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Global Bonding: Do U.S. Bond and Equity Spillovers Dominate Global Financial Markets?

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Global Bonding: Do U.S. Bond and Equity Spillovers Dominate Global Financial Markets?

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Abstract

This paper uses a novel variant of identification through hetroscedacity to estimate spillovers across U.S., Euro area, Japanese, and UK government bond and equity markets in a vector autoregression. The results suggest that U.S. financial shocks reverberate around the world much more strongly than shocks from other regions, including the Euro area, while inward spillovers to the U.S. from elsewhere are minimal. There is also evidence of two-way spillovers between the UK and Euro area financial markets and spillovers from Europe to Japan. The results also suggest that the uncertainty about the direction of causality of contemporaneous correlations—an issue that other techniques cannot tackle—is the dominant source of uncertainty in the estimated impulse response functions.

JEL Classification Numbers: C13, C32, F30, G15

Keywords: Identification, international financial linkages

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I. INTRODUCTION

The recent global crisis has highlighted the importance of financial linkages as the major conduit of spillovers from one economy to the others, particularly among the advanced market countries.[1] The financial meltdown originating in the U.S. mortgage markets reverberated around the world, and led to the deep retrenchment of the world financial markets and the largest global recession in living memory. More recently, problems in the Euro area have again led to global financial volatility although the process was less abrupt. Hence, while the crisis confirmed the global importance of U.S. financial shocks, the broader linkages among other advanced financial markets are less documented. In particular, does a similar size of shock to the Euro Area financial markets hit the U.S. and rest of the countries with the same ferocity as the Lehman one did?

It is a challenge both economically and econometrically to identify these spillovers using time series techniques. Price movements across world financial markets, including bonds and equities, are highly contemporaneously correlated using daily or even higher frequency data. The vector autoregression (VAR) technique has been commonly used to analyze these cross-border linkages. However, the widely used Cholesky decomposition assumes the direction of contemporaneous causality. Hence, it cannot be used to independently identify causal relationships across asset markets whose comovements are so large, and hence accurately identify the size of spillovers.

This paper studies the interconnectedness among systemic markets using the structural VAR framework which directly estimates spillovers using an innovative extension of identification using heteroskedasticity. Under this approach, causation can be endogenously measured within a VAR framework by relating changes in relative variance of shocks across countries to changes in correlations of these shocks. Furthermore, the extension we propose allows us to estimate standard errors on the coefficients that define contemporaneous causality, and hence the likelihood such a relationship is statistically significant. Identifying causality across simultaneous price movements is important as, given that asset prices are close to random walks, these linkages turn out to be the main conduit for spillovers.

The next section of this paper provides some evidence of the high level of synchronization of changes in prices across the four largest global financial markets (the United States, the Euro area, Japan, and the United Kingdom). This is followed by the description of the identification procedure developed for this paper, which to our knowledge has never been used before. We then present and analyze our results and their implications.

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[1] IMF (2011a, 2011b, 2012).

II. DATA

We consider the four systemic equity and government bond markets that comprise the United States, Euro Area, Japan, and the United Kingdom, Japan, and the United States.[2] These four systemic markets are the most advanced and integrated financial markets representing the majority share of the world market capitalization. Figure 1 reports two measures of the relative importance of these markets. In terms of market capitalization, the UK is notable for having a smaller government bond market than the other three while the United States has a notably larger equity market capitalization than the others. However, when it comes to turnover—an alternate measure of the importance of the market in the global financial system—the United States is clearly dominant compared to the other three markets. In short, while it is clear that U.S. markets are important, the jury is still out on the relative importance of the other three markets.

To analyze the linkages between these four systemic financial markets, we study the returns on government long-term bonds and on equities. The former is defined as the change in yields and the latter as the change in price. Economic theory implies that both of these series should be close to random walks. For bonds, we use end-week data on changes in nominal yields of 10-year sovereign bonds of the U.S., Japan, the U.K., and Germany (as a proxy for the Euro area bonds—see Bayoumi and Swiston, 2010 for a discussion of the validity of this assumption). Bond yields are available from Haver Analytics. For equities, we use end-week returns of the following indices: EURO First 300 (excluding U.K.), FTSE 100, Nikkei 225, and S&P 500. Stock market indices are available from Datastream.[3]

The sample spans January 1st, 2000 to December 31st, 2009. With financial markets in flux, these dates were chosen with an eye to covering a period over which underlying relationships were likely to have remained fairly constant while underlying volatility (essential to our identification technique) changed. The decade of the 2000s strikes us as a reasonable period to choose, since it incorporates the relatively low financial volatility characteristic of much of the 2000s boom before the global crisis and the high volatility of crisis. Extending beyond 2009 is problematic as the Euro area crisis may have made German data a less good proxy for Euro area bond yields, complicating identification. That said, we do report results for the period 2000-07 (i.e., eliminating the crisis) and for 2000 to October 2012 (including the subsequent Euro area crisis) as robustness checks.

A weekly frequency was chosen for several reasons. It reduces the issue of the different opening and closing times across the day, an issue that makes inference using daily

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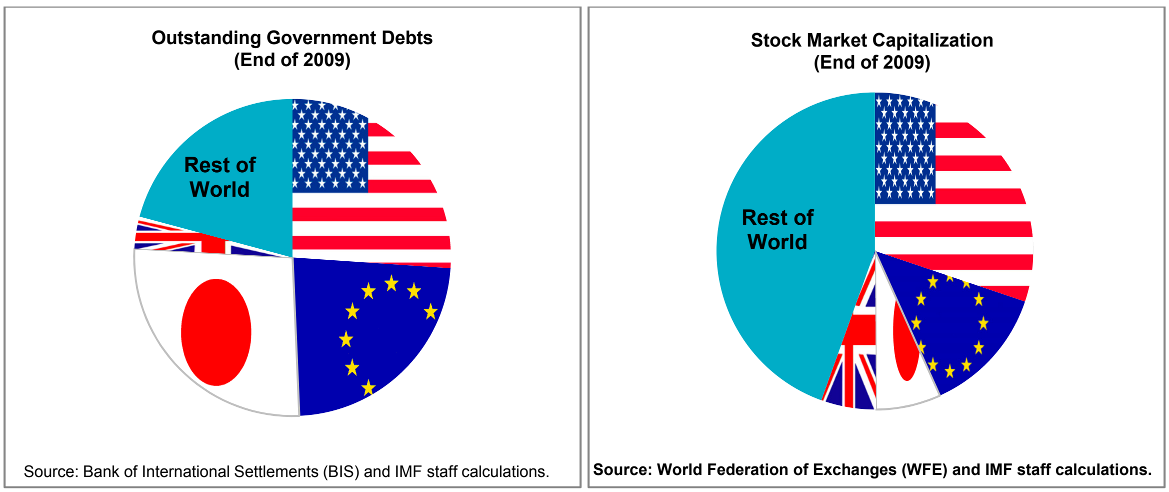
[2]IMF (2009) identifies five systemic economies including the Euro Area, the United Kingdom, Japan, the United States and China. China is left out of this study because of data availability in the earlier period of sample, its less integrated financial markets and stricter capital controls.

[3]Data are available upon request.

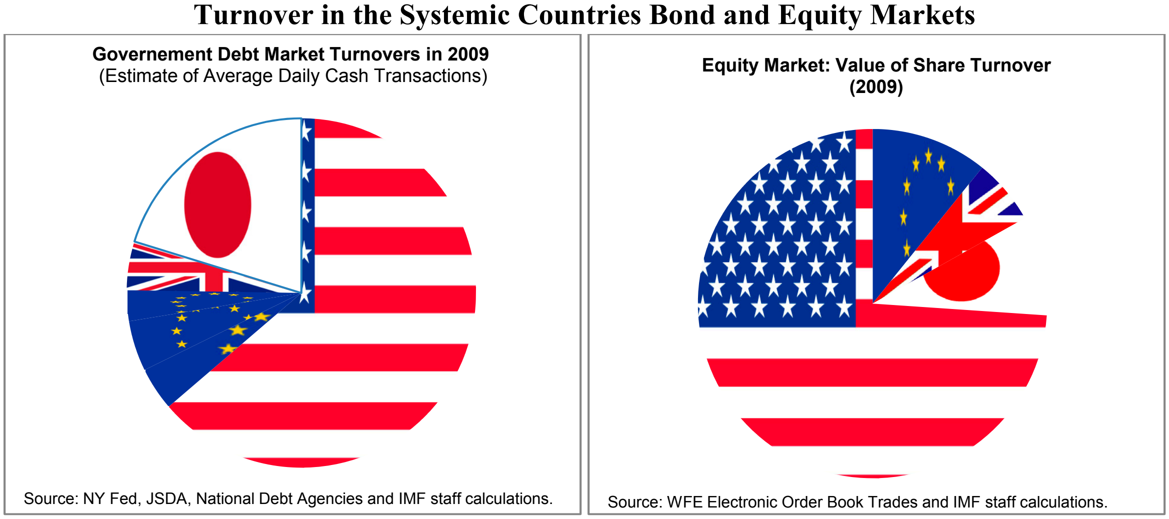
data tricky. It also allows us to study complete time series by minimizing the issue of missing data (holidays, market closings, etc.). Finally, it also seems to be the more relevant frequency for macroeconomic analysis since it allows responses to be measured over several weeks rather than several days.

Figure 1. Systemic Countries Financial Market Shares and Turnovers

Global Market Shares of the Systemic Countries

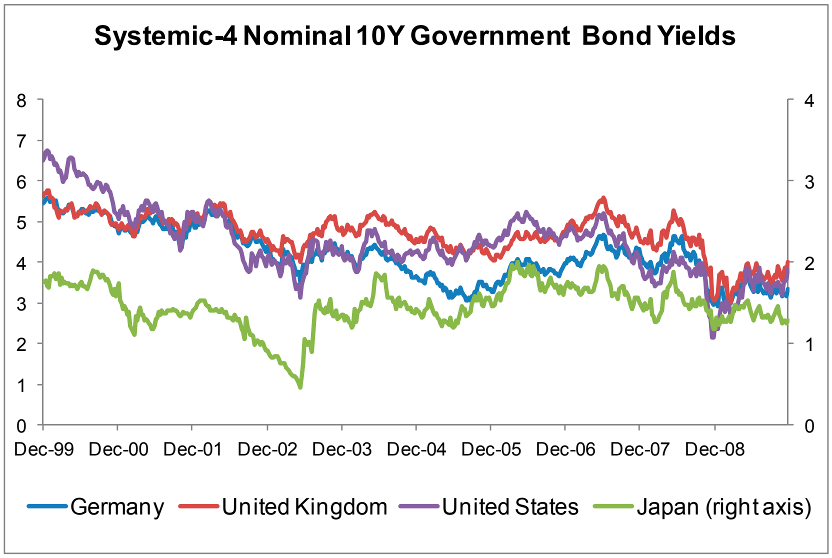


Turnover in the Systemic Countries Bond and Equity Markets



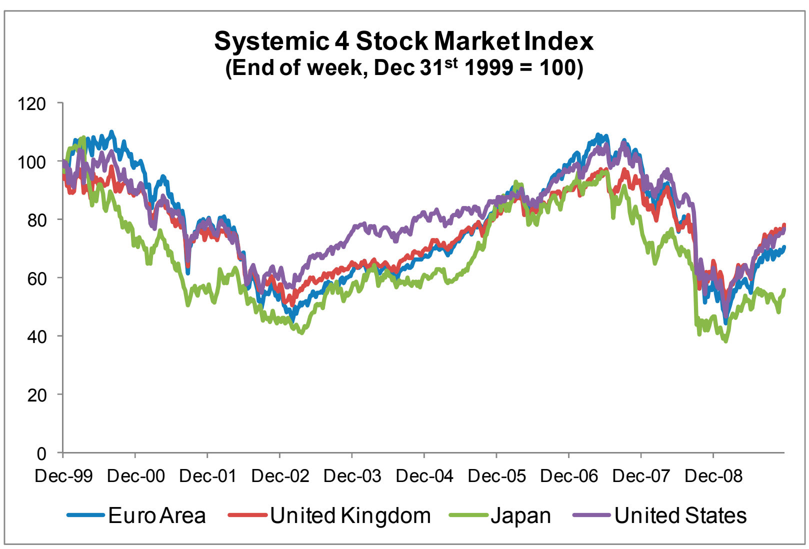
Turning to the data itself, returns are highly correlated across major markets, although lower with Japan than elsewhere. Figures 2 and 3 report the nominal yields of sovereign 10-year bonds and equity indices, respectively, for the four systemic countries. Government bond yields and equity prices comove closely over the sample, although Japanese bond market remains less integrated than the other three. Table 1 reports contemporaneous correlations of returns (the change in yields or prices) over the sample. As might be expected given the high integration of their economies, correlations are highest between the two European markets, the UK and the Euro area (0.83–0.92). But they are also high between the two European and U.S. markets (correlations vary from 0.71–0.83). Links between these three markets and Japan—while still notable—are lower (around 0.5 for equities and 0.3 for bonds). The key issue is to identify shocks in which markets drive these high correlations, which are often (and unhelpfully) simply attributed to unknown "common" factors.

Figure 2. Government 10-Year Nominal Bond Yields



Source: Haver Analytics

Figure 3. Normalized Weekly Equity Indexes (End of 1999 = 100)



Source: DataStream and IMF staff calculation

One area of contrast has been the reaction of bond and equity market volatility to the crisis. On the weekly basis, the volatility of bond yields has declined across the United States, Euro area and Japanese bonds after 2007, although this is partly offset by a three-fold increase in the United Kingdom. Equity returns volatility, however, has increased uniformly across markets post-2007. The S&P 500 volatility increases the most, by three-times, since the collapse of the U.S. housing market. These different patterns suggest that bond and equity markets contain significantly different periods of high and low volatility. Since this is crucial for our identification scheme, discussed in the next section, these differences add to the robustness of our results.

Table 1. Correlations of Weekly Systemic Countries Financial Asset Returns
(From the beginning of 2000 to the end of 2009)

		Equity returns			
		EUR	GBR	JPN	USA
Bond yields	EUR	.	**0.92**	**0.62**	**0.83**
	GBR	***0.83***	.	**0.58**	**0.81**
	JPN	***0.34***	***0.32***	.	**0.55**
	USA	***0.81***	***0.71***	***0.31***	.

III. Structural VAR Identification Methodology

We identify a structural model for systemic financial markets' linkages from an estimated reduced-form VAR. The identification method is along the line of Rigobon (2003) and Bayoumi and Bui (2010) which exploits the heteroskedasticity found in the data. Generally, a system of contemporaneous innovations can be modeled as $\varepsilon = Ae$, viz:[4]

$$A_{NxN}\begin{bmatrix} e_{1,t} \\ \vdots \\ e_{N,t} \end{bmatrix} = \begin{bmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{N,t} \end{bmatrix}$$

[4] Rigobon (2003) allows the inclusion of unobservable common shocks. In this paper, we assume there are no common shocks in the model. For simplicity, we do not present the corresponding formulas. See the original paper for more details.

Where the contemporaneous correlation *A* matrix typically has the following form:

$$A_{NxN} = \begin{bmatrix} 1 & a_{12} & \dots & a_{1N} \\ a_{21} & 1 & \dots & a_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ a_{N1} & a_{N2} & \dots & 1 \end{bmatrix}$$

The upper (or lower) triangular elements $a_{ij}(i < j)$ are not necessarily equal to zero. The vector of structural shocks ε_t is assumed to be contemporaneously independent across elements and serially uncorrelated; whereas the reduced-form VAR disturbance e_t (estimated by OLS) and is contemporaneously correlated.

A is the *nxn* matrix of coefficients representing the contemporaneous causal relations between the endogenous variables in the system. Identification of this matrix is of central interest because it contains important information regarding the contemporaneous transmission of shocks from one market to the other—a form of transmission that is particularly important across financial prices that often approximate a random walk. This matrix also allows us to calculate impulse responses of endogenous variables to orthogonal structural shocks $\varepsilon_t$and their respective variance decompositions.

There are a number of approaches used in the VAR literature to identify the matrix *A*. The most common approach involves the Cholesky decomposition, which assigns all of the correlations between orthogonal errors to the equation that is earliest in the ordering (i.e., assuming the *A* matrix is lower-triangular). The Cholesky decomposition, however, assumes causality rather than estimating it and hence depends on the ordering of the endogenous variables in the VAR.

As an alternative, Bayoumi and Swiston (2009) suggest a Bayesian-like procedure based on a weighted average of the Cholesky decompositions to provide a more nuanced view of the true value of the uncertainty of the impulse responses. Other approaches include exclusion restrictions and/or long-term restrictions to achieve identification—see, for example, Christiano, Eichenbaum, and Evans (1999) and Blanchard and Quah (1989). Alternatively, structural VARs can be identified using sign restrictions as in Uhlig (2005). Though better than a single Cholesky ordering, these alternative approaches are still subject to a number of additional assumptions and/or restrictions, which can be challenged.

By contrast, Rigobon (2003) proposes a far more flexible route to identification that relies only on heteroskedasticity. Identification of the structural transmissions in the model is achieved by exploiting the change (if any) in the variance of structural shocks implicit in the data. Heteroskedasticity is empirically well-known in financial asset return data.

Intuitively, identification through heteroskedasticity works in a similar fashion as the (probabilistic) instrument variable approach. The simplest intuition can be developed by looking at a special bivariate case. Assume that we can split the sample into two periods, in the second of which the variance of x_1 variable increases relative to the variance of x_2. At the same time, we observe an increase in the covariance between these two series. Everything else constant, this implies that it is shocks to x_1 that are driving the positive correlation with x_2.

In the general case, assuming there are *S* regimes of variability in the sample data. The model can be estimated by the generalized method of moments (GMM) where moment conditions are:

$$A\Omega_s A' = \Omega_{\varepsilon,s} \qquad s = \{1,2,..,S\}$$

With Ω_s and $\Omega_{\varepsilon,s}$ are the covariance matrices of the estimated reduced-form errors and the structural shocks in each regime *s*, respectively. In the absence of common shocks, Rigobon (2003) shows that only *TWO* regimes are required to achieve exact identification of matrix *A* irrespective of the number of endogenous variables, *N*.

A clear advantage of this approach is that it does not rely on a specific ordering of variables in the VAR. As such, identification through heteroskedasticity method is preferred for VAR analysis. It directly estimates rather than imposes the pattern of contemporaneous correlations between structural shocks. More importantly, Rigobon (2003) shows that the contemporaneous correlation matrix is still identified and its estimators are consistent even if heteroskedasticity is misspecified. In other words, this method is robust to either misspecification of the regime windows or under-specification of the number of regimes. Below we exploit this characteristic to calculate a series of consistent estimates of *A*, which can then be bootstrapped to calculate standard errors on the estimated coefficients in the *A* matrix.

Identification through heteroskedasticity requires users to distinguish “low” versus “high” regimes within the data sample. In Rigobon (2003), the historically recorded start and end dates of well-known crises were used to separate the data sample into crisis (i.e. high volatility) and tranquil (low) periods. In order to work with macroeconomic data, particularly the Great Moderation phenomenon, Bayoumi and Bui (2010) propose a “rolling-identification” procedure applying to the trend of decreasing volatility in industrialized economies’ output growth since the early 1980s.

In this paper, we propose an alternative way to identify high/low regimes using observed volatility. In order to assign a data period to either “low” or “high” volatility regime, we compare the period disturbances (of each variable) relative to their respective full-sample standard deviations.[5] If at least one of those ratios is higher than a pre-selected threshold, then we classify that period as the "high" regime. This procedure separates the sample into two collections of (discontinuous) periods defined as "low" and "high" regimes. This regime selection procedure is repeated for a range of thresholds between a reasonably chosen minimum and maximum with a small increment each time. By doing these steps, we effectively divide our sample into different combinations of low and high periods, yet still get consistent estimates of the structural coefficients. This selection procedure has the essence of Markov Switching (MS-) VAR models where the Markov switching property is confined only in the covariance of innovations.[6]

We apply the original Rigobon (2003) approach to each possible sample division, using the GMM method to generate a set of valid (unbiased) estimates for the contemporaneous correlation matrix. The procedure generates a set of estimated contemporaneous correlation A matrices, one for each possible division of the sample. The inverse of A is of particular interest because it contains information about contemporaneous correlations between structural shocks. Given the set of consistently estimated A matrices, we use a bootstrap procedure to estimate the inverse of the average A matrix as the mean of all of the inverses of A and calculate standard errors with respect to this average A-inverse matrix. In doing so, we normalize the leading diagonal of the A-inverse matrix to one so that the estimated non-diagonal coefficients reflect the size of spillovers elsewhere from a unit shock in any given country.

Using the consistent estimates of VAR coefficients and the average A matrix, we then calculate the impulse response functions of endogenous variables in the VAR to orthogonalized shocks ε. These can then be used to estimate the uncertainty around the impulse responses coming both from uncertainties around the coefficient estimates in the VAR (the usual confidence intervals reported for Cholesky decompositions) and from uncertainties around the estimates of the A-inverse matrix. As might be expected given that the series are highly contemporaneously correlated and approximate random walks, it turns out that the uncertainty over the A-inverse matrix—an estimate that is unique to our procedure—that dominates the empirical results.

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[5]For the purpose of estimation, we assume that there is no common shock in the model so that the model is identified with TWO regimes. The order condition is always satisfied and independent of number of exogenous variables. See Rigobon (2003) for detailed proofs and discussion.

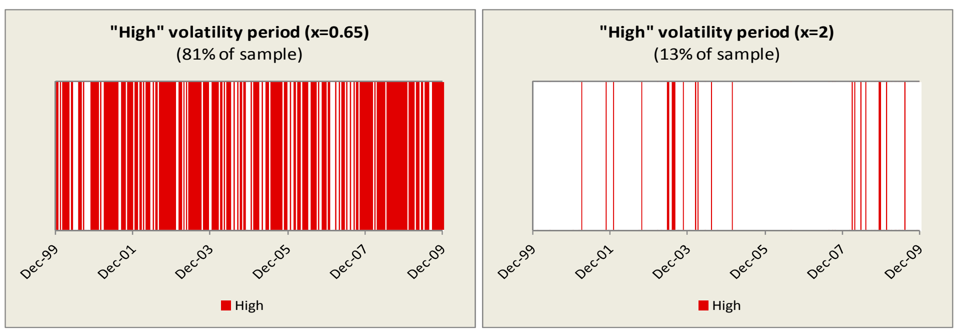
[6]This special feature of MS-VAR method is discussed and used in Lanne, Lütkepohl, and Maciejowska (2010).

IV. Empirical Estimates of Systemic Countries Financial Markets’ Linkages

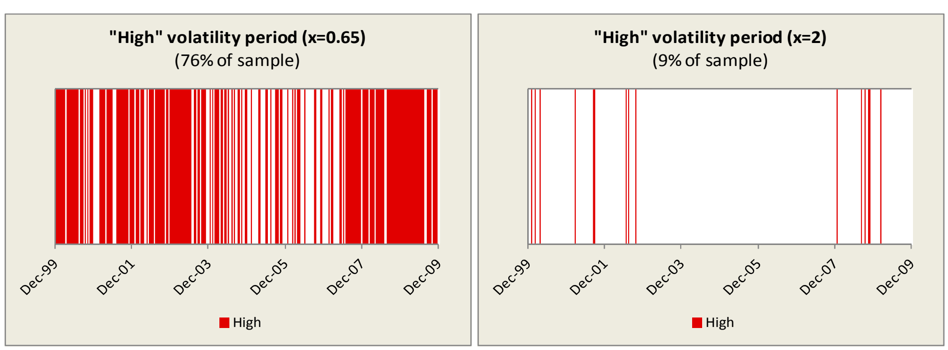
We use this approach to investigate linkages across the Euro area, the United Kingdom, Japan, the United States sovereign bond yields and equity prices. As our analysis focuses on the international linkages within each asset classes, we estimate separate VARs for bond and equity markets.[7] The VARs contain the first difference of weekly yields or prices of the corresponding markets. We choose lag length according to the Akaike information criteria, which indicated a lag of 1 and 2 weeks for equity and bond markets respectively. The estimated VAR residuals were tested for homoskedasticity, which is strongly rejected in both cases. As robustness checks, we also report results from a VAR with no lags—i.e., results assuming market prices are pure random walks—and for different samples. Common shocks are not included as the objective of the analysis is to identify which markets drive higher underlying correlations across markets.

Figure 4. High/Low Volatility Regimes at Min/Max Thresholds

Bond Markets



Equity Markets



[7] Ehrmann, Fratzscher, and Rigobon (2005) study both the intra- and inter- linkages between international asset markets. They find that the strongest cross-border financial spillovers between the U.S. and the euro area take places *within* asset classes and indirect spillovers across domestic markets can magnify these spillovers. Clearly, our technique could also be used to look at intra-market causality.

We apply our selection procedure on the reduced-form disturbances from the estimated VAR. Since the procedure already allows for differences in volatility by dividing residuals in each regression by the standard error of that regression, we use the same thresholds for both bond yields and equity returns. These range from a low of 0.65 of the standard error of the regression to a high of 2 times the standard error in increments of 0.05. At the minimum threshold around 80 percent of the sample is classified as high volatility regime, while at the maximum more like 10 percent is in this category (Figure 4). Note also that the periods of volatility and calm across these markets do appear to be significantly different. Both series show a pickup in volatility over the crisis, but in bond markets there was an earlier bout of instability in from mid-2003 to mid-2004 while in equity markets higher volatility was evident from 2000 through mid-2003. We first analyze the normalized *A*-inverse matrix, which contains information on contemporaneous spillovers across markets, then the impulse responses of bond yields and equity prices to orthogonal shocks originated in each country.

A. *A*-Inverse Matrix Estimates

Table 2 shows the estimated contemporaneous spillover coefficients between the four systemic bond markets. Standard errors are reported for off-diagonal coefficient and statistical significance is identified by the (*), (**), and (***) for the standard 10, 5, and 1 percent significant levels.[8] The matrix is constructed such that the coefficients in the first column show how much bond yields in other countries are increased by a 1 percent increase in the Euro Area bond yield. Across the rows, the coefficients show contemporaneous inward spillovers onto the corresponding-row country's bond yield from one percentage point shocks to other countries' yields.

The results emphasize the importance of spillovers from U.S. bond markets. All of the outward spillover coefficients from U.S. markets are over 0.5 and usually highly significant (the exception is the UK where the probability value on the coefficient is 11 percent). By contrast, the inward spillovers to the U.S. market are minimal. None of the coefficients are statistically significant and the maximum estimated coefficient is 0.11.

Turning to results for other countries, there appears to be notable two-way spillovers across the two European markets with estimated outward spillover coefficients of 0.43 (UK to Germany) and 0.34 (Germany to the UK). However, the procedure does not identify the direction of causality with much precision (the probability values on the point estimates being 0.15 and 0.14, respectively). German yields also matter for Japan. At 0.27 the

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[8]These significant levels are computed from the distributions of the estimated A-inverse matrix coefficients. Details are available upon request.

Table 2. Contemporaneous Spillovers: Systemic Countries Bond Markets

	EUR	GBR	JPN	USA
EUR	**1**	0.43 (0.28)	0.02 (0.13)	***0.69****** (0.18)
GBR	0.34 (0.24)	**1**	0.06 (0.14)	0.51 (0.29)
JPN	**0.27**** (0.12)	0.12 (0.13)	**1**	**0.55**** (0.11)
USA	0.11 (0.39)	0.03 (0.47)	-0.00 (0.15)	**1**

Table 3. Contemporaneous Spillovers: Systemic Countries Equity Markets

	EUR	GBR	JPN	USA
EUR	**1**	0.34 (0.31)	0.03 (0.13)	***0.68****** (0.21)
GBR	*0.58** (0.39)	**1**	-0.02 (0.15)	**0.51**** (0.27)
JPN	*0.38** (0.27)	0.29 (0.25)	**1**	**0.44**** (0.23)
USA	0.23 (0.59)	0.09 (0.55)	-0.02 (0.18)	**1**

coefficient is highly significant even if it is only around half of the U.S. value. The outward spillover coefficient of the UK to Japan, by contrast, is smaller still (about half of the German one) and insignificant. Finally, Japan has minimal outward spillovers—all three of the outward spillover coefficients are well under 0.1 and statistically insignificant.[9]

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[9]Yang (2005) uses the zero first-order conditional correlation constraints to identify causal relationships between the U.S., U.K, Germany, Japan, and Canada bond markets from January 1986 to December 2000. He

(continued…)

The pattern across equity markets is remarkably similar to those across bond markets. Table 3 shows the estimated A-inverse matrix across equity markets. Again, the U.S. equity market has large and largely statistically significant outward spillovers (with coefficients ranging around a half) while Japan has minimal outward spillovers on the other advanced markets.[10] Again, there are strong intra-European spillovers whose causality is difficult to determine definitively. And again there are positive and significant spillovers to Japan from German markets. The similarity in results is all the more striking given the significant differences in the timing of pre-crisis volatility across the two markets discussed above.

We conducted a series of robustness checks on the results. One possibility is that the results are being driven by the decision to include estimates involving a large proportion of high volatility observations, when such volatility might be considered rarer than low volatility observations. To test this hypothesis we reran the procedure with the lower threshold on the split between low-and high-volatility events raised from 0.65 to unity. Results (not reported for the sake of brevity) are very similar to the main case, although less well estimated given the smaller number of independent estimates of the *A*-inverse matrix.

Next we tested if the results were being driven by the including of lagged returns in the VAR. To do this we re-estimated the model with no lags in the VAR—this is the equivalent of assuming a random walk with drift, as the only parameter being estimated in each equation is a constant term on change in yields or equity prices. The estimated A-inverse matrices (reported in Table A1) are similar in magnitude and in statistical significance to the baseline model for bonds and for equities. For bonds the overall significance of the spillover coefficients (defined as the sum of the t-values on the off- diagonal elements in the matrix) falls slightly under the random walk specification. In the case of equities, however, it rises, suggesting that the random walk assumption may provide a more powerful approach to estimating spillovers.

Finally, to investigate the role of the crisis we estimated the same model over 2000–07 and 2000–12. By limiting the sample to end-2007 we essentially take out the crisis period, while extending the sample to October 5, 2012 includes the Euro crisis. The results for the shorter sample, reported in Tables A2 and A3, find that the estimated spillover coefficients generally fall and the standard errors increase, resulting in fewer significant off-diagonal elements. But the changes in spillover coefficients compared to the baseline

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finds smaller U.S. spillover impacts (except to Canada) and a stronger causal direction from Japan to Germany. However, the Japan-Germany result is sensitive to the presumption of the causal direction.

[10]Ishii (2008) also uses the identification through heteroskedasticity method in a bivariate case between U.S. and Japan equity markets. He finds a smaller U.S.–Japan contemporaneous impact and similarly zero impact in the reversed direction.

estimates are relatively modest and the overall story remains very similar, although the importance of bond market spillovers to Japan tends to fall for both bond and equity markets. Extending the sample period through 2012 to include the Euro area crisis also produces some subtle shifts—equity market spillovers from Europe to Japan, in particular, become somewhat more pronounced. But the bottom line is that none of the spillover coefficients change by much. In short, the results appear highly robust to changes in the sample.

B. Estimated Impulse Responses

Figure 5 and 6 show the cumulative impulse responses from (orthogonal) percentage point shocks in bond yields and equity prices in each market. We report effects for the first four weeks as bond yields and equity prices (and their returns) adjust rapidly to news and hence dynamics are likely to the short. The results also report 90 percent confidence intervals taking account only "standard" uncertainty on lagged coefficients in the VAR (the dashed red lines) and the results coming from including uncertainty over contemporaneous spillovers (the *A*-inverse matrix) to that from the lagged VAR coefficients (the solid red lines). (Figures A1–4 in the appendix shows the breakdown for different sources of uncertainty).

The first thing to note about the results is that the random walk model seems to be a good approximation. Even in the few cases where the impulse responses wiggle somewhat, the size of the uncertainty around these responses—at least once uncertainty about contemporaneous correlations, which represent the vast majority of the estimated uncertainty, are included—means that the hypothesis that the spillovers are the same over time cannot be rejected. As can be seen on the leading diagonal, own shocks to yields and to prices are significant and highly persistent in all countries across both markets.

Turning to the off-diagonal (spillover) results the basic patterns seen in the earlier discussion of the *A*-inverse matrices is repeated, but the addition of a time dimension helps illuminate causality in some cases. The impulse responses again emphasize that outward spillovers from U.S. market shocks are large and clearly significant or, at worst, marginally so at the 90 percent level. A percentage point increase in U.S. yield leads to a rise of around ½ percentage points in European yields and a ¼ percentage point in Japan while equivalent coefficients on outward spillovers of U.S. equity price shocks are more like ¾ percentage point. Inward spillovers to U.S. markets are minimal and insignificant.[11]

Within European markets, the bond market impulse response functions suggest that outward spillovers flow more from UK gilts to German bunds than the other way around.

[11]These results reinforce Bayoumi and Bui (2011) analysis of the dominance of U.S. financial markets in the trans-Atlantic relationship. By contrast, Ehrmann, Fratzscher, and Rigobon (2005) find stronger spillover impact from the euro area bond (but not equity) market using a different model allowing for cross-market interaction and different data sample (by frequency and period coverage).

Figure 5. Bond Yields: Cumulative Impulse Responses with 90 percent Confidence Intervals

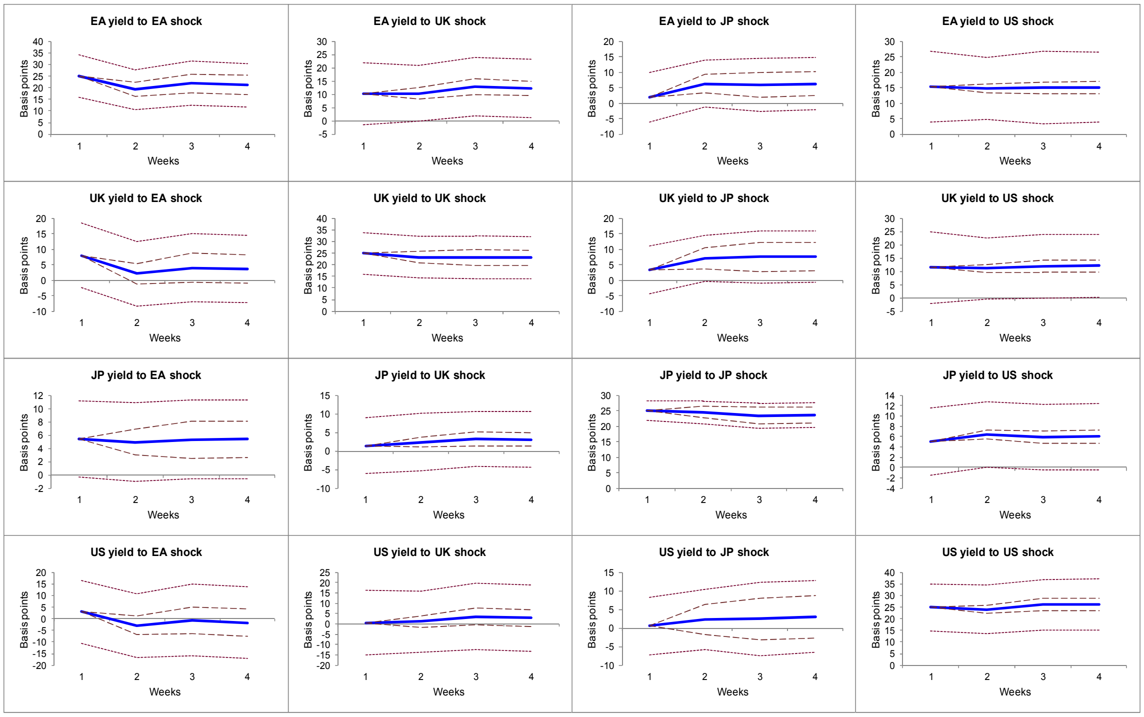
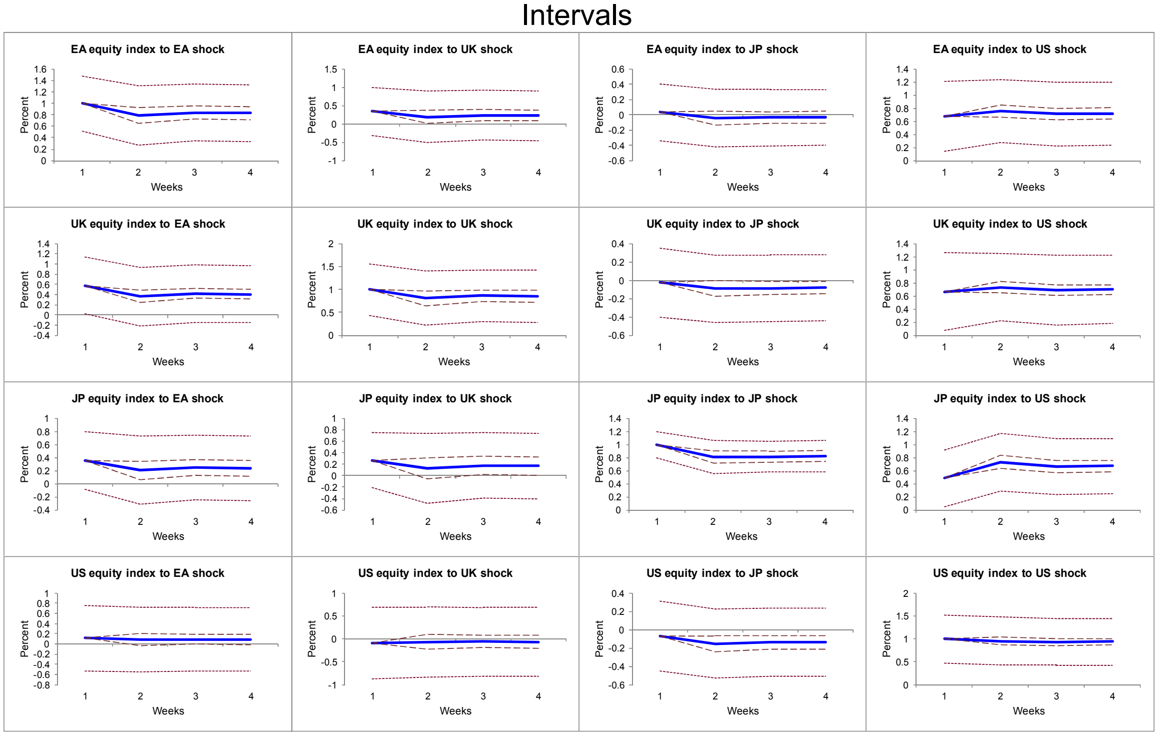


Figure 6. Equity Prices: Cumulative Impulse Responses with 90 percent Confidence Intervals



Note: The dashed lines are 90 percent confidence intervals due to uncertainty in VAR estimation. The dotted lines are 90 percent confidence intervals due to combined uncertainty in VAR and *A*-matrix estimation.

The UK spillover to Germany of around ½ percentage point after 4 weeks is significant while the German spillover is under ¼ and insignificant. While less definitive, the equivalent results for equity markets suggest the opposite result—that Euro area shocks drive UK prices more than the other way round. The impulse response functions also suggest dynamic interactions across European and Japanese markets, with bunds affecting JGBs and, in contrast to the results using only contemporaneous correlations, an increasingly large impact of JGB shocks on gilts and bunds over time that is on the margins of significance. By contrast, spillovers between European and Japanese equity markets are small and universally insignificant.

Finally, the variance decomposition after 1 week and 4 weeks for each shock is reported in Tables 4–5. The volatility in U.S. financial markets is overwhelmingly explained by its own shocks while U.S. shocks contribute 1/6 to 1/3 of the volatility in other markets' (except for Japanese bonds, which are dominated by own shocks). The intra-European linkages echo the results from contemporaneous relationships as the UK bond yield shock contributes a slightly larger proportion of Euro Area bond yield volatility than the vice versa. The reverse conclusion is true for their stock market returns.

V. Conclusions

This paper has examined spillovers across bond and equity markets in the world's most important markets, those of the U.S., Euro area, Japan, and UK. The main issue with such an analysis is that market returns are highly contemporaneously correlated, making inference about causality difficult. We solve this using vector autoregression and an extension of the method of identification via heteroskedacity suggested by Rigobon (2003). The extension allows us to not only endogenously estimate the contemporaneous direction of causation across markets but also the uncertainty around these estimates. This is particularly important in the case of these asset markets, as this turns out to be the dominant source of uncertainty for the spillover impulse response functions in our vector autocorrelations.

The results suggest that U.S. bond and equity market shocks reverberate around the world much more than shocks in other areas. A percentage point increase in U.S. bond yields raises yields elsewhere by ½ percent point in Europe and ¼ percent point in Japan. By contrast, shocks elsewhere have no significant inward spillovers on the United States. The European markets appear to have two-way spillovers on each other and there is some evidence that Euro area shocks also impact Japan. Japanese spillovers are generally the weakest across the markets that are examined, although they may build over time. Similar results are found for equity markets, where the dominance of U.S. market shocks is, if anything, even more pronounced.

Table 4. Variance Decomposition of Bond Yields

			Shock from			
			EUR	GBR	JPN	USA
Explained	EUR	1-week	0.66	0.11	0.00	0.23
		4-week	0.57	0.17	0.01	0.25
	GBR	1-week	0.10	0.74	0.00	0.16
		4-week	0.04	0.78	0.02	0.17
	JPN	1-week	0.09	0.02	0.84	0.05
		4-week	0.09	0.04	0.80	0.07
	USA	1-week	0.01	0.00	0.00	0.98
		4-week	0.02	0.02	0.00	0.96

Table 5. Variance Decomposition of Equity Market Returns

			Shock from			
			EUR	GBR	JPN	USA
Explained	EUR	1-week	0.75	0.06	0.00	0.19
		4-week	0.70	0.04	0.00	0.26
	GBR	1-week	0.26	0.56	0.00	0.18
		4-week	0.20	0.55	0.00	0.25
	JPN	1-week	0.16	0.06	0.62	0.16
		4-week	0.10	0.04	0.54	0.32
	USA	1-week	0.02	0.01	0.01	0.96
		4-week	0.02	0.01	0.01	0.96

U.S. bond and equity shocks are estimated to be clearly the largest source of spillovers elsewhere. That said, Euro area shocks do appear to matter for Japanese and UK markets. Hence, severe instability in the Euro area could have significant spillovers to markets outside of the United States. However, they are unlikely to be of the size of those seen after the collapse of Lehman Brothers.

Appendix

Figure A1. Bond Markets: Cumulative IRFs without Uncertainty in *A* Matrix Estimation

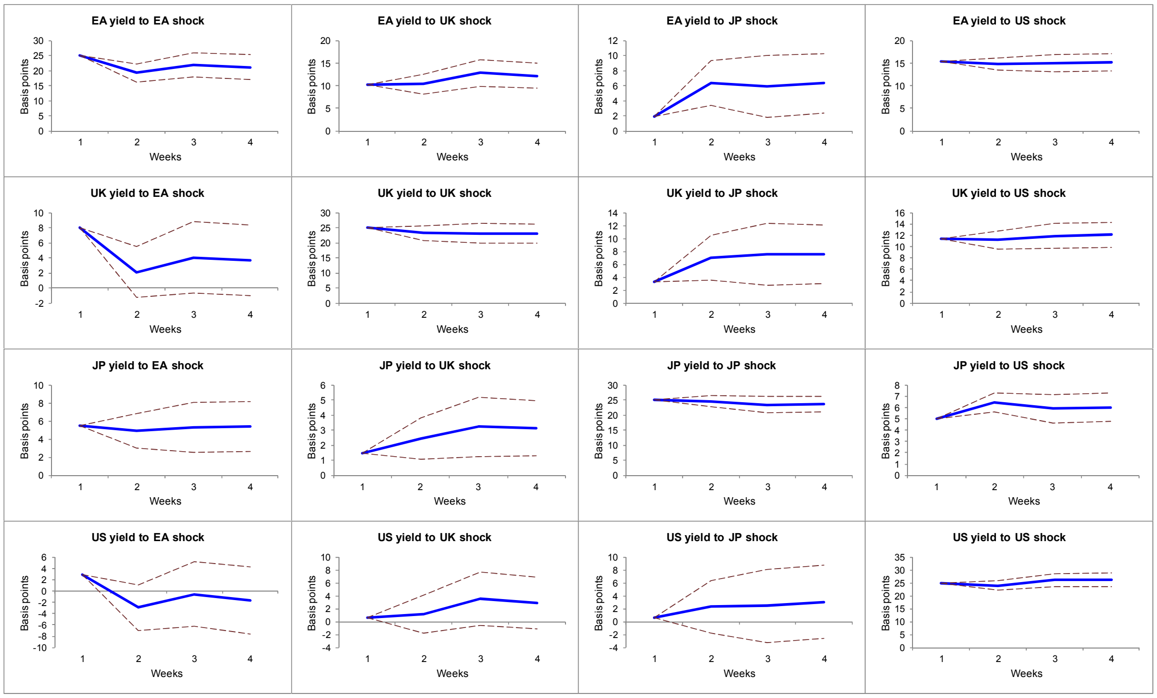


Figure A2. Bond Markets: Cumulative IRFs with Uncertainty in *A* Matrix Estimation <u>Only</u>

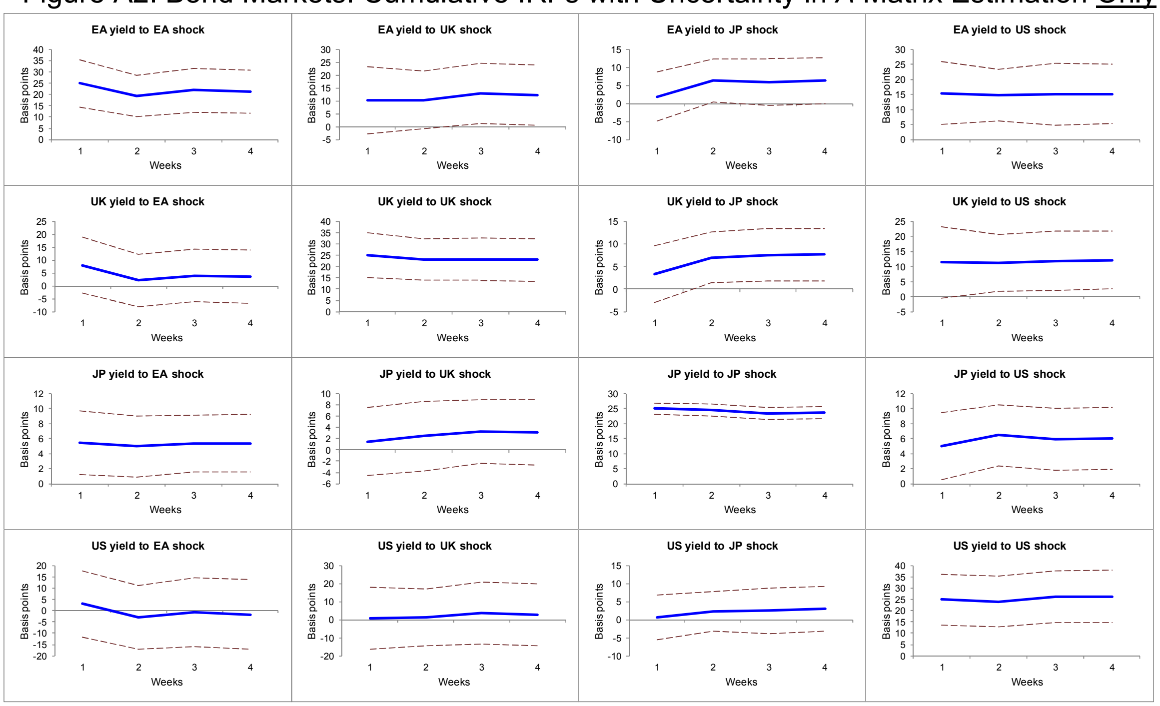


Figure A3. Equity Markets: Cumulative IRFs without Uncertainty in *A* Matrix Estimation

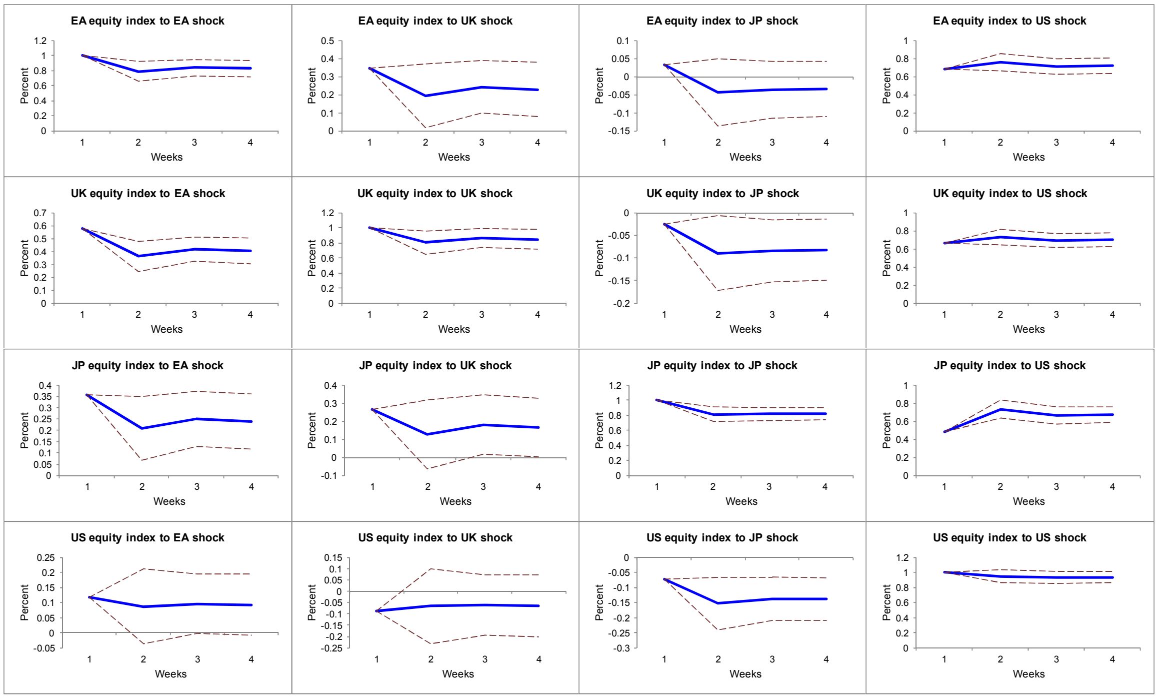


Figure A4. Equity Markets: Cumulative IRFs with Uncertainty in *A* matrix Estimation <u>Only</u>

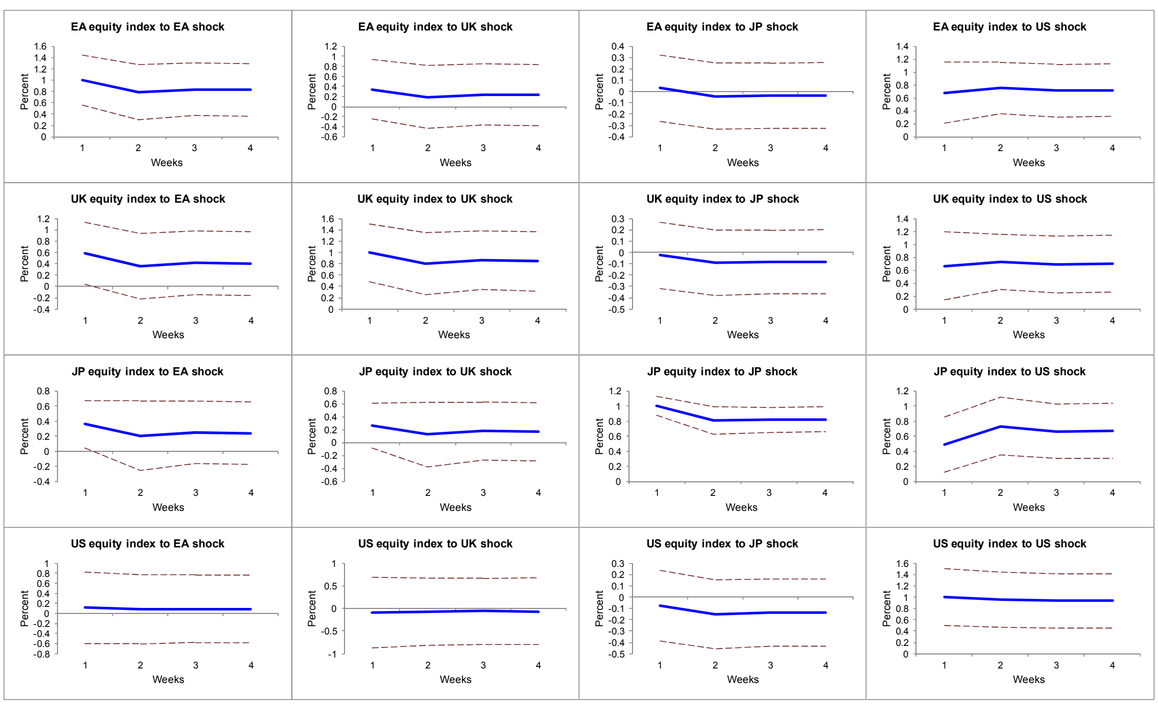


Table A1. Robustness Check: *A*-Inverse with Random Walk Specification

Bond Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.50 (0.30)	0.01 (0.15)	0.64*** (0.25)
GBR	0.28 (0.23)	**1**	0.05 (0.16)	0.39 (0.32)
JPN	0.26*** (0.09)	0.14 (0.11)	**1**	0.22** (0.11)
USA	0.16 (0.29)	0.12 (0.40)	-0.01 (0.14)	**1**

Equity Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.32 (0.32)	0.04 (0.20)	0.80*** (0.24)
GBR	0.51* (0.28)	**1**	0.00 (0.18)	0.75** (0.27)
JPN	0.42 (0.27)	0.22 (0.26)	**1**	0.52** (0.18)
USA	0.06 (0.30)	-0.15 (0.30)	-0.02 (0.18)	**1**

Table A2. Robustness Check: Alternative Sample 2000-07

Bond Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.37 (0.24)	0.14 (0.16)	0.58 (0.38)
GBR	0.32 (0.33)	**1**	0.15 (0.15)	0.61 (0.37)
JPN	0.13 (0.10)	-0.05 (0.10)	**1**	0.10 (0.14)
USA	-0.01 (0.39)	-0.12 (0.34)	0.10 (0.16)	**1**

Equity Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.45 (0.27)	0.13 (0.13)	0.56* (0.31)
GBR	0.39 (0.38)	**1**	0.05 (0.14)	0.37 (0.35)
JPN	0.21 (0.13)	0.27** (0.12)	**1**	0.19 (0.12)
USA	0.15 (0.33)	0.14 (0.31)	0.07 (0.13)	**1**

Table A3. Robustness Check: Alternative Sample 2000–October 5, 2012

Bond Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.39 (0.25)	0.14 (0.18)	0.51 (0.30)
GBR	0.42 (0.39)	**1**	0.14 (0.16)	0.44 (0.27)
JPN	0.18 (0.15)	0.05 (0.15)	**1**	0.15 (0.12)
USA	0.22 (0.32)	0.11 (0.35)	0.09 (0.16)	**1**

Equity Markets: *A*-Inverse Matrix

	EUR	GBR	JPN	USA
EUR	**1**	0.35 (0.35)	0.07 (0.19)	0.65** (0.31)
GBR	0.59** (0.26)	**1**	0.01 (0.18)	0.62* (0.34)
JPN	0.42** (0.17)	0.31 (0.24)	**1**	0.44* (0.22)
USA	0.21 (0.32)	-0.01 (0.45)	0.03 (0.17)	**1**

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