapolis Research Department, Mimeo.

Colacito, Riccardo, Mariano Massimiliano Croce, Yang Liu, and Ivan Shaliastovich (2015). "Volatility Risk Pass-Through.", SSRN Working Paper, October. http://dx.doi.org/10.2139/ssrn.2695343

Corsetti, G., M. Pericoli, and M. Stracia (2003): "'Some Contagion, some Interdependence' More Pitfalls in Tests of Financial Contagion," Corsetti's web page: http://www.econ.yale.edu/corsetti/.

Corsetti, G., P. Pesenti, N. Roubini, and C. Tille (1998): "Competitive Devaluations: A Welfare-Based Approach," working paper, New York University.

Elliott, M., B. Golub, and M. Jackson (2014): "Financial Networks and Contagion," *American Economic Review*, 104(10), 3115–3153.

Erten, Bilge, (2012). "Macroeconomic Transmission of Eurozone Shocks to Emerging Economies," Working Paper No. 2012-12 (Paris: CEPII).

Garcia-Cicco, Javier & Roberto Pancrazi & Martin Uribe, (2010). "Real Business Cycles in Emerging Countries?," *American Economic Review*, American Economic Association, vol. 100(5), pages 2510-31, December.

Gerlach, S., and F. Smets (1995): "Contagious Speculative Attacks," *European Journal of Political Economy*, 11, 45–63.

Giannone, Domenico, Michèle Lenza and Giorgio E. Primiceri, (2012). "Prior Selection for Vector Autoregressions," *Review of Economics and Statistics*, 97(2), May 2015, pp. 412-435.

Goldstein, M., G. L. Kaminsky, and C. M. Reinhart (2000): Assessing Financial Vulnerability : An Early Warning System for Emerging Markets. Institute for International Economics.

Hsieh Chang-Tai and Ralph Ossa (2011) "A Global View of Productivity Growth in China," University of Chicago, mimeo.

International Natural Disaster Database (EM-DAT). Center for the Research of the Epidemiology of Disasters. Retrieved online August 2016. Available online at http://www.emdat.be/database

Kaminsky, G. L., and C. M. Reinhart (2002): "The Center and the Periphery: The Globalization of Financial Turmoil," working paper, University of Maryland.

LeSage James & Robert Kelley Pace, 2009. "Introduction to Spatial Econometrics", 1st Edition, January, Chapman and Hall/CRC, New York.

Mendoza, E. G., and K. A. Smith (2002): "Margin Calls, Trading Costs, and Asset Prices in Emerging Markets: The Financial Mechanics of the 'Sudden Stop' Phenomenon," NBER working paper 9286.

Nakamura Emi & Jón Steinsson, High-Frequency Identification of Monetary Non-Neutrality: The Information Effect, *The Quarterly Journal of Economics*, Volume 133, Issue 3, 2018, Pages 1283–1330, August.

Österholm, Pär, and Jeromin Zettelmeyer, (2007). "The Effect of External Conditions on Growth in Latin America," IMF Working Paper No. 07/176 (Washington: International Monetary Fund).

Utlaut, Johannes, and Björn van Roye, (2010). "The Effects of External Shocks on Business Cycles in Emerging Asia: A Bayesian VAR Model," Working Paper No. 1668 (Kiel, Germany: Kiel Institute for the World Economy).

Ramey, Valerie A., (2011). "Identifying Government Spending Shocks: It's all in the Timing," *Quarterly Journal of Economics*, Oxford University Press, vol. 126(1), pages 1-50.

Rey, Helene (2013). "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence," paper presented at "Global Dimensions of Unconventional Monetary Policy," a symposium sponsored by the Federal Reserve Bank of Kansas City, held in Jackson Hole, Wyo., August 22-24.
www.kansascityfed.org/publicat/sympos/2013/2013Rey.pdf

Rigobón, Roberto. "Contagion, Spillover, and Interdependence." *Economía*, vol. 19 no. 2, 2019, p. 69-99.

Romer and Romer (2010). Christina D. Romer & David H. Romer, 2010. "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *American Economic Review*, American Economic Association, vol. 100(3), pages 763-801, June.

Schmitt-Grohe, Stephanie & Uribe, Martin, (2003). "Closing small open economy models," *Journal of International Economics*, Elsevier, vol. 61(1), pages 163-185, October.

Strömberg, David, (2007). "Natural Disasters, economic development, and humanitarian aid," *Journal of Economic Perspectives*, Volume 21, Number 3, Summer, pp. 199-222(24).
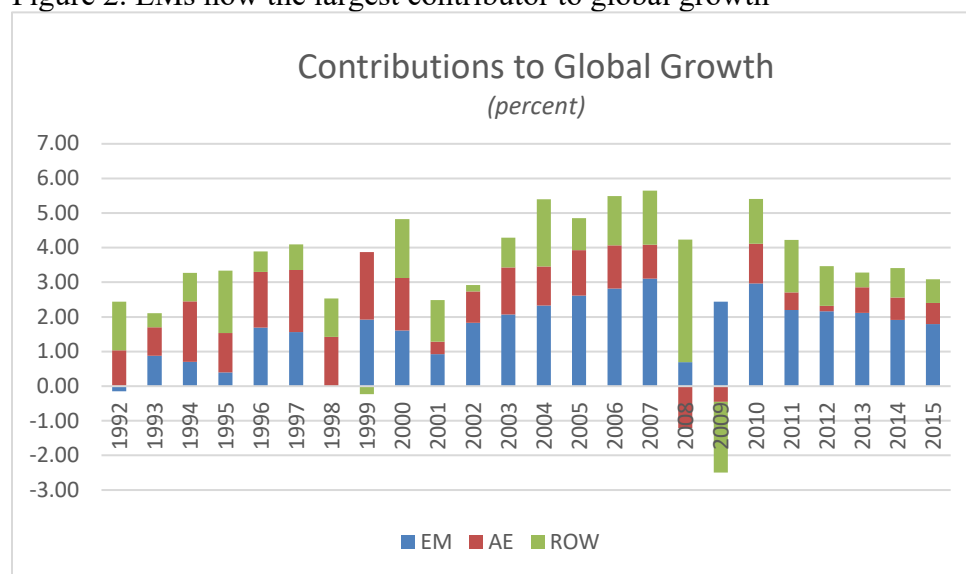
Appendix I. Figures and Tables

Figure 1. EMs as the largest economic bloc in the world economy
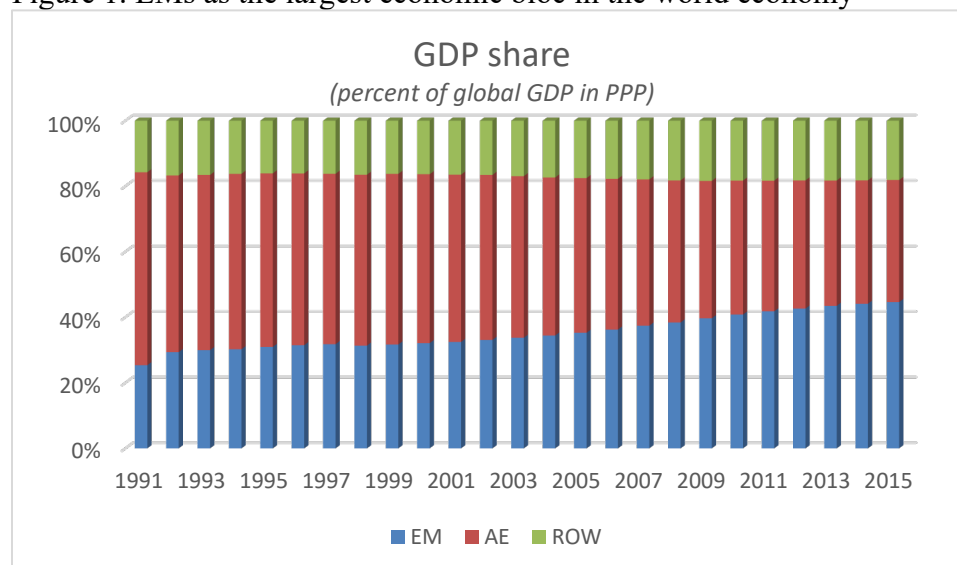
GDP share
(percent of global GDP in PPP)

Source: IMF World Economic Outlook database.
Note: EM and AE stand for emerging markets and advanced economies. ROW stands for rest of the world.

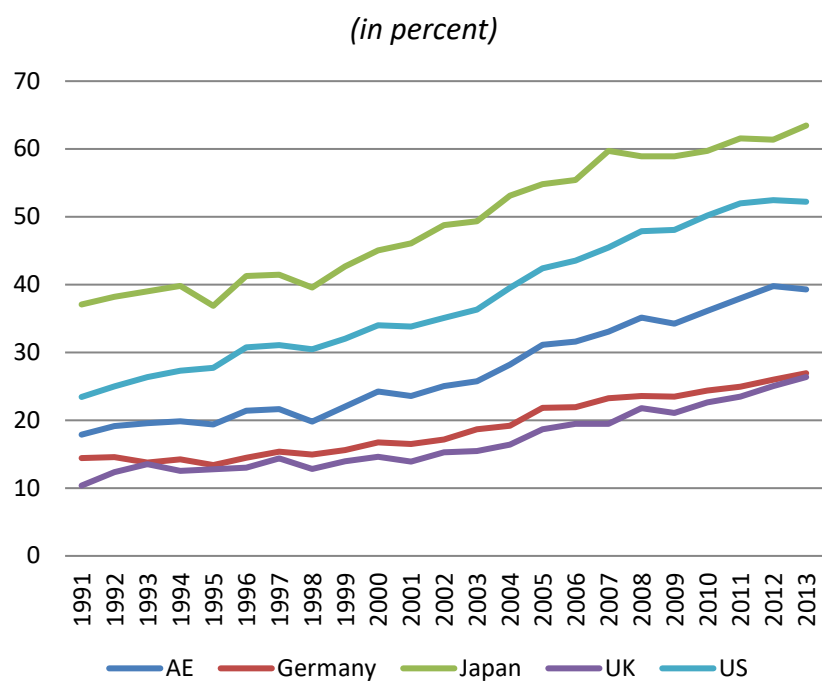Figure 2. EMs now the largest contributor to global growth

Contributions to Global Growth
(percent)

Source: IMF World Economic Outlook database.
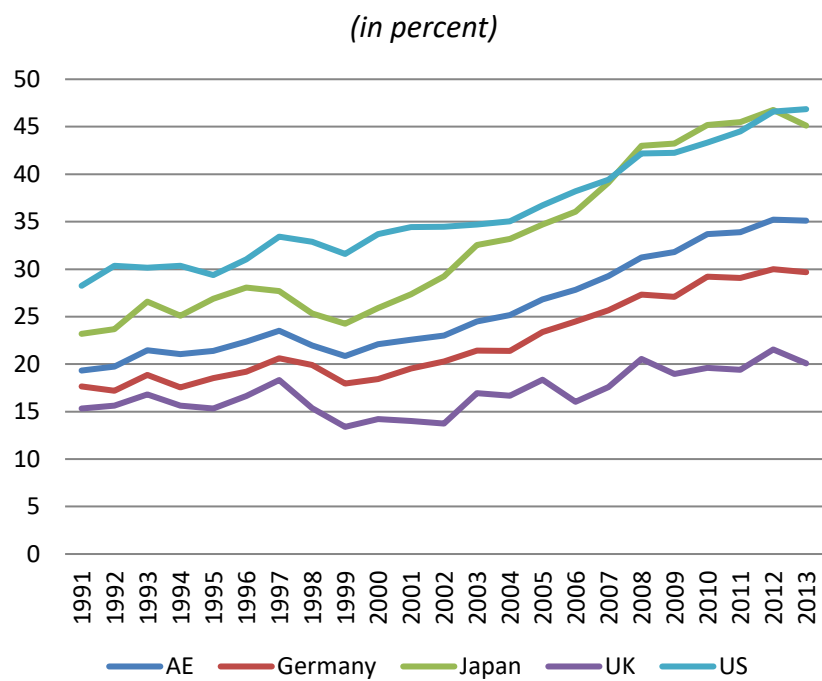Note: EM and AE stand for emerging markets and advanced economies. ROW stands for rest of the world.
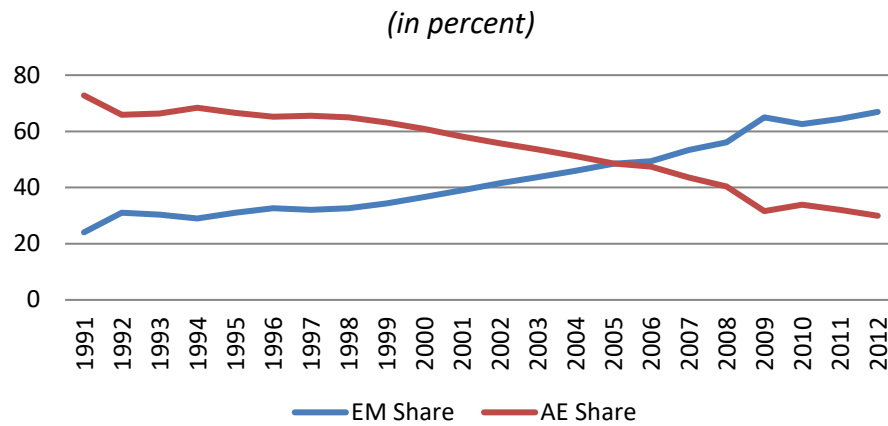
Figure 3. EMs' share of total AEs' imports

(in percent)

Source: IMF Direction of Trade Statistics.

Figure 4. EMs' share of AEs' total exports
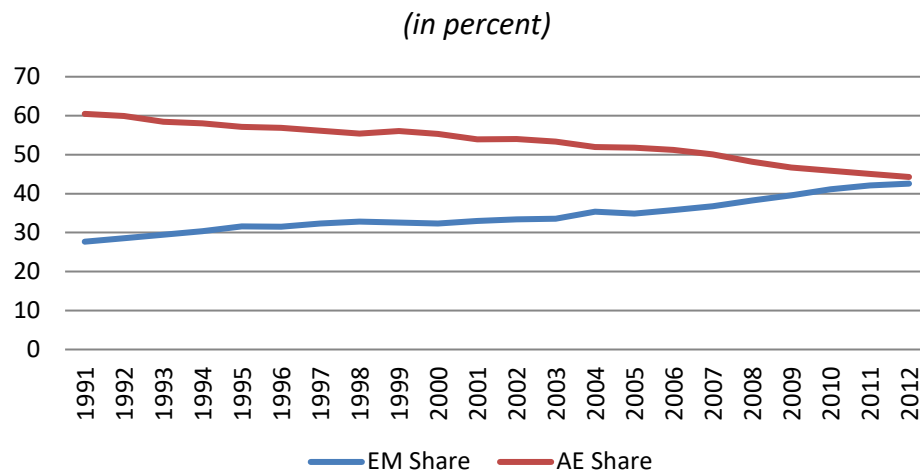
(in percent)

Source: IMF Direction of Trade Statistics.

Figure 5. Shares of global consumption of metals

(in percent)

Source: World Bureau of Metal Statistics; IMF Primary Commodity Price System.

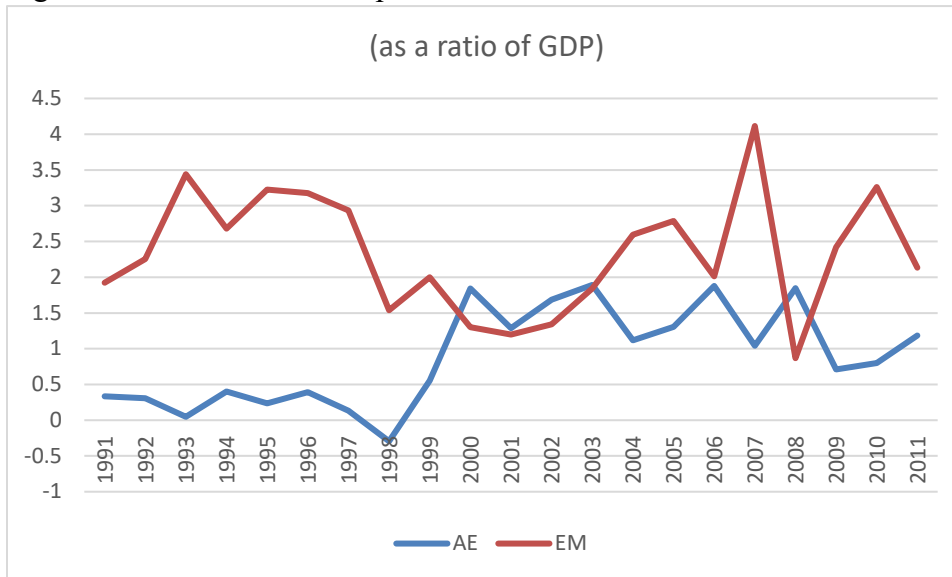Figure 6. Shares of global consumption of energy

(in percent)

Source: International Energy Agency, BP Statistical Review of World Energy June 2013; IMF Primary Commodity Price System.

Figure 7. EMs heavy reliance on external demand
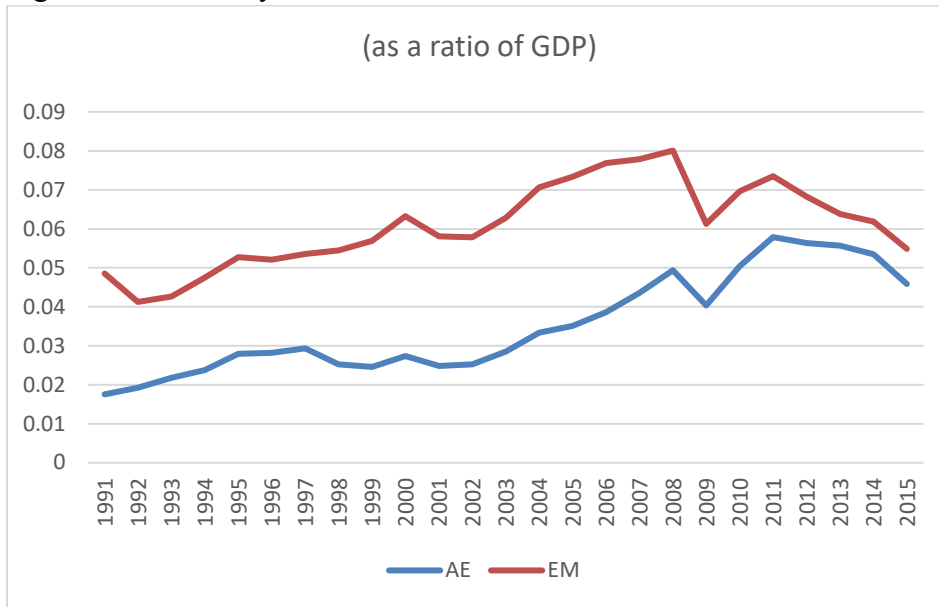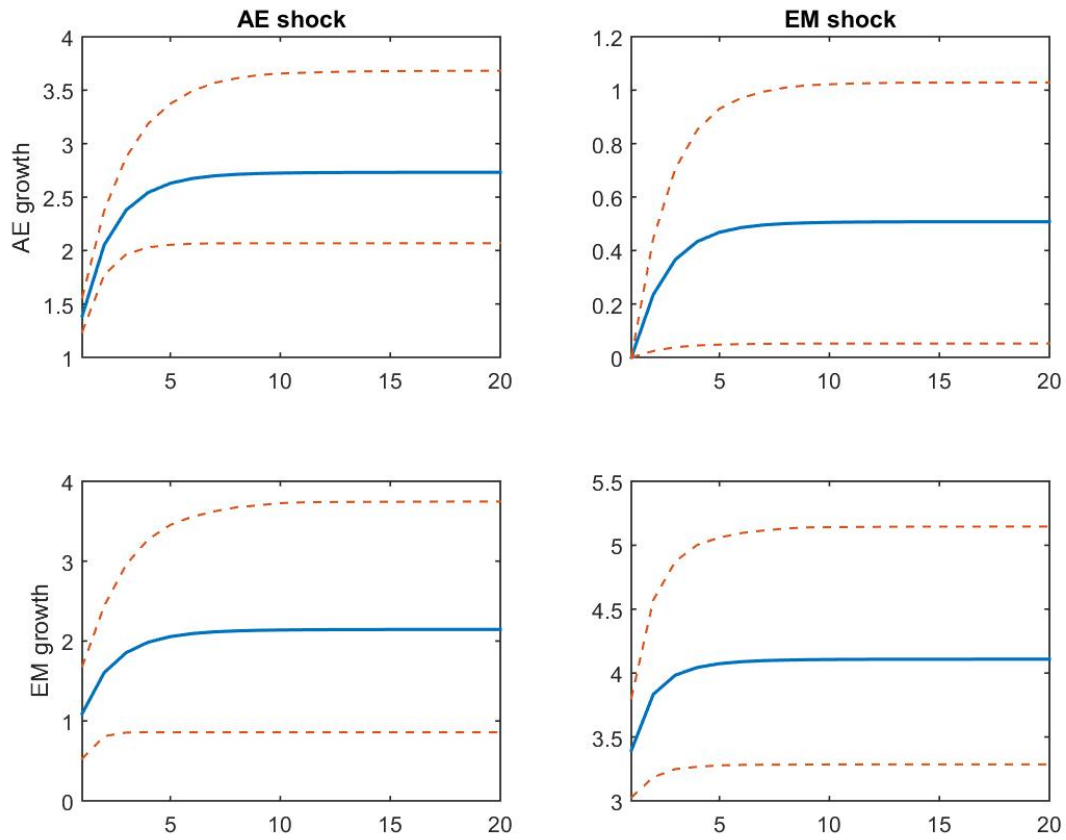

Source: IMF Direction of Trade Statistics.

Figure 8. EMs reliance on capital inflows

Source: Bluedorn et al. (2011)

Figure 9. Impulse response functions using our benchmark specification

Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a bi-variate VAR with AEs and EMs growth. Dash lines show the 90-percent Bayesian credible interval.

Figure 10. Impulse response functions over the two sub-sample periods
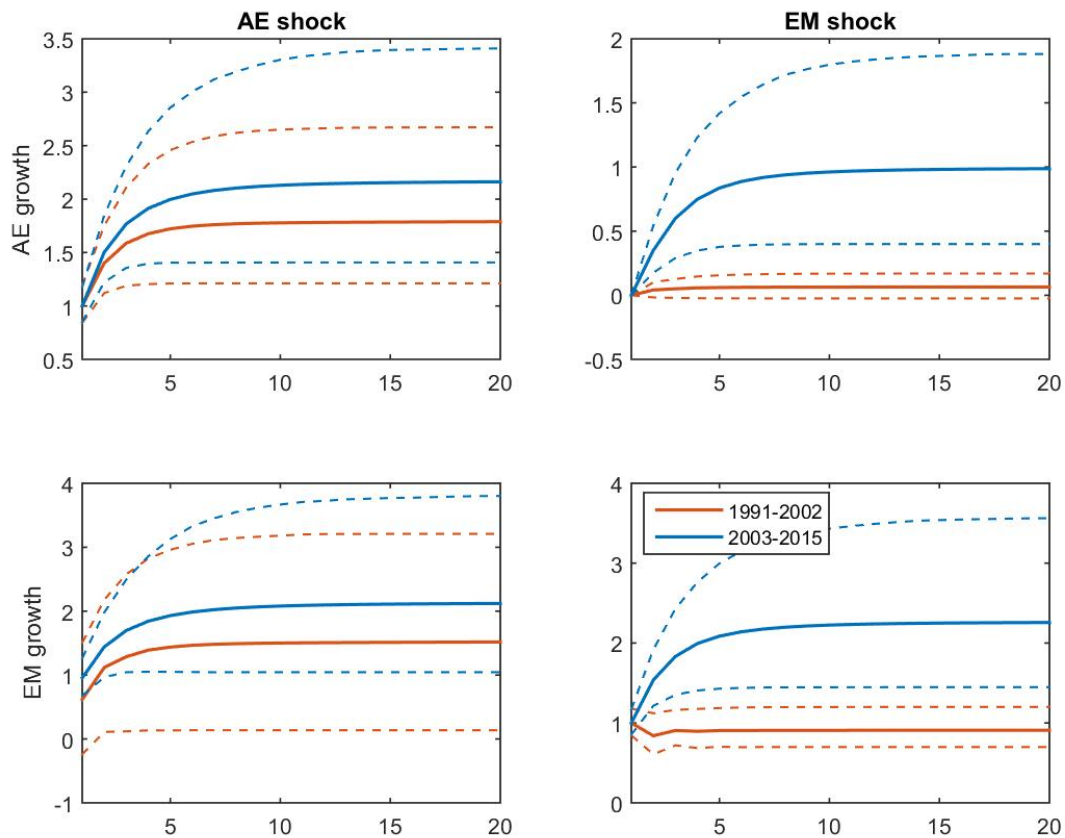
Notes: The sub-periods are 1991Q1-2002Q4 and 2003Q1-2015Q4. The impulse response functions are based on a bi-variate VAR with AE and EM growth. Dash lines show the 90-percent Bayesian credible interval.

Figure 11. Impulse response functions using the augmented specification with spending and tax news
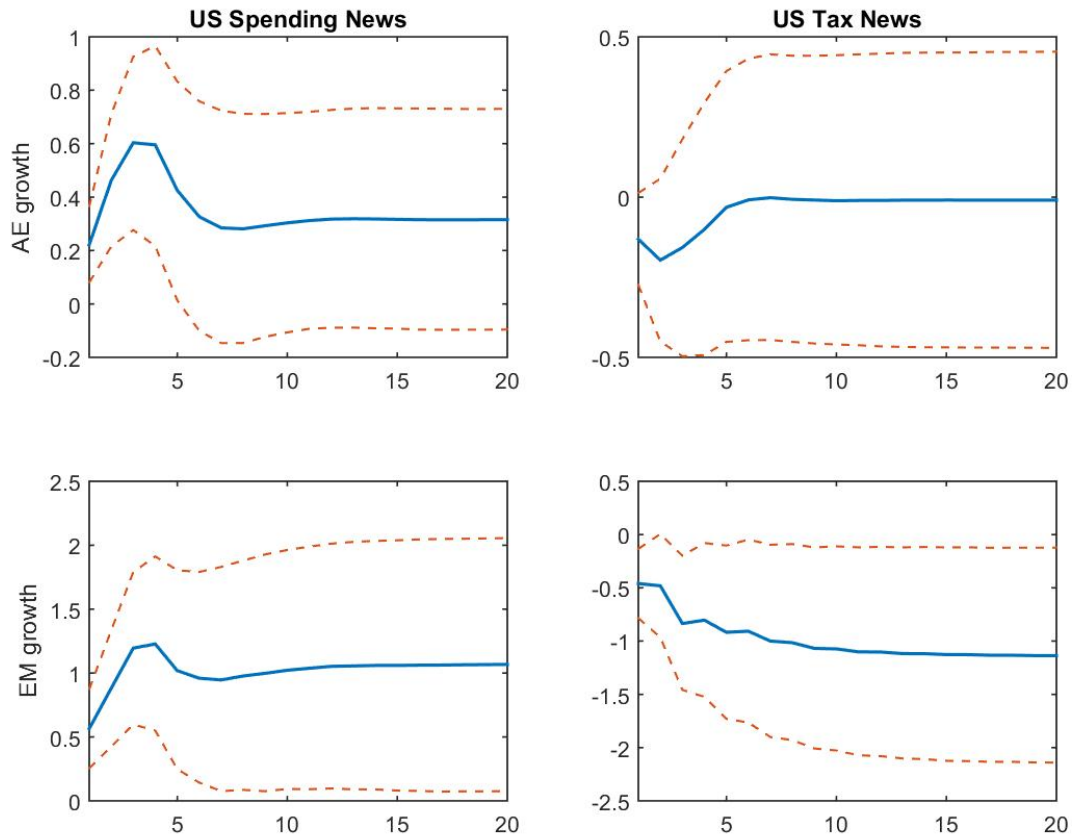
Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a 3-variable VAR with spending news obtained from Ramey (2011), tax news Romer and Romer (2012) and AE and EM growth. Dash lines show the 68-percent Bayesian credible interval.

Figure 12a. Impulse response functions using an augmented specification with damages from natural disasters

Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a 3-variable VAR with natural disaster shocks obtained from the International Natural Disaster Database, AE and EM growth. Dash lines show the 68-percent Bayesian credible interval.
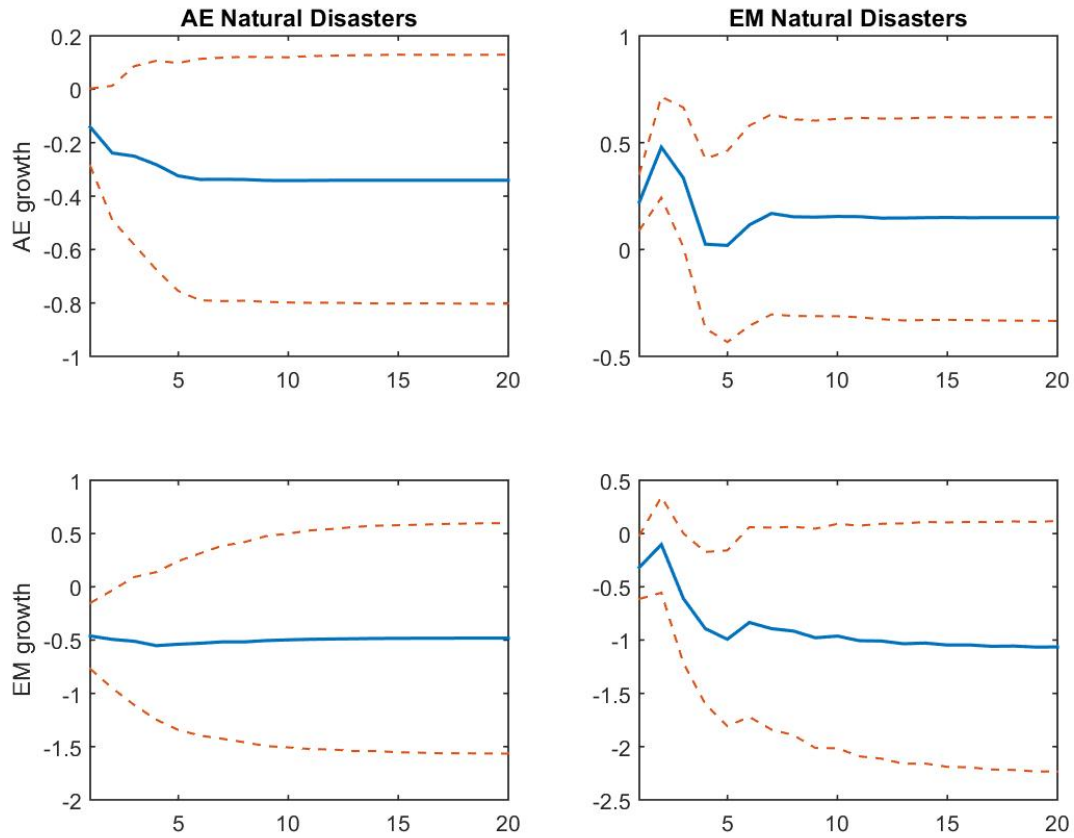
Figure 12b. Impulse response functions using an augmented specification with damages from natural disasters over the two sub-sample periods

Figure 13. Impulse response functions using an augmented specification with monetary policy shocks

Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a 3-variable VAR with monetary policy shocks (Fed funds futures or forward guidance), AEs and EMs growth. Dash lines show the 68-percent Bayesian credible interval.

Figure 14. Impulse response functions using an augmented specification with monetary policy shocks

Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a 4-variable VAR with AE and EM growth, Euro (German) and Chinese monetary policy rate. Dash lines show the 68-percent Bayesian credible interval.
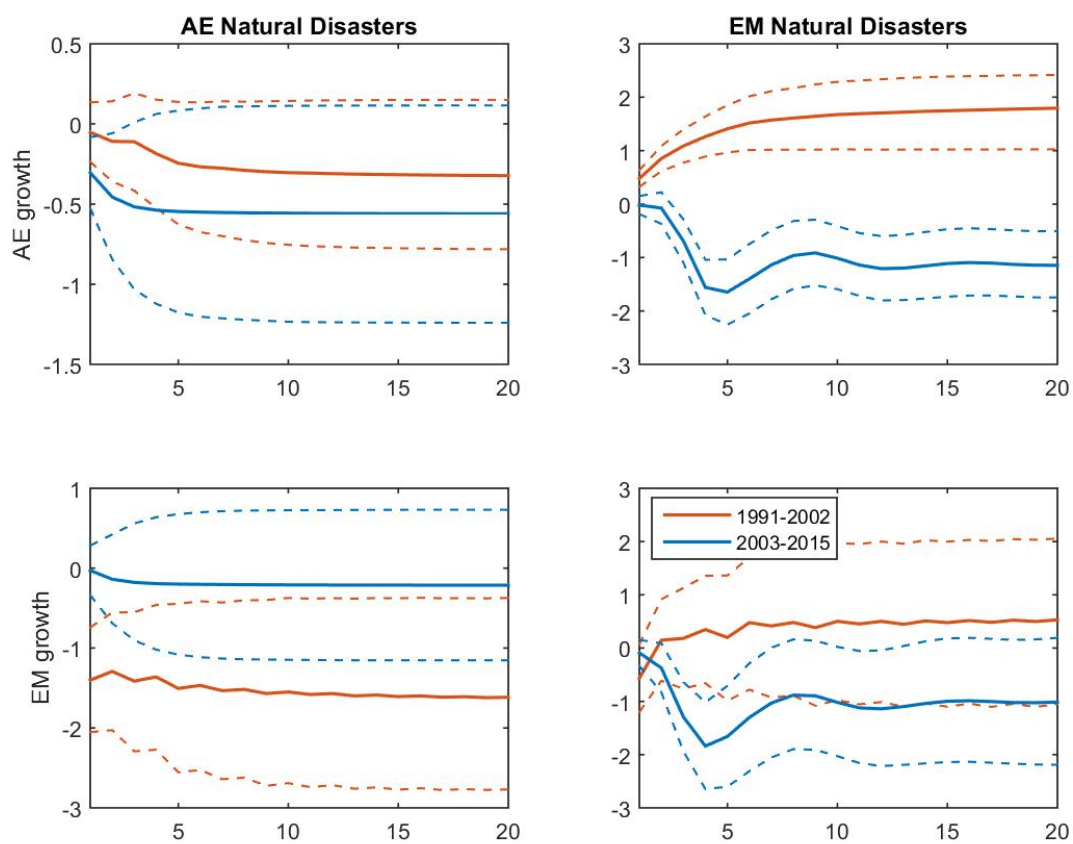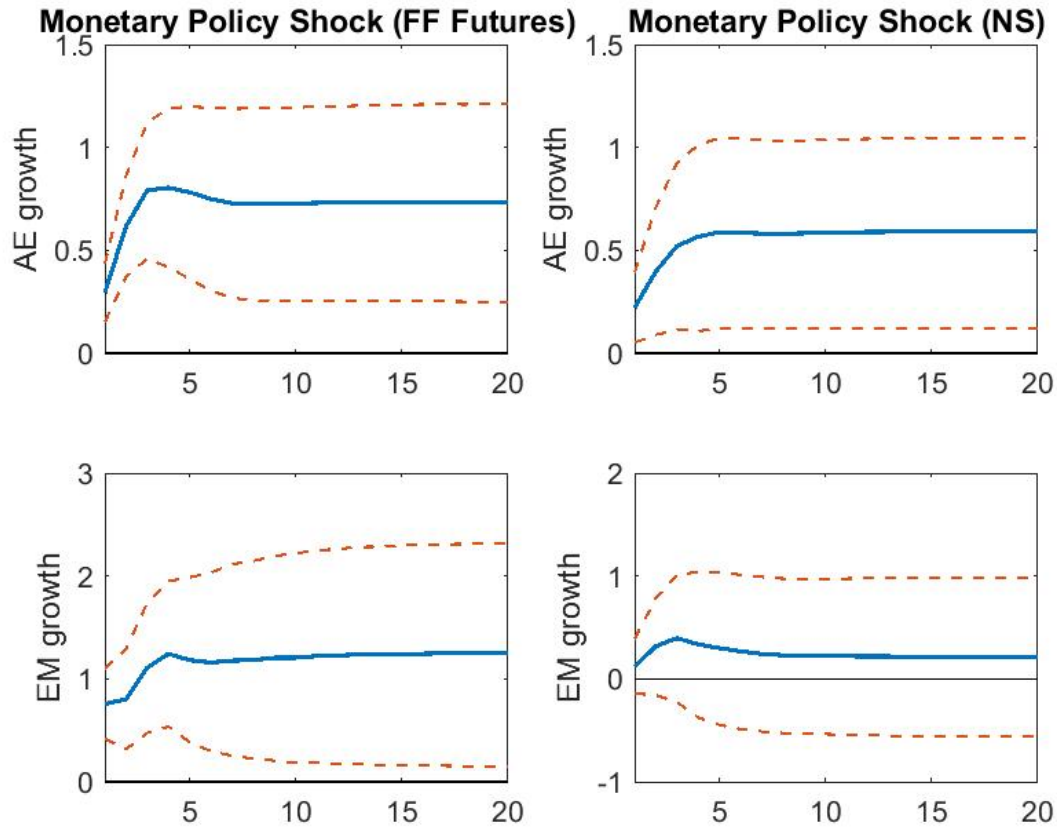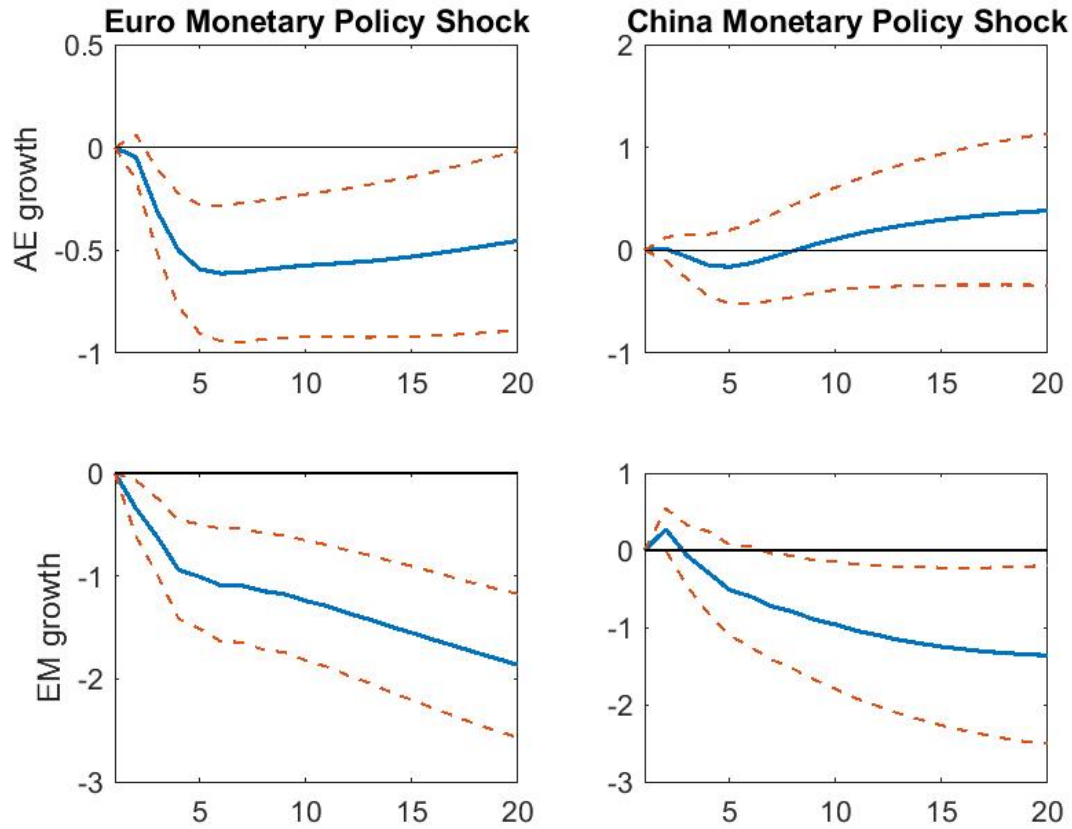
Figure 15. Impulse response functions using an augmented specification with geopolitical risk

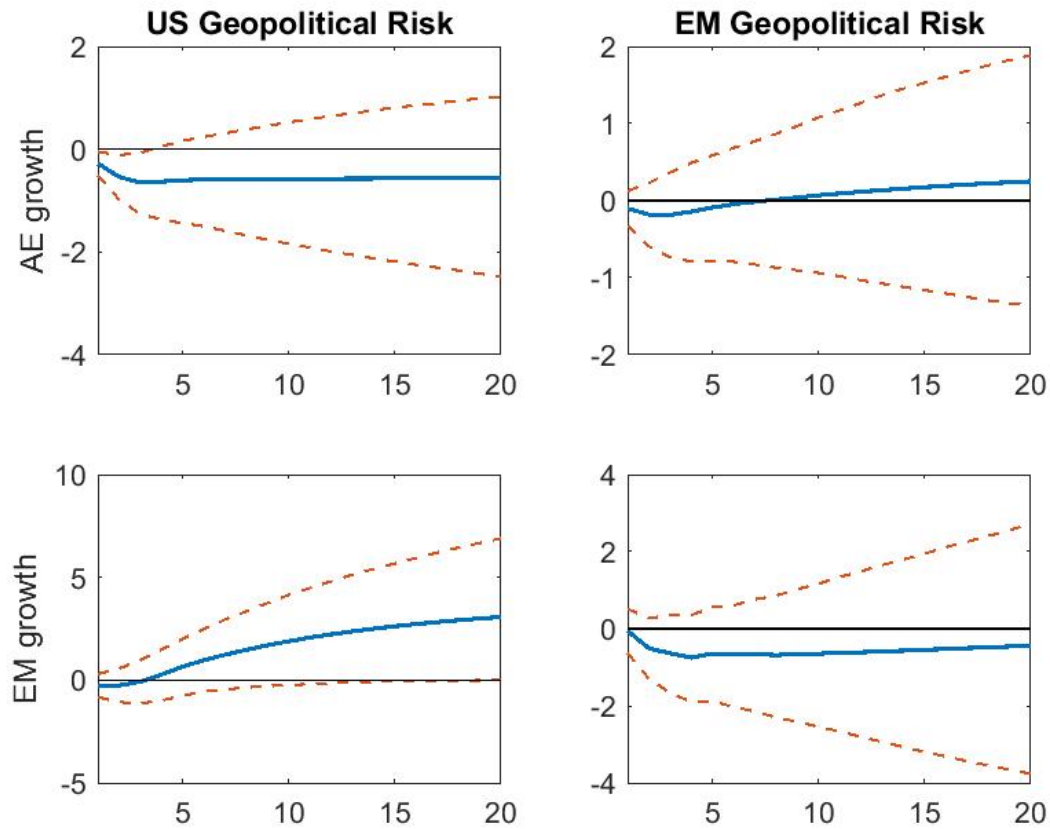Notes: The sample period is 1991Q1-2015Q4. The impulse response functions are based on a 4-variable VAR with US and EM geopolitical risk, AE and EM growth. Dash lines show the 68-percent Bayesian credible interval.

Table 1. Export to GDP ratio

Period	AE	EM
1991-2015	3.53	6.09
1991-2002	2.46	5.24
2003-2015	4.53	6.88

Note: The table shows net export to GDP ratio (in percent) obtained from the IMF's Direction of Trade Statistics.

Table 2. Net capital inflow to GDP ratio

Period	AE	EM
1991-2011	0.89	2.34
1991-2002	0.58	2.25
2003-2011	1.31	2.45

Note: The table shows net capital inflow to GDP ratio (in percent) obtained from Bluedorn et al (2011).

Table 3. Cumulative responses to growth shocks and spillovers

Horizon	AE growth	5%	95%	EM growth	5%	95%	spillover	5%	95%
					AE shock				
1Y	2.54	2.03	3.19	1.99	0.86	3.27	**0.78***	0.37	1.18
2Y	2.71	2.07	3.61	2.13	0.86	3.67	**0.78***	0.36	1.20
					EM shock				
1Y	0.43	0.04	0.85	4.04	3.27	5.00	**0.11***	0.01	0.19
2Y	0.50	0.05	1.01	4.10	3.28	5.13	**0.12***	0.01	0.22

Notes: The cumulative responses of AE growth and EM growth to an AE shock and an EM shock are based on a bi-variate VAR with AE and EM growth. The spillover is computed as the ratio between the cumulative response in the destination and origin of the shock. "*" indicates 90 percent significance.

Table 4. Spillovers over time

Period	AE spillover	5%	95%	EM spillover	5%	95%
1991-2002	0.82*	0.08	1.54	0.06	-0.03	0.15
2003-2015	0.95*	0.68	1.21	0.37*	0.23	0.50

Notes: The cumulative responses of AE growth and EM growth to an AE shock and an EM shock are based on a bi-variate VAR with AE and EM growth. The spillover is computed as the ratio between the one-year cumulative response in destination and origin of the shock. "*" indicates 90 percent significance.

Table 5. Spillovers using different country grouping

AE	AE spillover	5%	95%	EM spillover	5%	95%
			EM			
AE	0.78*	0.37	1.18	0.11*	0.01	0.19
G7	0.76*	0.36	1.16	0.10*	0.01	0.19
Germany	0.33*	0.08	0.57	0.33*	0.20	0.46
Japan	0.38*	0.18	0.58	0.31*	0.16	0.45
US	0.38*	0.01	0.76	-0.01	-0.09	0.07
			BRIC			
AE	0.69*	0.13	1.25	0.06*	0.00	0.12
G7	0.63*	0.08	1.19	0.05	-0.01	0.12
Germany	0.36*	0.03	0.68	0.16*	0.07	0.25
Japan	0.29*	0.01	0.56	0.16*	0.06	0.26
US	0.25	-0.23	0.74	-0.01	-0.06	0.03
			China			
AE	0.29	-0.13	0.71	0.09	-0.03	0.20
G7	0.30	-0.12	0.72	0.09	-0.03	0.20
Germany	0.01	-0.26	0.27	0.23*	0.05	0.40
Japan	0.18	-0.03	0.38	0.21*	0.02	0.39
US	0.31	-0.06	0.68	0.05	-0.07	0.16

Notes: The cumulative responses of AE growth and EM growth to an AE shock and an EM shock are based on bi-variate VAR with AE and EM growth. For advanced economies, the growth series are either one of the following: AE, G7, Germany, Japan and US. For emerging markets, the growth series are either one of the following: EM, BRIC and China. The spillover is computed as the ratio between the one-year cumulative response of destination and origin of the shock. "*" indicates 90 percent significance.

Table 6. Channels of transmission

	A. Spillovers					
	AE spillover	5%	95%	EM spillover	5%	95%
Baseline VAR	0.78*	0.37	1.18	0.11*	0.01	0.21
VAR with channels	0.68*	0.33	1.02	0.12*	0.00	0.23

B. Variance Decomposition			
Spillover from AE to EM	Trade	Finance	Commodity
portion of variance from spillover	10.5%	10.5%	10.5%
portion of variance from spillover controlling for a channel	8.2%	3.5%	4.0%
portion of variance from spillover through a channel	2.3%	7.0%	6.6%
share of a channel	21.8%	66.6%	62.3%
Spillover from EM to AE			
portion of variance from spillover	2.7%	2.7%	2.7%
portion of variance from spillover controlling for channel	2.1%	1.3%	1.6%
portion of variance from spillover through channel	0.6%	1.4%	1.1%
share of a channel	22.2%	50.8%	40.8%

Notes: Panel A shows the spillovers of bi-variate VAR (AE and EM growth) and 6-variable VAR (AE and EM growth, export-total-trade ratio, growth of Bloomberg commodity index, total return on MSCI Emerging market index and world index). "*" indicates 90 percent significance. Panel B shows the one-year variance decomposition and contribution of the variance of spillover to trade, commodity and finance channels.

Table 7. Spillovers from a spatial autoregressive model

	Shocks from									
	Canada	France	Germany	Italy	Japan	UK	US	Brazil	China	Russia
Canada	1.006	0.005	0.006	0.007	0.012	0.005	0.073	0.021	0.011	0.009
France	0.012	1.006	0.038	0.038	0.013	0.068	0.011	0.019	0.014	0.025
Germany	0.011	0.027	1.004	0.034	0.014	0.027	0.010	0.017	0.015	0.035
Italy	0.009	0.022	0.027	1.003	0.012	0.018	0.009	0.018	0.013	0.024
Japan	0.006	0.003	0.004	0.005	1.003	0.003	0.006	0.009	0.045	0.008
UK	0.012	0.065	0.036	0.030	0.013	1.006	0.012	0.019	0.014	0.024
US	0.071	0.005	0.006	0.006	0.011	0.005	1.006	0.023	0.010	0.008
Brazil	0.008	0.003	0.004	0.005	0.006	0.003	0.009	1.001	0.006	0.005
China	0.006	0.003	0.005	0.005	0.049	0.003	0.006	0.009	1.003	0.010
Russia	0.009	0.010	0.020	0.017	0.015	0.011	0.008	0.014	0.018	1.002

Note: Coefficients are spatial multipliers. The spatial effects are based on the multiplier as follows: $(1 - \rho W)^{-1}$ where ρ captures the importance of spatial dependence and W is a N-by-N spatial weight matrix that captures the distance between countries.

Appendix II. Bayesian hierarchical VAR estimation

The VAR model specification employed in our empirical analysis is as follows:
$$y_t = \Phi'x_t + u_t, u_t \sim N(0, \Sigma)$$
where $x_t = [y_{t-1}, \dots, y_{t-p}, z_t]$

We estimate the model from a Bayesian perspective.
The prior is the most widely-used natural conjugate prior.
It is a standard result that a Normal-Inverse-Whishart natural conjugate prior
$$\Sigma \sim IW(\underline{S}; \underline{v})$$
$$\Phi|\Sigma \sim N(\underline{\Phi}; \Sigma \otimes \underline{V})$$
yields the posterior distribution that has the following closed form solution:
$$\Sigma \sim IW(\overline{S}; \overline{v})$$
$$\Phi|\Sigma, y \sim N(\overline{\Phi}; \Sigma \otimes \overline{V})$$
$$\overline{\Phi} = (X'X + \underline{V}^{-1})^{-1}(X'X + \underline{V}^{-1}\underline{\Phi})$$
$$\overline{V} = (X'X + \underline{V}^{-1})^{-1}$$
$$\overline{S} = \hat{S} + \underline{S} + \hat{\Phi}'X'X\hat{\Phi} + \underline{\Phi}'\underline{V}^{-1}\underline{\Phi} - \overline{\Phi}'\overline{V}^{-1}\overline{\Phi}$$
$$\overline{v} = T + \underline{v}$$
where $\hat{\Phi} = (X'X)^{-1}X'Y$ and $\hat{S} = (Y - \hat{\Phi}'X)(Y - \hat{\Phi}'X)'$

We treat $\overline{S}$ as a diagonal matrix with a hyperparameter ψ on the main diagonal to control the tightness of variance. The degrees of freedom of the Inverse-Wishart distribution is $\overline{v} = n + 2$. The prior mean Φ is based on the Minnesota prior. Since the model variables are I(0), we set the coefficient of the first-order auto lag to be 0.3 to capture the moderate persistence and everything else 0.

$$E[(\Phi_s)_{ij}|\Sigma] = \begin{cases} 0.3 & if\ i = j\ and\ r = s \\ 0 & otherwise \end{cases} \text{ for } \Phi = [\Phi_{1,\dots}, \Phi_p; \Phi_z]$$

We set $\underline{V}$ such that

$$Cov[(\Phi_s)_{ij}, (\Phi_r)_{hm}|\Sigma] = \begin{cases} \lambda \dfrac{1}{s^\alpha} \dfrac{\Sigma_{ih}(v-n-1)}{\psi_j} & if\ m = j\ and\ r = s \\ 0 & otherwise \end{cases}$$

In sum, we specify hyperparameters $\Gamma = [\psi, \alpha]$ for the tightness of priors. We choose the hyperparameters to maximize the marginal data density

$$p(Y|\Gamma).p(Y|\Gamma) = \pi^{-\frac{Tn}{2}} \Gamma_n\left(\frac{T+v}{2}\right)\Gamma_n\left(\frac{v}{2}\right)^{-1} |\underline{V}|^{-\frac{n}{2}}|X'X + \underline{V}^{-1}|^{-\frac{n}{2}}|\underline{S}|^{\frac{v}{2}}|\overline{S}|^{-\frac{T+v}{2}}$$

It is then convenient to conduct the optimization routine and perform the further inference based on the maximizer.
The estimation is based on the algorithm of Gibbs working as follows:
1. Maximizing the $p(Y|\Gamma)$ with respect to Γ.
2. Gibbs:
(a) Draw $\Sigma_j \sim IW(\overline{S}; \overline{v})$.
(b) Draw $\Phi_j|\Sigma_j, y \sim N(\overline{\Phi}; \Sigma \otimes \overline{V})$
Until the draws of Σ, Φ converges to their stationary distributions.