Uncertainty and financial asset return spillovers: Are they related? Empirical evidence from three continents

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Acknowledgments:

This research is funded by the University of Macedonia Research Committee as part of the Principal Research 2021 funding program.

We thank an anonymous referee for valuable comments. We also thank participants in IMAEF conference (Kefalonia, Greece, 2022), Nordic Econometric Meeting (Sandbjerg, Sonderborg, Denmark, 2022), ASSET conference (Rethymno, Greece, 2022), AMEF conference (Thessaloniki, Greece, 2023) and the Symposium on Money, Banking and Finance (Lille, 2023). The usual disclaimer applies.

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Abstract

This paper focuses on financial asset return spillovers and economic policy uncertainty spillovers in 3 continents (Europe, America, and Asia) in the last few decades. We examine three financial asset markets (stock, bond, and foreign exchange). Spillovers are measured using the Diebold-Yilmaz spillover index. In the first part, we measure the size of spillovers and find a significant increase in spillovers during the global financial crisis, the European sovereign crisis, and the recent pandemic. In the second part, we test for the effect of uncertainty spillovers on financial asset return spillovers. Using rolling impulse response functions, we obtain the following results: First, the responses of financial markets spillovers to uncertainty spillovers are time-varying and are mostly positive. Second, the highest responses in financial market return spillovers to uncertainty spillovers occur in America and the smallest responses in financial market return spillovers occur in Europe. Third, among the three financial markets, the highest responses apply to the foreign exchange market. Finally, the largest responses during the pandemic apply in Europe.

JEL classification: C32, D80, E20, E66, F42, G18

Keywords: economic policy uncertainty, rolling impulse responses, uncertainty spillovers, financial asset market return spillovers.

"As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality"

Albert Einstein

1. Introduction

Following the global financial crisis of 2008-09, the subsequent European sovereign crisis, the Covid-19 pandemic crisis, the energy crisis, and even more recently the Russia-Ukraine war, uncertainty at the macroeconomic and policy level seems to be on the rise at a global scale. Since the creation of the Economic Policy Uncertainty (hereafter EPU) index by Baker, Bloom, and Davis (hereafter BBD, 2016), and the macroeconomic uncertainty proxy constructed by Jurado et al. (2015) research on uncertainty has mushroomed. The Eurozone, from the end of 2008, when the first bailout programme was offered as help to Latvia, until August 2018, when Greece's third and last bailout programme ended, is a good example of heightened uncertainty. Due to the strong economic, financial, and trade links among industrial countries arising from financial and trade globalisation, it is anticipated that uncertainty episodes in one country may be easily transmitted to other member states. Furthermore, uncertainty is expected to have an influence on financial returns given the return-risk connection. Similarly, due to highly interconnected financial markets, we expect financial returns to be highly correlated across countries. Along these lines, we may also expect increasing spillovers in uncertainty to be followed by financial return spillovers.

The global financial crisis, followed by the Eurozone crisis with high rates of unemployment and high debt levels have been heightening uncertainty, as expressed through the media for several years. This increasing uncertainty for the future of each country's economy, the effectiveness of the subsequent economic policies, and the regulations applied by governments, some of which were part of memorandum programmes for several European countries, is depicted in the European EPU index. The literature has shown that EPU is negatively correlated with the business cycle and has caused significant negative effects on macroeconomic variables such as GDP, employment, investment, etc. (BBD, 2016; Stockhammar and Österholm, 2016; Kaya, et al., 2018, Tzika and Fountas, 2021). Uncertainty has also affected the stock market, as investors in the financial markets closely observe GDP, investment, and other macro variables, that might be negatively impacted by an uncertainty shock. Combining all this information, EPU could further intensify the negative consequences of the crises.

So far, the biggest part of the literature on uncertainty focuses on the negative macroeconomic effects of an uncertainty shock. However, another important aspect is to examine the spillovers of such a shock to other economies, as the national economy may also be affected by uncertainty shocks in other countries. Despite the recent appearance of the EPU concept in the literature, empirical work on EPU has quickly attracted the interest of researchers. However, to date, there has been only a small number of papers dealing with uncertainty shock spillovers, with most of them focusing on the transmission of US uncertainty shocks (Colombo, 2013; Armelius et al., 2017; Caggiano et al., 2020). Another part of the literature investigates the effects of US or European uncertainty shocks on the economies of other countries outside the US and Europe (IMF, 2013). Klossner and Sekkel (2014) and Balli et al. (2017) examine the EPU cross-country spillovers in developed countries. The last paper also investigates the determinants of these spillovers and finds that trade links and common language are transmission-enhancing factors.

In this paper, we contribute to the literature on policy uncertainty by concentrating on uncertainty spillovers at a global scale looking at three different continents (Europe, America, and Asia). We also investigate the effects of uncertainty spillovers on the spillovers of financial asset returns. Three financial markets are considered: stock, bond, and foreign exchange markets. We contribute to the related literature in two ways: First, we examine the dynamic behaviour of the EPU connectedness and the dynamic net uncertainty spillovers of, as well as financial asset returns, at a global scale and for the three continents separately, in a period that includes the Global Financial Crisis (hereafter GFC), the European Sovereign Crisis (hereafter ESC) and the Covid-19 pandemic. Second, using rolling impulse response functions, we estimate the time-varying effects of uncertainty spillovers on financial asset return spillovers. This will allow us to determine whether the transmission of uncertainty across countries is an important determinant of the cross-country transmission of asset returns, and whether or not this intensifies during periods of crises. The contribution of the paper lies upon the examination of the spillovers among economic uncertainty and the financial markets to provide support to decision-making both for the policymakers and investors.

We address the first objective by examining the EPU transmission within a Vector Autoregressive (VAR) context, using the Diebold-Yilmaz (2009, 2012) spillover index. Monthly data from January 1998 until October 2021 for 24 countries spanning over three continents are used. Our findings indicate that there is considerable transmission of uncertainty on a global scale, as well as in each continent, which is time-varying. We observe increased uncertainty spillovers during the GFC and the recent pandemic across all continents. We also find high uncertainty transmission in Europe during the ESC which is, however, falling rapidly afterwards. With regard to our second objective and contribution, we apply rolling impulse response analysis using global data and data for each separate continent. This analysis indicates some noteworthy results: First, the responses of financial market spillovers to uncertainty spillovers are time-varying and mostly positive. Second, the highest responses in financial market return spillovers occur in America. This is despite the smallest EPU spillovers in America. Third, the smallest responses of financial market return spillovers occur in Europe. The result is robust across the three financial markets. Fourth, among the three financial markets, the highest responses apply to the foreign exchange market. Finally, the highest responses of financial market return spillovers to uncertainty spillovers during the pandemic apply to Europe.

The rest of the paper is outlined as follows. Section 2 contains a review of the literature on the findings of uncertainty and financial asset return spillovers across various countries using the Diebold-Yilmaz spillover index. Section 3 presents the methodology and the empirical analysis of the uncertainty and financial asset return spillovers at a global scale and on three continents. Section 4 presents the data and the results on the relationship between uncertainty and financial asset return spillovers. Finally, section 5 concludes the paper.

2. Literature Review

Financial innovation and regulatory competition have spurred a remarkable boost in financial globalization around the world. The relaxation of capital controls and other impediments to movements of financial capital have contributed to immense capital flows, thus facilitating the spillovers in asset returns across countries. Indeed, the empirical literature on spillovers has mushroomed in the last few decades. Important papers include Booth et al. (1997), Kanas (1998), Diebold and Yilmaz (2009), Yilmaz (2010), Singh et al. (2010), Atenga and Mougoue (2021), etc. This literature concludes that there has been a significant transmission among the financial markets across countries in both the average financial returns and their volatility.

Recently, applied macroeconomists have attempted to find an appropriate measure that quantifies the multi-dimensional concept of uncertainty. Moore (2017) refers to different categories of uncertainty measurement, the newspaper-based, the finance-based, and the forecaster disagreement measures (Grier and Perry, 1998; Bredin and Fountas, 2005; Bekaert et al., 2009; Bredin and Fountas, 2009; Hamilton, 2010; Bredin et al., 2011; Jurado et al., 2015; Moore, 2017). The EPU index introduced by BBD (2016) deviates from the previous measures of uncertainty in applied macroeconomics, as it focuses on uncertainty triggered by economic policy-making. It is a newspaper-based indicator that captures both short- and long-run uncertainty. BBD have developed the EPU index data series for several major industrial countries, including the US, the UK, France, Germany, Japan, etc. Finally, the EPU data has been constructed for other countries, like Ireland (Zalla, 2017), Chile (Cerda et al., 2018), Greece (Fountas et al., 2018), Cyprus (Tzika, 2022), etc. following BBD's approach. BBD also proceeded with some tests for the credibility and validity of the EPU index. The support for the credibility of the index is remarkable.

According to several studies, a large and steep increase in uncertainty has been observed in every country during or after economic crises (BBD, 2016; Cerda et al., 2018, Fountas et al., 2018, Tzika, 2022). Moreover, some research papers examine the transmission of uncertainty shocks to some domestic sectors (e.g., housing) or across a spectrum of domestic uncertainty categories using the Diebold-Yilmaz spillover index (Diebold & Yilmaz, 2009; 2012). Antonakakis et al. (2016) and Thiem (2018) look at the US uncertainty effects on the domestic economy. Antonakakis et al. (2016) test for the existence of spillovers among the EPU, the stock, and the housing market in the US. They find evidence for time-varying spillovers which seem to be increasing significantly after the of 2008. Thiem (2018) examines the connectedness among 6 different EPU index categories (monetary, fiscal, healthcare, national security, regulatory, and trade policy uncertainty) for the US and finds evidence for high spillovers.

Several studies concentrate on cross-country uncertainty spillovers. Uncertainty may spill over across national borders via various transmission mechanisms. These include trade links, financial links, trade and fiscal imbalances, a common language, and a common border. However, a distinct EPU spillover channel (where a domestic EPU spike creates uncertainty abroad) has also been identified, even in the presence of a separate trade channel (Caggiano et al., 2020). Balli et al. (2017) estimate cross-country uncertainty spillovers and find out that the main channels through which uncertainty is transmitted from one country to the other are trade and the common language. They also find that the less-balanced countries are in financial, fiscal, and trading terms, the higher the possibilities of EPU transmissions. Liow et al. (2018) analyse the EPU spillovers among 7 countries (US, UK, Canada, Germany, France, China, and Japan) and estimate the respective spillover index to be almost equal to 50%. Klossner and Sekkel (2014) also examine the EPU spillovers among six developed countries and find that they account for a large share of the dynamics of policy uncertainty with this share rising during the recent financial crisis. Caggiano et al. (2020) examine the EPU spillovers between the US, Canada, and the UK. They find that US uncertainty spills over to the EPU index in Canada and affects unemployment negatively, thus pointing to an EPU spillover channel. Another part of the literature examines the spillovers between the EPU indices of major countries and the S&P500 using the Diebold-Yilmaz spillover index, to conclude that the stock market volatility is a net recipient of spillovers from the uncertainty of major countries (He et al., 2020), while according to Mensi et al. (2023) this is the case for bearish and tranquil periods, but during bullish periods of the stock market the reverse is the dominant spillover. Finally, Śmiech et al. (2020) add more to the literature, by investigating the connectedness among three types of uncertainty (consumer, industrial, and financial) across countries. A major finding is that uncertainty transmissions are usually higher among geographically close countries (which have higher trade and financial links) and Southern European countries are net volatility transmitters during the debt crisis. Moreover, they find that the strength of connection across the EU countries weakens in the post-ESC period.

3. Empirical Analysis: Data and Methodology

3.1 Data

We use monthly data for the EPU index, the stock market index, the bond yield, and the exchange rate for 24 countries (global data). These countries are the US, the UK, Australia, Belgium, Brazil, Canada, Chile, China, Croatia, Cyprus, France, Germany, Greece, Hong Kong, India, Ireland, Italy, Japan, the Netherlands, Russia, Singapore, South Korea, Spain, and Sweden. In addition, we perform our empirical analysis using data for three subgroups of data corresponding to three continents (Europe, America, Asia). The country choice is based on the availability of EPU data. The data frequency choice is based on the availability of the EPU series only in monthly frequency. Our sample covers the period from January 1998 to October 2021. In some cases, we use a smaller sample dictated by data (country and variable) availability considerations. Our intention was to include the years of the GFC and try to incorporate the beginning of the Covid-19 pandemic, when possible.

The EPU index data have been retrieved from the policyuncertainty.com website which is the official database maintained by BBD[1]. The construction of the index is based on newspapers' coverage frequency. The stock market variable is represented by the stock market index, bond returns are measured by the long-term government yield for the 10-year government bond, and the exchange rates used are spot exchange rates expressed in units of national currency per US dollar. Stock market data are obtained from Yahoo Finance, and bond yields and exchange rates are retrieved from FRED.

3.2 Empirical Methodology

As mentioned above, the aim of this paper is twofold. First, to investigate the dynamic spillovers of EPU, as well as of the stock, bond, and exchange rate markets at

[1] Data for the following countries have been constructed by other researchers and not by BBD: Belgium (Algaba, Borms, Boudt, & Van Pelt, 2020), Chile (by Rodrigo Cerda, Alvaro Silva & Jose Tomas Valente), Croatia (Sorić & Lolić, 2017), Cyprus (Tzika, 2022), Greece (Fountas, Karatasi, & Tzika, 2018), Hong Kong (Luk, Cheng, Ng, & Wong, 2020), Japan (Arbatli, Davis, Ito, & Miake, 2017), Netherlands (Kroese, Kok, & Parlevliet, 2015), Singapore (Davis, 2016), Sweden (Armelius, Hull, & Köhler, 2017).

a global scale using the full set of countries. Second, to examine the differences in spillovers between different geographical regions dividing the full set of countries into three continents (i.e. America, Asia, Europe). For this purpose, we apply the Diebold-Yilmaz spillover index (Diebold & Yilmaz, 2009; 2012). Diebold and Yilmaz introduced a measure of connectedness which analyses the return or the volatility spillovers among different countries or different markets. The analysis is based on the variance decomposition of generalised VAR models in a multivariate framework. When the spillover index value is high, the connectedness among the examined countries or markets is high. Diebold and Yilmaz have proposed several indices to get a more complete picture of this connectedness. These are, in addition to the total spillover index, the net spillover index, the net pairwise spillover index, and the dynamic spillover index.

In this paper, we start by applying a VAR(p) model to measure the connectedness across the countries under investigation for each of the 4 variables, namely, EPU indices, stock market returns, bond market returns, and exchange rate market returns, following the Diebold-Yilmaz methodology:

$$y_t = \sum_{i=1}^{p} \Phi_i y_{t-i} + \varepsilon_i \,, \tag{1}$$

where $\varepsilon \sim (0, \Sigma)$ is a vector of *iid* errors. From equation (1), we derive the respective moving average (MA) representation:

$$y_t = \sum_{i=1}^{\infty} A_i \varepsilon_i \,, \tag{2}$$

where A_i is a *nxn* matrix of coefficients and $A_i = \Phi_1 A_{i-1} + \cdots + \Phi_p A_{i-p}$, A_0 is a *nxn* identity matrix, and $A_i=0$ for $i<0$.

To avoid the sensitivity of the results to the variables' ordering arising from the Cholesky decomposition, we use the generalised VAR framework proposed by Koop et al. (1996) and Pesaran and Shin (1998), which provides a variance decomposition irrelevant to the ordering of the variables[2].

The Z-step ahead forecast error variance decomposition of the generalised framework will be:

[2] Using the generalised shocks the sum of the elements of each row in the variance decomposition will not necessarily be equal to one, hence the row sum of the spillovers will not be one.

$$\varphi_{ij}^{g}(Z) = \frac{\sigma_{jj}^{-1} \sum_{t=0}^{Z-1} (e'_i A_z \Sigma e_j)^2}{\sum_{t=0}^{Z-1} (e'_i A_z \Sigma A'_z e_j)}, \tag{3}$$

with Σ the error variance-covariance matrix, σ_{jj} the standard deviation of the error term for the j^{th} equation, and e_i the selection vector, where the i^{th} element is one and the rest are *0*.

The spillover index is given by normalising the row sum of the variance decomposition:

$$\tilde{\varphi}_{ij}^{g}(Z) = \frac{\varphi_{ij}^{g}(Z)}{\sum_{j=1}^{N} \varphi_{ij}^{g}(Z)}. \tag{4}$$

The total spillover index is estimated by the following equation:

$$S^{g}(Z) = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ij}^{g}(Z)}{\sum_{i,j=1}^{N} \tilde{\varphi}_{ij}^{g}(Z)} x100 = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ij}^{g}(Z)}{N} x100. \tag{5}$$

While the directional spillover indices that quantify the spillovers received by variable *i* from all the variables *j* is:

$$S_{i\bullet}^{g}(Z) = \frac{\sum_{\substack{j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ij}^{g}(Z)}{\sum_{i,j=1}^{N} \tilde{\varphi}_{ij}^{g}(Z)} x100 = \frac{\sum_{\substack{j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ij}^{g}(Z)}{N} x100. \tag{6}$$

and the directional spillover transmitted by country i to all other countries j is estimated by the index:

$$S_{\bullet i}^{g}(Z) = \frac{\sum_{\substack{j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ji}^{g}(Z)}{\sum_{i,j=1}^{N} \tilde{\varphi}_{ji}^{g}(Z)} x100 = \frac{\sum_{\substack{j=1 \\ i\neq j}}^{N} \tilde{\varphi}_{ji}^{g}(Z)}{N} x100. \tag{7}$$

Finally, the net spillover index is the simple difference:

$$S_{i}^{g}(Z) = S_{\bullet i}^{g}(Z) - S_{i\bullet}^{g}(Z). \tag{8}$$

Finally, to examine the spillovers over time, we estimate the dynamic spillover index through a rolling estimation framework of a 60-month window.

Having investigated the spillovers among the EPU indices, and the returns in the stock market indices, the bond yields, and the exchange rates of several countries globally, we next examine the rolling impulse responses of the spillovers in the stock, bond, and foreign exchange markets to EPU spillover shocks. For this reason, we will apply a VAR(p) model, where the endogenous variables will be the dynamic spillover indices of EPU, stock returns, bond yields, and exchange rate returns. The VAR model in its standard form that is estimated in a 60-month rolling window is given by the following equation:

$$y_t = A_0 + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \beta t + e_t \, , \tag{9}$$

where y_t is an *nx1* vector of 4 endogenous variables (EPU spillovers, stock market return spillovers, bond return spillovers, foreign exchange spillovers), A_i s are *4x4* coefficient matrices, e_t a *4x1* vector of error terms, *p* the lag length, and *t* a linear time trend. We use a rolling estimation because we intend to analyse the evolution of the responses over time and try to capture potential higher responses during the GFC, the ESC, or the recent Covid-19 pandemic crisis. The variance decomposition on which the impulse responses are based is again estimated in a generalised VAR framework, to avoid any variable ordering issues.

At first, we run this rolling Generalised Impulse Response Functions (hereafter GIRF) estimation for all the countries, and then we split the countries into different geographical regions, to examine in which continents the connectedness of the spillovers among the bonds, stocks, currency markets have higher responses to EPU spillover shocks.

4. Empirical Analysis: Results

4.1. Results of the Spillover Analysis

Table 1 presents the results of the EPU spillover index for the full set of countries. According to this, the total spillover of uncertainty among all the estimated countries is 79.7%. Each element in Table 1 shows how much uncertainty the country in the row “imports” from the country in the column. For example, 3.0% of the forecast error variance of the UK is due to US uncertainty shocks. Additionally, the UK exports 2.2% of its forecast error variance to the US. The difference between these numbers indicates the net contribution from one country to the other. In our example, the net contribution of the US to the UK EPU is 0.8%. This number implies that the US uncertainty innovations affect UK uncertainty more than vice versa. In Table 1, the column sum (excluding the diagonal entry) for each country shows the contribution to others. For the US, this figure is 101.3. The row sum (excluding the diagonal entry) for each country shows the contribution from others. The difference between the column and row sums is the net contribution. The US figure is 14. Taking the sum of the row sums for all countries we get the entry 1914. Dividing this figure by the contributions to others and own contributions (i.e., the sum of the diagonal entries), we get the total spillover value of 79.7%. This figure indicates that almost 80% of the forecast error variance of uncertainty is due to uncertainty spillovers and only about 20% is due to own (domestic) uncertainty shocks.

The total net contribution to the forecast error variance of the countries is indicated in the last row of Table 1. Singapore, Japan, Sweden, Canada, Australia, Cyprus, Germany, Spain, and France are above the US in the ranking of the countries with the greatest net contribution to forecast error variance to other countries with values of 71.8, 44.5, 44, 40.5, 38.7, 36.5, 33.9, 28.3, 18.6, respectively. At the bottom lie Ireland (-68.3), Russia (-55.3), and Greece (-44.4), countries that import economic uncertainty.

Moreover, Singapore's uncertainty mainly affects China, South Korea, the UK, the US, Canada, and Germany holding the greatest values of 16.3, 12.7, 10.1, 9.9, 9.8, and 8.7, respectively. Australia exports 10.7% of its forecast error variance to India and 9.9% to Japan indicating its close relations with its neighbours. Interestingly, Sweden and Chile are connected by the value of 8.5% (contribution of Sweden to Chile), indicating their connected economies and the Chilean contribution to Sweden after 1973 (Lindholm, 2016). Sweden also exports to Croatia and Russia, the amounts of its contribution to their forecast error variance of 7.8 and 7, respectively.

[insert table 1]

Table 2 presents the spillover index results of stock market returns for the US, the UK, Australia, Belgium, Brazil, Canada, Chile, China, France, Germany, Hong Kong, India, Ireland, Italy, Japan, the Netherlands, Singapore, South Korea, and Spain. The total spillover index of stock returns among all the aforementioned countries is 83.7%. The countries with the highest net contributions of the forecast error variance to other countries are France, Belgium, Netherlands, and Germany with values of 51.2%, 47.1%, 44.7%, and 41.5% respectively. It is increasingly clear that neighbours mainly affect each other. Therefore, our results propose that the level of stock market spillovers depends on regional aspects (Kishor and Singh, 2017; Lehkonen and Heimonen, 2014). French shocks account for 10.6%, 10.5%, and 9.8% of the forecast error variance of Italy, Germany, and the Netherlands, respectively. Similarly, Singapore shocks account for 10.2% of the forecast error variance of Hong Kong, 8.8% of India, 8.3% of South Korea, 7.5% to China, and 7% to Japan. Similarly, Hong Kong shocks account for 12.2% of the forecast error variance of China, 8.8% of Singapore, 8% of India, etc. These results corroborate the literature view which claims that the stock markets could be divided into American, Asian, and European regions (Bekaert, Hodrick, and Zhang, 2009). On the other hand, Brazil's forecast error variance seems to be affected by Australia (7.5%), Hong Kong (8.2%), India (7.1%), and Singapore (8.4%), while the US contribution to other countries is 4.9%. These results are in line with the literature view that the influence of the US stock market on Australian and Asian markets has diminished in recent years (Kishor and Singh, 2017; Elyasiani, Pereira and Puri, 1998). Moreover, the US stock market does not have pairwise co-integration with any of the European markets (Kanas, 1998).

[insert tables 2-4]

Table 3 presents the results of the spillover index of bond returns for the US, the UK, Australia, Belgium, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, the Netherlands, Russia, South Korea, Spain, and Sweden. The total spillover of bond yields (returns) among all the examined markets is 72.4%. Australia, the UK, Canada, and Germany are the top countries concerning net contribution of their bond yield forecast error variance to the other examined countries with values of 35.6, 29.4, 25.6, and 24.9 respectively. Germany accounts for 11.2% of the forecast error variance of the Netherlands, 10% of Sweden, and 9.3% of France and Canada. Australia accounts for a significant part of the forecast error variance of Canada (11%), the US (10.3%), Sweden (9.6%), South Korea (9.2%), France (8.8%), Germany (8.6%) and India (7.9%). China has the lowest values of contribution to other countries (10.3%) and from other countries (19.1%), probably as a result of its late involvement with the global economy. Only in 1993 the Bank of China announced floating foreign currency bonds in the domestic market (Bell, Khor and Kochhar, 1993). On the other hand, the magnitude of the spillover effect (net contribution from other countries) is negative in India (-40.5%), Chile (-38%) and Greece (-34.9%). Generally, bond yields spill over from major advanced economies to emerging economies and are more pronounced among countries within the same region (Bleke, et al, 2018; Boninghousen and Zbel, 2015).

Table 4 presents the spillover index results of exchange rate returns for the Eurozone, the UK, Australia, Brazil, Canada, Chile, China, Hong Kong, India, Japan, Russia, South Korea, and Sweden. The total spillover of exchange rate returns among the above countries is 52.4%, lower than the other financial markets. The findings show that the net contribution of Hong Kong forecast error variance of the exchange rate to the other countries is 141.9%, the highest of all examined countries. Hong Kong owns one of the busiest container ports in the world and serves as a platform for enterprises and financial institutions all over the world to conduct RMB[3] trade settlement, payments, financing, and investments making the world's largest offshore RMB business hub, with the world's largest offshore pool of RMB liquidity (Financial Services and the Treasury Bureau July 2020, http://www.fstb.gov.hk/).

Australia also has a positive net contribution of its forecast error variance to other countries with a value of 16.6%. On the contrary, the exchange rate of all the other countries is affected by those two countries. In particular, the Eurozone countries mostly export to the other European countries which are not Eurozone members. The UK and Sweden account for 7.6% and 14.9% of the forecast error variance of the exchange rate of the Eurozone countries, and the rest of the Eurozone accounts for 11.6% and 14.4% of the forecast error variance decomposition of the UK and Sweden, respectively. Australia mainly interacts with Canada, Chile, and South Korea. The UK with the Eurozone, Australia, and Canada, while Hong Kong accounts mainly for the Eurozone, South Korea, and Australia.

[insert figure 1]

Figure 1 lists the continent dynamic spillover indices in the same graph for comparison purposes, while Figures 2-5 show the dynamic spillover index for the full-country sample and for each one of the three continents separately. These figures indicate significant variation in uncertainty spillovers. Figure 2 shows an increase in global uncertainty spillovers during the GFC. This is also observed in Figures 3-5 for each of the three continents (America, Asia, and Europe respectively). Obviously, the increase in uncertainty spillovers during the recent GFC is the highest in America. In

[3] The official name of China's currency, Renminbi, Yuan.

Figure 5 we observe a steep increase in uncertainty spillovers among European countries starting in late 2008 which is the year identified with the onset of the ESC. Uncertainty spillovers have remained quite large till late 2012. Afterward, we observe a persistent decline in European spillovers until the pandemic outbreak in March 2020. Another result that we deduce from Figures 1-5 is that uncertainty spillovers increased at the start of the pandemic but fell gradually afterward. This result is consistent across the three continents.

[insert figures 1-5]

Tables 5 and 6 provide the descriptive statistics of the spillover indices, per variable for all countries (Table 5), and per continent for the EPU index (Table 6). The main insight from Table 5 is that the spillovers in the foreign exchange market have the highest volatility (standard deviation), but the lowest value. Regarding Table 6, the country with the lowest uncertainty spillovers is America. At the same time, America has the highest volatility of uncertainty spillovers, which can also be observed in Figure 1, which portrays the EPU spillover indices of all continents.

[insert tables 5-6]

4.2. Results of the Rolling Impulse Response Analysis

Figure 6 shows the responses for 12 months-horizon of the bonds market spillovers to EPU spillover shocks over time for all countries. The responses are positive throughout the whole sample and statistically significant after mid-2016; the few negative values at the beginning of the sample are not statistically significant. However, the responses of the bond yield connectedness reach a maximum of 0.15 in January 2018, 12 months after the shock. The GIRFs of the stock market return spillovers are represented in Figure 7. The responses are statistically significant 4 to 10 months after the EPU spillover shock in 2014 and until mid-2015, with the stock market spillovers responding negatively to uncertainty spillover shocks. However, after 2016 the GIRFs are again statistically significant for the 12-month horizon examined, however this time positive, reaching values of 0.4 in June 2018.

[insert figures 6-8]

On the other hand, the responses of the exchange rate spillover index to EPU spillover index innovations, depicted in Figure 8, are statistically significant throughout the whole sample. However, in some cases, the exchange rate spillover index responds with a lag of 1 or 2 months. The findings also point out that the exchange rate spillover index is the most sensitive one to policy uncertainty spillover shocks, as the values of the GIRFs are the highest and longest in duration, meaning that the responses to EPU spillover shocks persist, and do not fade away easily.

The following three figures (Figure 9 to Figure 11) show the impulse responses of the bond, stock, and currency market spillovers respectively to EPU spillover shocks for the geographical region of America. Noting that all the negative impulse responses are not statistically significant, we observe that the bond yield spillovers have a positive reaction to EPU spillovers, meaning that during periods of increased uncertainty connectedness, the respective bond markets are also interacting more (Figure 9). The responses become statistically significant 6 months after the shock between 2016 and the third quarter of 2017, while the response is immediate and lasts for at least a year during 2018. Since January 2019 the bond spillover responses are significant only for the first 3 quarters after the shock. The responses take the highest value during February and March of 2018, reaching a maximum value of 1.29%.

[insert figures 9-11]

The positive responses of the stock return spillover to EPU spillover shocks among the countries of the American region are obvious in Figure 10. The responses throughout the examined period start with low values in the first months, gradually increasing for the next 4-5 months, and gradually decreasing in the following months. After a period of lower responses between 2018 and 2020, the outburst of the Covid-19 pandemic seems to have affected the examined responses. Indeed, the GIRFs peaked in June 2020, reaching a value of 3%, meaning that the spillovers in the stock markets respond even more intensively than before to the spillovers of EPU among the countries in America.

Figure 11 shows the responses of the exchange rate spillovers to EPU spillover shocks in the American region. It should be noted that all the responses, in this case, are positive and statistically significant throughout the sample, except for the response one month after the shock until 2017, which however is not significant. From 2014 until

2016 the responses are low, and then gradually increase and the higher values are reported in September 2018, where the value of the GIRFs after 12 months reaches 3%. Interestingly, during the outburst of the pandemic, the foreign exchange markets connectedness seems to respond less to EPU connectedness shocks, and even fall to negative values in June and July 2020.

[insert figures 12-14]

The rolling GIRFs for the Asian countries are shown in Figures 12-14. The bond, stock, and foreign exchange market connectedness to EPU spillover shocks are higher and more volatile until 2018, while after 2018 their value and volatility are much lower.

Figures 15 to 17 portray the GIRFs for the spillovers among the European countries. Spillovers in all markets (bond, stock, currency) are quite high at the beginning of the sample in 2012, but they gradually fall for a short period and reach even negative levels during 2014 and 2015. Afterward, the values start rising again. The responses of the European financial market spillover indices to EPU spillover shocks take a high value in June 2016. This increase in the GIRF values is probably related to the Brexit referendum which took place the same month. As Li (2020) points out there is significant interaction among the European stock markets. However the responses in Europe peaked after the Covid-19 pandemic outbreak in 2020.

[insert figures 15-17]

Considering the dynamic spillover index of the EPU for the examined regions we reach the following conclusions. First, we observe that the EPU spillovers in the European region are not that high, in comparison to the other two regions. Second, we see that the responses in Europe, contrary to the other geographical regions, are affected more by the Covid-19 pandemic, with the highest GIRF values being recorded during 2020-2021. Third, the responses of the bond market spillovers are less intense compared to those of the stocks and currency markets. Finally, the highest impulse responses to EPU spillover shocks apply in the foreign exchange market. This finding is probably justified by the very large volume of transactions in this market owing to the market size compared to other financial markets.

5. Conclusion

The objective of this paper was to contribute to the literature on policy uncertainty spillovers and their effects on financial market return spillovers. Our focus was on a global scale looking at a group of 24 countries and regional data covering three different continents (Europe, America, and Asia). In the first part, we employed the Diebold - Yilmaz spillover index to measure uncertainty and financial market return spillovers. Our results indicate large uncertainty spillovers and significant transmission in the financial markets across countries. We also found a significant increase in spillovers during the global financial crisis, the European sovereign crisis, and the recent Covid-19 pandemic.

The second objective of the paper was to investigate the effects of uncertainty spillovers on the spillovers of financial asset returns in the stock, bond, and foreign exchange markets using rolling impulse response analysis. Our analysis led to the following results: First, the responses of financial markets spillovers to uncertainty spillovers are time-varying and mostly positive. Second, the smallest responses in financial market return spillovers occur in Europe. Third, among the three financial markets, the highest responses apply to the foreign exchange market. Finally, the European region presents the highest impact of the Covid-19 pandemic on the value of the responses, among the three examined geographical areas.

Our results have important implications for policymakers and investors. At the macroeconomic level, policymakers should perhaps apply more stable economic policies to reduce economic policy uncertainty, given the significant uncertainty spillovers estimated in this study and the apparent negative effects associated with this uncertainty. These negative effects relate not just to the uncertainty impact on the real economy as the recent empirical evidence has suggested, but also the transmission of uncertainty to the functioning of the financial markets. Given the significant evidence obtained in our study for financial market return transmission in various financial markets, implying evidence for financial contagion, we may explain the increasing volatility observed in recent periods in the financial markets. This necessitates the application of appropriate risk management strategies for investors in order to contain their exposure to increasing risk.

Policymakers and investors should consider the changes in economic uncertainty or in financial market returns of other countries as well when making decisions, since, based on the aforementioned conclusions, a significant share of uncertainty or financial market returns can be attributed to spillovers from other countries. Given that 79% of the forecast error variance of uncertainty is attributed to foreign uncertainty spillovers, policymakers should be aware not only of domestic events that trigger uncertainty, but they should also follow foreign uncertainty shocks. Especially countries like Ireland, Greece, and Brazil, which are among others the countries with the lowest net contribution of uncertainty. Table 1 provides an indication of which countries are the ones from which each economy's uncertainty is more likely to be affected.

The results of the present research can provide investors with useful information regarding portfolio diversification among different financial markets (bond, stock, foreign exchange) and across different countries. For example, investors can adjust their portfolio and reduce investments in the foreign exchange market during times of high uncertainty spillovers, since this market has been shown to have the highest spillover responses to EPU spillover shocks. Investors can also choose to invest in financial markets of specific geographical regions, based on their risk aversion and the insights of the present research, since the European markets seem to have the lowest responses to uncertainty, but at the same time the highest responses during turmoil periods, like the Covid-19 pandemic. Moreover, as our results show that the responses of the financial markets' spillovers to uncertainty spillover shocks change over time, investors would be better off investing over predefined periods.

Our study is subject to some limitations. One of the limitations lies in the data availability for the EPU index as the data cover only a small number of countries. Another alternative to the EPU index would be using the World Uncertainty Index (WUI) created by Ahir, Bloom, & Furceri (2022). The advantage of this choice is that there are WUI data available for more countries, thus allowing for a more representative picture of the various continents. The drawback however would be that the WUI is available at a lower (quarterly) frequency, thus implying the loss of valuable information.

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Table 1. EPU Spillover (Connectedness) index4

	US	UK	AUS	BEL	BRA	CAN	CHL	CHN	CRT	CYP	FRA	GER	GRE	HKG	IND	IRE	ITA	JPN	NET	RUS	SIN	SKR	SPA	SWE	From Others
US	12.7	2.2	6.6	6.4	1.7	7.5	3.2	4.5	3.0	3.0	4.1	7.7	0.7	0.5	1.0	1.0	1.6	5.2	1.3	1.8	9.9	3.1	5.6	5.6	87.3
UK	3.0	22.0	3.5	0.3	1.1	4.9	0.8	6.3	3.8	5.6	7.0	4.9	1.3	2.6	1.1	1.4	2.0	7.0	0.5	0.0	10.1	5.1	1.2	4.4	78.0
AUS	5.1	3.5	16.6	3.9	1.0	5.0	3.2	2.6	0.8	4.6	4.8	5.8	1.4	1.2	4.6	0.6	2.1	11.2	1.8	0.4	7.7	2.2	5.1	4.8	83.4
BEL	7.5	0.1	8.3	18.8	2.5	5.7	3.9	1.2	3.6	4.3	2.2	7.4	0.3	0.0	1.8	0.8	0.9	5.8	3.0	3.7	4.2	0.4	8.0	5.4	81.2
BRA	3.4	2.8	2.4	2.3	26.8	3.6	4.8	2.6	6.7	2.4	4.7	4.0	5.3	3.8	1.1	0.5	0.5	3.3	1.4	0.8	5.6	4.9	1.0	5.3	73.2
CAN	6.6	4.6	5.1	3.4	1.1	14.4	2.5	5.8	4.1	4.6	4.6	6.9	0.6	0.6	1.5	1.1	1.7	4.8	0.9	1.2	9.8	2.3	4.9	6.9	85.6
CHL	3.6	2.2	5.3	3.5	1.7	5.8	25.2	3.7	3.0	1.8	3.2	5.0	1.9	0.8	1.0	1.9	1.2	3.8	1.3	1.7	5.3	1.7	6.8	8.5	74.8
CHN	4.8	6.9	3.5	1.5	0.9	7.5	2.9	20.5	2.2	1.2	3.0	6.0	0.2	0.8	0.2	1.3	1.8	4.3	0.1	0.7	16.3	5.1	3.1	5.1	79.5
CRT	4.1	2.4	1.7	4.3	3.8	6.9	5.7	1.6	18.1	7.1	4.8	5.4	2.8	0.8	1.0	1.0	1.5	2.3	1.7	3.4	4.1	0.7	6.9	7.8	81.9
CYP	2.5	2.9	4.7	4.4	1.3	6.1	1.5	1.0	4.6	24.5	5.5	3.9	1.2	1.2	4.6	0.0	3.0	4.8	3.6	1.1	4.0	0.5	8.3	4.8	75.5
FRA	4.0	5.7	3.4	1.5	2.4	5.8	1.9	2.9	4.4	7.2	14.8	6.0	2.8	2.9	2.3	0.4	4.1	4.7	2.4	0.4	8.0	5.0	3.0	3.9	85.2
GER	6.5	4.0	6.0	3.4	1.6	6.8	4.1	3.7	4.0	3.3	6.0	13.4	1.1	1.4	1.4	0.5	2.4	6.1	1.4	0.8	8.7	3.4	4.6	5.4	86.6
GRE	1.5	1.7	2.4	2.5	3.2	3.9	7.3	0.2	7.0	6.6	7.7	2.8	25.4	1.7	1.8	0.7	2.3	3.1	3.0	1.5	1.9	2.2	5.3	4.4	74.6
HKG	2.1	2.6	4.2	0.3	0.1	2.8	2.9	5.4	0.6	3.9	3.7	2.3	0.8	34.5	5.0	0.1	2.3	5.8	0.3	0.3	5.8	6.4	2.8	5.1	65.5
IND	2.0	0.7	10.7	4.2	0.6	2.7	1.6	0.4	0.6	8.0	3.6	2.8	1.3	3.8	25.6	0.2	2.6	8.4	3.0	0.8	3.3	2.0	7.4	3.8	74.4
IRE	5.7	4.5	5.1	5.6	2.9	6.2	2.6	3.2	4.5	4.7	4.6	5.7	0.6	0.6	1.4	15.2	1.2	5.1	1.1	1.4	7.2	2.0	4.7	4.4	84.8
ITA	4.0	2.6	5.3	3.3	0.3	5.1	2.3	1.9	1.7	7.0	6.6	6.4	1.2	0.4	2.1	0.3	23.1	5.3	4.9	0.8	5.8	1.9	4.9	2.8	76.9
JPN	4.7	3.0	9.9	5.2	1.5	3.7	2.4	3.6	1.4	5.5	4.1	4.8	1.1	2.4	3.1	0.4	1.9	18.1	1.4	0.4	8.2	3.6	3.7	6.0	81.9
NET	4.6	1.0	9.5	6.1	1.4	5.1	2.5	0.6	0.7	8.2	4.1	4.5	1.4	0.5	4.2	0.4	2.6	7.7	20.2	0.5	4.1	1.4	4.3	4.6	79.8
RUS	4.4	2.0	3.4	5.3	1.4	7.1	8.2	4.7	6.1	2.4	1.8	6.1	0.5	0.3	0.8	1.9	1.3	2.9	0.4	18.9	5.5	0.8	6.8	7.0	81.1
SIN	6.3	5.2	5.8	3.1	1.3	7.7	2.7	10.4	2.7	3.0	4.5	6.9	0.4	0.9	1.1	0.9	2.2	6.0	0.6	0.8	13.8	4.4	4.2	5.2	86.2
SKR	5.6	6.0	4.2	1.3	0.7	5.8	2.1	7.9	0.9	2.1	5.3	6.3	1.2	2.0	1.4	0.5	2.8	6.3	0.5	0.2	12.7	19.3	1.8	3.2	80.7
SPA	4.4	1.2	5.8	6.2	1.0	5.0	4.2	2.0	4.5	8.1	4.3	4.5	1.2	0.7	4.2	0.2	2.8	4.8	3.0	2.4	4.9	0.5	19.6	4.7	80.4
SWE	4.9	3.0	5.1	2.3	0.9	5.8	5.7	1.3	2.9	7.5	3.7	4.5	1.1	2.6	2.3	0.3	0.9	7.6	1.0	0.6	4.7	1.9	4.6	24.7	75.3
Contribution to others	101.3	71.0	122.1	80.3	34.7	126.1	78.7	77.5	73.6	112.0	103.8	120.5	30.2	32.5	49.0	16.5	45.8	126.4	38.6	25.9	158.0	61.5	108.7	119.3	1914.0
Net contribution	14	-7	38.7	-0.9	-38.5	40.5	3.9	-2	-8.3	36.5	18.6	33.9	-44.4	-33	-25.4	-68.3	-31.1	44.5	-41.2	-55.2	71.8	-19.2	28.3	44	
Contribution including own	114.0	93.0	138.7	99.1	61.5	140.5	103.9	98.0	91.7	136.5	118.6	133.9	55.6	67.0	74.6	31.7	68.8	144.4	58.8	44.8	171.7	80.8	128.3	144.0	79.7%

4 The abbreviations of the countries are presented in Appendix B.

Table 2. Stock return Spillover (Connectedness) index

	US	UK	AUS	BEL	BRA	CAN	CHL	CHN	FRA	GER	HKG	IND	IRE	ITA	JPN	NET	SIN	SKR	SPA	From Others
US	3.5	4.2	7.9	8.6	0.1	0.7	0.2	2.1	8.8	8.7	6.4	4.8	3.1	6.9	6.4	8.0	7.1	6.0	6.5	96.5
UK	0.2	14.9	7.2	7.7	0.1	0.5	0.5	1.4	8.2	7.1	5.1	4.1	5.6	6.4	4.2	7.7	7.0	4.9	7.3	85.1
AUS	0.3	3.8	14.5	8.4	0.0	0.3	0.1	2.1	8.8	7.4	5.9	5.4	2.9	7.1	5.6	7.7	7.1	5.4	7.0	85.5
BEL	0.2	4.0	7.2	12.6	0.0	0.3	0.2	1.5	9.7	8.1	5.2	4.4	3.8	8.5	5.4	9.4	6.5	5.3	7.7	87.4
BRA	0.4	3.7	7.5	6.5	10.4	1.3	0.4	3.4	6.0	5.7	8.2	7.1	1.3	6.1	4.2	5.9	8.4	7.1	6.4	89.6
CAN	0.7	3.2	8.8	8.3	0.5	4.8	0.3	2.1	8.0	7.3	6.7	5.6	2.7	6.6	5.5	8.2	7.8	6.6	6.4	95.2
CHL	0.8	2.4	4.1	3.3	0.1	1.3	52.0	2.6	3.9	3.3	3.7	2.3	1.1	2.7	3.1	3.7	4.0	2.2	3.5	48.0
CHN	0.4	1.3	4.3	3.7	0.3	0.1	0.6	36.7	3.0	3.9	12.2	4.3	0.7	3.4	4.4	3.9	7.5	6.3	3.0	63.3
FRA	0.1	4.0	7.4	9.4	0.0	0.3	0.1	1.1	11.8	9.7	4.5	3.9	3.3	9.3	5.9	9.3	6.1	5.2	8.5	88.2
GER	0.3	3.4	6.7	8.4	0.1	0.2	0.1	1.5	10.5	12.7	4.9	4.7	3.0	8.3	6.1	8.8	6.5	6.3	7.6	87.3
HKG	0.3	3.8	6.0	6.0	0.3	0.4	0.3	5.2	5.8	5.9	15.8	6.8	2.1	5.6	5.9	6.1	10.2	7.6	6.0	84.2
IND	0.1	2.6	6.6	6.6	0.1	0.5	0.4	2.1	6.0	6.6	8.0	18.0	2.1	5.7	5.7	6.4	8.8	7.2	6.4	82.0
IRE	0.2	6.7	6.5	9.1	0.1	0.3	0.3	1.6	8.3	6.7	3.5	3.1	18.4	7.6	4.9	8.2	4.7	4.2	5.7	81.6
ITA	0.3	3.5	6.9	9.3	0.1	0.2	0.1	1.3	10.6	8.7	4.8	4.1	3.4	13.1	5.4	8.3	5.8	4.6	9.8	86.9
JPN	0.1	2.8	6.1	7.1	0.2	0.2	0.3	2.3	8.2	7.8	6.3	5.0	3.1	6.6	16.1	8.2	7.0	5.9	6.7	83.9
NET	0.1	4.6	6.4	9.4	0.0	0.3	0.3	1.3	9.8	8.7	4.9	4.3	3.9	7.7	6.1	12.4	6.8	5.9	7.0	87.6
SIN	0.2	4.0	6.3	7.1	0.3	0.4	0.7	2.8	6.9	7.0	8.8	6.6	2.4	5.9	6.0	7.4	13.6	7.1	6.4	86.4
SKR	0.2	3.3	6.0	6.9	0.2	0.1	0.3	2.7	7.1	7.9	7.6	6.4	2.6	5.5	5.7	7.6	8.3	15.7	6.0	84.3
SPA	0.2	3.9	6.7	8.6	0.1	0.2	0.0	1.2	9.8	8.1	5.3	4.8	2.7	10.0	5.7	7.6	6.4	5.1	13.6	86.4
Contribution to others	4.9	65.1	118.6	134.5	2.4	7.6	5.0	38.4	139.4	128.8	112.2	87.6	49.9	120.0	96.1	132.3	126.2	102.8	117.7	1589.4
Net contribution	-92	-20	33.1	47.1	-87.2	-87.6	-43	-24.9	51.2	41.5	28	5.6	-31.7	33.1	12.2	44.7	39.8	18.5	31.3	
Contribution including own	8.4	79.9	133.1	147.0	12.8	12.4	56.9	75.1	151.2	141.6	128.0	105.7	68.3	133.1	112.2	144.8	139.8	118.5	131.3	83.7%

Table 3. Bond return Spillover (Connectedness) index

	US	UK	AUS	BEL	BRA	CAN	CHL	CHN	FRA	GER	GRE	IRE	ITA	JPN	NET	SKR	SPA	SWE	From Others
US	21.6	7.6	8.1	0.6	0.1	13.5	2.9	6.5	5.5	7.2	0.1	3.1	0.7	0.3	3.9	6.2	1.0	10.9	78.4
UK	3.8	19.2	2.3	0.1	0.1	4.1	16.1	11.7	5.0	10.6	0.2	6.2	1.5	2.4	10.9	0.3	1.3	4.3	80.8
AUS	4.3	11.6	12.8	0.4	0.4	4.7	15.0	6.8	6.1	9.7	1.1	7.3	0.2	2.0	10.0	1.4	0.4	5.8	87.2
BEL	0.8	0.9	1.6	70.5	0.7	1.2	1.2	2.3	3.4	1.2	0.6	2.9	2.5	3.3	1.0	0.7	3.9	1.4	29.5
BRA	0.1	0.8	0.1	0.6	88.4	0.9	0.0	0.9	0.9	0.4	0.3	0.2	3.0	0.5	0.3	2.0	0.2	0.3	11.6
CAN	13.9	8.8	8.6	1.2	0.1	21.6	3.2	4.9	5.6	7.2	0.5	4.9	0.8	0.4	5.2	3.1	1.1	8.8	78.4
CHL	1.2	3.6	1.3	0.5	1.6	1.4	58.3	3.7	2.1	3.7	0.8	12.2	0.6	1.2	3.7	2.7	0.7	0.8	41.7
CHN	1.5	1.5	1.3	0.1	0.4	0.1	24.5	44.6	1.4	3.9	0.3	0.4	6.2	3.5	4.8	1.5	2.9	1.3	55.4
FRA	4.0	9.0	4.9	1.9	0.7	4.8	2.5	0.9	15.9	14.1	1.3	13.4	0.3	1.1	13.7	0.8	1.9	8.8	84.1
GER	4.1	10.0	2.7	0.4	0.1	4.0	6.7	3.6	8.5	19.6	0.6	12.5	0.2	2.3	16.2	0.1	0.5	8.1	80.4
GRE	2.4	5.3	0.7	0.2	0.6	2.6	0.6	0.3	3.9	5.9	28.5	22.3	11.8	0.1	2.9	0.1	7.8	3.9	71.5
IRE	5.7	9.9	2.0	0.6	0.1	5.9	2.1	0.1	2.7	8.1	1.9	43.8	0.7	0.4	6.6	0.1	3.1	6.0	56.2
IT	3.0	6.5	0.9	0.5	3.5	3.1	1.3	0.6	3.6	5.1	1.3	25.9	29.1	0.1	3.7	0.3	8.0	3.5	70.9
JPN	2.1	2.0	1.6	3.7	0.9	1.7	2.6	2.7	1.0	0.5	0.1	1.9	1.0	67.4	0.5	5.2	3.6	1.5	32.6
NET	2.9	10.0	2.7	0.9	0.2	4.1	4.4	1.8	10.9	18.9	0.3	8.9	0.0	4.7	21.0	0.1	0.6	7.6	79.0
SKR	4.5	0.9	4.5	0.1	0.1	1.9	19.5	27.0	2.6	4.1	0.3	0.2	3.8	1.8	4.7	19.4	2.3	2.2	80.6
SPA	3.6	8.3	1.8	0.7	1.0	3.4	0.9	0.1	6.6	9.2	2.0	29.1	6.1	0.1	5.1	0.2	16.1	5.9	83.9
SWE	7.0	10.2	5.1	0.3	0.2	4.2	7.0	8.5	7.9	15.8	0.4	5.6	1.0	0.7	12.0	1.2	0.6	12.3	87.7
Contribution to others	64.9	107.0	50.1	12.8	10.8	61.7	110.6	82.6	77.4	125.8	12.3	156.7	40.4	24.9	105.2	26.1	39.9	80.8	1190.0
Net contribution	-13.5	26.2	-37.1	-16.7	-0.8	-16.7	68.9	27.2	-6.7	45.4	-59.2	100.5	-30.5	-7.7	26.2	-54.5	-44	-6.9	
Contribution including own	86.5	126.2	62.8	83.2	99.2	83.3	168.9	127.1	93.3	145.4	40.8	200.5	69.5	92.3	126.2	45.6	56.0	93.1	66.1%

Table 4. Exchange rate return spillover (Connectedness) index

	EZ	UK	AUS	BRA	CAN	CHL	CHN	HKG	IND	JPN	RUS	SKR	SWE	From Others
EZ	24.7	7.6	6.5	0.7	3.8	2.5	0.6	32.7	0.5	0.5	2.5	2.4	14.9	75.3
UK	11.6	37.7	9.6	0.8	6.0	2.0	1.2	11.3	0.6	1.1	3.2	3.3	11.7	62.3
AUS	5.7	5.9	27.1	5.2	10.7	6.7	0.6	13.7	4.0	0.6	4.4	6.9	8.6	72.9
BRA	1.1	1.0	9.1	44.3	6.1	7.9	3.0	4.2	4.2	0.1	9.5	5.7	3.9	55.7
CAN	5.3	5.2	13.8	4.1	34.9	5.7	0.7	6.4	2.1	0.7	5.7	6.3	9.2	65.1
CHL	4.0	1.9	10.8	7.6	6.7	43.2	1.5	9.0	2.6	0.5	4.5	3.2	4.4	56.8
CHN	1.5	1.2	1.4	2.3	1.5	3.6	71.8	5.5	2.9	0.1	4.8	1.2	2.4	28.2
HKG	0.1	0.3	0.9	0.2	0.2	0.9	0.2	92.6	0.3	0.7	0.4	3.1	0.1	7.4
IND	0.7	0.9	9.2	4.9	3.1	3.3	2.4	12.5	51.9	0.6	3.2	4.6	2.5	48.1
JPN	0.8	1.5	1.1	0.6	1.5	1.1	0.1	7.7	1.6	82.1	0.1	0.7	1.1	17.9
RUS	4.2	3.8	7.7	7.0	7.5	4.8	3.4	1.1	2.8	0.5	46.7	3.8	6.8	53.3
SKR	2.9	2.7	10.2	4.5	6.7	2.9	0.7	21.7	3.1	0.3	3.0	37.0	4.2	63.0
SWE	14.4	7.0	9.2	2.0	6.6	2.8	0.9	23.6	1.2	0.5	3.7	2.7	25.4	74.6
Contribution to others	52.4	39.1	89.5	39.8	60.3	44.2	15.4	149.3	25.9	6.2	45.1	43.8	69.7	680.9
Net contribution	-22.9	-23.2	16.6	-15.9	-4.8	-12.6	-12.8	141.9	-22.2	-11.7	-8.2	-19.2	-4.9	
Contribution including own	77.1	76.8	116.6	84.1	95.2	87.3	87.1	241.9	77.8	88.4	91.8	80.8	95.1	52.4%

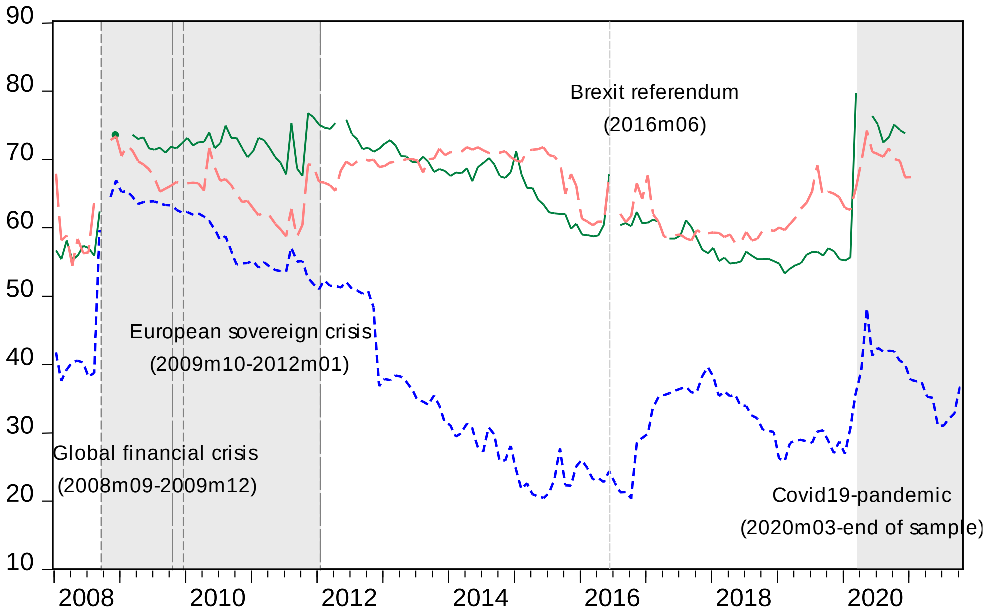
Table 5. Descriptive statistics of the spillover indices of all variables (all countries)

	BOND RETURN SPILLOVER INDEX	EPU SPILLOVER INDEX	EXCHANGE RATE RETURN SPILLOVER INDEX	STOCK RETURN SPILLOVER INDEX
MEAN	82.13	83.64	70.78	84.84
MEDIAN	82.43	83.94	71.08	83.30
MAXIMUM	87.06	89.00	82.46	91.56
MINIMUM	71.76	76.68	56.70	78.95
STD. DEV.	3.41	2.87	6.52	4.14
OBSERVATIONS	142	136	144	143

Table 6. Descriptive statistics of the EPU spillover indices

	ALL COUNTRIES EPU SPILLOVER INDEX	AMERICA EPU SPILLOVER INDEX	ASIA EPU SPILLOVER INDEX	EUROPE EPU SPILLOVER INDEX
MEAN	83.64	39.64	65.48	65.42
MEDIAN	83.94	35.78	66.36	67.68
MAXIMUM	89.00	66.82	74.09	79.57
MINIMUM	76.68	20.22	54.30	53.17
STD. DEV.	2.87	13.52	4.81	7.49
OBSERVATIONS	136	157	156	161

Figure 1 Dynamic spillover indices of EPU for three continents



Notes: The blue (highly-dashed) line is the uncertainty spillover index for America, the red (simple dashed) line is the uncertainty spillover index for Asia, and the green line is the uncertainty spillover index for Europe.

Figure 2 Dynamic spillover index of EPU – all countries

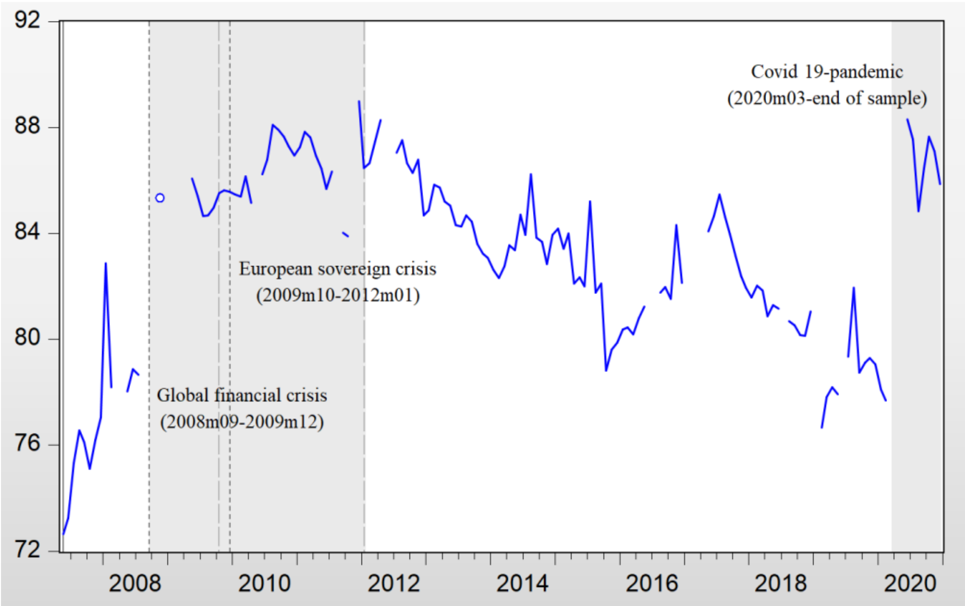


Figure 3 Dynamic spillover index of EPU – America

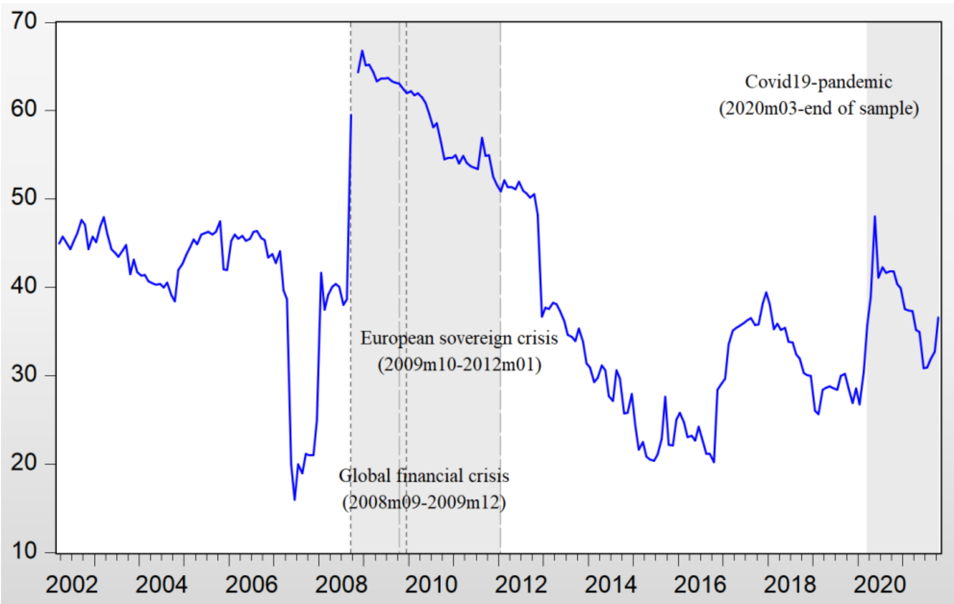


Figure 4 Dynamic spillover index of EPU - Asia

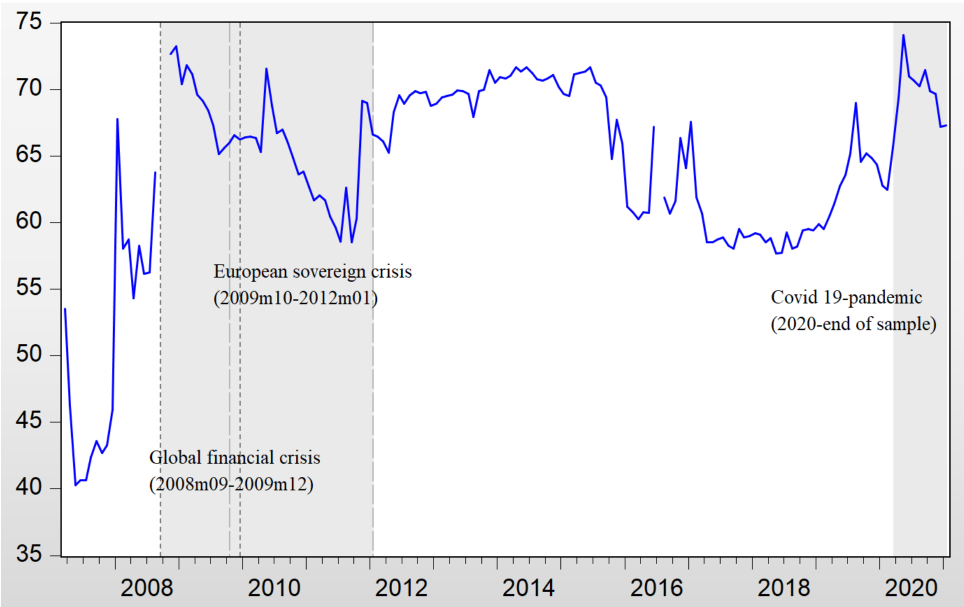


Figure 5 Dynamic spillover index of EPU – Europe

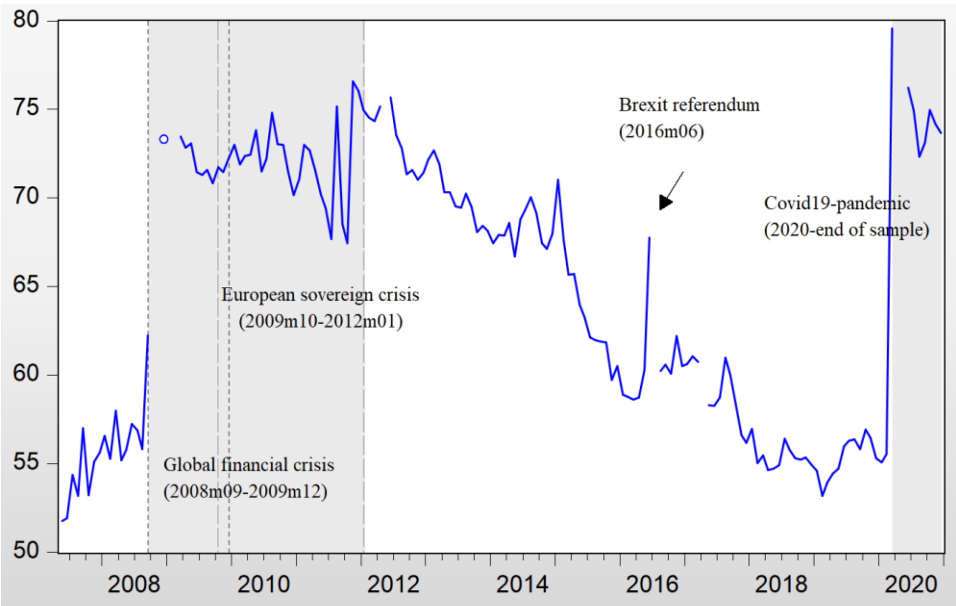
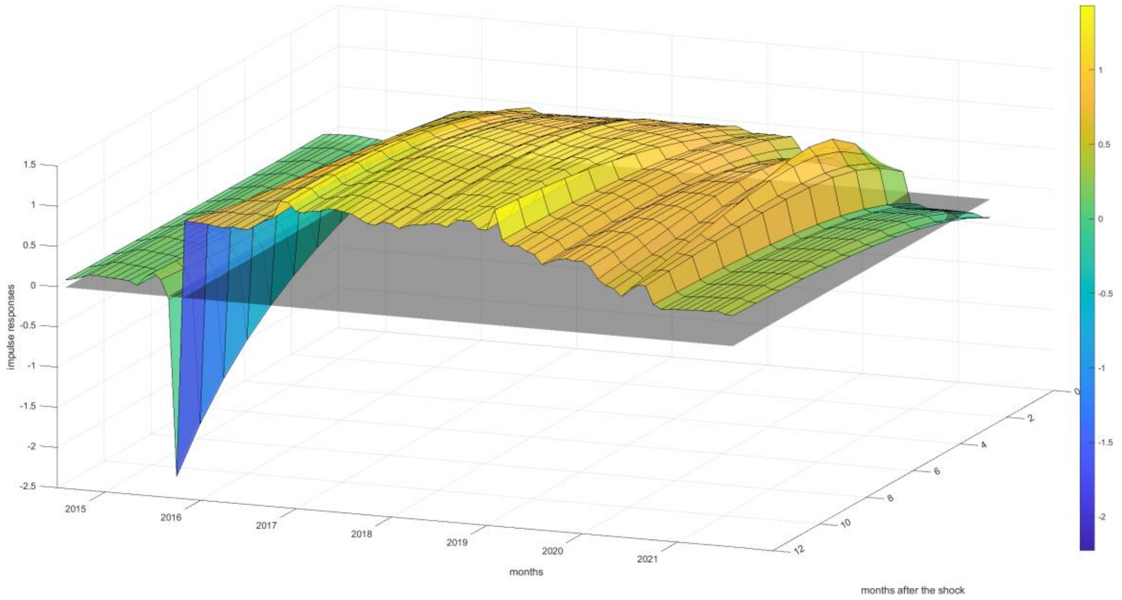
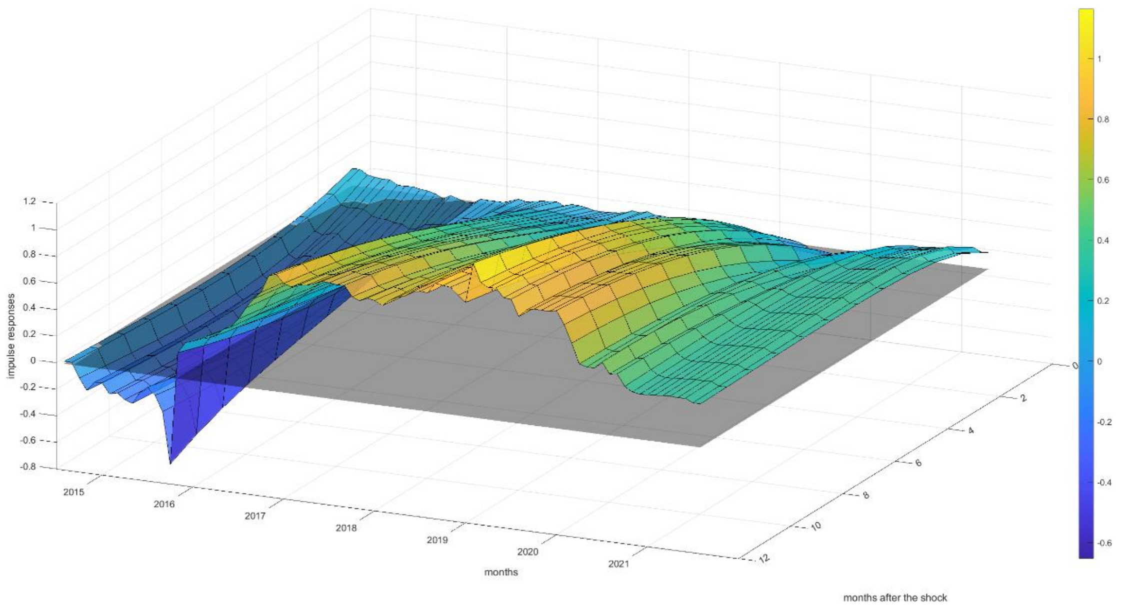


Figure 6 Rolling GIRFs of bond yield spillover index to EPU spillover index shocks – all countries



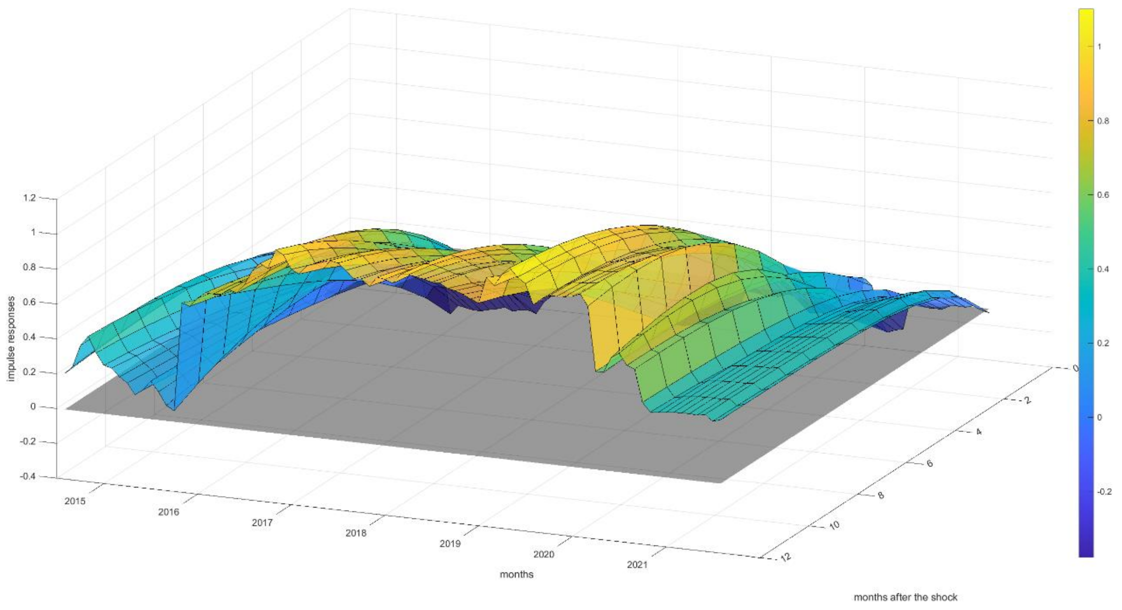
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 7 Rolling GIRFs of stock market returns spillover index to EPU spillover index shocks – all countries



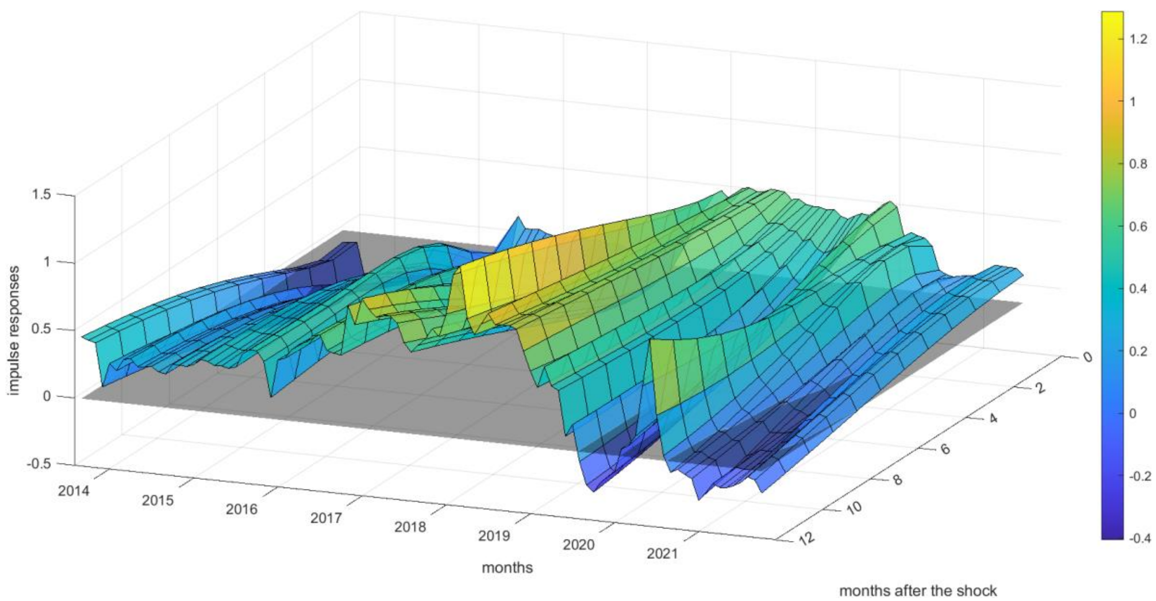
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 8 Rolling GIRFs of exchange rate spillover index to EPU spillover index shocks – all countries



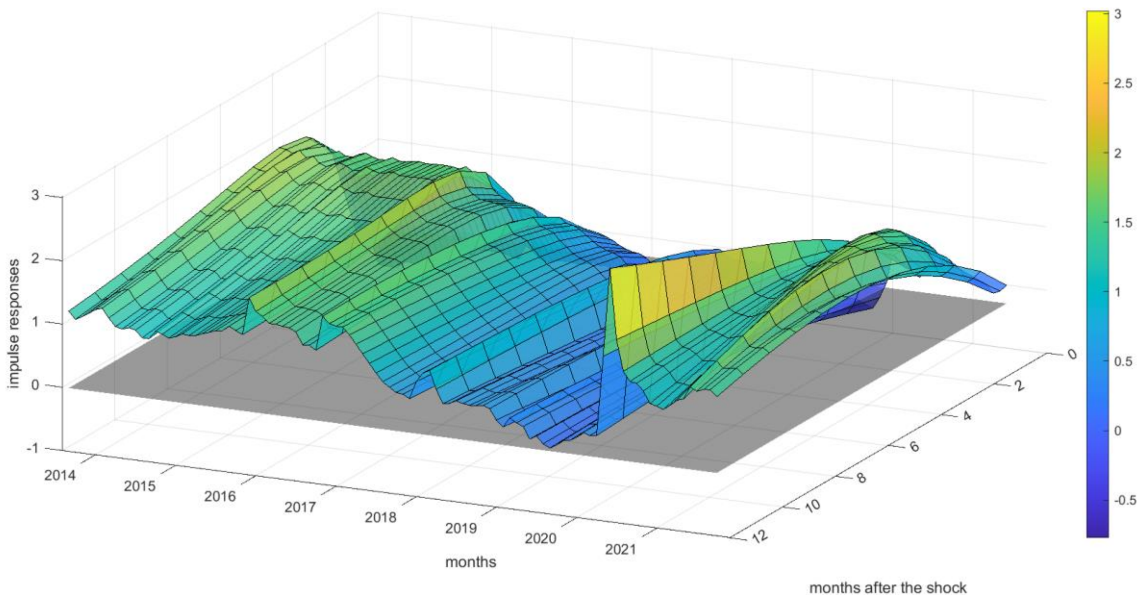
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 9 Rolling GIRFs of bond yield spillover index to EPU spillover index shocks - America



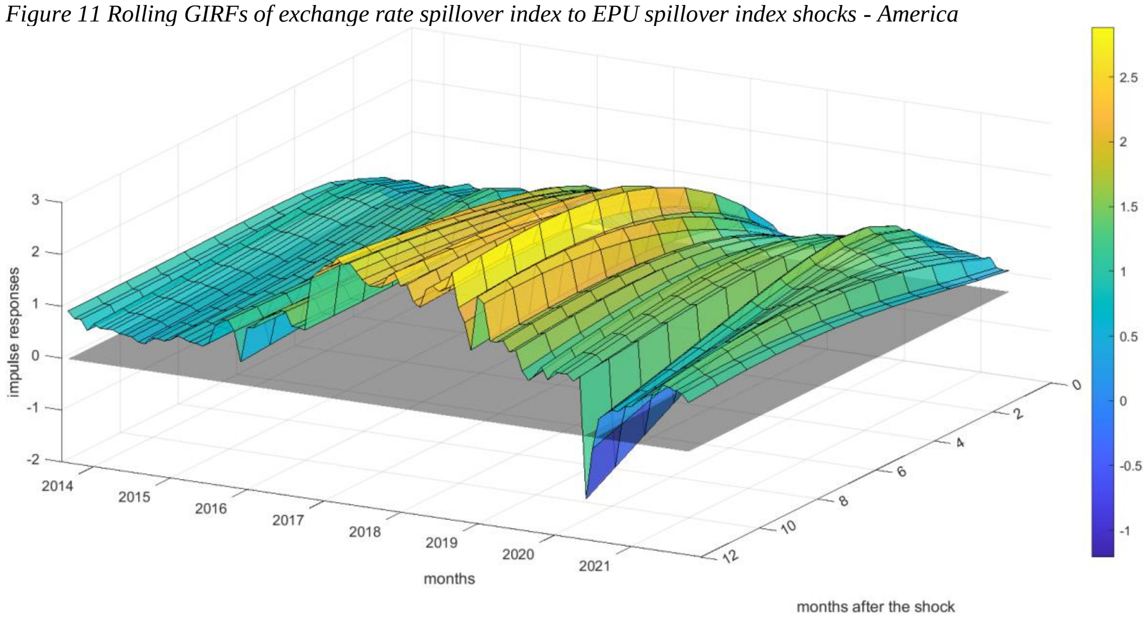
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 10 Rolling GIRFs of stock market returns spillover index to EPU spillover index shocks - America



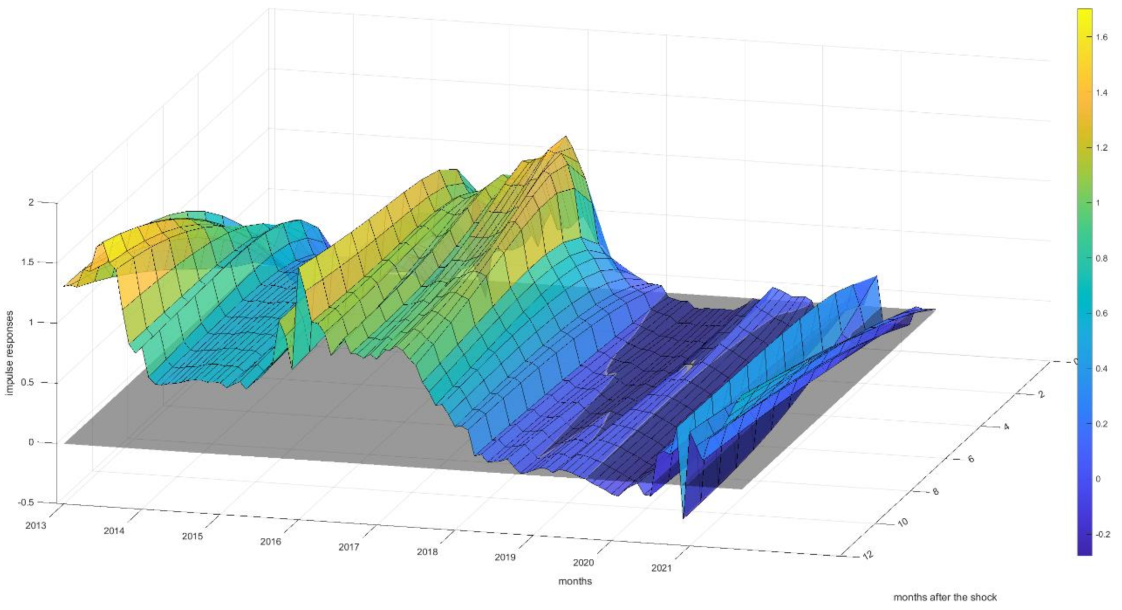
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 11 Rolling GIRFs of exchange rate spillover index to EPU spillover index shocks - America



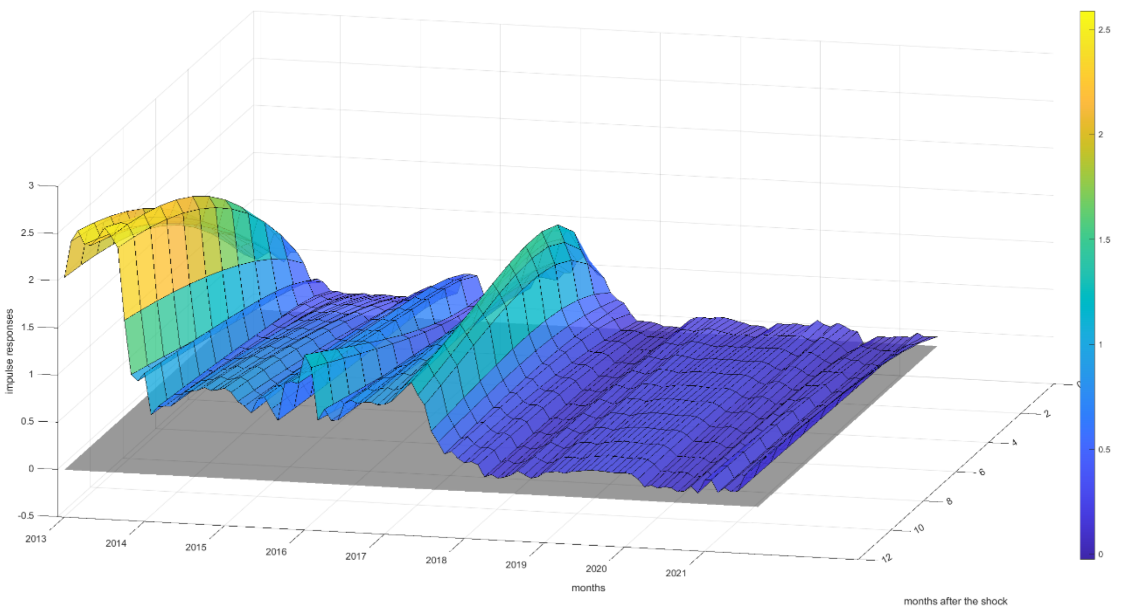
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 12 Rolling GIRFs of bond yield spillover index to EPU spillover index shocks - Asia



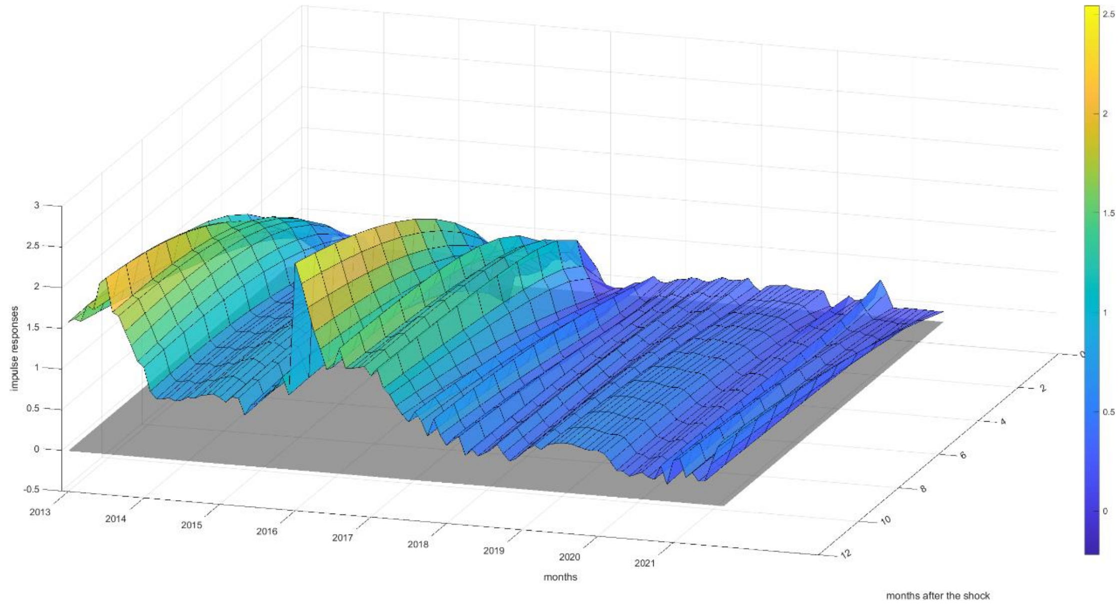
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 13 Rolling GIRFs of stock market returns spillover index to EPU spillover index shocks - Asia



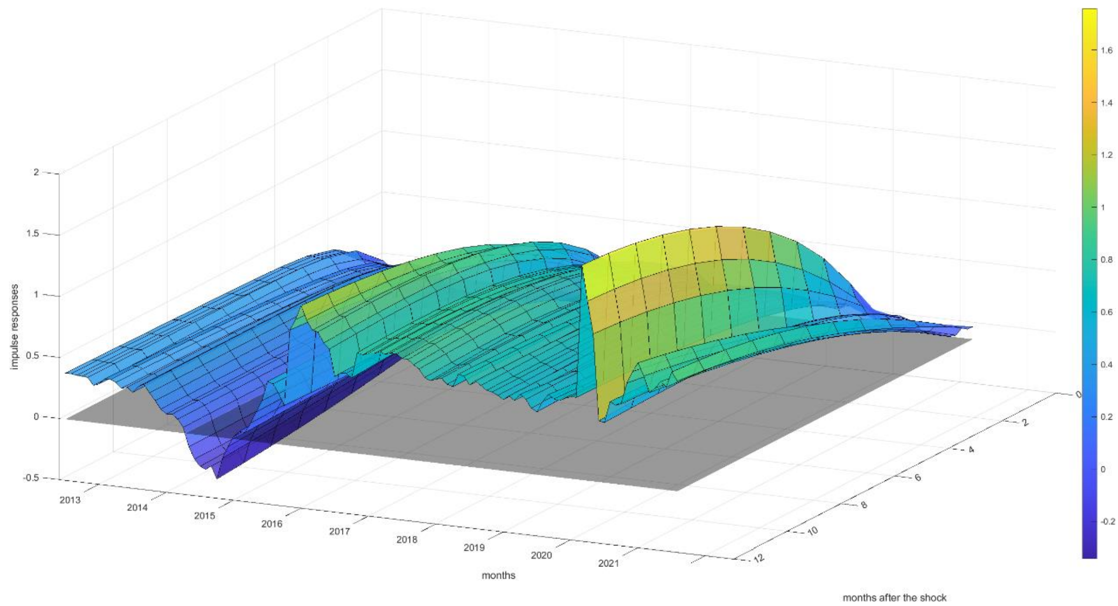
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 14 Rolling GIRFs of exchange rate spillover index to EPU spillover index shocks - Asia



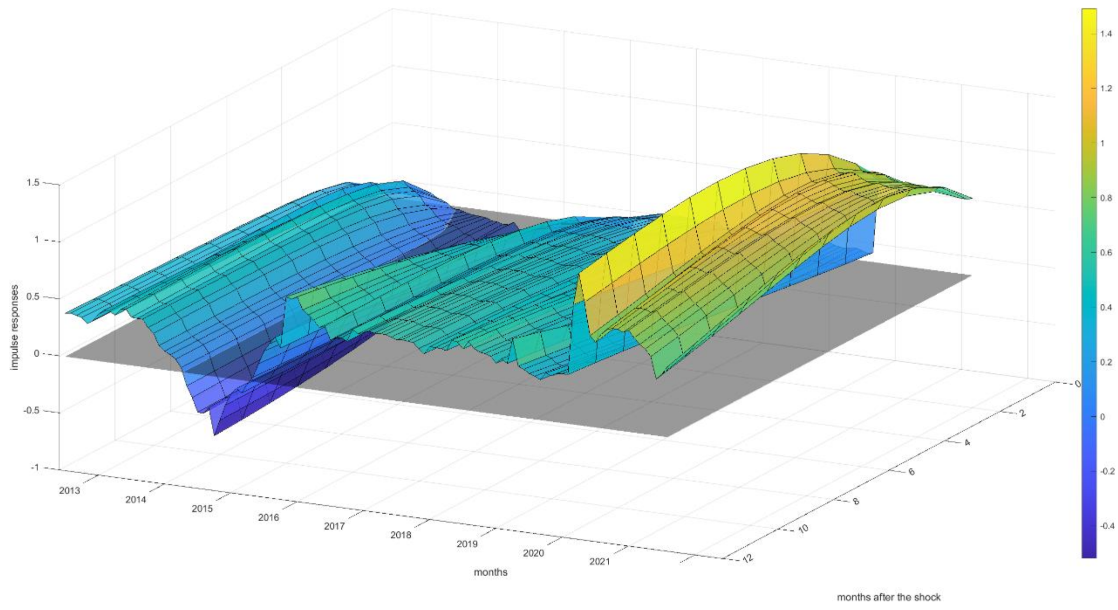
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 15 Rolling GIRFs of bond yield spillover index to EPU spillover index shocks - Europe



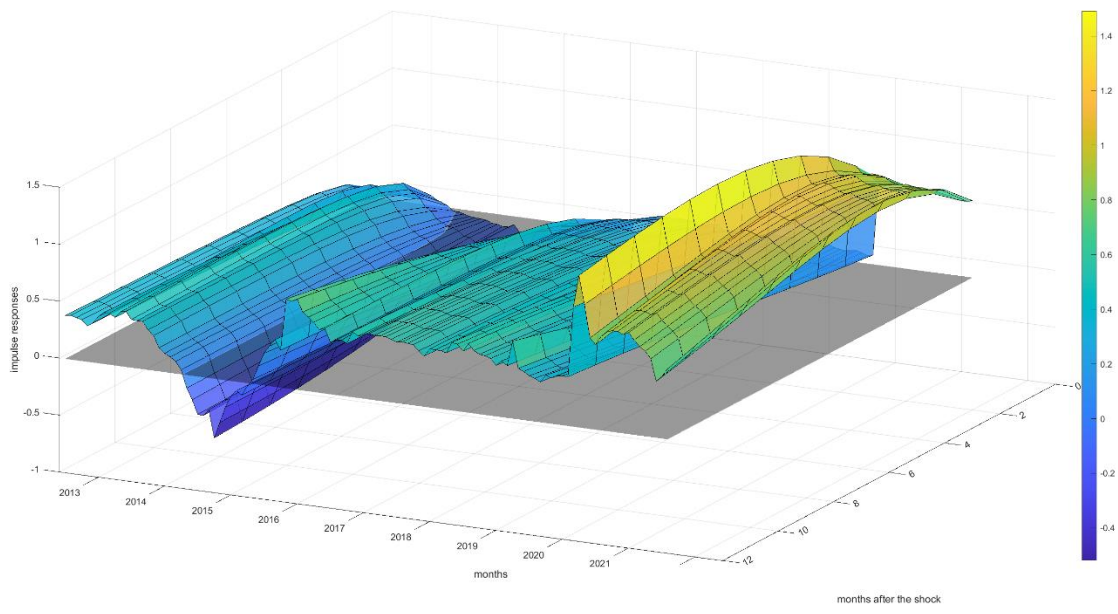
Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 16 Rolling GIRFs of stock market returns spillover index to EPU spillover index shocks - Europe



Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Figure 17 Rolling GIRFs of exchange rate spillover index to EPU spillover index shocks - Europe



Notes: The Generalised Impulse Response functions are estimated to one standard deviation shocks on the EPU spillover index.

Appendix A

The descriptive statistics of the main variables of the analysis, the EPU index, for all countries under examination are presented in Table 1.

Table 1. Descriptive statistics of the EPU index for the sample January 1998 until October 2021[5].

	MEAN	MEDIAN	MAXIMUM	MINIMUM	STD. DEV.
AUSTRALIA	107.67	89.84	337.04	25.66	62.46
BELGIUM	114.80	96.38	522.38	49.23	61.97
BRAZIL	165.83	141.51	676.96	22.30	97.31
CANADA	188.71	163.00	678.82	40.44	119.79
CHILE	112.46	96.38	345.65	31.60	59.44
CHINA	244.47	146.73	970.83	26.14	235.84
CROATIA	112.05	108.44	495.98	1.74	76.52
CYPRUS	109.27	118.85	228.55	28.80	43.95
FRANCE	204.48	199.39	574.63	30.62	98.57
GERMANY	152.39	138.53	498.06	28.43	80.98
GREECE	122.79	106.63	344.23	13.43	62.73
HONG KONG	144.15	131.85	425.36	31.50	71.15
INDIA	93.49	80.81	283.69	24.94	50.39
IRELAND	135.58	128.96	367.34	22.97	66.17
ITALY	112.67	104.57	279.39	31.70	40.86
JAPAN	107.45	104.81	240.23	48.37	34.91
NETHERLANDS	95.62	89.14	233.73	27.21	40.94
RUSSIA	169.34	129.55	793.63	24.11	122.47
SINGAPORE	139.00	120.32	407.74	49.39	73.88
S. KOREA	143.61	128.87	538.18	37.31	70.19
SPAIN	117.62	112.36	261.61	54.16	37.70
SWEDEN	93.94	93.69	183.18	53.73	20.76
UK	235.09	204.62	1141.80	30.47	160.24
US	136.52	115.49	503.96	44.78	70.21

[5] The sample may differ in some countries, based on EPU data availability.

Appendix B

Table 2: Countries' acronyms

US	United States of America
UK	United Kingdom
AUS	Australia
BEL	Belgium
BRA	Brazil
CAN	Canada
CHL	Chile
CHN	China
CRT	Croatia
CYP	Cyprus
FRA	France
GER	Germany
GRE	Greece
HKG	Hong-Kong
IND	India
IRE	Ireland
ITA	Italy
JPN	Japan
NET	Netherlands
RUS	Russia
SIN	Singapore
SKR	South Korea
SPA	Spain
SWE	Sweden