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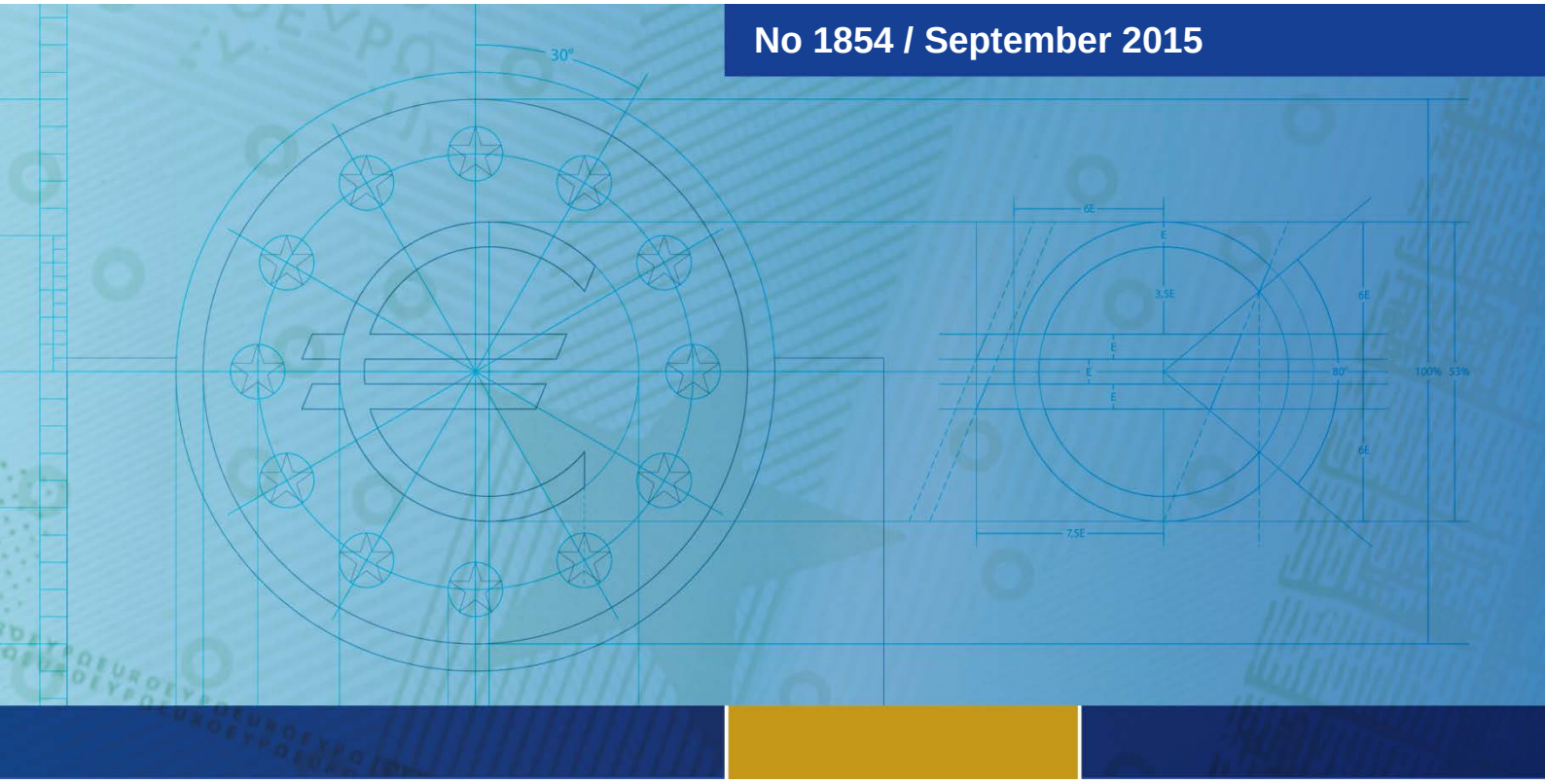
Determinants of global spillovers from US monetary policy



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Abstract

This paper assesses the global spillovers from identified US monetary policy shocks in a global VAR model. US monetary policy generates sizable output spillovers to the rest of the world, which are larger than the domestic effects in the US for many economies. The magnitude of spillovers depends on the receiving country's trade and financial integration, de jure financial openness, exchange rate regime, financial market development, labor market rigidities, industry structure, and participation in global value chains. The role of these country characteristics for the spillovers often differs across advanced and non-advanced economies and also involves non-linearities. Furthermore, economies which experience larger spillovers from conventional US monetary policy also displayed larger downward revisions of their growth forecasts in spring 2013 when the Federal Reserve upset markets by discussing tapering off quantitative easing. The results of this paper suggest that policymakers could mitigate their economies' vulnerability to US monetary policy by fostering trade integration as well as domestic financial market development, increasing the flexibility of exchange rates, and reducing frictions in labor markets. Other policies—such as inhibiting financial integration, industrialisation and participation in global value chains—might mitigate spillovers from US monetary policy, but are likely to reduce long-run growth.

Keywords: Mixed cross-section global VAR, spillovers, US monetary policy.
JEL-Classification: F4, E5, C3.

Non-technical summary

The global economy has witnessed a substantive deepening of trade and financial integration and associated increase in the relevance of spillovers to the domestic economy from shocks in other economies. For example, in May 2013 discussions of tapering of the unconventional monetary policies of the Federal reserve led to global spillovers, in particular exemplified by sell-offs of emerging market securities by international investors. Also, it has been argued that financial conditions and growth worldwide are driven by a global financial cycle, which appears to be determined to a large extent by monetary policy in the center country: the US (Rey, 2013; Bekaert et al., 2014; Bruno and Shin, 2014). This paper advances our understanding of cross-country spillovers by estimating the global effects on real activity of conventional US monetary policy and by shedding light on the determinants of their magnitude across economies. In particular, I employ a global VAR model estimated for 61 countries over the time period from 1999 to 2009 and I identify a US monetary policy shock by imposing sign restrictions on the responses of output growth and inflation. I find that the global spillovers from US monetary policy shocks are substantial, being larger than the domestic effects in the US in many economies. Moreover, I find that the magnitude of spillovers from US monetary policy economies experience depends on a number of country characteristics. For example, economies which are more integrated in global capital markets and less in trade, which feature more rigid labor and less developed domestic financial markets, and which have a high share of output accounted for by manufacturing industries experience larger spillovers. Moreover, there appear to be some differences in the determinants of the magnitude of spillovers across advanced and non-advanced economies. In particular, advanced economies that limit the flexibility of their exchange rate experience larger spillovers; more de jure financially open non-advanced economies experience larger spillovers. The magnitude of spillovers from US monetary policy is also determined by the joint constellation of country characteristics. For example, some results suggest that in non-advanced economies trade integration amplifies spillovers if their industry structure is tilted towards the production of manufactured goods, if they participate in global value chains and allow only limited flexibility of their exchange rate. Also, exchange rate liberalisation tends to magnify spillovers if non-advanced economies do not trade much. And financial integration is associated with larger spillovers if non-advanced economies have an inflexible exchange rate. Finally, even though in this paper I study the spillovers from conventional US monetary policy, I obtain evidence suggesting that the transmission channels of global spillovers from exit from quantitative easing may be similar: there is a statistically significant positive correlation between the spillovers from conventional US monetary

policy and the revisions in growth forecasts in spring 2013 when Federal Reserve chairman Bernanke upset financial markets by discussing tapering off quantitative easing. The results of this paper offer some recommendations regarding the policies that could help to mitigate spillovers from (un)conventional monetary policy in the US – and possibly external shocks more generally. In particular, economies could reduce their vulnerability to US monetary policy by fostering domestic financial market development, trade integration, the liberalisation of exchange rates, reducing frictions in labor markets and ensuring fiscal space. Other policies that may mitigate the spillovers from US monetary policy are likely to conflict with the pursuit of other important objectives of policymakers. For example, participation in global value chains through trade in intermediates has helped economies to raise their potential growth similarly, capital market integration and financial openness allows economies to reap collateral benefits from financial globalisation Clearly, a completely closed economy will not experience any spillovers whatsoever, but is likely to grow more slowly in the long run. In these cases, the trade-offs should be carefully considered before any measures are taken.

1 Introduction

Over the last decades the global economy has witnessed a substantive deepening of trade and financial integration. The associated growing importance of spillovers from shocks in other economies has given impetus to academics and practitioners alike to devote more efforts to understand the relevant transmission channels (see, for example, IMF, 2013a). It has even been argued that financial conditions and growth worldwide are driven by a global financial cycle, which, in turn, appears to be determined to a large extent by monetary policy in the US (Rey, 2013; Bekaert et al., 2013). This paper advances our understanding of cross-country spillovers by quantifying the global effects on real activity of conventional US monetary policy and by shedding light on the channels through which these materialise.

I find that the spillovers from US monetary policy are substantial; in fact, for many economies the spillovers are larger than the domestic effects in the US. Furthermore, I find that in line with existing literature the magnitude of spillovers depends on a number of country characteristics including financial integration, trade openness, the exchange rate regime, industry structure, financial market development and labour market rigidities (Rey and Martin, 2006; Cavallo and Frankel, 2008; Calvo et al., 2008; Edwards, 2004, 2007b,a; Milesi-Ferretti and Tille, 2011; Broda, 2001; Edwards and Levy Yeyati, 2005). For example, economies which are more integrated in global capital markets and less in trade, which feature more rigid labor and less developed domestic financial markets, and which have a high share of output accounted for by manufacturing industries experience larger spillovers. Moreover, there appear to be some differences in the determinants of the magnitude of spillovers across advanced and non-advanced economies. In particular, advanced economies that limit the flexibility of their exchange rate experience larger spillovers; more de jure financially open non-advanced

economies experience larger spillovers. The magnitude of spillovers from US monetary policy is also determined by the joint constellation of country characteristics. For example, some results suggest that in non-advanced economies trade integration amplifies spillovers if their industry structure is tilted towards the production of manufactured goods, if they participate in global value chains and allow only limited flexibility of their exchange rate. Also, exchange rate liberalisation tends to magnify spillovers if non-advanced economies do not trade much. And financial integration is associated with larger spillovers if non-advanced economies have an inflexible exchange rate. Finally, even though in this paper I focus on the spillovers from conventional US monetary policy, I obtain some tentative evidence suggesting that the transmission channels of global spillovers from exit from quantitative easing may be similar: there is a statistically significant positive correlation between the global spillovers from conventional US monetary policy and the revisions in countries' growth forecasts in spring 2013 when Federal Reserve chairman Bernanke upset financial markets by discussing tapering off quantitative easing.

The results of this paper suggest that economies could reduce their vulnerability to US monetary policy by fostering domestic financial market development, trade integration, the liberalisation of exchange rates, and reducing frictions in labor markets. Other policies that may mitigate the spillovers from US monetary policy are likely to conflict with the pursuit of other important objectives of policymakers. For example, participation in global value chains through trade in intermediates has helped economies to raise their potential growth (see IMF, 2013c); similarly, capital market integration and financial openness allow economies to reap collateral benefits from financial globalisation (see Kose et al., 2009; Binder et al., 2013). Clearly, a completely closed economy will not experience any spillovers whatsoever, but is likely to grow more slowly in the long run. In these cases, the trade-offs should be carefully

considered before any measures are taken (see, for example, the IMF's institutional view on capital flow management, IMF, 2012).

The paper is related to and contributes to four strands of the literature. First, several papers investigate the global output spillovers from conventional US monetary policy (see, for example, Kim and Roubini, 2000; Kim, 2001; Faust and Rogers, 2003; Faust et al., 2003; Canova, 2005; Nobili and Neri, 2006; Mackowiak, 2007; Bluedorn and Bowdler, 2011). The empirical approach in these papers is based on two-country VAR models which involve the US and domestic macroeconomic variables of one additional economy (or vice versa) and which are estimated for a few countries only. The results of this literature suggest that US monetary policy has substantial global spillovers across both advanced and emerging market economies, and that these arise mainly through spillovers in interest rates.[1] However, these papers do not shed light on why some countries experience larger spillovers than others. As a result, this literature offers few insights to policymakers that could help them to render their economies more resilient to changes in US monetary policy. In addition, these papers may also suffer from methodological constraints. Specifically, as they build on two-country VAR models they do not account for the multilateral nature of global interlinkages; spillovers from US monetary policy may affect all economies, and thereby give rise to third-country effects and spillbacks that a bilateral model fails to capture. Exceptions to the use of bilateral models in this literature are Dées et al. (2010) and Chen et al. (2012). The former examine the global effects of US monetary policy based on a multi-country New Keynesian dynamic stochastic general equilibrium model that they solve using the GVAR approach. The latter

[1] Frankel and Roubini (2001) and Reinhart and Reinhart (2002) take a more general approach and examine the effects of changes in world rather than US interest rates on domestic growth and obtain similar results. di Giovanni and Shambaugh (2008) focus on changes in base-country rather than US interest rates and find that the spillovers to domestic output are statistically significant only for economies which do not let their exchange rate float. Finally, Canova and Ciccarelli (2009) as well as Dées and Saint-Guilhem (2011) examine spillovers from shocks to US GDP growth rather than US monetary policy.

use a GVAR model to analyse the global spillovers from unconventional monetary policy in the US. However, while both do account for the multilateral nature of cross-country interlinkages, they do not study the sources of the heterogeneities in the spillovers they find. In contrast, in this paper I set up a multilateral GVAR model for a large number of economies in order to identify the country characteristics that give rise to variations in the magnitude of the spillovers from US monetary policy.

Second, this paper is also related to the literature on the spillovers from US monetary policy to global financial markets (see Craine and Martin, 2008; Ehrmann and Fratzscher, 2009; Wongswan, 2009; Neely, 2010; Hausman and Wongswan, 2011; Gurkaynak and Wright, 2011; Fratzscher et al., 2013; Moore et al., 2013; Rogers et al., 2014). These papers study the effects of US monetary policy shocks on other countries' equity and bond markets, capital flows and exchange rates, typically at high frequency. This literature finds that financial spillovers are large, and it establishes that country characteristics referring to financial market structure and integration explain a substantial fraction of the cross-country heterogeneities. The papers in this literature investigate different dimensions of US monetary policy, such as conventional and unconventional policies, surprises to the federal funds rate target and to its future path as well as announcements and asset purchases. However, in contrast to this paper this literature does not examine the global *output* spillovers from US monetary policy and their determinants. Moreover, these papers do not account for the multilateral nature of spillovers.

Third, this paper is related to the literature analysing the role of specific country characteristics—such as the exchange rate regime or the extent of capital controls—for spillovers (see Philippon et al., 2001; Frankel et al., 2004; Shambaugh, 2004; Miniane and Rogers, 2007). In contrast to this paper, this literature typically does not focus on the spillovers from US

monetary policy, but more generally on interest rate changes in the country which represents the base country for the domestic economy's exchange rate. Moreover, as they build on bilateral regression models these papers do not account for the multilateral nature of global spillovers. Most importantly, however, in contrast to this paper they examine the spillovers from foreign to domestic *interest rates* rather than to real activity. Even though interest rates play an important role in the transmission of shocks and in macroeconomic management, ultimately the variables of interest to policymakers are real activity and inflation. And, the empirical literature on domestic monetary transmission suggests that a given change in interest rates does not map uniquely into changes in output growth and inflation (see Carlino and DeFina, 1998; Cecchetti, 1999; Ehrmann, 2000; Georgiadis, 2014); rather, the strength of the transmission depends on a host of country characteristics. As a result, these papers offer only limited guidance to policymakers as to how they could render their economies more resilient to changes in US monetary policy. In contrast, the results of this paper identify policies which could mitigate economies' vulnerability to US monetary policy.

Finally, this paper adds to the quickly expanding literature on spillovers estimated by GVAR models. By now, GVAR models have been applied to the analysis of numerous empirical questions (see Chudik and Pesaran, 2014, for a survey). However, in this literature the information contained in the cross-country heterogeneities of the spillover estimates is typically not exploited in order to improve our understanding of the transmission channels.[2] In contrast, this paper advances our understanding of the transmission channels by moving beyond the estimation of the responses of domestic variables to foreign shocks and by analysing the role of country characteristics for the magnitude of the spillovers.

The remainder of the paper is organised as follows. The next section introduces the GVAR

[2] An exception is Chudik and Fratzscher (2012).

model on which the analysis of spillovers from US monetary policy in this paper builds. Section 3 presents the results for the spillover estimates as well as the role of country characteristics for heterogeneities in the global transmission of US monetary policy. Section 4 describes the results from a number of robustness checks regarding the GVAR model specification and the identification of US monetary policy shocks. Finally, Section 5 concludes.

2 The Empirical Model

By combining country-specific VAR models into a global model, the GVAR approach introduced by Pesaran et al. (2004) allows one to model the dynamics of several economies jointly. Unfortunately, the institutional framework of currency unions such as the euro area—a number of currency union members which are subject to a common monetary policy shaped by union-wide variables—complicates the inclusion of individual member economies in a standard GVAR model: the equation reflecting monetary policy cannot be included in any of the country-specific VAR models, as the central bank responds to *union-wide* rather than an individual member's endogenous variables. Recognising this complication, in the GVAR literature the euro area economy is typically included "as a whole [in order to avoid] being subject to possible inconsistencies that could arise if the different economies in the euro area were modelled separately" (see Dées et al., 2007, p. 2), see also Eickmeier and Ng (2011); Cashin et al. (2012); Rebucci et al. (2012); Chudik and Smith (2013). While being consistent with the institutional framework of the euro area, by aggregating individual economies into a euro area economy this approach implies renouncing to entering a relatively large number of advanced economies individually; and this reduces the amount for cross-sectional

information for the analysis of the determinants of spillovers from US monetary policy.

In order to maximise the number of advanced economies that I can draw on in the analysis below, I build on the mixed cross-section GVAR model set up in Georgiadis (forthcoming). The model in Georgiadis (forthcoming) allows—in contrast to the standard approach in the GVAR literature—to include euro area economies individually and at the same time to model euro area monetary policy in a manner consistent with EMU, namely as being shaped by euro area *aggregate* output growth and inflation dynamics. Specifically, in the model of Georgiadis (forthcoming) the ECB is introduced as a separate cross-sectional unit in which euro area short-term interest rates are determined as a function of GDP-weighted euro area output growth and inflation. In turn, each euro area country-specific VAR model describes the evolution of output growth and inflation given euro area short-term interest rates which are determined in the ECB's model. Of course, both the ECB's model and those of the individual euro area economies are also affected by non-euro area real and financial developments. The non-euro area part of the GVAR model is treated in the standard way (except for oil prices, see below).

Denote the country-specific VARX models on which the GVAR model builds by

$$\boldsymbol{x}_{it} = \boldsymbol{a}_i + \sum_{j=1}^{p_i} \boldsymbol{\Phi}_{ij} \cdot \boldsymbol{x}_{i,t-j} + \sum_{j=0}^{p_i^*} \boldsymbol{\Gamma}_{ij} \cdot \boldsymbol{x}_{i,t-j}^* + \boldsymbol{u}_{it}, \quad i = 1, 2, \ldots, N, \tag{1}$$

where $\boldsymbol{x}_{it}$ is a k_i-dimensional vector of domestic macroeconomic variables, and $\boldsymbol{x}_{it}^*$ is a k_i^*-dimensional vector of foreign macroeconomic variables. For the euro area economies the vector of endogenous variables $\boldsymbol{x}_{it}$ includes output and prices;[3] the vector of foreign vari-

[3]The economies which are modelled as being subject to euro area monetary policy are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. Slovenia, Slovakia and Estonia are not treated as euro area economies for the estimation of the model as they adopted the euro only recently.

ables $\boldsymbol{x}_{it}^{*}$ includes trade-weighted foreign output and prices, euro area short-term interest rates, and trade-weighted foreign interest rates determined in the remaining economies. For all non-euro area economies, the vector of endogenous variables includes output and prices as well, but in addition also short-term interest rates; the corresponding vector of foreign variables comprises trade-weighted foreign output, prices and interest rates. Short-term interest rates in the euro area are not determined in any of the individual euro area economies' VARX models. Rather, as in Georgiadis (forthcoming) a separate model is introduced for the ECB which features the short-term interest rate as the only endogenous variable; the corresponding vector of "foreign" variables in the ECB model comprises GDP-weighted averages of output and prices of euro area economies as well as GDP-weighted interest rates of non-euro area economies. As in Pesaran et al. (2004), bilateral exchange rates are not entered in each country VARX model symmetrically. In particular, as all euro area economies feature the same nominal bilateral exchange rate, the euro is chosen as the numéraire currency: In each euro area economy VARX model the trade-weighted nominal bilateral euro exchange rate of the euro enters the vector of foreign variables; in contrast, in the non-euro area economies' VARX models, the nominal bilateral exchange rate vis-à-vis the euro is entered as an endogenous variable.[4] I also introduce an oil block in order to model commodity prices endogenously. Specifically, the VARX model for the oil block features oil prices as the only endogenous variable. The corresponding vector of foreign variables includes GDP-weighted averages of global output, prices and short-term interest rates. In turn, oil prices enter the VARX models of all economies and the ECB as an additional foreign variable.

I enter output, prices, the nominal bilateral exchange rate and oil prices in first differences of their logarithms.[5] The sample I investigate runs from 1999Q1 to 2009Q4 and includes 61

[4]The euro area trade-weighted nominal exchange rate enters the ECB model as foreign variable.
[5]See Georgiadis (forthcoming) for a discussion about the specification of GVAR models in first differences.

economies. The sample begins in 1999 when the ECB assumed responsibility for monetary policy in the euro area. I drop the most recent years in the sample in order to reduce the likelihood that the data include structural breaks and non-linearities associated with the euro area sovereign debt crisis.[6] Table 1 provides information on the full set of economies that are included. I summarise the economies of Estonia, Latvia and Lithuania into a Baltic (BAL) region, and the economies of Venezuela, Ecuador and Saudi Arabia into an Oil Exporting Countries (OPC) block, which is different from the oil block described above. Due to the small time-series dimension, for estimation I set the lag order to one for the endogenous variables and restrict the foreign variables in each VARX model to enter only contemporaneously. Finally, in order to account for the extraordinary role of the US in the global economy, I treat the US as a dominant unit in the sense of Pesaran and Chudik (2010).[7]

2.1 Identification of US Monetary Policy Shocks

In the baseline specification I consider the effects of US monetary policy shocks identified by sign restrictions following the approach of Eickmeier and Ng (2011). Consider the global representation of the MCSGVAR model

$$\boldsymbol{G}_0 \cdot \boldsymbol{x}_t \quad = \quad \boldsymbol{a} + \sum_{j=1}^{q} \boldsymbol{G}_j \cdot \boldsymbol{x}_{t-j} + \boldsymbol{u}_t, \tag{2}$$

where the global matrices $\boldsymbol{G}_j$ collect the relevant$\boldsymbol{\Gamma}_{ij}$ and $\boldsymbol{\Phi}_{ij}$ from the unit-specific VARX models in Equation (1). Let $\boldsymbol{v}_{it}$ denote the structural (orthogonal) VARX model innovations

[6] I use the data from Georgiadis (forthcoming). For some countries real GDP had to be interpolated from annual to quarterly frequency due to missing data.

[7] The estimated model is stable and the fraction of instances in which residual serial correlation is detected is small (see Georgiadis, forthcoming).

which are related to reduced-form residuals $\boldsymbol{u}_{it}$ of the unit-specific VARX models in Equation (1) according to

$$\boldsymbol{v}_{it} = \boldsymbol{P}_i^{-1}\boldsymbol{u}_{it}, \tag{3}$$

where $\boldsymbol{P}_i$ is a $k_i \times k_i$ matrix of parameters to be identified and that satisfies $\boldsymbol{\Sigma}_{u_i} = Cov(\boldsymbol{u}_{it}) = \boldsymbol{P}_i\boldsymbol{P}_i'$. The sign restrictions approach to structural shock identification essentially consists of constructing impulse response functions for a large number of candidate shocks $\boldsymbol{v}_{it}^{(r)}$, $r = 1, 2, \ldots, R$ which are all orthogonal (and thus labeled structural), and which are associated with impulse response functions that satisfy the required sign restrictions; finally, one reports some statistic of this set of impulse response functions (such as the median).

To implement the sign restrictions approach in the GVAR context of this paper, I first determine the Cholesky decomposition of the covariance matrix $\boldsymbol{\Sigma}_{u_i}$ of the vector of reduced-form residuals $\boldsymbol{u}_{it}$ for each unit i to obtain a lower-triangular matrix $\boldsymbol{P}_i$. I then set up the global matrix $\boldsymbol{P}$ which has the $\boldsymbol{P}_i$'s on its diagonal blocks and zeros elsewhere. The impulse responses to the structural shocks $\boldsymbol{v}_t = (\boldsymbol{v}_{1t}, \boldsymbol{v}_{2t}, \ldots, \boldsymbol{v}_{Nt})'$ at horizon h are then given by $\boldsymbol{\Psi}_h\boldsymbol{G}_0^{-1}\boldsymbol{P}$, where $\boldsymbol{\Psi}_h$ is the relevant moving-average coefficient matrix of the global solution of the GVAR model. The responses to alternative structural shocks can now be obtained by multiplying the Choleski factors $\boldsymbol{P}_i$ by some orthonormal matrix $\boldsymbol{Q}_i^{(r)}$. The set of impulse responses to alternative structural shocks $\boldsymbol{v}_t^{(r)}$ is then given by $\boldsymbol{\Psi}_h\boldsymbol{G}_0^{-1}\boldsymbol{P}\boldsymbol{Q}^{(r)}$, where $\boldsymbol{Q}^{(r)}$ is a block-diagonal matrix with blocks $\boldsymbol{Q}_i^{(r)}$.[8] I impose sign restrictions on the responses of the US short-term interest rate and US inflation. In particular, I require that the US short-term interest rate increases on impact and that US inflation turns negative after four quarters, reflecting the stickiness of aggregate prices. The responses of US inflation at shorter horizons

[8] I construct the impulse responses to alternative structural shocks using the QR-decomposition and collect 500 impulse responses which satisfy these sign restrictions.

and all other economies' variables are left unrestricted.

3 Results

3.1 Spillover Estimates

Figure 1 presents the trough responses to a 100 basis points contractionary US monetary policy shock on the level of real GDP. The cross-border spillovers to real activity are substantial: with the exception of most Australasian economies and a few emerging market economies in Africa and Latin America the spillovers are at least as large as the domestic impact in the US. The spillovers to Russia, the Baltics, Greece, Ireland, and Luxembourg are particularly large. In contrast, South East Asian countries and, in particular, China exhibit rather weak spillovers. Spillovers to non-advanced economies are in general smaller than those to advanced economies. Even though at the upper end, overall, the magnitudes of the estimates for the spillovers from US monetary policy are in line with the findings in the existing literature, see Table 2.[9]

3.2 The Determinants of Spillovers

In order to shed light on the determinants of the output spillovers from US monetary policy, I consider cross-sectional regressions of the spillovers depicted in Figure 1 and denoted by s_i

[9]di Giovanni and Shambaugh (2008) focus on changes in interest rates in countries' base country, which include countries which are much smaller than the US, such as Belgium or Portugal; this may lead to output spillover estimates that are much smaller than those found in this paper. Kim (2001) and, to a lesser extent, Faust and Rogers (2003) as well as Faust et al. (2003) investigate earlier sample periods in which spillovers might have been smaller due to lower levels of international trade and, in particular, financial integration.

on time-averages of a set of country characteristics collected in the vector $\boldsymbol{x}_i$:

$$s_i = \alpha + \boldsymbol{x}_i \cdot \boldsymbol{\beta} + w_i. \tag{4}$$

Table 3 presents the country characteristics I consider, grouped in the categories of openness/integration, economic structure and vulnerabilities.[10,11] I now discuss in more detail the motivation for considering the country characteristics in $\boldsymbol{x}_i$.

Integration and openness Both financial and trade integration may affect the magnitude of spillovers from US monetary policy through various channels. On the one hand, an economy more integrated in global trade may experience larger spillovers to domestic output as foreign demand—which is dampened in line with US and global demand in response to the contraction in US monetary policy—accounts for a larger share of aggregate demand of the domestic economy; in fact, there exists considerable evidence showing that trade integration is a crucial determinant of business cycle synchronisation and spillovers (see Clark and van Wincoop, 2001; Baxter and Kouparitsas, 2005). On the other hand, trade integration could dampen the impact of external shocks, for example by rendering sudden stops and current account reversals in response to a tightening in US monetary policy less likely (see Rey and Martin, 2006; Cavallo and Frankel, 2008; Calvo et al., 2008), or by mitigating the effects on

[10]When data for one of these country characteristics are missing I resort to imputation in order to preclude a contraction of the sample. Specifically, for a given country characteristic I impute the missing observations based on the fit of a regression of the data for that country characteristics for all countries for which there are data on the spillover estimates; if the relationship is statistically significant, for the countries with the missing observations I calculate the implied fitted value given their spillover estimates and add error terms drawn from a normal distribution with mean zero and standard deviation of the regression residuals. If the relationship is not statistically significant, I draw random numbers from a normal distribution with mean and standard deviation taken from the sample of the countries for which data are available. Missing data are imputed only in few instances: for labor market rigidities for Paraguay, Costa Rica and Albania; and financial liberalisation for Croatia, Slovenia and the Slovak Republic.

[11]In addition to these variables, due to their particularly large spillover estimates I include a dummy for the Central and Eastern European countries of Russia, Croatia, the Slovak Republic and Slovenia in Equation (4).

growth once a current account reversal has occurred (see Edwards, 2004, 2007b). Moreover, to the extent that the expenditure-switching effect associated with a rise in exports to the US in response to an appreciation of the US dollar outweighs the expenditure-reducing effect associated with the rise in global interest rates, economies which are more integrated in global trade should display smaller spillovers. Ultimately, it is an empirical question which of these effects dominates.

Financial integration and de jure financial openness may give rise to larger swings in capital flows and spillovers in interest rates. For example, evidence suggests that in particular non-advanced economies which are more financially integrated and/or which are more financially open de jure are more likely to experience sudden stops and current account reversals (see Rey and Martin, 2006; Edwards, 2007a; Calvo et al., 2008; Milesi-Ferretti and Tille, 2011); also, the adverse consequences once the latter occur are more severe in financially integrated and open economies (see Edwards, 2004, 2007b).[12] Moreover, spillovers in interest rates may be more pronounced the more strongly an economy is integrated in global financial markets. Finally, financial integration may be associated with stronger contagion effects (see Edwards, 2007a).

Economic structure To the extent that domestic interest rates rise in line with those in the US, economies which feature a large share of aggregate output accounted for by industries which service more interest-rate sensitive demand should display stronger responses of domestic real activity to US monetary policy (see Georgiadis, 2014). Moreover, to the

[12] In contrast, Miniane and Rogers (2007) find that the extent of capital controls does not have a significant impact on the response of domestic interest rates to changes in US interest rates. Similarly, Forbes and Warnock (2012) find that capital controls do not have an impact on the likelihood of capital flow surges, stops, flights and retrenchments. The breadth and the strictness of enforcement of capital controls is notoriously difficult to quantify and has given rise to numerous measures, and may to some extent explain the differences in the results in the literature.

extent that exports drop in response to a tightening in US monetary policy, economies which rely more on manufactured goods production should also display larger spillovers as a significant share of trade is accounted for by manufactured intermediate goods, in line with the progressive fragmentation of supply chains across countries (see IMF, 2013c). Financial development may also affect the magnitude of spillovers from US monetary policy. On the one hand, economies with deeper financial markets tend to be more leveraged, giving rise to more pronounced credit channel effects in response to exogenous changes in interest rates. On the other hand, financial systems in which competitive pressures are stronger and which are less repressed may be more efficient in reducing informational asymmetries, thereby mitigating financial accelerator effects. Deeper financial markets may also be better able to withstand capital outflows in response to a tightening in US monetary policy, and thereby to preserve domestic lending. Again, it is an empirical question which of these effects dominates. Finally, the literature on domestic monetary transmission has shown that the effects of interest rate changes on real activity are amplified by real wage and mitigated by unemployment rigidities, as they shift the burden of adjustment from prices to quantities (see Abbritti and Weber, 2010).

Vulnerabilities Flexible exchange rates could help economies to mitigate external shocks (see Broda, 2001; Edwards and Levy Yeyati, 2005), for example by reducing the likelihood of current account reversals in response to a tightening of US monetary policy and by mitigating their impact once they occur (see Edwards, 2004, 2007a). Moreover, a flexible exchange rate that depreciates in response to a tightening in US monetary policy may also help to mitigate spillovers by expenditure-switching, in particular by depreciating relative to the US dollar and currencies which are pegged to the US dollar. Also, if its public debt ratio is low an

economy may have sufficient fiscal policy space to counter adverse spillovers arising from a tightening in US monetary policy. Finally, more developed market economies characterised by fewer rigidities, market imperfections and informational asymmetries as summarised by measures of institutional quality should be able to adjust more efficiently to shocks, giving rise to larger spillovers from US monetary policy.

3.2.1 Baseline Results

I adopt a general-to-specific approach to identify the determinants of global spillovers from US monetary policy. In particular, I allow the effects to differ across advanced and non-advanced economies.[13] The results are reported in Table 4. Specifically, I start with a relatively large set of country characteristics in each group discussed in the previous subsection (column (1)). Only few coefficient estimates are statistically significant at conventional significance levels. Therefore, I narrow down the set of country characteristics by dropping those for which neither the coefficient estimate for advanced nor that for non-advanced economies has a t-value above unity (so that the adjusted R-squared would increase): financial liberalisation. In the resulting model with a reduced set of country characteristics (column (2)), in order to improve efficiency I test for the equality of coefficients for those country characteristics whose estimates for advanced and non-advanced economies have the same sign: trade integration, financial integration, the manufacturing share, financial system competition, financial depth, labor market rigidities, and institutional quality. The test results (not reported) suggest that the hypotheses of equal coefficients across advanced and

[13]The set of advanced economies includes Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the UK, Greece, Hong Kong, Ireland, Israel, Italy, Japan, South Korea, the Netherlands, Norway, New Zealand, Portugal, Singapore, the Slovak Republic, Slovenia and Sweden. I drop Luxembourg from the analysis of the determinants of spillovers due to its extraordinarily large spillovers that are very likely to be due to special features related to its role as a small international financial center.

non-advanced economies cannot be rejected. Based on these test results, I replace the distinct coefficients for advanced and non-advanced economies by pooled coefficients (column (3)). Finally, I drop those country characteristics whose coefficient estimates have t-values below unity (column (4)).

The final model features pooled and statistically significant coefficient estimates for trade and financial integration, the manufacturing share, institutional quality, financial system competition and depth, and labor market rigidities; statistically significant coefficient estimates for de jure financial openness, the exchange rate regime and public debt relative to GDP for advanced economies; and for non-advanced economies a statistically significant coefficient estimates for de jure financial openness. Thus, economies which are more integrated in global financial markets and which trade less, which feature more rigid labor markets, less efficient and shallower financial systems as well as a higher share of aggregate output accounted for by manufacturing display larger spillovers. Also, economies with stronger institutions experience larger spillovers; this last result is similar to the findings of Giannone et al. (2011), who find that countries with better regulatory quality in credit markets experienced stronger spillovers from the global financial crisis in 2008/09. Moreover, advanced economies which feature inflexible exchange rates, higher public debt ratios and which are less financially open de jure display larger spillovers; this latter result may stem from the likelihood of sudden stops and reversals in advanced economies not being affected by the extent of capital controls, and from less financially open advanced economies experiencing fewer safe-haven capital inflows in response to a tightening in US monetary policy. Finally, non-advanced economies which are more open de jure experience larger spillovers, suggesting that imposing capital controls could reduce their vulnerability to US monetary policy. The R-squared of the final model suggests that a large share of the variation in the spillovers

from US monetary policy can be accounted for by the country characteristics considered. The next subsection explores to what extent specific country characteristics are relevant in conjunction with other country characteristics.

3.3 Non-Linearities

I introduce interaction terms in order to investigate the role of non-linearities:

$$s_i = \delta + \boldsymbol{x}_i^{\setminus k,j} \cdot \boldsymbol{\beta}^{\setminus k,j} + \beta_j \cdot x_{ij} + \beta_k \cdot x_{ik} + x_{ik} \cdot x_{ij} \cdot \gamma + u_i, \tag{5}$$

where $\boldsymbol{x}_i^{\setminus k,j}$ is the original set of country characteristics without x_{ik} and x_{ij} which are involved in the non-linear hypothesis in question. The hypotheses and the corresponding results are reported in Table 5.

The results suggest that there are non-linearities in the effects of industry mix, exchange rate liberalisation, global value chain participation as well as trade and financial integration on the spillovers from US monetary policy. Specifically, trade integration amplifies spillovers in non-advanced economies if a large share of their aggregate output is accounted for by manufactured goods and if they participate strongly in global value chains, even though these results are not estimated very precisely.[14] Similarly, in non-advanced economies an industry mix tilted towards the production of manufactured goods is associated with larger spillovers the more integrated these economies are in global trade; in contrast, in advanced economies an industry structure tilted more towards manufacturing does not amplify spillovers if they

[14]Strong participation in global value chains reflects that a large share of a country's domestic value added component of its exports is used in exports of other countries and suggests that its trade is focused on intermediate goods. The index for participation in global value chains I use is constructed as in Koopman et al. (2010), using the newly released World Input-Output Database. Missing data for GVC participation have been imputed based on its bivariate correlation of around 0.8 with trade openness as measured by total trade relative to GDP.

are more integrated in global trade. These results are consistent with the hypothesis that industry mix affects the magnitude of spillovers from US monetary policy in advanced economies mostly through spillovers to interest rates and subsequently domestic demand for domestically-produced interest-rate sensitive goods, while in non-advanced economies industry mix affects the magnitude of spillovers through the importance of manufactured goods in their trade.

The results in Table 5 also suggest that the exchange rate regime plays a non-linear role for the spillovers from US monetary policy. In particular, non-advanced economies experience larger spillovers the more strongly they are integrated in global trade if they also feature an inflexible exchange rate regime. An explanation for this finding could be that an inflexible exchange rate appreciates in line with the US dollar in response to a tightening in US monetary policy—at least to the extent that the US dollar is the base rate—and thereby worsens the trade balance. This explanation is corroborated by the result that liberalising the exchange rate is associated with larger spillovers from US monetary policy when non-advanced economies do not trade much: In this case, a depreciation in response to a tightening in US monetary policy does not provide a relief because the contribution of net exports to aggregate demand is small. Moreover, the results in Table 5 suggest that in non-advanced economies financial integration is associated with larger spillovers if the exchange rate is inflexible. This result is consistent with the hypothesis that capital outflows in response to a tightening of US monetary policy are mitigated by a depreciation of the domestic currency. Similar to the case with trade integration, liberalising the exchange rate mitigates spillovers if non-advanced economies are financially integrated and thereby benefit from a depreciation in response to a US monetary policy shock as capital outflows are dampened.

3.4 Relationship to Spillovers from Unconventional US Monetary Policy

A natural question is to what extent the estimates of the spillovers from conventional US monetary policy from this paper allow us to draw inferences about spillovers from exit from unconventional monetary policy. Unfortunately, the effects of exit may be hard to capture in a linear, quarterly GVAR model that employs the short-term interest rate as a measure for the monetary policy stance. Therefore, I confine the analysis to a cmparison of the spillovers from conventional and unconventional US monetary policy. Specifically, I resort to a stylised event-study approach by comparing countries' growth forecast revisions in spring 2013 when Federal Reserve chairman Bernanke upset markets by discussing the start of tapering off quantitative easing with the global spillovers from conventional monetary policy estimated in this paper. To the extent that market participants correctly anticipated how exit from unconventional monetary policies would transmit to global growth, forecast revisions may be a good proxy for the actual spillovers. The top panel in Figure 2 plots the real GDP spillovers from conventional contractionary US monetary policy as estimated by the GVAR against the revisions in real GDP growth forecasts for 2014 between April and May 2013 obtained from Consensus Economics. The results suggest that economies which display larger spillover estimates from conventional US monetary policy also displayed larger downward revisions of their GDP growth projections. This result does not seem to be a statistical artifact: The bottom panel in Figure 2 shows that such a positive and statistically significant correlation between the growth forecast revisions and the spillovers from US monetary policy exists only for the revisions around the time of the first tapering discussions. These results suggest that the transmission channels of global spillovers from conventional and unconventional US

monetary policy might be similar. Of course, this evidence can only be suggestive and needs to be bolstered by more research (see, for example, Chen et al., 2012).

4 Robustness

4.1 Alternative Model Specification

In order to preclude that the result of large global spillovers from US monetary policy shocks are an artifact stemming from the treatment of the US as a dominant unit, I consider a specification of the GVAR model in which the US is entered symmetrically to all other economies. Second, in order to preclude that the finding of large spillovers from US monetary policy stems from the sample including the financial crisis and the Federal Reserve hitting the zero lower bound, I include dummy variables for 2008Q3, 2008Q4 and 2009Q1 for all economies/units as well as—in addition—for 2009Q2, 2009Q3 and 2009Q4 for the US. Moreover, I use the shadow federal funds rates of Wu and Xia (2014) as well as Lombardi and Zhu (2014) which are not constrained by the zero lower bound as an alternative measure of US monetary policy. Third, I determine whether the results are robust to the sovereign debt crisis by extending the sample period to 2012Q1; this robustness check also addresses the possibility that the estimation is compromised by the short sample period in the baseline. Fourth, I include the VIX in order to ensure that the spillovers are driven by a monetary policy rather than a shock to risk aversion and uncertainty. The results displayed in the top panel of Figure 3 suggest that the spillover estimates obtained from these alternative specifications are very similar to those from the baseline specification.

While the correlation between the spillover estimates from the baseline and these alternative specifications are high they are not perfect, begging the question which of these specifications to consider as the reference point. In order to ensure that the results for the determinants of the spillovers from US monetary policy obtained from Equation (5) in the baseline chosen in this paper are not unique to this specification, I run the following robustness check. Denote by $\boldsymbol{s}^*$ the true spillovers. Moreover, denote by $\boldsymbol{s}^{(j)}$ the spillover estimates from alternative specification j, with $j \in \{\text{w/o dominant unit}, \text{FC dummies}, ..., \text{VIX}\}$ described above. Assume that each specification j of the total $\mathcal{S}$ different alternative specifications involves an error $\boldsymbol{h}^{(j)}$ due to mis-specification so that $\boldsymbol{s}^{(j)} = \boldsymbol{s}^* + \boldsymbol{h}^{(j)}$. Then,

$$\boldsymbol{s}^* = \boldsymbol{x}\boldsymbol{\beta} + \boldsymbol{u}, \tag{6}$$

$$\boldsymbol{s}^{(j)} = \boldsymbol{x}\boldsymbol{\beta} + \boldsymbol{u} + \boldsymbol{h}^{(j)}, \tag{7}$$

where $\boldsymbol{u}$ captures the effects of omitted country characteristics on the spillovers which are uncorrelated with those in $\boldsymbol{x}$. Next, denote by $\boldsymbol{s}$ the vector which stacks all $\boldsymbol{s}^{(j)}$

$$\boldsymbol{s} = (\boldsymbol{\iota}' \otimes \boldsymbol{x})\boldsymbol{\beta} + \boldsymbol{\nu}, \;\; \boldsymbol{\nu} = (\boldsymbol{\iota}' \otimes \boldsymbol{u}) + \boldsymbol{h}, \tag{8}$$

where $\boldsymbol{\iota}$ is a $1 \times \mathcal{S}$ vector of ones. Equation (8) can then be estimated by GLS to account for correlation of $\boldsymbol{\nu}$ within alternative specifications and countries. Equation (8) can be interpreted as a regression of repeated measurements of the spillovers from US monetary policy on countries' characteristics that has improved efficiency relative to Equation (5).

The results for the alternative specifications discussed above are reported in the second column of Table 6 and suggest that the results from the baseline specification are mostly

robust. An exception is the result for financial depth.

4.2 Alternative Identification of US Monetary Policy Shock

In order to ensure that the drop in inflation and the increase in short-term interest rates is driven by a monetary policy rather than a money demand shock, I impose an additional sign restriction on the response of money by requiring that M1 drops in response to a tightening in monetary policy. Moreover, to the strong cross-country correlation of interest rates, imposing the restriction that domestic interest rates rise and inflation drops might fail to identify a monetary policy shock specific to the US; rather, the identified shock may reflect a convolution of foreign monetary policy shocks. Therefore, in a second robustness check in addition to the restriction on the response of US short-term interest rates and inflation I also restrict the US nominal effective exchange rate to appreciate in response to a US monetary policy shock (see Eichenbaum and Evans, 1995; Kim and Roubini, 2000; Kim, 2001; Nobili and Neri, 2006; Miniane and Rogers, 2007; Binder et al., 2010).

In addition, I consider monetary policy shocks that have been identified outside the model. First, I use the monetary policy shocks from the structural VAR model of Sims and Zha (2006) for the US economy based on non-recursive contemporaneous restrictions implied by a theoretical model. While the contemporaneous restrictions imposed by Sims and Zha (2006) are underpinned by a theoretical model, their VAR only incorporates a limited number of variables which do not perfectly match the variables from the theoretical model. Therefore, as a second alternative, I consider the monetary policy shocks constructed by Romer and Romer (2004). Under their approach, they first determine the intended change of the federal funds rate target on the occasion of FOMC meetings. From these intended changes in the federal

funds rate target they then remove those parts that are a systematic response to current and expected economic developments captured in internal Fed briefings, other Fed publications and readings of minutes. While the monetary policy shocks of Romer and Romer (2004) are constructed outside of a VAR and thus do not require that the included endogenous variables are sufficient to describe the economy's dynamics, their approach involves some subjective judgement and might fail to consider all information concerning current and future economic developments that was available to FOMC members. Therefore, as a third alternative I use the monetary policy shocks constructed by Bernanke and Kuttner (2005) which are based on the difference between last periods federal funds futures rate and the current period's average federal funds rate target, purged from the effects of economic news. Bernanke and Kuttner (2005) focus only on the one-month future, which might be subject to more volatile risk premia and be less liquid than longer maturities. Therefore, as a fourth alternative I resort to the monetary policy shocks constructed by Barakchian and Crowe (2010); in contrast to Bernanke and Kuttner (2005), Barakchian and Crowe (2010) use federal funds futures of various maturities and extract the information about the monetary policy shocks from these maturities using a factor model. The advantage of the approaches to the identification of monetary policy shocks based on federal funds futures is that they do not require to model the Fed's reaction function and to make an assumption about the information set of policymakers on the time of a rate decision. However, a disadvantage is that when the approaches to the identification of monetary policy shocks by Bernanke and Kuttner (2005) and Barakchian and Crowe (2010) are used at lower than daily frequencies they cannot perfectly differentiate between random movements in monetary policy and economic news that trigger endogenous policy responses. I enter each series of alternative monetary policy shocks as an exogenous variable to the GVAR model one at a time and determine dynamic

multipliers.

The middle panel in Figure Figure 3 suggest that the spillovers arising in response to these alternative monetary policy shocks are closely related to those obtained from the baseline specification. Similarly, the regression results for the determinants of the spillovers reported in column (3) of Table 6 suggest that the results from the baseline are largely robust to alternative identifications of US monetary policy shocks. Exceptions are de jure financial openness and public debt in advanced economies.

4.3 Levels GVAR

To the extent that the GVAR model in levels involves non-stationary and co-integrated variables, the model in first differences might be mis-specified and give rise to inconsistent estimates. In order to determine whether such mis-specification might have an effect on the results of this paper, I estimate the model in levels. More specifically, I determine the responses of real GDP to a US monetary policy shock as represented by the time series constructed by Romer and Romer (2004) in order to avoid imposing sign restrictions on a non-stationary model.[15] The bottom panel in Figure 3 suggests that the spillover estimates obtained from the GVAR in levels based on the Romer and Romer (2004) monetary policy shocks are similar to those from the baseline GVAR in first differences based on sign restrictions; also, the spillover estimates obtained from the GVAR in levels based on the Romer and Romer (2004) monetary policy shocks are similar to those from the baseline GVAR in first differences based on the Romer and Romer (2004) monetary policy shocks. Moreover,

[15]The largest eigenvalue of the companion matrix of the global solution of the levels GVAR model is slightly above unity. As is common in the GVAR setting, this gives rise to impulse responses which explode faster than in single-country VAR models. Relying on sign restrictions in this setting is likely to give rise to implausible spillovers estimates. Because the dynamics of the spillovers are somewhat different, for this robustness check I consider the trough values of the spillovers rather than the spillover after seven quarters.

columns (2) and (3) in Table 7 suggest that the results for the determinants of the spillovers are similar when they are estimated in a levels GVAR.

4.4 Alternative Timing for Data in Link Matrices

The bottom panel in Figure 3 and columns (4) and (5) of Table 7 show that the spillover estimates are hardly changed when bilateral trade and GDP data for 1999 and 2009 rather than averages over the time period from 1999 to 2009 are used to set up the link matrices that include the weights used to construct the foreign variables in the GVAR model.

4.5 Additional Explanatory Variables

Columns (6) to (8) of Table 7 report the results for the determinants of the spillovers from regressions in which the bilateral distance to the US, bilateral trade with the US and bilateral financial integration with the US are included as additional explanatory variables.[16] In all cases do the baseline results remain unchanged. Interestingly, the coefficient estimates for bilateral financial and trade integration with the US are not statistically significant. For bilateral trade integration, this suggests that the spillovers arising through expenditure-switching and expenditure-reducing effects stemming directly from the US offset each other. For bilateral financial integration, the lack of statistical significance suggests that the bilateral spillovers which operate through financial channels are considerably less important than a country's integration with global markets. Finally, Table 7 also reports the results

[16] In each case, the null that the coefficient is the same for advanced and non-advanced economies cannot be rejected. Distance to the US is taken from the CEPII database, bilateral trade integration is proxied by the sum of exports to and imports from the US relative to GDP taken from the IMF Direction of Trade Statistics, and financial integration by the sum of the stocks of portfolio assets in the US and domestic portfolio liabilities held by US residents relative to GDP.

from regressions in which the spillovers after seven quarters as the dependent variable are replaced by the trough spillovers. Again, the results are mostly unchanged.

5 Conclusion

The finding that US monetary policy has sizable spillovers to the rest of the world begs the question whether global welfare could be improved if these spillovers were internalised by US policymakers, in particular given the US dollar's role as the global reserve currency. At least to the extent that the benefits depend on the magnitude of spillovers, the results of this paper raise the question whether it might be worthwhile to strengthen international coordination of monetary policies and global safety nets (see Ostry and Ghosh, 2013; Rajan, 2013; Jeanne, 2014). Future research should examine possible asymmetries in the spillovers across conventional and unconventional as well as across expansionary and contractionary monetary policy. Finally, the finding that the global spillovers from US monetary policy are very large is in line with the hypothesis of a global financial cycle driven by financial conditions in the center economy, and therefore begs the question of whether domestic monetary policy in non-US economies has been undermined by financial globalisation (Shin, 2012; Rey, 2013; Georgiadis and Mehl, 2014).

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A Tables

Table 1: Country Groups

Region	*Countries*
Indiv. countries/units	ALB, AUS, AUT, BAL, BEL, BGR, BOL, BRA, CAN, CHE, CHL, CHN, COL, CRI, CZE, DEU, DNK, ECB, EGY, ESP, FIN, FRA, GBR, GRC, HKG, HRV, HUN, IDN, IND, IRL, ISR, ITA, JOR, JPN, KOR, LUX, MAR, MEX, MYS, NLD, NOR, NZL, OIL, OPC, PER, PHL, POL, PRT, PRY, ROU, RUS, SGP, SVK, SVN, SWE, THA, TUR, USA, ZAF
Baltics (BAL)	EST, LVA, LTU
Oil exporting countries (OPC)	VEN, ECU, SAU

Note: The table reports the countries included and details the composition of the country groups.

Table 2: Overview of the Existing Evidence on the Magnitude of Spillovers from US Monetary Policy Shocks

Paper	**For. rel. to US response**	**Countries**	**Remark**
Kim (2001)	0.25 to 0.5	G6	"The increase in output in the non-US G6 countries is about one fourth to one half of the increase in US output" (p. 353)
Faust and Rogers (2003)	0.5 to 1	DEU and GBR	Figure 2
Faust et al. (2003)	0.5 to 0.75	DEU and GBR	Figures 1, 2, 3 and 4
Nobili and Neri (2006)	0.75	Euro Area	
Mackowiak (2007)	>1	KOR, MYS, PHL, THA, HKG, SGP, CHL, MEX	"The price level and real output in a typical emerging market respond to US monetary policy shocks by more than the price level and real output in the US itself" (p. 2512)
di Giovanni and Shambaugh (2008)	0.1 to 0.2	160 countries	Results refer to responses of output in countries with pegged exchange rates to changes in base country interest rates (p. 347). Base countries include AUS, BEL, FRA, DEU, IND, MYS, PRT, USA, GBR, ZAF
Dées et al. (2010)	≈1	25 AEs and non-AEs	"The effects on output in other countries are [on average] similar to those in the US. (...) The US variables tend to return to their steady state values relatively quickly compared to other countries" (p.29 and Figure 1c)
Bluedorn and Bowdler (2011)	0.5 to 1	DEU, CAN, GBR, JPN, ITA, FRA	Figures 5 and 6
Ilzetzki and Jin (2013)	≈1	not specified	Foreign impulse response "is similar to (but slightly smaller than)" (p.11) in the US. Spillover estimates refer to sample for 1973 to 1990
IMF (2013b)	0.25 to 0.5	Asia, Europe and Latin America	Figure 3.12

Note: Other papers on spillovers from US monetary policy are not included in the table as they do not report the domestic impact in the US and/or do not allow to compare the spillovers to the domestic impact in the US, see Kim and Roubini (2000), Canova (2005), and Fukuda et al. (2013).

Table 3: Candidate Determinants of Spillovers from US Monetary Policy

Group	Country Characteristics	Measurement
Openness/integration	De jure financial openness	Chinn and Ito (2003).
	Trade integration	Exports plus imports relative to GDP from WDI.
	Financial integration	Gross foreign assets and liabilities relative to GDP Lane and Milesi-Ferretti (2007)
Economic Structure	Industry structure	Manufacturing share in total value added from WDI.
	Financial system competition	H-statistic, Lerner-index, Boone-indicator[1], net interest margin, bank overhead costs taken from the Global Financial Development Database of Cihak et al. (2013).
	Financial depth	Domestic credit relative to GDP, stock market capitalisation relative to GDP, private debt securities capitalisation relative to GDP, bank credit to deposits taken from the Global Financial Development Database of Cihak et al. (2013).
	Financial liberalisation	Database on financial reform of Abiad et al. (2010).
	Labor market rigidities	Social Security Laws, Employment Laws and Collective Relations Laws index of Botero et al. (2004), union density and the Strictness of Employment Protection Indicator taken from the OECD.
Vulnerabilities	Institutional quality	Bureaucracy quality, corruption, democratic accountability, ethnic tensions, government stability, internal conflict, investment profile and law and order from the International Country Risk Guide.
	Exchange rate regime	Based on Ilzetzki et al. (2010).
	Public debt burden	Public debt relative to GDP from WDI.

Note: The table provides information on the measurement and the data sources for the determinants of spillovers from US monetary policy. When more than one variable is used the average of the standardised individual series is taken. The data of Botero et al. (2004) refer to earlier time periods. For missing data for individual component variables in the labor market rigidities variable, I apply the imputation procedure outlined in Footnote 10.

[1] *The H-statistic is a measure of the degree of competition in the banking market, measuring the elasticity of banks revenues relative to input prices. The Boone-indicator is a measure of degree of competition, calculated as the elasticity of profits to marginal costs; the rationale behind the indicator is that higher profits are achieved by more-efficient banks. The Lerner-index is a measure of market power in the banking market, defined as the difference between output prices and marginal costs (relative to prices).*

Table 4: Determinants of Spillovers from US Monetary Policy - Baseline Results

	(1)	(2)	(3)	(4)
AE fin. openness	0.16**	0.17**	0.13*	0.13*
Non-AE fin. openness	-0.02	-0.03	-0.06*	-0.06**
AE trade integration (trade to GDP)	0.29***	0.28***		
Non-AE trade integration (trade to GDP)	0.08	0.06		
AE financial integration (GFA to GDP)	-0.18***	-0.18***		
Non-AE financial integration (GFA to GDP)	-0.19+	-0.20+		
AE FX regime	0.04***	0.04***	0.03***	0.03***
Non-AE FX regime	-0.00	-0.01	-0.01	
AE manufacturing share	-0.78*	-0.78*		
Non-AE manufacturing share	-0.79+	-0.62		
AE financial system competition	0.21**	0.21**		
Non-AE financial system competition	0.06	0.08		
AE financial system depth	0.03	0.03		
Non-AE financial system depth	0.15+	0.15+		
AE financial liberalisation	0.21			
Non-AE financial liberalisation	-0.23			
AE labor market rigidities	-0.11**	-0.11**		
Non-AE labor market rigidities	-0.10+	-0.10+		
AE institutional quality	-0.02***	-0.02***		
Non-AE institutional quality	-0.01+	-0.01*		
AE debt to GDP	-0.12+	-0.14*	-0.14*	-0.13*
Non-AE debt to GDP	0.38+	0.37+	0.38+	0.40+
AE dummy	-0.11	0.21	-0.16	-0.09
BAL, HRV, RUS, SVK, SVN dummy	-0.69***	-0.71***	-0.70***	-0.69***
Trade integration			0.18***	0.19**
Financial integration (GFA to GDP)			-0.15***	-0.15***
Manufacturing share			-0.91**	-0.94**
Financial system competition			0.13*	0.12*
Financial depth			0.06+	0.08*
Labor market rigidities			-0.09*	-0.09*
Institutional quality			-0.02***	-0.02***
Constant	0.64+	0.54+	0.82***	0.75***
Observations	55	55	55	55
Adjusted R^2	0.70	0.71	0.72	0.72

Robust standard errors.
+ $p < 0.325$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Non-Linearities in the Determinants of Spillovers

Hypothesis		**AEs**		**non-AEs**	
		$\widehat{\beta}_k + \widehat{\gamma} \cdot x_j$	p-value	$\widehat{\beta}_k + \widehat{\gamma} \cdot x_j$	p-value
Trade integration amplifies spillovers if the economy's manufacturing share is high					
Trade integration $\times$ x_j, x_j : *Manufacturing share*	at $max(z)$	0.33	0.00	-0.05	0.74
	at p_z^{75}	0.28	0.00	0.16	0.32
	at p_z^{25}	0.21	0.04	0.37	0.30
	at $min(z)$	0.21	0.04	0.37	0.30
Trade integration amplifies spillovers if economies participate in global value chains					
Trade integration $\times$ x_j, x_j : *GVC participation*	at $max(z)$	0.22	0.07	-0.09	0.57
	at p_z^{75}	0.25	0.04	0.13	0.48
	at p_z^{25}	0.32	0.31	1.01	0.13
	at $min(z)$	0.32	0.31	1.01	0.13
A higher manufacturing share amplifies spillovers if economies are integrated in global trade					
Manufacturing share $\times$ x_j, x_j : *Trade integration*	at $max(z)$	-0.39	0.46	-2.13	0.16
	at p_z^{75}	-0.88	0.06	-1.45	0.10
	at p_z^{25}	-1.08	0.09	-0.66	0.27
	at $min(z)$	-1.52	0.16	0.45	0.77
Trade integration reduces spillovers in flexible exchange rate regimes					
Trade integration $\times$ x_j, x_j : *FX regime*	at $max(z)$	0.20	0.00	0.36	0.02
	at p_z^{75}	0.27	0.00	0.12	0.14
	at p_z^{25}	0.30	0.00	-0.36	0.05
	at $min(z)$	0.30	0.00	-0.36	0.05
Liberalising the exchange rate regime reduces spillovers in economies integrated in trade					
FX regime $\times$ x_j, x_j : *Trade integration*	at $max(z)$	0.02	0.09	0.04	0.10
	at p_z^{75}	0.03	0.00	0.01	0.43
	at p_z^{25}	0.03	0.00	-0.02	0.04
	at $min(z)$	0.04	0.00	-0.07	0.01
Spillovers in financially integrated economies are mitigated by a flexible exchange rate regime					
Financial integration $\times$ x_j, x_j : *FX regime*	at $max(z)$	-0.13	0.04	0.18	0.36
	at p_z^{75}	-0.12	0.01	-0.16	0.09
	at p_z^{25}	-0.12	0.05	-0.84	0.01
	at $min(z)$	-0.12	0.05	-0.84	0.01
Liberalising the exchange rate regime reduces spillovers in financially integrated economies					
FX regime $\times$ x_j, x_j : *Financial integration*	at $max(z)$	0.03	0.00	0.06	0.12
	at p_z^{75}	0.03	0.00	-0.01	0.66
	at p_z^{25}	0.04	0.01	-0.03	0.04
	at $min(z)$	0.04	0.01	-0.08	0.03

Note: The table reports estimates of the marginal effects of interacted candidate determinants of the spillovers from US monetary policy evaluated at different values of the interacting variable x_j and the corresponding level of significance. Specifically, the marginal effects are reported at the maximum and the minimum values as well as at the 75% and 25% percentile of the distribution of the interacting variable x_j. The marginal effects are reported for advanced as well as non-advanced economies.

Table 6: Robustness: Stacked Regressions for Additional Explanatory Variables and Alternative Monetary Policy Shocks

	Baseline	Alternative specifications	Alternative identification
AE fin. openness	0.13*	0.09^{-}	0.06
Non-AE fin. openness	-0.06**	-0.04^{-}	-0.07***
AE FX regime	0.03***	0.02***	0.03***
AE debt to GDP	-0.13*	-0.15^{-}	-0.07
Non-AE debt to GDP	0.40^{-}	0.46***	0.49***
Trade integration	0.19**	0.10*	0.15***
Financial integration (GFA to GDP)	-0.15***	-0.16***	-0.13**
Manufacturing share	-0.94**	-0.89**	-0.82**
Financial system competition	0.12*	0.09^{-}	0.11**
Financial depth	0.08*	0.05	0.07^{-}
Labor market rigidities	-0.09*	-0.08**	-0.11***
Institutional quality	-0.02***	-0.01**	-0.01***
AE dummy	-0.09	0.03	0.09
BAL, HRV, RUS, SVK, SVN dummy	-0.69***	-0.63***	-0.73***
Constant	0.75***	0.18	0.44**
Observations	55	385	385
Adjusted R^2	0.72		

Robust standard errors in baseline and clustered at country level in stacked regressions.
$^{-}$ $p < 0.2$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

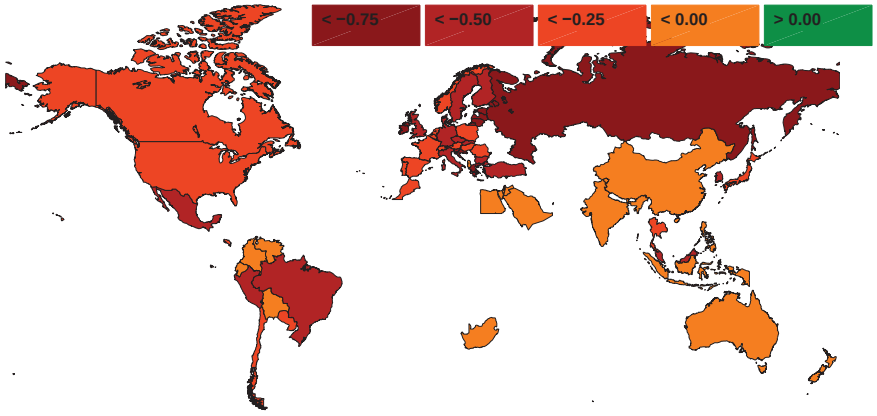
Table 7: Robustness: Additional Explanatory Variables

	Baseline	Levels GVAR	w/o TUR	1999 weights	2009 weights	Distance US	Fin. integr. US	Trade US	Trough spillover
AE fin. openness	0.13*	0.08	0.10*	0.09	0.08^{-}	0.14*	0.13*	0.14*	0.12^{-}
Non-AE fin. openness	-0.06**	0.04	-0.01	-0.07**	-0.03^{-}	-0.05*	-0.06**	-0.06**	-0.02
AE FX regime	0.03***	0.01	0.01	0.03***	0.02***	0.03***	0.03***	0.03***	0.03***
AE debt to GDP	-0.13*	0.28*	0.19*	-0.18*	-0.09	-0.14*	-0.14*	-0.13^{-}	-0.13^{-}
Non-AE debt to GDP	0.40^{-}	0.31^{-}	0.35^{-}	0.45*	0.37*	0.39^{-}	0.40^{-}	0.41^{-}	0.31^{-}
Trade integration	0.19**	0.14^{-}	0.10	0.15*	0.09^{-}	0.18**	0.18**	0.22**	0.13*
Financial integration	-0.15***	-0.16**	-0.14**	-0.19***	-0.11**	-0.155***	-0.14*	-0.16***	-0.14***
Manufacturing share	-0.94**	-1.48**	-1.26**	-0.98**	-0.80**	-0.95**	-0.93**	-0.97***	-1.03**
Financial system comp.	0.12*	0.26*	0.16**	0.11^{-}	0.11**	0.10^{-}	0.12^{-}	0.12^{-}	0.17***
Financial depth	0.08*	0.14*	0.09*	0.04	0.06*	0.07^{-}	0.08*	0.08*	0.06^{-}
Labor market rigidities	-0.09*	-0.10^{-}	-0.10*	-0.09^{-}	-0.08**	-0.08^{-}	-0.09*	-0.08*	-0.08^{-}
Institutional quality	-0.02***	-0.01^{-}	-0.01^{-}	-0.01**	-0.01***	-0.01***	-0.02***	-0.02***	-0.01***
AE dummy	-0.09	-0.11	-0.06	0.13	-0.01	-0.09	-0.09	-0.10	-0.09
BAL,HRV,RUS,SVK,SVN	-0.69***	-0.39***	-0.45***	-0.75***	-0.50***	-0.69***	-0.69***	-0.71***	-0.62***
Distance to US						0.04			
Bil. fin. integration							-0.02		
Bil. trade integration								-0.25	
Constant	0.75***	0.10	0.04	0.48^{-}	0.38**	0.35	0.74***	0.83***	0.58**
Observations	55	55	54	55	55	55	55	55	55
Adjusted R^2	0.72	0.31	0.52	0.67	0.71	0.72	0.71	0.72	0.66

Robust standard errors.
$^{-}$ $p < 0.2$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

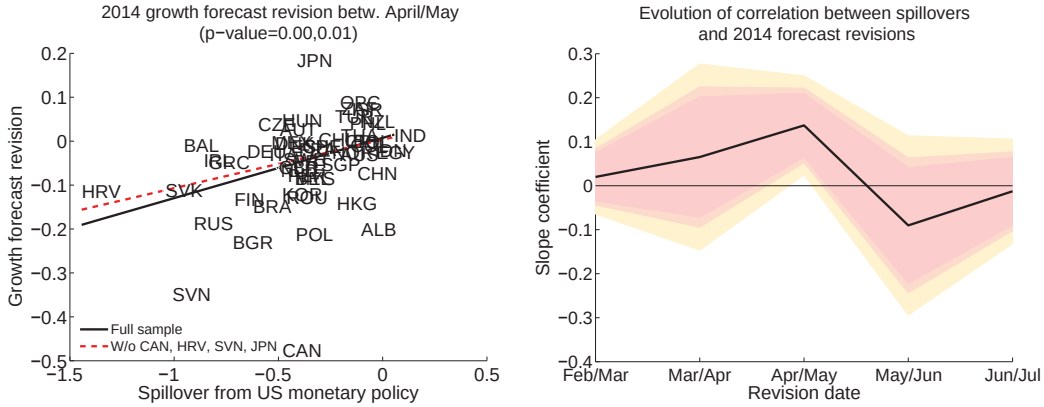
B Figures

Figure 1: Real GDP Spillovers from US Monetary Policy Shock



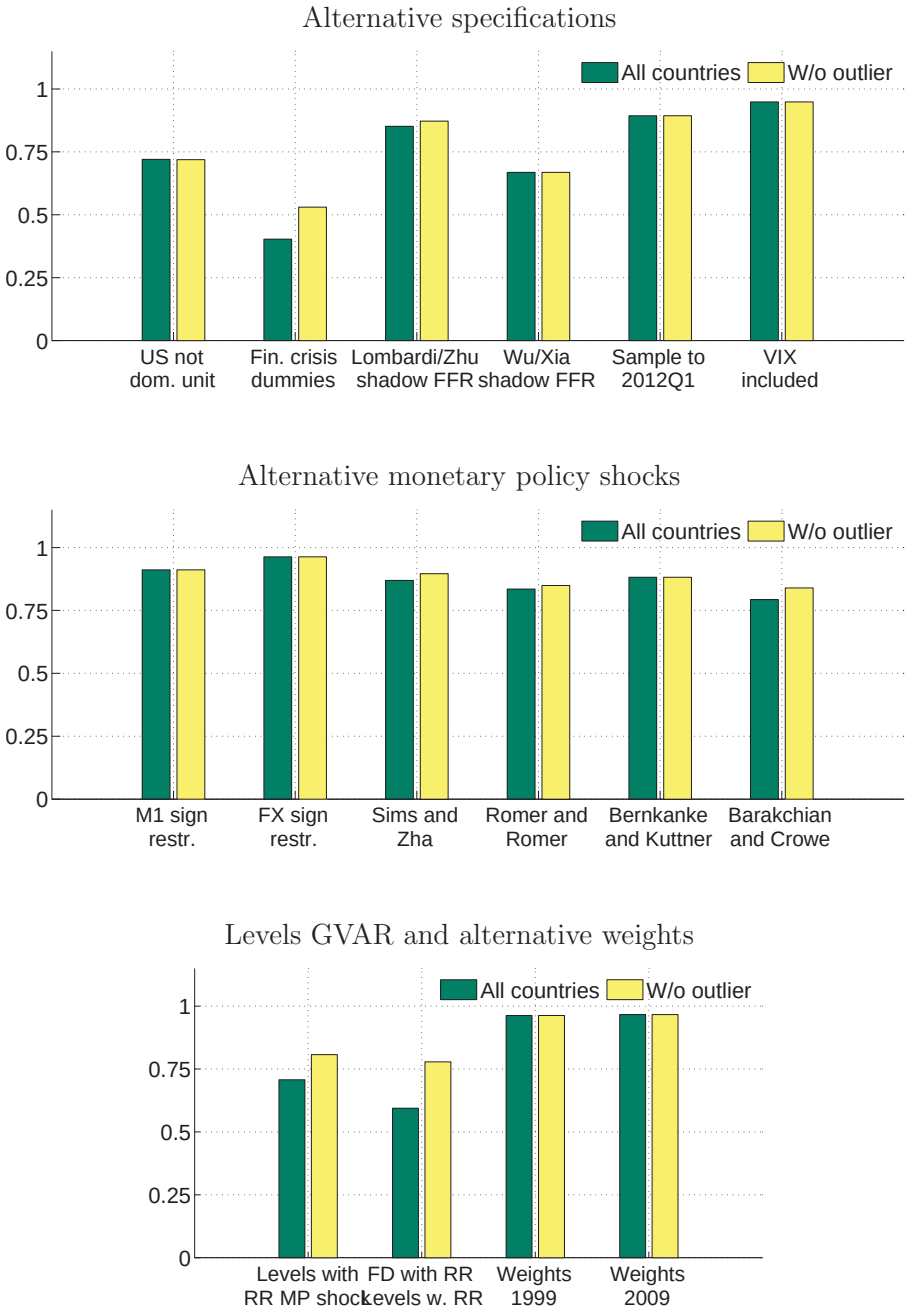
Note: The top panel displays the trough spillovers to real GDP to a 100 basis points monetary policy shock in the US identified by sign restrictions, see Section 3 for details. The magnitude of these trough spillovers is indicated by the color bar. The bottom panel compares the domestic trough impact in the US to GDP-weighted average trough spillovers to different regions in the sample.

Figure 2: Comparison of Real GDP Spillovers Estimated by the GVAR and Revisions of Growth Forecasts for 2014



Note: The left-hand side panel displays the correlation between the trough responses of real GDP obtained from the GVAR model and the revisions between April and May 2013 of Consensus Economics real GDP growth forecasts for 2014. The black solid line represents the fitted values of a regression of the growth forecast revisions on the spillovers. The red-dashed line represents the fitted values for the case in which Canada, Croatia, Slovenia and Japan are dropped. The p-values are provided in the chart titles. The right-hand side panel displays the evolution of the slope estimate from this regression for the revisions at different dates. The shaded areas indicate the 99%, 95% and 90% confidence bands. The results are unchanged when the outliers are dropped at each revision date.

Figure 3: Correlation of Trough Responses from Robustness Checks with Baseline



Note: The figure shows the correlation between the responses of the level of real GDP to a US monetary policy shock after seven quarters from the baseline specification and those from alternative specifications. The green bars display the correlation if all countries are considered and the yellow bars if a single outlier is removed. For the alternative specification with dummies during the financial crisis the outlier is Singapore, for the levels GVAR with the monetary policy shocks of Romer and Romer (2004) the outlier is Turkey, and in all other cases it is the Baltics.

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