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International spillovers in global asset markets

Ansgar Belke, Irina Dubova

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Please direct any enquiries to the current ROME coordinator
Prof. Dr. Albrecht F. Michler,
Heinrich-Heine-University of Duesseldorf, Department of Economics, Universitaetsstr. 1,
Build. 24.31.01.01 (Oeconomicum), D-40225 Duesseldorf, Germany
Tel.: ++49(0)-211-81-15372
Fax: ++49(0)-211-81-15261
E-mail: helpdesk@rome-net.org
albrecht.michler@hhu.de or markus.penatzer@hhu.de

Abstract

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JEL-Classification: E52, E58, F42

Keywords: asset markets, financial transmission, financial market integration, rolling estimations, spillovers, Vector Autoregression

International spillovers in global asset markets

by

Ansgar Belke
(University of Duisburg-Essen, Centre for European Policy Studies, Brussels, and Institute for the Study of Labor, Bonn)

and

Irina Dubova
(University of Duisburg-Essen and Ruhr Graduate School, Essen)

Brussels and Essen
May 22, 2017

Abstract

The paper empirically estimates the financial transmission between bond and equity markets within and across the four largest global financial markets - the United States, the Euro area, Japan, and the United Kingdom. We argue that international bond and equity markets are highly connected both within and across asset classes in a globalized world, where the complex transmission process across various financial assets is not restricted to just the domestic market. This paper employs identification through generalized forecast error variance decompositions to estimate spillovers across four systemic markets in a Vector Autoregression (VAR) framework. We find that asset prices react strongest to international shocks within the same asset class, but that there are also substantial international spillovers across asset classes. Rolling estimations analysis provides evidence that global asset markets have become more integrated and the bilateral relationships change over time. Our results are robust to specifications which take into account the monetary policy stance and include foreign exchange markets.

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Corresponding author: Irina Dubova, University of Duisburg-Essen, Campus Essen, Universitaetsstraße 12, D-45117 Essen, Germany, e-mail: irina.dubova@uni-due.de.

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1. Introduction

The turbulence in asset markets during the global financial crisis (GFC) has caused manifold debates about asset market linkages across countries, with a particular interest in spillovers originating from the United States (US) financial shocks. Moreover, it initiated discussions about whether these linkages are different in times of financial crisis compared to non-crisis times. The subsequent Euro area debt crisis resulted in global financial volatility as well, although to a lesser extent than the GFC. Thus, a new strand of research was dedicated to the analysis of broader linkages among advanced (as well as emerging countries) financial markets (Bayoumi and Bui, 2012, Beirne and Gieck, 2014, and Raddant and Kenett, 2016). There seems to be general agreement on the fact that the global financial markets have become increasingly integrated and highly complex, with cross-border connections and dependencies. Thus, a thorough analysis of these relationships is needed for the successful managing of the financial risks and preserving financial stability, which, in turn, contributes to the smooth functioning of the real economy.

The recent interest in financial spillovers is clearly related to the current tightening of the Fed's monetary stance, which is likely to create non-negligible spillovers for the other countries such as the Euro area, the United Kingdom (UK) and Japan, among others (Buitron and Vesperoni, 2015, Horváth, 2016, and IMF, 2014). Rising interest rates in the US are likely to spill over to the rest of the world by the different transmission channels. First, higher expected returns in the US may entail portfolio shifts toward US assets as international investors may withdraw capital from other countries, thereby creating upward pressure on yields there (Belke, Beckmann and Czudaj, 2014). Second, international market participants may believe that the Fed is signaling some private information about the state of the global economy through policy actions (Belke, Gros and Osowski, 2017). Market participants thus will update their beliefs about future global prospects and domestic central bank's potential policy actions according to the received signals. Third, the pass-through of an appreciated US dollar could result in a higher inflation and output growth in other countries, which will, in turn, cause the increase in non-US interest rates (Bernoth and Koenig, 2016). It is important to note that spillovers may take place independent of the exchange rate regime (for the related arguments see Belke and Rees, 2014). Finally, given the international role of the US dollar in global financial markets, the risk premia, volatility of asset prices and global credit growth are largely affected by US monetary policy. Furthermore, Miranda-Agrippino and Rey (2015) argue that US monetary policy drives the "global financial cycle".

The identification of complex financial market spillovers is a challenging econometric issue. First, a suitable empirical framework is expected to map the various transmission channels simultaneously. Second, the model should take into account markedly contemporaneous correlations in the data, so that both the causal relationships and the size of spillovers are identified in a proper way. This paper investigates the connectedness among systemic bond and equity markets of the US, the Euro area, the UK and Japan, using the spillover measures proposed by Diebold and Yilmaz (2012) based on generalized VAR forecast error variance decompositions. This approach enables us to incorporate bond and equity markets of the US, the Euro area, the UK and Japan in one model framework and to construct spillover measures which are invariant to the orderings of the variables. Moreover, our preferred method allows us to examine the directions of these spillovers and analyze the time-dependent properties of the constructed spillover indices.

The remainder of this paper is organized as follows. Section 2 reviews the literature on domestic and on international financial linkages and integration. Section 3 outlines our estimation approach and the data and variables we use. Section 4 presents our estimations of spillovers, followed by robustness checks in Section 5. Section 6 finally sums up our findings and discusses policy implications.

2. Related Literature

This paper is closely related to various strands of the literature on spillover effects both within and between countries. A number of studies is dedicated to monetary policy spillovers (e.g. Caceres, Carriere-Swallow and Grus, 2016) as well as interactions between monetary policy and financial markets (e.g. Rigobon and Sack, 2003). For the Euro area, Chinn and Frankel (2003) show that, prior to the creation of European Monetary Union (EMU), European rates were strongly impacted by interest rate changes in the US, whereas the effects became more ambiguous in the early stages of the Euro when US rates were influenced by Euro area rates as well. Eijffinger (2008) finds evidence that it is generally the US interest rate (at both the short and the long horizon) that adjusts in order to close interest differentials between the US and the Euro area, whereas the Euro area rates hardly move. Thus, Eijffinger (2008) concludes that there exist statistically significant (“error-correcting”) interdependencies between the Euro area and the US. Using the GVAR framework, Dees, Mauro, Pesaran, and Smith (2007) find that the changes in US short-term interest rates do only exert negligible effects on short-term rates in the Euro area.

Since the financial markets have become increasingly integrated, both domestically and internationally as well as within and between different asset classes, a growing body of empirical research is dedicated to the connectedness and contagion in the financial markets. But what is the dominant pattern excavated by the leading literature in the field?

First, considering spillovers within one particular asset class, Diebold and Yilmaz (2009) provide evidence that there exist substantial return spillovers across equity markets in 19 different countries, which vary widely over time. However, Bekaert, Cho and Moreno (2010) refute the presence of cross-border contagion in international equity markets. Bayoumi and Bui (2012) examine spillovers within bond market and within equity market in the two separate models for the world’s most important markets, i.e. those of the US, the Euro area, Japan, and the UK in the period from 2000 to 2009. Their results suggest that US bond and equity market shocks reverberate around the world much more than shocks originating in other areas. The European markets, however, appear to have two-way spillovers on each other and there is some evidence that Euro area shocks also impact Japan. Moreover, Japanese spillovers are generally the weakest across the markets that are examined.

The second strand of the literature examines cross-market and intra-market spillovers within one particular country. Here the research of Diebold and Yilmaz (2012) has to be mentioned which highlights the importance of the volatility spillovers across equity, bond, currency and commodity markets in the US. Barunik, Kočenda and Vácha (2016) analyze the intra-market connectedness of US stocks. At the disaggregate level they provide evidence of, on the one hand, asymmetry in the connectedness of US stocks, and on the other hand, the increase in overall spillovers during the recent financial crisis.

A comparison of our contribution with the seminal study of Diebold and Yilmaz (2009) seems to be warranted here. Whereas Diebold and Yilmaz (2009) employ daily returns on nominal local-currency stock market indexes, we make use of a slightly lower two-day frequency of data on government bond yields and stock market indices and are thus able to investigate volatility spillovers in an across-asset dimension. We thus go beyond the asset class analysed by Diebold and Yilmaz (2009) and look at a wider array of them.

What is more, in contrast to Diebold and Yilmaz (2009), we analyze only four systemic financial markets – the US, the Euro area, the UK and Japan. This is because they are considered as the most advanced and integrated financial markets and represent the majority share of the world market capitalization. Furthermore, along with the developments in emerging markets we also incorporate in our model oil prices and "market fear" measures, in order to disentangle common shocks from the spillovers between our underlying variables. Moreover, different from Diebold and Yilmaz (2009) who only plot different monetary policy regimes to indicate potentially different volatility regimes, we consider money market and foreign exchange market variables explicitly in the robustness check part of our empirical analysis.

A third strand of the literature analyzes spillovers both between and within several asset classes and is recently growing. For instance, Ehrmann, Fratzscher and Rigobon (2011) underline the importance of international spillovers by analyzing the financial integration and the transmission channels in the period 1989–2008 for seven asset price categories: short-term interest rates, bond yields and equity market returns as well as the exchange rate in the USA and the Euro area. They find that US financial markets explain on average around 30 percent of Euro area financial market movements, whereas Euro area markets account for only about 6 percent of the variance of US asset prices. Moreover, the direct transmission of financial shocks within certain asset classes is indeed often amplified substantially through indirect spillovers via other asset prices. However, since the authors analyze the pre-crisis period, the results may not hold for the period during and after the financial crisis.

Furthermore, omitting emerging markets in the model might also distort the results. Beirne and Gieck (2012) analyze bond, stock and currencies markets by means of a GVAR model for the period 1998-2011, for over 60 economies, thus taking into account the role of emerging market economies. In the case of advanced economies their results suggest a high significance of within-market effects for each asset market in advanced economies, as well as cross-market contagion from global stocks to domestic bonds. According to the study of Louzis (2013), who examines the return and volatility spillovers exclusively in the financial markets of the euro area, the stock market could be seen as the main transmitter of spillovers even during the sovereign debt crisis, whereas money markets play a key role of volatility transmission in the Euro area since the outbreak of the global financial crisis.

Our paper investigates the connectedness among four systemic bond and equity markets of the US, the Euro area, the UK and Japan, based on two-daily data using the spillover measures proposed by Diebold and Yilmaz (2012) for the period from 1995 to 2016. As said, this approach enables us to construct spillover measures, which are invariant to the orderings of the variables, and examine the directions of these spillovers. Furthermore, using high-frequency data, the dynamics of which is less affected by macroeconomic fundamentals, provides an advantage in identifying spillovers in financial markets where the news are priced rapidly. Our preferred method as well as using a large number of daily data allows us to analyze time-dependent properties of the constructed spillover indices. Finally, we include oil prices, developments in emerging markets and “market fear” measures in our model, just in order to identify the spillovers of interest in a more accurate way.[1]

3. Data and empirical approach

3.1 Data

We analyze four systemic financial markets – the US, the Euro area, the UK and Japan. They are considered as the most advanced and integrated financial markets and represent the majority share of the world market capitalization (Bayoumi and Bui, 2012). Our main focus lies on the international interactions (spillovers) of bond and stock markets, whereas some other specifications which take into account the monetary policy stance and foreign exchange markets are discussed and presented as robustness checks in section 5.

[1] In section 5 we also consider monetary policy stance measures and foreign exchange markets.

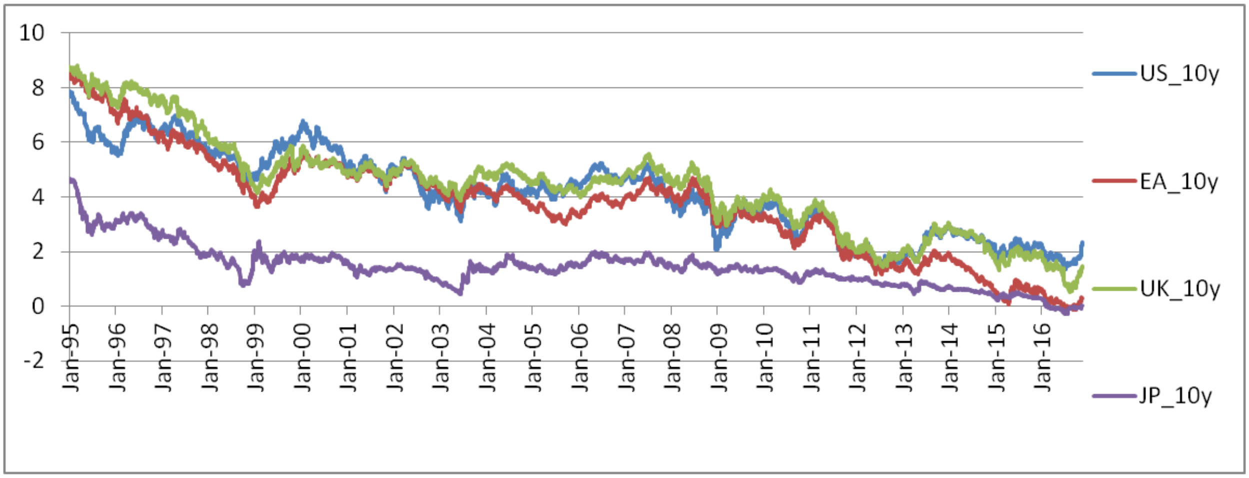
The two-day frequency of data was chosen for several reasons. On the one hand, it reduces the issue of the different opening and closing times across the day in different countries. On the other hand, using high-frequency data, whose dynamics are by nature not affected by macroeconomic fundamentals, should have an advantage in identifying the spillovers in financial markets where the news are priced in rapidly. Additionally, by using high-frequency data, we have sufficient observations for investigating possible time-varying patterns of spillovers.

We assume consistent with theory that financial markets are forward-looking by nature; so they already include the expected component of macroeconomic conditions. The main objective of our analysis is to identify which markets actually drive the high underlying correlations. Hence, for a more accurate identification one needs to take into account common shocks to the system as well.

In our investigation we will consider three major common shocks which stem from global risk aversion, oil prices and stock developments in emerging markets. As shown by Miranda-Agrippino and Rey (2015), the global financial cycle is highly negatively correlated with “market fear” measures. This means that the inclusion of the Chicago Board Options Exchange (CBOE) volatility index should control for the common global financial cycle shocks. Hájek and Horváth (2016) highlight the importance of oil prices and economic performance in emerging markets for the monetary policy spillovers between the US and the Euro area. Beirne and Gieck (2012) stress the important role of emerging market economies as well. Finally, Ehrmann, Fratzscher and Rigobon (2011) also mention that, although being neglected in their analysis, the Asian markets, among others, might be of relevance for bilateral US–Eurozone financial relationships.

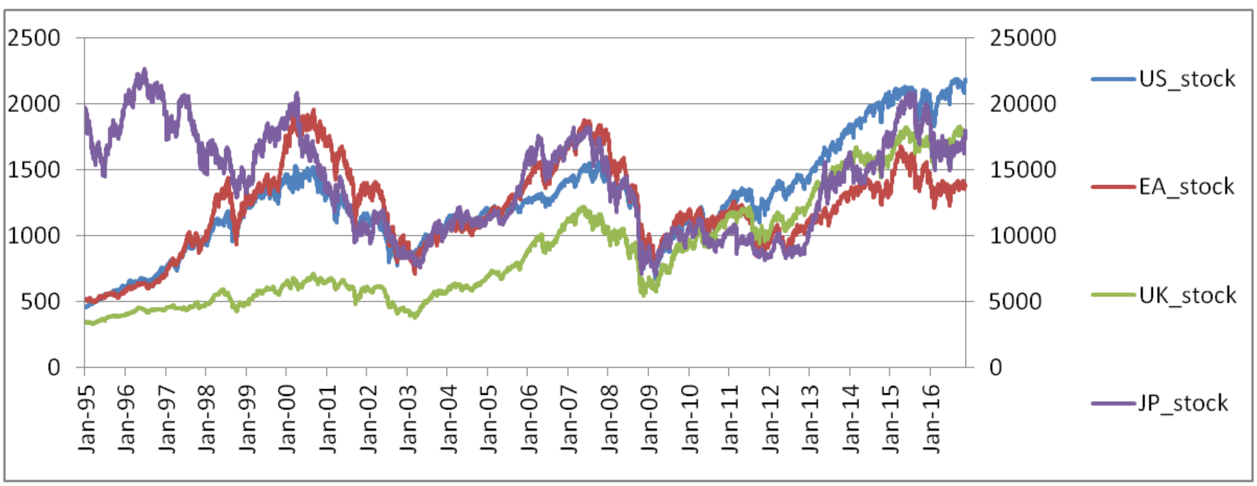
Figure 1 below presents the development of the 10-year government bond yields for the US, the Euro area, the UK and Japan over time. Figure 2 plots the development over time of the stock indices – the S&P 500 for the US, the S&P Euro for Euro area, the FTSE 250 for the UK and the NIKKEI for Japan. The sample under consideration ranges from January 3, 1995, to October 31, 2016. Our data source is Thomson Reuters Datastream.

Figure 1. Bond markets in the US, the Euro area, the UK and Japan over time



Source: Thomson Reuters Datastream.

Figure 2. Equity markets in the US, the Euro area, the UK and Japan over time



Note: The right axis displays values for FTSE 250 (UK_stock) and NIKKEI (JP_stock); on the left axis values for the S&P 500 (US_stock) and the S&P Euro (EA_stock) are denoted. Source: Thomson Reuters Datastream.

Since we are interested in the short-run dynamics, up to the next four weeks, our estimations are performed in first differences of the bond yields and log price changes of the stocks[2]. This usual data transformation also accounts for VAR stability, so that no root lies outside the unit circle.

[2] Oil prices, the VIX and MSCI emerging market indices were taken in the model as log differences.

3.2 Estimation approach

In order to estimate the spillovers we follow the empirical approach proposed by Diebold and Yilmaz (2009, 2012) which is based on VAR variance decompositions.

First, we estimate the VAR(p) model:

$$x_t = \sum_{i=1}^{p} \Phi_i x_{t-i} + \varepsilon_t, \tag{1}$$

where $\varepsilon \in (0, \Sigma)$ is the i.i.d. errors vector.

A VAR-framework allows us to consider all variables as endogenous, which allows considering non-trivial linkages within and between asset markets in advanced economies in a proper way. The moving-average representation, thus, can be written as

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}, \tag{2}$$

where $A_i = \sum_{k=1}^{p} \Phi_k A_{i-k}$, A_0 is the identity matrix $I_{N\times N}$ and $A_i = 0$ for $i < 0$.

Our further analysis relies on variance decompositions which allow assessing the fraction of the H-step-ahead error variance in forecasting x_i that is due to shocks to x_j. In order to deal with contemporaneous correlations of VAR shocks, we use the generalized VAR framework, which produces variance decompositions invariant to ordering choice. The generalized approach allows for correlated shocks, taking into account the historically observed distribution of errors. Thus, although the method does not identify the causality of spillovers, it relies on historical patterns to identify directionality.

The H-step-ahead forecast error variance decomposition[3] is calculated as

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, \tag{3}$$

where Σ is the variance matrix for the errors ε, σ_{ii} is the standard deviation of the error term for the i-th equation of VAR and e_i is a vector which contains one as i-th element and zeros otherwise.

The *Total Spillover Index (TSI)* is then constructed as:

[3] We consider 4 weeks ahead forecast error decompositions.

$$\mathrm{TSI}(\mathrm{H}) = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N} \widetilde{\theta_{ij}^{g}}(\mathrm{H})}{\sum_{i,j=1}^{N} \widetilde{\theta_{ij}^{g}}(\mathrm{H})} \times 100, \tag{4}$$

where $\widetilde{\theta_{ij}^{g}}(\mathrm{H})$ is the normalized value for $\theta_{ij}^{g}(\mathrm{H})$, so that $\widetilde{\theta_{ij}^{g}}(\mathrm{H}) = \frac{\theta_{ij}^{g}(\mathrm{H})}{\sum_{j=1}^{N} \theta_{ij}^{g}(\mathrm{H})}$. The total spillover index, thus, measures the contribution of spillovers of shocks across variables under consideration to the total forecast error variance.

In order to investigate the direction of spillovers, i.e. the portion of total spillover index that comes from x_i to x_j, the *Directional Spillover Index (DSI)* is applied:

$$\mathrm{DSI}_{i\rightarrow j}(\mathrm{H}) = \frac{\widetilde{\theta_{ji}^{g}}(\mathrm{H})}{\sum_{i,k=1}^{N} \widetilde{\theta_{ik}^{g}}(\mathrm{H})} \times 100. \tag{5}$$

The last spillover measure of interest is the *Net Pairwise Spillover Index (NPSI)* between the variables x_i and x_j which is defined as the difference between gross shocks transmitted from x_i to x_j and gross shocks transmitted from x_j to x_i:

$$\mathrm{NPSI}_{ij}\,(\mathrm{H}) = \left(\frac{\widetilde{\theta_{ji}^{g}}(\mathrm{H})}{\sum_{i,k=1}^{N} \widetilde{\theta_{ik}^{g}}(\mathrm{H})} - \frac{\widetilde{\theta_{ij}^{g}}(\mathrm{H})}{\sum_{j,k=1}^{N} \widetilde{\theta_{jk}^{g}}(\mathrm{H})} \right) \times 100. \tag{6}$$

The chosen approach allows us to investigate changing-over-time dynamics of spillovers in the form of rolling regressions, and thus, the time variations of total, directional and net pairwise spillovers during the period of observation.

4. Empirical results

4.1 Spillover pattern

Table 1 shows the estimated contemporaneous spillovers between and across systemic bond and equity markets, as well as included control variables.

The matrix is constructed such that each *ij*-entry (where *i≠j*) represents the spillover from the *j*-variable to the *i*-variable, whereas each diagonal element stands for the own contribution part. Hence, just to convey an example, the first row of Table 1 considers US government bond yields for which the own contribution is equal to 51.98 percent, the spillovers from US stock market which amount to 4.46 percent, the spillovers from the Euro area bond and stock markets which are equal to 14.14 and 4.42 percent respectively, etc. The first row's last entry shows the sum of the spillovers which the US bond market receives from all other variables, i.e. 48 percent. In the second last row we see the spillovers from the variable listed as the column name to all other variables taken together, whereas in the last row we add to the previous row the own contribution. Hence, the spillovers from the US bond market are equal to 52.4 percent, whereas the sum of the US bond market's own contribution and spillovers to others is 104.4. The total spillover index for all included variables across the whole sample period is then calculated according to equation (4) and turns out to be equal to 50.7 percent.

Table 1. Spillovers in bond and equity markets

	US_10y	US_stock	EA_10y	EA_stock	UK_10y	UK_stock	JP_10y	JP_stock	VIX	MSCI_EM	OIL	*From Others*
US_10y	51.98	4.46	14.14	4.42	14.07	3.62	0.39	0.55	2.71	2.75	0.91	48
US_stock	3.17	37.54	1.57	14.39	1.18	9.5	0.11	1.02	20.64	9.72	1.15	62.5
EA_10y	15.15	2.08	48.7	3.96	21.66	3.41	0.45	0.55	1.52	2.06	0.46	51.3
EA_stock	3.1	15.67	2.69	33.32	2.36	18.72	0.12	1.91	10.29	10.76	1.07	66.7
UK_10y	15.07	1.68	21.88	3.57	50.09	3.18	0.31	0.56	1.19	2.06	0.42	49.9
UK_stock	2.83	13.26	2.43	19.37	2.17	33.75	0.16	2.18	9.99	12.55	1.32	66.2
JP_10y	4.61	1.09	2.68	1.11	2.26	0.94	82.11	3.19	0.82	1.14	0.05	17.9
JP_stock	2.25	12.34	1.49	9.63	1.29	8.09	1.72	44.61	7.97	9.92	0.68	55.4
VIX	2.5	21.36	1.7	11.35	1.21	8.63	0.05	0.95	42.97	8.45	0.84	57
MSCI_EM	2.28	15.1	1.61	12.79	1.45	13.44	0.3	4.98	10.38	35.63	2.04	64.4
OIL	1.41	2.65	0.7	2.68	0.68	3.18	0.1	0.51	1.88	4.27	81.92	18.1
Contribution to others	52.4	89.7	50.9	83.3	48.3	72.7	3.7	16.4	67.4	63.7	8.9	557.4
Contribution including own	104.4	127.2	99.6	116.6	98.4	106.5	85.8	61	110.3	99.3	90.9	50.70%

The results emphasize the importance of international spillovers within the same asset classes. However, there are still substantial domestic and international cross-market linkages. The US and the two considered European bond and equity markets are found to be highly integrated, whereas the Japanese markets are to a great extent decoupled – first, they are less exposed to spillovers from outside, and second, contribute only negligible amounts of spillovers to others. The latter finding is clearly in line with Beirne and Gieck (2014).

The stock market in Japan is substantially more prone to the spillovers from outside than its bond market. Moreover, for both asset classes in Japan we observe that the role of the US is prevailing. Considering the two European markets, there appear to be notable two-way spillovers across the Euro area and the UK, the empirical realizations of the connectedness indices within their equity and bond markets even exceed those with the US.

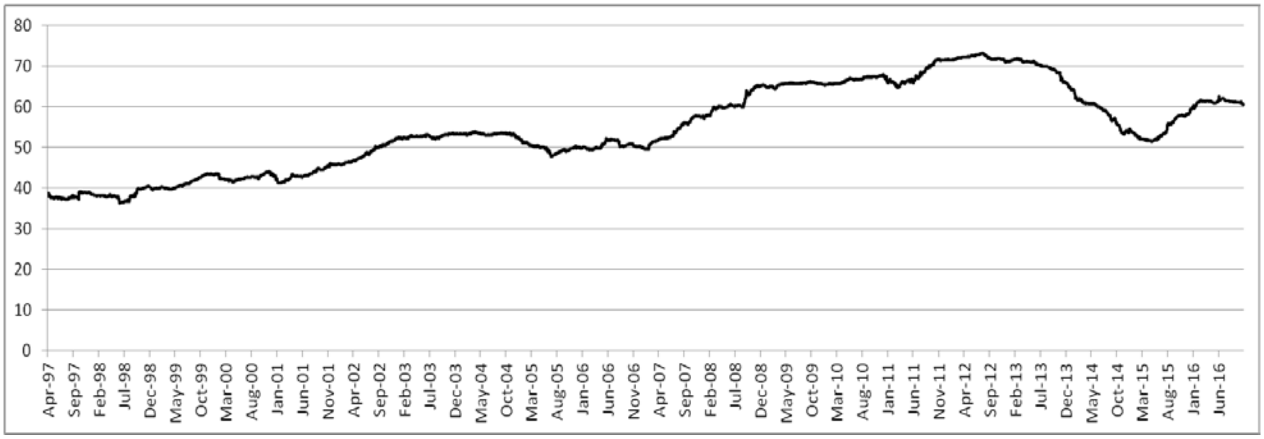
In contrast to Ehrmann, Fratzscher and Rigobon (2011) and Beirne and Gieck (2014), however, inward spillovers to the US from elsewhere are found to be considerable. The difference might be attributed to the use of different empirical approaches, the inclusion of the relevant control variables, as well as the recently more complex financial structure captured by extending the sample until 2016. Our results for the control variables of global risk aversion and developments in emerging markets underline their role as both spillovers' contributors and recipients, whereas the spillovers associated with oil prices are very modest, with the directionality running presumably from stock markets. We now turn to our dynamic analysis of the spillovers, i.e. their change over time.

4.2 Dynamic Analysis

Over the last twenty years covered by the dataset, global economic and political events occurred that are likely to have led to significant fluctuations in the spillovers across markets – the introduction of the Euro, the 2007-09 global financial crisis, the Euro crisis, the implementation of unconventional monetary policies in major advanced countries are a few examples. In the following we will thus perform a dynamic analysis of spillovers in order to monitor the changes in global financial integration.

Figure 3 below shows the estimated dynamics of total spillover index. There is a general upward trend in spillovers – bond and stock markets became more integrated both within and across countries. They became more intense in the periods 2007-2009 and 2011-2013, i.e. in the times of the global financial crisis and Euro crisis which is essentially an important finding of our analysis. After 2013 we observe two striking developments – initially the spillovers have gradually diminished, but then, since 2015, our estimated spillover index is again on an upward trend. The first finding is in line with Raddant and Kenett (2016), who also found that by 2012 the connectedness in global stocks shows an empirical co-movement pattern which is very similar to pre-2008 levels. The recent amplification of spillovers detected by us appears to be related to the divergence of the monetary policy stances in the US versus other economies such as the Euro area, and, in this vein, represents a pattern which is clearly corroborating the views of Buitron and Vesperoni (2015), Horváth (2016), IMF (2014) and Bernoth and Koenig (2016).

Figure 3. Total spillover index over time



Source: own estimations.

In the following, we continue with our country-wise analysis. In this context, the Figures 4 to 7 show the stability of directional spillovers stemming from each country's both within and across bond and equity markets. Some striking common patterns are observable for spillovers stemming from the US, the Euro area and the UK.

First, spillovers across different asset classes exhibit significant time variations, in relative terms even larger than changes in spillovers within the same asset classes. Thus, we feel legitimized to conclude that the dynamics of total spillover index, presented in Figure 3, is driven by linkages both between and within bond and equity markets.

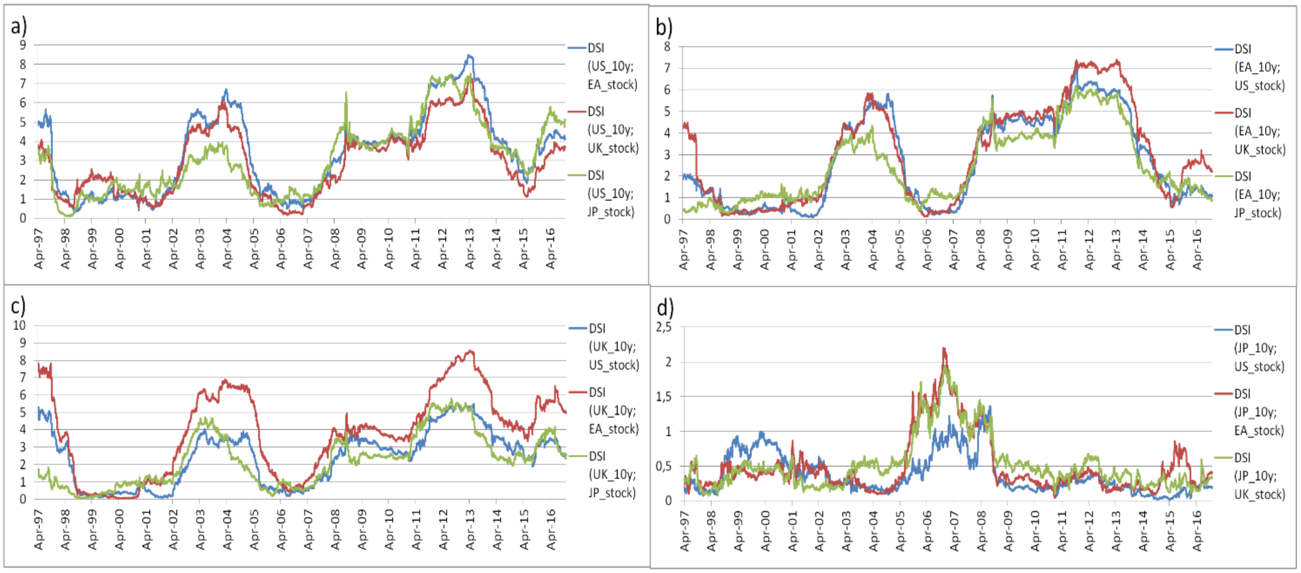
Second, we are able to identify a common pattern of the spillovers from the US, the Euro area and UK bonds to each of the other country's stock market (Figure 4). Thus, bond shocks originating in the particular country spill over globally to the equity markets of other advanced countries in a more or less homogeneous way, although UK bonds shocks spill over on average at higher magnitude to the Euro area rather than to US or Japanese stocks. With respect to the spillovers from the US, the Euro area and the UK equities to the other country's bond markets (Figure 5), we observe a similar pattern. However, spillovers to Japan's bond market are rather decoupled, especially for the time span before 2007-2008.

According to our estimations, the spillovers from the US stock market to the European ones were relatively stable starting in 2006, whereas spillovers to Japanese stock markets show an upward trend over the whole time period (Figure 6a). Another overall picture emerges from the Figure 7a: the spillovers from US bond market to European bond markets were steadily increasing from 2001 to 2007.

However, during the acute phase of the GFC the spillovers decreased substantially and recently, beginning in 2014, increased again. Japanese bond markets started to be prone to the increasing US, Euro area and UK bond markets spillovers not earlier than in 2004. The spillovers from the Euro area bond markets to the respective US and UK markets clearly intensified in the first years after the introduction of the Euro, but have decreased with the outbreak of GFC (Figure 7b). Interestingly, we observe an overall upward trend for the spillovers from the UK stock market to other countries' stock markets over time (Figure 6c).

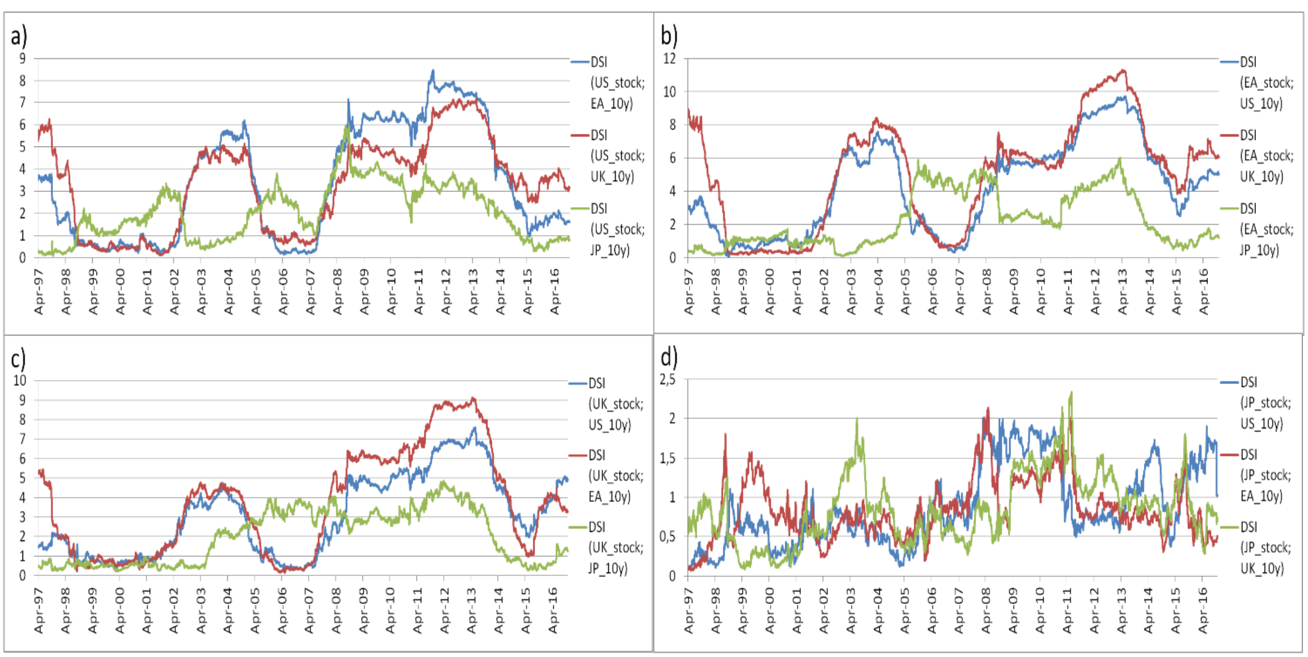
As mentioned above, the spillovers originating from Japan are found to be very limited (in accordance with the vast majority of the literature in this field), so that only Japanese stock market spillovers can be said to play at least some role at the global markets. Accordingly, from Figure 6d we observe that, until 2011, European stock markets were more prone to the spillovers from Japan's stocks than from the US stock market. However, starting in 2011, the spillovers were quite similar for all countries.

Figure 4. Directional spillovers from the US, the Euro area, the UK and the Japanese bond markets to each of the other country's stock market



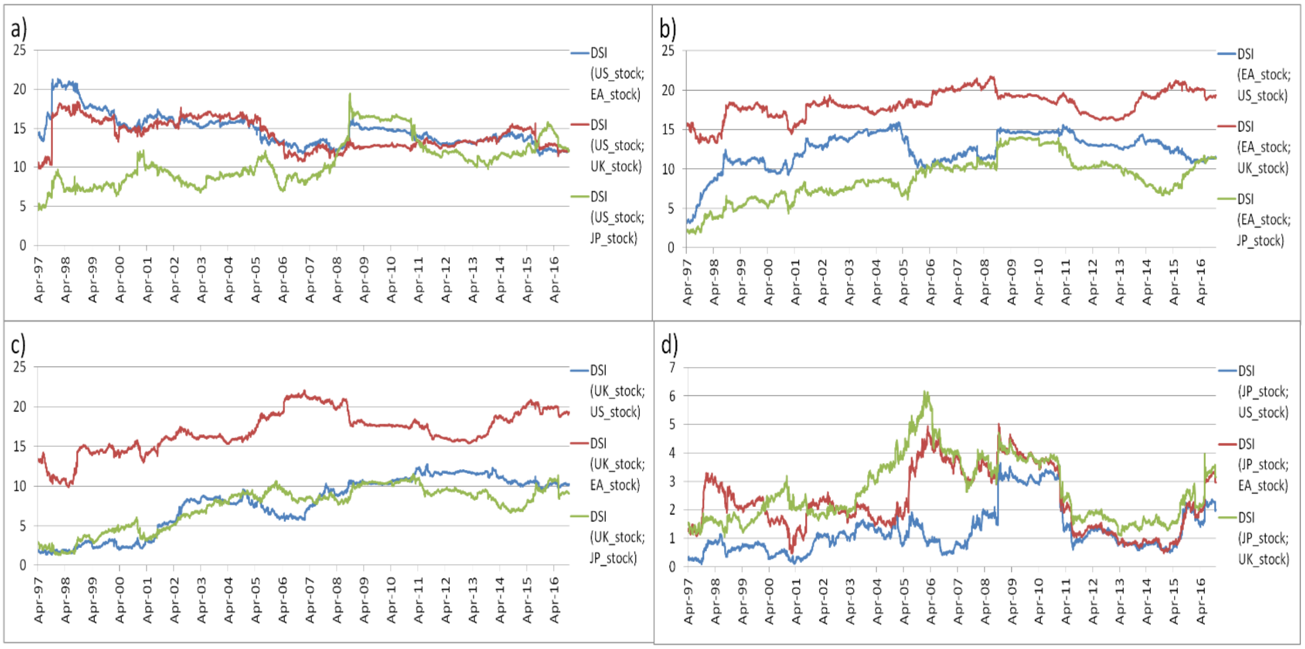
Source: Own estimations. Panel (a) refers to the US, panel (b) to the Euro area, panel (c) to the UK and panel (d) to Japan.

Figure 5. Directional spillovers from the US, the Euro area, the UK and the Japanese stock markets to each of the other country's bond market



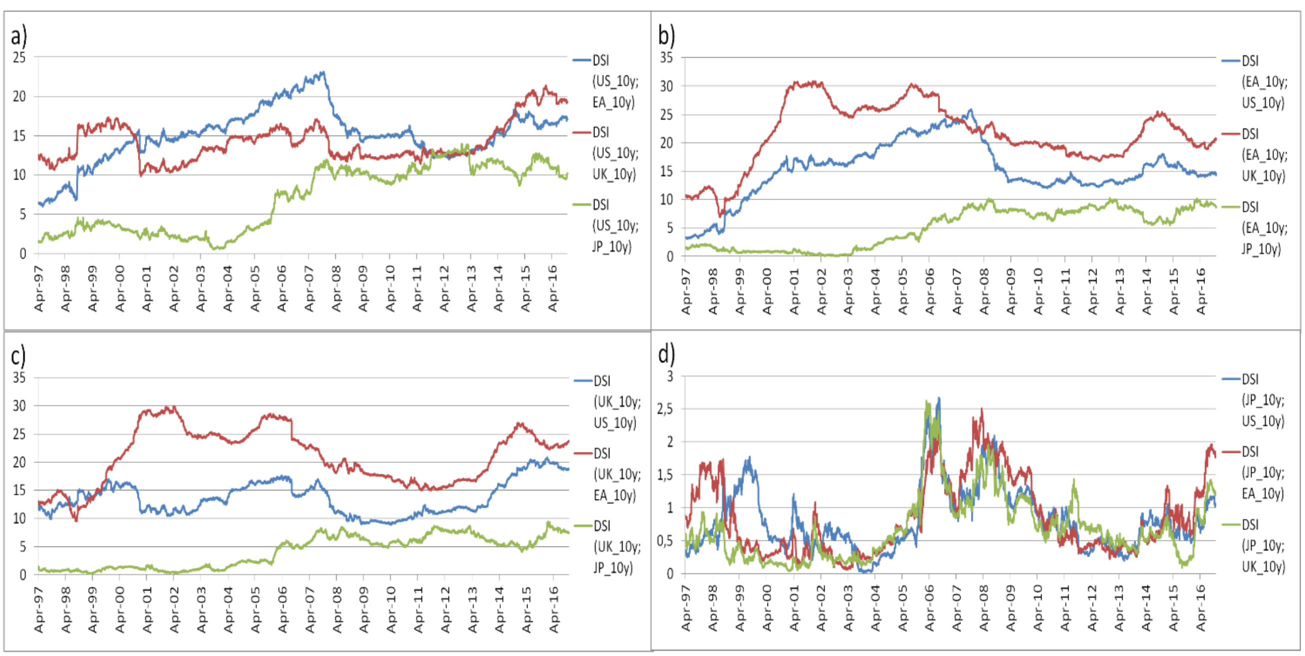
Source: own estimations. Panel (a) refers to the US, panel (b) to the Euro area, panel (c) to the UK and panel (d) to Japan.

Figure 6. Directional spillovers from the US, the Euro area, the UK and the Japanese stock markets to the stock markets of other countries



Source: own estimations. Panel (a) refers to the US, panel (b) to the Euro area, panel (c) to the UK and panel (d) to Japan.

Figure 7. Directional spillovers from the US, the Euro area, the UK and the Japanese bond markets to bond markets of the other countries



Source: own estimations. Panel (a) refers to the US, panel (b) to the Euro area, panel (c) to the UK and panel (d) to Japan.

Taken together, we feel legitimized to conclude that the bond and equity markets in the four systemic countries are indeed connected in a rather complex way, with the US markets as something like the dominant "gravitation center". Moreover, the structure of these connections shows significant time variation which follows a distinct pattern. Hence, our results contribute to that recent strand of the literature which advocates the presence of time variation in the financial spillovers' patterns.[4]

5. Robustness checks

We conducted a number of robustness tests in order to check whether our results are sensitive to the model specification and the choice of model parameters[5].

In our baseline model presented above we have included international bond and equity variables and analyzed linkages between and within countries. One important question arises with respect to the role of the money markets (i.e. policy rates) and foreign exchange markets (i.e. exchange rates) for the obtained relationships. However, the additional inclusion of associated variables in the model poses a number of challenges.

First, in the environment in which the policy interest rates are constrained by the zero lower bound and unconventional measures are implemented by the major central banks, the levels and changes of policy interest rates or short-maturity interest rates do no longer provide a complete and coherent measure of monetary policy and its shocks (Claus, Claus and Krippner, 2016). From an econometric point of view, the inclusion of the levels and/or changes of policy interest rates or short-maturity money market rates are also not desirable due to their recently very low variations. The latter could lead to difficulties in the interpretation of the results. In order to tackle, at least partially, these issues we have applied shadow short-term rates (SSRs) for the US, the Eurozone, the UK and Japan, which are taken from the research of Leo Krippner and can be

[4] See, for instance, Barunik, Kočenda and Vácha (2016). The results with respect to the dynamics of directional spillovers from the common shocks (i.e. from oil prices, developments in emerging markets and VIX index) to bond and equity markets are available upon request.

[5] The robustness tests for different choices of parameters were plausible. The results are available upon request.

downloaded from the Reserve Bank of New Zealand website[6]. The SSRs have become a popular and intuitive indicator of the stance of monetary policy across the conventional and the unconventional environment (see e.g. Krippner, 2013, and Wu and Xia, 2016). Shadow rates are usually equal to the policy interest rate in non-lower bound/conventional monetary policy environments, but can freely evolve to negative values in lower bound/unconventional monetary policy environments to indicate an overall stance of policy that is more accommodative than a near-zero policy rate alone.

The SSRs used here are estimated from yield curve data, and, thus, naturally by construction, we expect high spillovers among these synthetic measures of monetary policy stance and bond yields. One should also be cautious with the interpretation of the spillovers associated with the money markets, since the negative values of SSRs do not represent interest rates at which economic agents transact in reality. Therefore, the levels and changes in SSRs when they are negative should not necessarily be expected to influence the economy and financial markets in the same way as policy rate levels and changes in conventional policy periods (Krippner, 2016).

Despite of the aforementioned caveats we still believe that the inclusion of such monetary policy measures is a useful exercise to check the sensitivity of the spillovers in international bond and equity markets obtained in section 4, not least with an eye on the fact that they are widely used. From Table 2 we indeed see that the additional inclusion of money markets, represented by shadow short-term interest rates, do not disturb the relationships between international bond and equity markets.

[6] Data is available online at http://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures.

Table 2. Spillover model with shadow short-term interest rates

	US_10y	US_stock	EA_10y	EA_stock	UK_10y	UK_stock	JP_10y	JP_stock	VIX	MSCI_EM	OIL	SSR_US	SSR_EA	SSR_UK	SSR_JP	From Others
US_10y	35.39	3.01	9.74	2.99	9.56	2.43	0.26	0.38	1.77	1.9	0.62	21.74	6.91	3.29	0.01	64.6
US_stock	2.99	35.71	1.52	13.65	1.1	8.99	0.11	0.97	19.64	9.26	1.11	2.25	1.87	0.79	0.05	64.3
EA_10y	11.3	1.55	36.05	2.99	16.15	2.57	0.33	0.41	1.15	1.55	0.33	6.66	13.8	5.13	0.02	64
EA_stock	2.91	14.73	2.58	31.33	2.21	17.54	0.11	1.8	9.66	10.08	1.02	2.17	2.51	1.31	0.03	68.7
UK_10y	10.95	1.19	16.06	2.59	36.5	2.32	0.24	0.4	0.84	1.5	0.31	6.47	10.69	9.9	0.04	63.5
UK_stock	2.67	12.56	2.34	18.32	2.07	32.01	0.15	2.07	9.44	11.85	1.25	1.94	2.2	1.1	0.05	68
JP_10y	4.22	1.01	2.49	1.01	2.11	0.86	75.88	2.94	0.73	1.07	0.04	3.43	1.84	0.87	1.49	24.1
JP_stock	2.1	11.82	1.46	9.23	1.24	7.75	1.65	43.05	7.58	9.61	0.67	1.75	1.25	0.65	0.19	56.9
VIX	2.37	20.37	1.61	10.91	1.19	8.31	0.03	0.88	40.72	8.2	0.76	2.24	1.41	0.91	0.1	59.3
MSCI_EM	2.22	14.5	1.56	12.21	1.39	12.81	0.29	4.77	10.02	34.11	1.96	1.59	1.56	0.99	0.01	65.9
OIL	1.39	2.61	0.68	2.67	0.69	3.15	0.1	0.5	1.82	4.24	80.37	0.46	0.93	0.35	0.03	19.6
SSR_US	22.63	2.18	6.62	2.33	6.52	1.85	0.23	0.3	1.76	1.35	0.2	41.71	6.87	5.42	0.02	58.3
SSR_EA	8.67	2.21	12.37	2.46	9.68	2.48	0.27	0.27	1.05	1.74	0.5	8.46	41.48	8.31	0.06	58.5
SSR_UK	6.28	1.93	6.29	2.33	11.46	1.75	0.13	0.3	1.13	1.74	0.42	8.81	10.01	47.24	0.18	52.8
SSR_JP	0.69	0.35	0.45	0.29	0.69	0.27	4.83	0.35	0.34	0.16	0.03	1.66	2.25	1.06	86.57	13.4
Contribution to others	81.4	90	65.8	84	66.1	73.1	8.7	16.4	66.9	64.2	9.2	69.6	64.1	40.1	2.3	801.9
Contribution including own	116.8	125.7	101.8	115.3	102.6	105.1	84.6	59.4	107.7	98.4	89.6	111.4	105.6	87.3	88.8	53.50%

The second issue arises with respect to controlling for the developments in foreign exchange markets. We have decided to include the nominal effective exchange rates (NEERs) for all countries under consideration in order to control the developments in the foreign exchange markets[7]. Although the interpretation of the spillovers associated with the NEERs is not an easy task, it is still worth to check whether the inclusion of exchange rate measures distorts the linkages between bond and equity markets within and between countries estimated in section 4. Table 3 finally presents our spillover results for the model extended by NEERs. Our results obtained in section 4 are shown to be not sensitive to the inclusion of exchange rate measures.

Table 3. Spillover model with nominal effective exchange rates

[7] Additionally, we estimated an alternative specification including bilateral USD/EUR, USD/GBP, USD/JPY exchange rates. Using bilateral instead of nominal effective exchange rates, our main results do not change: 1) the linkages obtained from the basic specification (Table 1) are preserved; 2) bilateral exchange rates as well as NEERs have very limited contribution to the financial shocks spillovers in the countries under consideration. The latter finding is not in line with the results of Ehrmann, Fratzscher and Rigobon (2011) for the role of bilateral exchange rates for US-Euro area financial spillovers. Thus, we went a step further and estimated our model only until 2008, as in Ehrmann, Fratzscher and Rigobon (2011). Interestingly, estimated on the pre-crisis period, our model indeed indicates existence of much more notable spillovers to bond and stocks returns from the foreign exchange market. Hence we can conclude that the foreign exchange transmission channel has significantly weakened in the recent (after GFC) times, which is a quite innovative observation and should be scrutinized further by future research. The estimation results for the model specification with included dominant bilateral exchange rates are presented in the Appendix, Table A.1 (for the whole sample) and Table A.2 (for the sample until 2008).

	US_10y	US_stock	EA_10y	EA_stock	UK_10y	UK_stock	JP_10y	JP_stock	VIX	MSCI_EM	OIL	NEER_US	NEER_EA	NEER_UK	NEER_JP	From Others
US_10y	50.52	4.38	13.77	4.29	13.65	3.5	0.38	0.58	2.66	2.69	0.88	0.11	0.39	0.17	2.04	49.5
US_stock	3.08	36.16	1.53	13.93	1.16	9.24	0.11	0.97	19.89	9.34	1.11	1.18	0.15	0.17	1.97	63.8
EA_10y	14.89	2.06	47.76	3.92	21.24	3.33	0.45	0.58	1.49	1.96	0.47	0.33	0.08	0.06	1.39	52.2
EA_stock	2.95	14.93	2.58	31.63	2.23	17.81	0.11	1.84	9.79	10.32	1.03	1.09	0.76	0.16	2.78	68.4
UK_10y	14.7	1.66	21.36	3.47	48.9	3.09	0.31	0.59	1.16	1.98	0.43	0.28	0.1	0.56	1.4	51.1
UK_stock	2.66	12.61	2.29	18.37	2.04	31.95	0.15	2.14	9.46	11.99	1.26	2.1	0.11	0.1	2.77	68.1
JP_10y	4.63	1.11	2.72	1.09	2.27	0.96	81.42	3.15	0.84	1.19	0.05	0.04	0.2	0.04	0.29	18.6
JP_stock	2.22	11.74	1.47	9.25	1.3	7.86	1.62	42.34	7.6	9.61	0.64	0.68	0.18	0.17	3.3	57.7
VIX	2.42	20.39	1.6	10.92	1.14	8.37	0.05	0.91	41.23	8.13	0.81	1.22	0.44	0.01	2.36	58.8
MSCI_EM	2.1	13.72	1.43	11.78	1.31	12.39	0.29	4.65	9.4	32.45	1.89	6.44	0.01	0.06	2.09	67.5
OIL	1.33	2.49	0.69	2.55	0.66	3.05	0.1	0.48	1.8	4.09	77.28	4.1	0.2	0.19	1	22.7
NEER_US	0.17	3.5	0.36	2.17	0.33	3.69	0.04	0.63	1.99	10.79	3.13	55.59	15.94	0.1	1.55	44.4
NEER_EA	0.75	0.27	0.07	1.71	0.15	0.26	0.17	0.23	0.53	0.05	0.16	20.68	71.17	3.5	0.31	28.8
NEER_UK	0.3	0.48	0.11	0.48	1.2	0.24	0.15	0.33	0.31	0.28	0.24	0.15	4.34	89.44	1.97	10.6
NEER_JP	3.31	4.27	1.87	5.63	1.88	5.46	0.03	2.28	3.6	4.25	0.83	1.82	0.16	1.37	63.25	36.7
Contribution to others	55.5	93.6	51.9	89.6	50.6	79.2	3.9	19.3	70.5	76.7	12.9	40.2	23.1	6.7	25.2	698.9
Contribution including own	106	129.8	99.6	121.2	99.5	111.2	85.4	61.7	111.8	109.1	90.2	95.8	94.2	96.1	88.5	46.60%

6. Conclusions

In this paper we have estimated the financial transmission between bond and equity markets within and between across the four largest global financial markets. Understanding the complexity of the financial transmission process across various assets required the simultaneous modeling of the various transmission channels in a single, comprehensive empirical framework. For this purpose, we applied identification through generalized forecast error variance decompositions to estimate spillovers across four systemic markets in industrialized countries within a Vector Autoregression (VAR) framework.

We find that asset prices react strongest to international shocks within the same asset class, but there are also substantial international spillovers across asset classes. The US turn out to be dominant in a sense that, ceteris paribus, spillovers from the US are larger than spillovers received from outside. In that way, we corroborate the findings of leading research in the field. Our rolling estimations analysis provides evidence that global asset markets have become more integrated over time and, as a somewhat innovative result, that the linkages do not stay constant over time.

One striking finding is that, despite we do not see systematically larger spillovers after the GFC or the European debt crisis *within* the same asset classes, we do observe the increase of spillovers *across* bond and stock markets in the US, the Euro area and the UK from the end of 2007 to the start of 2014. This pattern has not been found as clearly in the previous literature and will certainly be part of future research, in terms of identifying economic or political reasons behind this striking pattern.

Moreover, our results were robust to the inclusion of monetary policy stance measures, as well as to the incorporation of foreign exchange markets.

In terms of policy conclusions, our estimates at least give some hints at potential contagion channels and, hence, transmission of financial instability. They thus have a bearing on the construction of financial stability safety nets which take account international spillovers. If, for instance, central banks are constrained in their ability to control domestic long-term interest rates, the whole arsenal of macro-prudential policies may to be used to try to control domestic credit creation and safeguard long-term financial stability. In that context, Bernoth and Koenig (2016) note correspondingly: “US monetary policy may be a key determinant of the global financial cycle (the co-movement of asset prices, credit creation and cross-border capital flows). As US banks hold a sizeable portion of cross-border claims against the Euro area, a tighter US monetary policy may induce a retrenchment in cross-border funding. This may counteract the ECB’s efforts to sustain ample funding conditions in Euro area economies“.

However, we do not at all think that our results per se can be used as arguments in favor of more (monetary, financial etc.) policy coordination. It is true that economic theory suggests that the justification for policy coordination is heavily linked to the existence of cross-border spillover effects. And the strength of such cross-border effects depends on the amount of economic ties, linkages, and the institutional framework – an important relation which is open to further research.

So what are the factors amplifying or mitigating financial spillovers? Various conditions influence the propagation of national shocks which can either intensify or diminish spillover effects. Apparently a high degree of trade openness might further increase cross-border effects. Nominal and real rigidities also affect the amplitude and persistence of spillover effects, as well as the adjustment to shocks. The extent of financial cross-border effects depends on a large variety of factors, such as "the degree of international portfolio diversification, the degree of prevailing risk aversion, the size and activity of multinational banks, access to funding, the degree of financial market integration and the nature of financial market regulations" (European Commission, 2014). Furthermore, the governance structure, the fiscal and monetary policy regime (continuity, in particular, and the existence or absence of supranational risk sharing mechanisms) are shown to play a crucial role. Even distance and common language are sometimes mentioned in this regard (Belke and Osowski, 2016).

But it is the existence of large externalities which in addition have to be identified as non-pecuniary which in theory may provide a rationale for any coordination. A necessary but not at all sufficient condition for the latter anyway is a thorough quantification of spillovers as conducted in our paper.

References

Barunik, J., Kočenda, E., and Vácha, L. (2016), Asymmetric Connectedness of Stocks: Bad and Good Volatility Spillovers, Journal of Financial Markets 27, pp. 55-78.

Bayoumi, T. and Bui, T. (2012), Global Bonding: Do U.S. Bond and Equity Spillovers Dominate Global Financial Markets?, IMF Working Paper No. 12/298, International Monetary Fund, Washington/DC.

Bekaert, G., Cho, S., and Moreno, A. (2010), New Keynesian Macroeconomics and the Term Structure, Journal of Money, Credit and Banking 42(1), pp. 33- 62.

Beirne, J. and Gieck, J. (2014), Interdependence and Contagion in Global Asset Markets. Review of International Economics 22, pp. 639–659.

Belke, A., Beckmann, J. and Czudaj, R. (2014), The Importance of Global Shocks for National Policymakers – Rising Challenges for Sustainable Monetary Policies, in: The World Economy 37/8, pp. 1101-1127.

Belke, A. and Osowski, T. (2016), Measuring Fiscal Spillovers in EMU and Beyond: A Global VAR Approach, CEPS Working Document, No. 428, Centre for European Policy Studies, Brussels, December.

Belke, A., Gros, D. and Osowski, T. (2017), The Effectiveness of the Fed's Quantitative Easing Policy: New Evidence Based on Interest Rate Differentials, Journal of International Money and Finance 73, pp. 335-349..

Belke, A. and Rees, A. (2014), Globalisation and Monetary Policy – A FAVAR Analysis for the G7 and the Euro Area, in: North American Journal of Economics and Finance 29, pp. 306–321.

Bernoth, K. and König, P.J. (2016), Implications for the Euro Area of Divergent Monetary Policy Stances by the Fed and the ECB – The Role of Financial Spillovers, in: http://www.europarl.europa.eu/RegData/etudes/IDAN/2016/569993/IPOL_IDA(2016)569993_EN.pdf.

Buitron, C.0. and Vesperoni, E. (2015), Spillover Implications of Differences in Monetary Conditions in the United States and in the Euro Area, Spillover Taskforce, International Monetary Fund, Washington/DC, July.

Caceres, C., Carriere-Swallow, J. and Grus, B. (2016), Global Financial Conditions and Monetary Policy Autonomy, IMF Working Paper No. 16/108, International Monetary Fund, Washington/DC.

Claus, E., Claus, I. and Krippner, L. (2016), Monetary Policy Spillovers across the Pacific When Interest Rates are at the Zero Lower Bound, Reserve Bank of New Zealand Discussion Papers, DP 2016/08.

Chinn, M. and Frankel, J. A. (2003), The Euro Area and World Interest Rates, Santa Cruz Department of Economics, Working Paper Series 1031, Department of Economics, UC Santa Cruz.

Dees, S., Mauro, F., Pesaran, M. H. and Smith, L.V. (2007), Exploring the International Linkages of the Euro Area: A Global VAR Analysis, Journal of Applied Econometrics 22 (2007), pp. 1–38

Diebold, F.X. and Yilmaz, K. (2009), Measuring Financial Asset Return and Volatility Spillovers, with Application to Global Equity Markets, Economic Journal 119, pp. 158–171.

Diebold, F.X. and Yilmaz, K. (2012), Better to Give Than to Receive: Predictive Directional Measurement of Volatility Spillovers, International Journal of Forecasting 28(1), pp. 57–66.

Ehrmann, M., Fratzscher, M. and Rigobon, R. (2011), Stocks, Bonds, Money Markets and Exchange Rates: Measuring International Financial Transmission. Journal of Applied Econometrics 26, pp. 948–974.

Eijffinger, S. (2008), How Much Inevitable US-Euro Area Interdependence Is There in Monetary Policy?, Intereconomics 43/6, pp. 341–348.

European Commission (2014), Quarterly Report on the Euro Area 13(4), Brussels.

Hájek, J. and Horváth, R. (2016), The Spillover Effect of Euro Area on Central and Southeastern European Economies: A Global VAR Approach, Open Economies Review 27, pp. 359-358.

Horváth, R. (2016), Divergent Monetary Policies of the US Federal Reserve and the ECB: Implications for the Euro Area - https://polcms.secure.europarl.europa.eu/cmsdata/upload/4b6c6540-3727-4874-b761-e2ee0f05b950/CASE_FINAL.pdf

IMF (2014), IMF Multilateral Policy Issues Report, 2014 Spillover Report, International Monetary Fund, Washington/DC.

Krippner, L. (2013), Measuring the Stance of Monetary Policy in Zero Lower Bound Environments. Economics Letters 118(1), pp. 135-138.

Krippner, L. (2016), Documentation of Measures of Monetary Policy, 13 July, http://www.rbnz.govt.nz/-

/media/ReserveBank/Files/Publications/Research/Additional%20research/Leo%20Krippner/5892888.pdf?la=en).

Louzis, D.P. (2013), Measuring Return and Volatility Spillovers in Euro area Financial Markets, Working Papers 154, Bank of Greece, Athens.

Miranda-Agrippino, S. and Rey, H. (2015), World Asset Markets and the Global Financial Cycle, NBER Working Papers 21722, National Bureau of Economic Research, Cambridge/MA.

Raddant, M., and Kenett, D.Y. (2016), Interconnectedness in the Global Financial Market, OFR Working Paper 16-09, Office of Financial Research, September.

Rigobon, R. and Sack, B. (2003), Measuring the Reaction of Monetary Policy to the Stock Market, Quarterly Journal of Economics 118 (2), pp. 639-669.

Wu, J. and Xia, F. (2016), Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. Journal of Money, Credit and Banking 48 (2-3), pp. 253–291.

APPENDIX

Table A.1 Model with included dominant bilateral exchange rates

	US_10y	US_stock	EA_10y	EA_stock	UK_10y	UK_stock	JP_10y	JP_stock	VIX	MSCI_EM	OIL	USD_EUR	USD_GBP	USD_JPY	From Others
US_10y	51.81	4.46	14.12	4.42	14.05	3.61	0.39	0.56	2.72	2.76	0.9	0.07	0.05	0.08	48.2
US_stock	3.17	37.32	1.57	14.34	1.19	9.46	0.11	1.03	20.54	9.69	1.15	0.06	0.35	0.03	62.7
EA_10y	15.11	2.07	48.47	3.97	21.6	3.39	0.45	0.56	1.51	2.03	0.47	0.13	0.19	0.06	51.5
EA_stock	3.1	15.62	2.7	33.17	2.35	18.67	0.11	1.91	10.27	10.78	1.07	0.06	0.2	0	66.8
UK_10y	14.98	1.68	21.75	3.54	49.68	3.17	0.31	0.56	1.19	2.03	0.42	0.02	0.55	0.12	50.3
UK_stock	2.8	13.12	2.4	19.19	2.15	33.37	0.16	2.2	9.87	12.5	1.31	0.23	0.7	0.02	66.6
JP_10y	4.64	1.11	2.7	1.1	2.26	0.96	81.87	3.12	0.82	1.15	0.05	0.13	0.04	0.05	18.1
JP_stock	2.25	12.29	1.48	9.58	1.3	8.09	1.67	44.21	7.92	9.88	0.68	0.05	0.28	0.32	55.8
VIX	2.44	21.34	1.66	11.34	1.19	8.61	0.05	0.95	43	8.51	0.84	0	0.07	0	57
MSCI_EM	2.22	14.66	1.55	12.46	1.4	13.1	0.29	4.85	10.08	34.52	2	1.14	1.67	0.07	65.5
OIL	1.36	2.58	0.7	2.61	0.66	3.11	0.1	0.49	1.85	4.18	79.32	1.34	1.63	0.07	20.7
USD_EUR	0.32	0.18	0.13	0.12	0.03	0.42	0.14	0.12	0.02	2.11	1.17	68.42	26.81	0.03	31.6
USD_GBP	0.09	1.05	0.24	0.39	0.77	1.26	0.03	0.45	0.47	3.22	1.38	25.51	65.08	0.06	34.9
USD_JPY	3.36	2.72	1.57	4.7	1.62	3.68	0.06	2.07	2.63	1.11	0.21	6.91	1.65	67.72	32.3
Contribution to others	55.8	92.9	52.6	87.7	50.6	77.5	3.9	18.9	69.9	70	11.7	35.6	34.2	0.9	662
Contribution including own	107.6	130.2	101	120.9	100.2	110.9	85.7	63.1	112.9	104.5	91	104.1	99.3	68.6	47.30%

Source: own estimations.

Table A.2 Model with included dominant bilateral exchange rates, the sample until 2008

	US_10y	US_stock	EA_10y	EA_stock	UK_10y	UK_stock	JP_10y	JP_stock	VIX	MSCI_EM	OIL	USD_EUR	USD_GBP	USD_JPY	From Others
US_10y	52.03	3.21	19.47	3.36	13.5	1.86	0.33	0.36	1.53	1.1	0.03	1.99	1.17	0.05	48
US_stock	2.57	42.38	1.11	14.2	0.59	6.24	0.22	0.82	24.05	6.78	0.03	0.71	0.21	0.09	57.6
EA_10y	17.08	1.23	43.56	3.5	25.21	2.05	0.37	0.52	0.73	0.94	0.17	3.06	1.47	0.1	56.4
EA_stock	2.63	15.78	3.09	36.23	2.1	15.67	0.16	1.81	10.24	7.48	0.05	2.96	1.65	0.16	63.8
UK_10y	13.45	0.96	27.75	2.68	47.81	1.91	0.25	0.4	0.75	1.01	0.28	2	0.56	0.19	52.2
UK_stock	1.91	13.43	1.87	17.43	1.49	37.26	0.31	2.51	10.81	11.53	0.14	0.7	0.55	0.05	62.7
JP_10y	3.43	1.47	2.3	1.08	1.78	1.27	80.67	3.68	1.37	1.73	0.12	0.62	0.32	0.17	19.3
JP_stock	1.32	9.67	1.28	7.95	0.87	6.65	2.2	51.32	6.96	10.55	0.09	0.44	0.24	0.46	48.7
VIX	1.89	25.24	0.78	10.42	0.69	6.85	0.01	0.35	47.16	4.96	0.25	0.64	0.68	0.07	52.8
MSCI_EM	0.99	15.09	0.68	10.88	0.65	12.73	0.6	5.79	12.55	39.38	0.2	0.09	0.16	0.2	60.6
OIL	0.21	0.39	0.06	0.24	0.39	0.17	0.14	0.13	0.77	0.38	96.3	0.26	0.38	0.17	3.7
USD_EUR	2.75	0.94	3.95	4.41	2.36	1.13	0.17	0.38	0.54	0.16	0.16	55.9	27.12	0.02	44.1
USD_GBP	1.75	0.4	2.09	2.67	0.82	0.83	0.08	0.23	0.44	0.34	0.09	29.48	60.74	0.06	39.3
USD_JPY	2.22	1.09	1.9	2.3	1.59	1.06	0.49	0.18	1.16	0.09	0.63	8.13	6.69	72.47	27.5
Contribution to others	52.2	88.9	66.3	81.1	52	58.4	5.3	17.2	71.9	47	2.2	51.1	41.2	1.8	636.8
Contribution including own	104.2	131.3	109.9	117.4	99.8	95.7	86	68.5	119.1	86.4	98.5	107	101.9	74.3	45.50%

Source: own estimations.