Dynamic Spillovers of Oil Price Shocks and Economic Policy Uncertainty

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Abstract

This study examines the dynamic relationship between changes in oil prices and the economic policy uncertainty index for a sample of both net oil–exporting and net oil–importing countries over the period 1997:01–2013:06. To achieve that, an extension of the Diebold and Yilmaz (2009, 2012) dynamic spillover index based on structural decomposition is employed. The results reveal that economic policy uncertainty (oil price shocks) responds negatively to aggregate demand oil price shocks (economic policy uncertainty shocks). Furthermore, during the Great Recession of 2007–2009, total spillovers increase considerably, reaching unprecedented heights. Moreover, in net terms, economic policy uncertainty becomes the dominant transmitter of shocks between 1997 and 2009, while in the post–2009 period there is a significant role for supply–side and oil specific demand shocks, as net transmitters of spillover effects. These results are important for policy makers, as well as, investors interested in the oil market.

Keywords: Economic policy uncertainty, Oil price shocks, Spillover index, Structural Vector Autoregression, Variance Decomposition, Impulse Response Function

JEL codes: C32; C51; E60; Q43; Q48

1. Introduction

This paper addresses an important question, which has recently emerged in the economic literature; that is, the relationship between oil prices and the economic policy uncertainty index. In particular, the aim of this paper is to examine spillovers between Brent crude oil prices and the Baker et al. (2013) economic policy uncertainty index (EPU). To achieve that, we extend the spillover index approach by Diebold and Yilmaz (2009, 2012), using structural decomposition rather than Choleski decomposition (Diebold and Yilmaz, 2009) or generalized forecast error variance decomposition

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(Diebold and Yilmaz, 2012). Furthermore, in order to generate more informative results, we disentangle oil price shocks according to their origin (i.e. supply–side shocks, aggregate demand shocks and oil specific demand shocks), as in Kilian and Park (2009), and we then investigate the spillover effects between these disaggregated shocks and the economic policy uncertainty indices. It is worth noting that disentangling oil price shocks is important to increase our understanding regarding the effects of oil prices. In fact, several authors have documented the significance of disentangling oil price shocks in order to assess their true impact on the economy (see, among others, Degiannakis et al., 2014; Baumeister and Peersman, 2013; Lippi and Nobili, 2012; Kilian and Lewis, 2011; Filis et al., 2011; Kilian and Park, 2009).

The economic policy-related uncertainty index of Baker et al. (2013) is constructed based on three underlying components. The first component quantifies newspaper coverage of policy-related economic uncertainty (specifically, the index of search results for articles containing terms related to economic policy uncertainty). The second US–specific component reflects the number of federal tax code provisions set to expire in future years, giving a measure of the level of uncertainty regarding the path that the federal tax code will take in the future. Finally, the third component measures fiscal and monetary policy uncertainty. In particular, the authors use forecaster disagreement over federal and state/local government purchases as the measure of fiscal policy uncertainty, while forecast disagreement over future inflation is used as the proxy for monetary policy uncertainty. Thus, the EPU index brings together economic policy uncertainty related to public views and economic policy making. In this regard, this paper complements previous research relating to the effects of oil price shocks on growth and financial markets as it focuses on the relationship between oil and economic policy issues. The countries under investigation are the US, Canada, China, India, and the aggregate Europe, which represent a sizeable portion of the global economy. In addition, we also consider individual European countries (the UK, Germany, France, Italy and Spain) to further investigate the possibility that spillover effects exhibit a heterogeneous pattern across European countries. This is important as the countries which constitute Europe are diverse in terms of the nature of their economic policy uncertainty. The study uses monthly data over the period 1997:01–2013:06. Although it would be informative to include more European countries in our sample, we are constrained by the data availability of the Baker et al. (2013) economic policy uncertainty indices.

Focusing on spillover effects, this study builds on the work of Kang and Ratti (2013) who examine the causal effects of oil price shocks on the economic policy uncertainty index in the US. They find that positive aggregate demand shocks exercise a significant negative effect on policy uncertainty, whereas oil specific demand shocks have the opposite effect. Furthermore, supply–side shocks do not seem to exert any effect.

In order to examine these spillover effects between oil prices (or their shocks) and the economic policy uncertainty index, first we need to explain their relationship. We start our analysis with the investigation of the effects of oil prices on economic policy. Since the seminal paper by Hamilton (1983), mounting empirical evidence indicates that oil prices exercise a strong negative influence on the economy. More specifically, past evidence suggest that there are significant effects of oil prices on industrial production and inflation (see, *inter alia*, Filis and Chatziantoniou, 2013; Balke et al., 2010; Tang et al., 2010; Du et al., 2010; Filis, 2010; Peter Ferderer, 1997). Furthermore, authors such as, Rahman and Serletis (2011), Elder and Serletis (2010), Cologni and Manera (2008), Cunado and Pérez de Gracia (2005), Lee et al. (1995) and Hamilton (1983) confirm that the US economic activity has been significantly affected by rises in oil prices, as well as, by the uncertainty about future oil price changes. Along a similar vein, Montoro (2012) and Natal (2012) also establish the link between increased inflation and low production output given an oil price increase. As it is understood, this trade–off raises the concerns of and creates pressure to policymakers with regard to choosing the most appropriate response towards these oil price effects. A much earlier study by Gelb (1988) provides a more direct relationship between oil prices and economic policy, by showing that increased oil prices cause a rise in federal government purchases. Furthermore, a recent study by El Anshasy and Bradley (2012) which focuses on net oil–exporting economies, suggests that higher oil prices increase the government size, which it turn, raises concerns regarding its efficient operation.

We further our analysis by focusing on the effects of economic policy on oil prices. Economic policy decisions have an immediate effect on economic activity. For example, Bloom (2009) emphasises the effects of economic policy uncertainty on the business cycle. Antonakakis et al. (2013) find that aggregate demand oil price shocks and US recessions affect negatively the dynamic correlations of stock market returns, implied volatility and the economic policy uncertainty index. Furthermore, uncertainty pertaining to economic policy decisions, regardless of its origin (i.e. whether the uncertainty originates in potential fiscal or monetary policy decisions), discourages firms' investing activity not only because firms are uncertain about future aggregate demand but also because it puts upward pressure on financing costs (see, among others, Pástor and Veronesi, 2012, 2013; Fernández-Villaverde et al., 2011; Byrne and Davis, 2004). As expected, lower investment levels will lead to reduced demand for oil, pushing its price downwards. Malliaris and Malliaris (2013) also maintain that inflationary pressures exercise a significant impact on oil prices.

All that said, the aforementioned studies do not distinguish between the various types of oil price shocks. However, as already discussed, this should be a main consideration when it comes to examining the effects of oil prices on the economy. The pioneers of the notion of oil price shocks are Hamilton (2009a,b) and Kilian (2009b). In particular, Hamilton (2009a,b) identifies two oil price shocks, that is; demand–side oil price shocks, which stem from changes in aggregate demand, and supply–side oil price shocks, which stem from changes in oil production. Kilian (2009b) further disentangles demand–side shocks into two components, i.e. aggregate demand shocks (similar to the Hamilton (2009a,b) classification) and oil specific demand shocks, which are related to the uncertainty of the future availability of oil.

Based on the aforementioned analysis, we argue that conditional on a structural relationship that exists between oil prices (or their shocks) and the economic policy uncertainty index, the following hypotheses can be formulated:

Hypothesis 1: Spillover effects from oil prices (or their shocks) to economic policy uncertainty exist. In particular, we postulate that negative effects of oil prices on economic activity and inflation put additional pressure on policy decision making, which ultimately leads to increased economic policy uncertainty.

Hypothesis 2: Spillover effects from economic policy uncertainty to oil prices (or their shocks) also exist. Specifically, policy decisions have a direct effect on firm investment and production decisions, which further impact demand for oil and thus its price.

Hypothesis 3: Spillover effects between oil prices (or their shocks) and economic policy uncertainty are time–varying. We put forward the argument that spillover effects exhibit a dynamic character, which can be explained by different economic– and oil–related events that take place at different time periods.

In this regard, this study makes an important contribution to the existing literature as (i) it is the first to examine time–varying spillover effects between oil prices and economic policy uncertainty, (ii) it investigates both the effects of oil prices and oil price shocks and (iii) it adds to the limited number of studies pertaining to Baker et al. (2013) economic policy uncertainty index.

Our findings suggest that according to the impulse response function analysis, there is a negative response from both policy uncertainty and changes in oil prices to respective shocks from each variable. Classifying oil price shocks into supply–side, aggregate demand and oil specific demand shocks, we report that the economic policy uncertainty index responds only to aggregate demand shocks (negatively), whereas all three types of shocks are negatively influenced by innovations in the economic policy uncertainty index. Furthermore, time–varying total spillovers between the economic policy uncertainty index and changes in oil prices range between 10%–25% in the pre–2007 period. During the Great Recession of 2007–2009 we observe a significant peak in spillovers, which ranges between 40%–50%, depending on the country. When we disentangle oil price shocks, total spillovers significantly increase, reaching even the level of 75%. Net–spillovers suggest that the main transmitter of shocks is the economic policy uncertainty index up until the end of the Great Recession of 2007–2009, while in the years that followed it is the changes in oil prices that assume this role. Once we disaggregate oil price shocks into their three components, we observe that all variables can be either net transmitters or net recipients of spillover shocks, depending on the time period. Finally, results are qualitatively similar for both net oil–exporters and net oil–importers.

Overall, the findings suggest that unless we disentangle oil price shocks and proceed with a time–varying framework, we are not able to capture the full dynamics of the relationship between oil and the economic policy uncertainty index. Given the dynamic interaction between oil and the uncertainty surrounding economic policy decisions, these results are important for policy makers and investors. To be more explicit, it is important for investors to understand that during turbulent periods, attention should be drawn to economic policy uncertainty, considering the fact that the latter affects the market in which they operate. On the other hand, policy makers should be cautious when formulating macroeconomic policies at relatively tranquil times, as oil price shocks could undermine the successful outcomes of these policies.

The remainder of the paper is organized as follows. Section 2 discusses the methodology and describes the data. Section 3 presents the empirical findings, and Section 4 summarises and concludes the paper.

2. Empirical Methodology and Data

2.1. Spillover methodology

The spillover index approach introduced by Diebold and Yilmaz (2009) builds on the seminal work on VAR models by Sims (1980) and the well-known notion of variance decompositions. It allows an assessment of the contributions of shocks to variables to the forecast error variances of both the respective and the other variables of the model. Using rolling-window estimation, the evolution of spillover effects can be traced over time and illustrated by spillover plots. Starting point for the analysis is the following p–order, N–variable VAR

$$\mathbf{y}_t = \sum_{i=1}^{P} \mathbf{\Theta}_i \mathbf{y}_{t-i} + \varepsilon_t \tag{1}$$

where $\mathbf{y}_t = (y_{1t}, y_{2t}, \ldots, y_{Nt})$ is a $N \times 1$ vector of N endogenous variables, $\mathbf{\Theta}_i, i = 1, ..., P$, are $N \times N$ parameter matrices and $\varepsilon_t \sim (0, \Sigma)$ is a $N \times 1$ vector of disturbances that are independently distributed over time; $t = 1$, ..., T is the time index and $n = 1$, ..., N is the variable index.

Key to the dynamics of the system is the moving average representation of model (1), which is given by $\mathbf{y}_t = \sum_{j=0}^{\infty} \mathbf{A}_j \varepsilon_{t-j}$, where the $N \times N$ coefficient matrices $\mathbf{A}_j$ are recursively defined as $\mathbf{A}_j = \mathbf{\Theta}_1 \mathbf{A}_{j-1} + \mathbf{\Theta}_2 \mathbf{A}_{j-2} + \ldots + \mathbf{\Theta}_p \mathbf{A}_{j-p}$, where $\mathbf{A}_0$ is the $N \times N$ identity matrix and $\mathbf{A}_j = 0$ for $j < 0$.

Diebold and Yilmaz (2009) use Cholesky decomposition, which yields variance decompositions dependent on the ordering of the variables, whereas Diebold and Yilmaz (2012) extend the Diebold and Yilmaz (2009) model, using the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), in which variance decompositions are invariant to the order of the variables. Both models yield an $N \times N$ matrix $\phi(H) = [\phi_{ij}(H)]_{i,j=1,\ldots N}$, where each entry gives the contribution of variable j to the forecast error variance of variable i. The main diagonal elements contain the (own) contributions of shocks to the variable i to its own forecast error variance, the off-diagonal elements show the (cross) contributions of the other variables j to the forecast error variance of variable i.

Since the own– and cross–variable variance contribution shares do not sum to one under the generalized decomposition, i.e., $\sum_{j=1}^{N} \phi_{ij}(H) \neq 1$, each entry of the variance decomposition matrix is normalized by its row sum, such that

$$\tilde{\phi}_{ij}(H) = \frac{\phi_{ij}(H)}{\sum_{j=1}^{N} \phi_{ij}(H)} \tag{2}$$

with $\sum_{j=1}^{N} \tilde{\phi}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H) = N$ by construction.

This ultimately allows to define a total (volatility) spillover index, which is given by

$$TS(H) = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}_{ij}(H)}{N} \times 100 \tag{3}$$

which gives the average contribution of spillovers from shocks to all (other) variables to the total forecast error variance.

This approach is quite flexible and allows to obtain a more differentiated picture by considering directional spillovers: Specifically, the directional spillovers received by variable i from all other variables j are defined as

$$DS_{i\leftarrow j}(H) = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\phi}_{ij}(H)}{N} \times 100 \tag{4}$$

and the directional spillovers transmitted by variable i to all other variables j as

$$DS_{i\rightarrow j}(H) = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\phi}_{ji}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ji}(H)} \times 100 = \frac{\sum_{j=1, j\neq i}^{N} \tilde{\phi}_{ji}(H)}{N} \times 100. \tag{5}$$

Notice that the set of directional spillovers provides a decomposition of total spillovers into those coming from (or to) a particular source.

By subtracting Equation (4) from Equation (5) the net spillovers from variable i to all other variables j are obtained as

$$NS_i(H) = DS_{i\rightarrow j}(H) - DS_{i\leftarrow j}(H), \tag{6}$$

providing information on whether a variable is a receiver or transmitter of shocks in net terms. Put differently, Equation (6) provides summary information about how much each variable contributes to the volatility in other variables, in net terms.

Finally, the net pairwise spillovers can be calculated as

$$\begin{aligned} NPS_{ij}(H) &= \left(\frac{\tilde{\phi}_{ji}(H)}{\sum_{i,m=1}^{N}\tilde{\phi}_{im}(H)} - \frac{\tilde{\phi}_{ij}(H)}{\sum_{j,m=1}^{N}\tilde{\phi}_{jm}(H)}\right) \times 100 \\ &= \left(\frac{\tilde{\phi}_{ji}(H) - \tilde{\phi}_{ij}(H)}{N}\right) \times 100. \end{aligned} \tag{7}$$

The net pairwise volatility spillover between variables i and j is simply the difference between the gross volatility shocks transmitted from variable i to variable j and those transmitted from j to i.

The spillover index approach provides measures of the intensity of interdependence across countries and variables and allows a decomposition of spillover effects by source and recipient.

The key innovation and contribution in this study is that, instead of using Cholesky or Generalised variance decomposition, so as to obtain the total, directional and net spillover indexes, we adopt a Structural variance decomposition methodology, as it allows the identification of oil price shocks. The choice of structural variance decomposition is predicated upon our empirical exercise. That is, to examine the effects of oil price shocks on economic policy uncertainty index. In particular, we disaggregate oil price shocks based on the framework of Kilian and Park (2009). Essentially, with the use of a Structural VAR (SVAR) model, we distinguish between three types of oil price shocks; namely, supply–side shocks (SS), aggregate demand shocks (ADS), as well as, oil specific shocks (OSS); and by including the economic policy uncertainty index of Baker et al. (2013) in the SVAR, we assess the effects of oil price shocks on economic policy uncertainty. The first type of shock is typically associated with changes in world oil production, whereas the second and the third type of shocks relate to changes in global economic activity and to concerns regarding the future availability of oil, respectively.

For the general case of a p–order Structural VAR model, we obtain the following standard representation:

$$\mathbf{A}_0\mathbf{y}_t = \mathbf{c}_0 + \sum_{i=1}^{p}\mathbf{A}_i\mathbf{y}_{t-i} + \varepsilon_t \tag{8}$$

where, $\mathbf{y}_t$ is a $[N \times 1]$ vector of endogenous variables. In this paper, first, N=2 when we assess the relationship between oil price returns and the economic policy uncertainty index. For the relationship among the three oil price shocks and the economic policy uncertainty index, N=4, containing world oil production, the global economic activity index, real oil price returns and the economic policy uncertainty index, noting that the order of the variables is important. A_0 represents the $[N \times N]$ contemporaneous matrix, A_i are $[N \times N]$ autoregressive coefficient matrices, ε_t is a $[N \times 1]$ vector of structural disturbances, assumed to have zero covariance and be serially uncorrelated. The covariance matrix of the structural disturbances takes the following form:

For N=2:

$$E[\varepsilon_t\varepsilon_t'] = \mathbf{D} = \begin{bmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix} \tag{9}$$

For N=4

$$E[\varepsilon_t\varepsilon_t'] = \mathbf{D} = \begin{bmatrix} \sigma_1^2 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix} \tag{10}$$

In order to get the reduced form of our structural model (8) we multiply both sides with $\mathbf{A}_0^{-1}$, such as that:

$$\mathbf{y}_t = \mathbf{a}_0 + \sum_{i=1}^{p} \mathbf{B}_i \mathbf{y}_{t-i} + \mathbf{e}_t \tag{11}$$

where $\mathbf{a}_0 = \mathbf{A}_0^{-1}\mathbf{c}_0$, $\mathbf{B}_i = \mathbf{A}_0^{-1}\mathbf{A}_i$, and $\mathbf{e}_t = \mathbf{A}_0^{-1}\varepsilon_t$, i.e. $\varepsilon_t = \mathbf{A}_0\mathbf{e}_t$. The reduced form errors $\mathbf{e}_t$ are linear combinations of the structural errors $\mathbf{e}_t$, with a covariance matrix of the form $E[\mathbf{e}_t\mathbf{e}_t'] = \mathbf{A}_0^{-1}\mathbf{D}\mathbf{A}_0^{-1'}$.

Imposing suitable restrictions on $\mathbf{A}_0^{-1}$ will help identify the structural disturbances of the model. In particular, for N=2 we impose the following short-run restrictions:

$$\begin{bmatrix} e_{1,t}^{\Delta \text{Real Oil Prices}} \\ e_{2,t}^{\text{Economic Policy Uncertainty}} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & 0 \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \times \begin{bmatrix} \varepsilon_{1,t}^{OPS} \\ \varepsilon_{2,t}^{EPS} \end{bmatrix} \tag{12}$$

where OPS =oil price shock and EPS =economic policy uncertainty shock.

For N=4, the restriction are as follows:

$$\begin{bmatrix} e_{1,t}^{\Delta \text{Oil Production}} \\ e_{2,t}^{\text{Real Global Economic Activity}} \\ e_{3,t}^{\Delta \text{Real Oil Prices}} \\ e_{4,t}^{\text{Economic Policy Uncertainty}} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} \end{bmatrix} \times \begin{bmatrix} \varepsilon_{1,t}^{SS} \\ \varepsilon_{2,t}^{ADS} \\ \varepsilon_{3,t}^{OSS} \\ \varepsilon_{4,t}^{EPS} \end{bmatrix} \tag{13}$$

where SS =supply–side shock, ADS =aggregate demand shock and OSS =oil specific demand shock and EPS =economic policy uncertainty shock.

The purpose of the short–run restrictions we impose on the model is to help us identify the underlying oil price shocks, similarly with Kilian and Park (2009). According to the restrictions for N=4, high adjustment costs forbid oil production to contemporaneously respond to changes in demand for oil. Furthermore, changes in the supply of oil are allowed to contemporaneously affect both global economic activity and the price of oil. In addition, given that it takes some time for the global economy to react to changes in the price of oil, global economic activity is assumed not to receive contemporaneous feedback from oil prices. However, changes in aggregate economic activity is expected to have a contemporaneous impact on oil prices and this is at large explained by the instantaneous response of commodities markets. Furthermore, it is understandable that oil price developments can be triggered by all types of shocks and in this regard all types of shocks are assumed to contemporaneously affect oil prices. Finally, the economic policy uncertainty index responds contemporaneously to all aforementioned oil price shocks.

2.2. Data description

In this study we use monthly data from 1997:01 until 2013:06 of the economic policy uncertainty indices for Canada, China, India, aggregate Europe and the US, as well as, for individual European countries, namely, Germany, France, Italy, Spain and the UK. The series come from Baker et al. (2013). It is worth noting that the choice of countries, as well as, the sample period are directed by the availability of data provided by Baker et al. (2013). Despite the fact that our study could be limited to countries such as Canada, China, India, aggregate EU and the US, which represent a sizeable portion of the global economy, it also comprises individual European countries. This is motivated by our conviction that the nature of economic policy uncertainty within individual

European countries is rather divergent and thus, it may not be reflected in one single aggregate index. In particular, given that macroeconomic policies differ across these countries (mainly in terms of fiscal policy but also in terms of monetary policy when the UK is considered), it is important to investigate whether heterogeneous spillover effects do in fact exist. As a final note, our sample comprises Canada, which is a net oil–exporting country in order to identify potential differences between net oil–exporters and net oil–importers. In addition, monthly data for the same period have been collected for oil prices, world oil production and the real global economic activity index (GEA), which are used for the estimation of oil price shocks. Data for the Brent crude oil price and world oil production have been extracted from the Energy Information Administration, whereas the data for the real global economic activity index have been retrieved from Lutz Kilian's personal website (http://www-personal.umich.edu/∼lkilian/). The period of study runs from 1997:01 until 2013:06. Oil prices and world oil production are expressed in log-returns. Furthermore, oil prices are transformed in real terms. Table 1 reports the descriptive statistics of the series.

Insert Table 1 here

As evident in Table 1, economic policy uncertainty indices have comparable mean values, with the exception of Canada, India and the UK. It is worth noting that Canada and the UK exhibit the lowest and highest mean values respectively. Economic policy uncertainty indices are fairly volatile, as shown by the standard deviation, the minimum and the maximum values. With regard to oil price changes, we observe a positive average value, with quite a high standard deviation. Furthermore, none of the series is normally distributed, as indicated by the skewness, kurtosis and the Jarque-Bera statistic. Finally, according to the ADF and the PP unit root test–statistics, all variables are stationary, indicating that no cointegrating relation exists between the underlying series. Thus, we will focus only on the short–run relationship among these series.

Figure 1 exhibits the evolution of the series during the sample period.

Insert Figure 1 here

All economic policy uncertainty indices exhibit some common peaks. For example, in all countries we notice an increase in the level of the policy uncertainty index during the period 2002–2003 (war in Afghanistan and second war in Iraq), the Great Recession of 2007–2009, as well as, during the European Debt crisis in 2011, signifying the increase of policy uncertainty during turbulent economic periods. Finally, the effects of the Great Recession of 2007–2009 can also be observed on oil price changes, which significantly declined in 2009.

3. Empirical Results

3.1. Impulse Response Effects

We begin our analysis by concentrating on the impulse response functions between oil prices and the economic policy uncertainty index. In particular, we seek to portray not only a narrow setting which merely describes the relationship between shocks in policy uncertainty and oil prices, but also, a broader framework which allows for the introduction of a disaggregated approach towards oil price shocks, and thus considers supply–side shocks, aggregate demand shocks and oil specific demand shocks, separately.

Figures 2, 3 and 4 present the structural impulse response functions of our different specifications of model 8 for a time period of 24–months. The one standard error bands are constructed using Monte Carlo integration based on 1000 draws.

Figure 2 reports the structural impulse responses of oil prices to one standard deviation shock to economic policy uncertainty (left column), and the structural impulse responses of economic policy uncertainty to one standard deviation shock to oil prices (right column) based on the SVARs with oil prices and economic policy uncertainty as the endogenous variables for each country.

According to this figure we see that, in general, a surprise increase in economic policy uncertainty leads to a very short–lived and statistically significant drop in the price of oil in a time frame between one and three months. The effect of an unanticipated positive oil price shock leads to a statistically significant decline in economic policy uncertainty which is more persistent and more pronounced for some countries. The fact that economic policy uncertainty responds negatively to positive changes in oil prices, is counter–intuitive. The peculiar feature of these results might be masked by the aggregate measure of oil price shocks. In other words, we maintain that the disaggregation of oil price shocks could provide a clearer picture with reference to the impulse response functions.

Insert Figure 2 here

Therefore, in Figures 3 and 4, we report the structural impulse responses of supply–side (SS), aggregate demand (ADS) and oil specific demand shocks (OSS) to one standard deviation shock to economic policy uncertainty (see, Figure 3), as well as, the structural impulse responses of economic policy uncertainty to one standard deviation shock to supply–side (SS), aggregate demand (ADS) and oil specific demand shocks (OSS)(see, Figure 4). According to these figures, the picture that emerges becomes more clear.

In particular, unanticipated innovations to economic policy uncertainty do not seem to cause any significant effects on supply–side shocks (SS) before 4 months have passed. At that time we observe a negative and significant response of the supply–side shocks to economic policy uncertainty innovations. This is suggestive of the fact that unanticipated positive economic policy uncertainty shocks trigger a decrease in oil production, which is somewhat expected. Furthermore, unanticipated innovations to economic policy uncertainty lead to significant reduction of aggregate demand shocks (ADS) and oil specific demand shocks (OSS) as reported in Figure 3. The fact that ADS respond negatively to economic policy uncertainty shocks is explained by the fact that the latter is causing a reduction in aggregate demand, which in turn, drives oil prices at lower levels. In addition, the same response is expected regarding the OSS given that increased policy uncertainty is conducive to lower demand for oil, and thus lower uncertainty about its future availability. These results are also in line with Kang and Ratti (2013).

Turning our attention to economic policy uncertainty responses to oil price shocks, we find that unanticipated positive supply–side shocks do not exert a significant effect on economic policy uncertainty (with the exception of India and Italy for which a significantly (yet short–lived) positive effect can be reported). This result accords with the related literature which maintains that supply–side shocks are no longer important for macroeconomic developments (see, among others, Baumeister and Peersman, 2013; Lippi and Nobili, 2012; Hamilton, 2009a,b). Furthermore, unanticipated positive aggregate demand shocks (ADS) lead the economic policy uncertainty index to lower levels, with the exception of China and India. This is expected, as, despite the fact that rises in aggregate demand push oil prices upwards, these are regarded as positive information, reflecting booming economic conditions and thus lowering economic policy uncertainty. This is partly in line with Antonakakis et al. (2013) who find that aggregate demand oil price shocks affect negatively the dynamic correlations of stock market returns, implied volatility and economic policy uncertainty. Oil specific demand shocks do not seem to trigger significant responses from economic policy uncertainty, with the exception of Canada, EU and France. Economic policy uncertainty in France, exhibits a persistent negative response to oil specific demand shocks, whereas respective responses are short–lived for Canada and the EU. This result is expected for Canada given its net oil–exporting character. Nevertheless, it is counter–intuitive for France and the EU and this deserves further attention.

Finally, we can observe that the negative response of the economic policy uncertainty indices to positive oil price innovations that was reported in Figure 2 is mainly driven by aggregate demand shocks (ADS), which confirms our initial claim that unless we disaggregate oil price shocks by virtue of their origin we cannot attain a deeper understanding of the issue at hand. These results reveal the dominance of aggregate demand shocks, rather than supply–side and oil specific demand shocks, as a source of economic policy uncertainty innovations.

Insert Figure 3 here

Insert Figure 4 here

Having established the main transmission channels pertaining to the variables of interest, we proceed with the analysis of their spillover effects, which constitutes the main research objective of this study.

3.2. Total spillovers between economic policy uncertainty and oil prices

Spillover effects between the economic policy uncertainty indices and changes in oil prices are presented in Table 2. Evidence show a quite low average effect, with the exception of Canada and France, where the average total spillover index is 12.6% and 12.1%, respectively. The lowest score is reported for Italy. Overall, the total spillover indices illustrate that, on average, there is a weak–to–moderate interdependence between oil and the economic policy uncertainty indices for most countries. Average net spillovers for the whole sample demonstrate that economic policy uncertainty is the net transmitter of shocks for China, India, the US, EU aggregate, as well as, Germany and the UK (see, Table 2). Nevertheless, net spillovers on average, are relatively small.

Insert Table 2 here

Turning our attention to spillover indices based on the disaggregated oil price shocks (see, Table 3) we observe that total spillovers and net spillovers, increase in magnitude. In addition, it is evident that this magnitude is pretty similar for all the countries in the sample with India and Italy exhibiting the highest and the lowest values, respectively. Moreover, considering all three types of oil price shocks, we observe that economic policy uncertainty acts as a net recipient of spillover shocks only in the cases of Spain and Germany, whereas it remains a net transmitter of spillover shocks for all other countries in our sample (Table 3). It is also worth noting that aggregate demand oil price shocks (ADS) behave as net transmitters for all countries but China and India. This accords with related literature which emphasises the importance of demand–side shocks, as opposed to supply–side shocks (see, among others, Baumeister and Peersman, 2013; Lippi and Nobili, 2012; Hamilton, 2009a,b).

Insert Table 3 here

Our analysis so far is based on single fixed parameters. Despite the fact that Tables 2 and 3 show some interesting information, we should not lose sight of the fact that during our sample period several events took place, such as the war in Afghanistan and Iraq, the Great Recession of 2007–2009 and the European debt crisis. Hence, the average values presented in Tables 2 and 3 are not expected to hold for the whole time span. Thus, it would be valuable to examine how these spillovers evolve over time. Therefore we proceed with our analysis by presenting the total and net spillovers using 60–month rolling samples. It should be underlined that different forecast horizons (from 5 up to 15 months) and different window lengths (48 and 72) were also considered and the results were qualitatively similar. Thus, we maintain that the results are not sensitive to the choice of the forecast horizon or the length of the rolling–windows.

The time–varying spillover indices are illustrated in Figure 5. The dotted line represents the intertemporal progression of the total spillover indices between the economic policy uncertainty indices and changes in oil prices, while the solid line, represents the intertemporal progression of the total spillover indices corresponding to the relation between the economic policy uncertainty indices and oil price shocks (disaggregated shocks in virtue of their origin).

Insert Figure 5 here

Starting with spillovers between shocks in the economic policy uncertainty index and changes in oil prices, we observe that for most countries, in the period preceding the Great Recession, total spillovers fluctuate within a range between 10% and 25%. Furthermore, this range of fluctuation is relatively stable for almost all countries under examination. The only exception to these findings is France, in which total spillover shocks, in the pre–Great Recession period, reach a high at almost 40%. During the peak of the Great Recession (i.e. mid–2008 until early–2009) total spillovers increase considerably reaching unprecedented heights. In the period succeeding the Great Recession (i.e. post–2009) total spillovers return to a stable fluctuation pattern, realised within the same range as in the pre–crisis period, for all countries with the exception of Canada. Evidently, for Canada, the post–crisis period is characterised by a higher level of total spillovers.

Turning to total spillovers between shocks in the economic policy uncertainty index and oil price shocks, the picture is somewhat different. To begin with, total spillovers fluctuate at a much higher range (i.e. within 50% and 75%) throughout the period of study. Next, although it is a fact that during the peak years of the Great Recession total spillovers reach very high levels, one could not argue that these levels are indeed unprecedented. Finally, with the exception of Spain, total spillovers appear to revert back to their pre–crisis fluctuation patterns. Interestingly enough, in European countries, Italy aside, another peak of the total spillover indices is observed in the beginning of 2011, which coincides with increased concerns regarding the migration of the effects of the debt crisis from Eurozone peripheral countries to the rest of Europe. The aforementioned findings constitute an additional indication that unless we disentangle oil price shocks by virtue of their origin, we are not able to extract all relevant information. However, in order to provide a more in–depth analysis of the results, we proceed with reporting country specific total spillover effects.

In the section that follows, we provide additional information, aiming to attain deeper knowledge of the evolution of spillover effects over time in each one of the countries of our sample.

3.3. Net spillover transmitters and recipients

By concentrating on net directional spillovers we can deduce whether one of the variables is either a net transmitter or a net receiver of spillover effects within a particular country. Initially we investigate the spillover effects between economic policy uncertainty and changes in oil prices. Results are shown in Figure 6. Economic policy uncertainty is considered to be a net transmitter when spillovers appear on the negative lower area of each panel.

Insert Figure 6 here

As can be seen in Figure 6, the early period of our study is characterised by the net transmitting behaviour of economic policy uncertainty. However, this does not hold true for France and Italy, where for the most period preceding the Great Recession oil prices are net transmitters of shocks. With reference to the Great Recession, we observe that economic policy uncertainty assumes an even greater net transmitting role, suggested by the trough of the time–varying net spillover indices. Prominent among the results is that the this trough is observed at different phases of the Great Recession. Stellar examples of this include France, Germany and the UK. As far as the former is concerned, the net transmitting character of the economic policy uncertainty index is observed in the early stages of the Great Recession. In the cases of Germany and the UK, it is during the last year of the Great Recession that economic policy uncertainty assumes the net transmitting character.

Furthermore, in the years after 2009, which marked the beginning of the recovery of the global economy, the contribution of economic policy uncertainty to spillover effects is diminishing (see the upward trend in almost all panels of Figure 6) for the majority of the countries of our sample. Even more, with the exception of Spain, Italy and India, oil prices are net transmitters of shocks from 2010 onwards, although their contribution is clearly diminishing during 2012–2013. The latter observation particularly holds for the European countries which experience the consequences of the ongoing Eurozone debt crisis. The fact that for Spain and Italy economic policy uncertainty retains its net transmitting character, even after the Great Recession, can be explained by the strong economic impact that the Eurozone debt crisis exerted on these two countries. Thus, we maintain that at times of economic turbulence, oil prices are the net recipients of shocks, suggesting that they are influenced by the economic policy uncertainty which emerges during these periods.

In order to gain a clearer perception of the situation, we proceed with our analysis by presenting net spillovers between economic policy uncertainty and oil price shocks. This information is presented in Figures 7, 8 and 9. Each country is associated with three panels, while each panel represents one of the three possible types of oil price shocks, as these were earlier defined in the study. As before, economic policy uncertainty is considered to be a net transmitter of spillover effects every time the net effect (depicted by the solid line) lies within the negative lower area of each panel. We have also included a dotted line which pertains to the results presented in Figure 6, to allow direct comparisons. By so doing, we are able to trace the contribution of each type of oil price shock and produce a more credible interpretation of the results.

Insert Figure 7 here

Insert Figure 8 here

Insert Figure 9 here

Results presented on Figures 7, 8 and 9 confirm our anticipation that disaggregated oil price shocks are more informative in relation to the spillover effects between oil price changes and economic policy uncertainty. More specifically, we notice that spillovers occur between economic policy uncertainty and aggregate demand shocks, rather than between economic policy uncertainty and supply–side or oil specific demand shocks. Furthermore, we observe that the magnitude of spillover effects is considerably smaller compared to Figure 6. In order to gain a deeper understanding of these net spillover effects based on the three oil price shocks, we proceed with country–specific results.

Starting with Canada (see, Figure 7) the period before and during the Great Recession is characterised by the net transmitting role of economic policy uncertainty, as far as supply–side and oil specific demand shocks are concerned. By contrast, we observe that for the same period, economic policy uncertainty is a net receiver of spillover effects with regard to aggregate demand shocks. Interestingly enough, in Canada, which is a net oil–exporting country, in the years that followed the Great Recession, it is only the oil specific demand shocks that contribute to the forecast error of economic policy uncertainty, whereas, supply–side and aggregate demand shocks appear to have no effect at all. A potential explanation of this result may lie within the arguments put forward by authors such as Auty and Gelb (2001), Lane (2003), as well as, Afonso and Furceri (2010) who identify a strong link between resource–revenues – such as revenues from oil – and fiscal policy. To elaborate further, Sturm et al. (2009) argue that public finances of resource–abundant countries may exhibit high levels of volatility depending on the whims of oil prices and demand for oil and thus they constitute a major source of uncertainty within the country. This is a very crucial insight as in relatively tranquil times the macroeconomic policy of the net oil–exporting country appears to have a strong link to demand–side oil price shocks.

According to IEA (2013) China is the second largest crude net oil–importer in the world. Interestingly enough, Figure 7 reveals similar results for China to those of Canada. Again, we notice that the aggregate demand shocks are the main source of spillover effects on economic policy uncertainty. Nevertheless, in the latter period of our study, supply–side and oil specific demand shocks assume a net transmitting character. Authors such as Yuan et al. (2008) highlight the strong nexus between oil and economic growth in China and stress the need for the Chinese Government to set up a national policy regarding the accumulation of a strategic level of oil reserves. According to Yuan et al. (2008), future availability of oil is a major concern within China and abrupt rises in the price of oil are generally the source of serious economic concerns, resulting in higher level of economic policy uncertainty. The necessity for national planning, targeting energy security, has also been brought up by authors such as Zhang et al. (2009) and Ma et al. (2011). In addition, Ma et al. (2012) emphasize the lack of some appropriate national policy with respect to energy resources in general and oil reserves in particular, which could help stave off future energy turbulence and secure a solid path of economic growth. This will in turn ease the formulation and implementation of macroeconomic policies.

Turning to India, there are certain restrictions relating to data availability and thus analysis is constrained to more recent years. The evidence illustrated in Figure 9 suggests that all types of shocks are important to India and that both supply-side shocks and oil-specific demand shocks can be credited with the fact that EPU mainly remains a net transmitter of spillover effects throughout the period. According to Gunatilake et al. (2014) all developing countries and especially countries like India which imports 75% of its crude oil supplies are typically faced with the major consideration that higher oil prices could undermine future standards of living. Furthermore, according to a report by the IEA (2007) the dependency of India on foreign crude oil supplies could reach a level of 90% by 2030 if current levels of consumption continue. This high dependency of India on foreign supplies of oil stresses the necessity for adopting policies which prioritise the implementation of alternative energy resources and guarantee energy security within the country. It also explains at large, the results obtained by the study for India.

We further our analysis with the European countries, which are net oil–importers. In this regard, part of the analysis in connection with China may also apply to most European countries and especially to countries in which oil is a major input of production. To be more explicit, uncertainty regarding both the future level of the price of oil and its future availability could influence their output level. In Figure 7, we can observe that economic policy uncertainty in the period that followed the Great Recession was mainly a net recipient of spillover effects transmitted by the supply–side and oil specific demand shocks. Further, empirical findings concerning individual European countries reveal a similar picture (see, Figures 8 and 9). Notable exceptions in these patterns are Spain and the UK. In the case of Spain, economic policy uncertainty appears to be the main transmitter of spillover effects, throughout our sample period. Although for the period of the Great Recession, both supply–side and aggregate demand shocks exhibit a net transmitting role. As far as the UK is concerned, it is also the aggregate demand shocks that transmit spillover effects to economic policy uncertainty even in the years succeeding the Great Recession.

Both demand–side shocks are important for Germany, although at different time periods. According to Carstensen et al. (2013) Germany in 2009 experienced one of its greatest economic downturns ever and that according to the author can be attributed not only to the financial crisis per se, but also, to developments in the market for crude oil (see also, Hamilton, 2009a; Kilian, 2009a). Most importantly, Carstensen et al. (2013) provide evidence suggesting that in the short run, despite the appreciation of oil prices due to aggregate demand shocks, an exporting country can enjoy economic benefits due to higher demand for its products. In the longer term, though, reduced domestic consumption, due to inflationary pressures driven by higher oil prices, dominates the economy and could potentially lead to recession. Understandably, this would increase economic policy uncertainty within the country. Carstensen et al. (2013) put forward the argument that this is exactly what happened in Germany and this is why although the price of crude oil peaked in mid–2008, the German economy did not enter a recession until 2009. This could potentially explain why rises in the price of oil that are related to booming global economic conditions can aggravate expectations regarding macroeconomic policy conduct, even in an economy which is heavily export–oriented, such as Germany. It is understandable that the foregone analysis can also apply to the rest of Europe; in fact, it may be even more appropriate considering that all other European countries export much less commodities than Germany.

Finally, according to the IEA (2013), the US economy is the world's top crude oil–importer. As evident in Figure 9, the net spillover behaviour for the US resembles the previous cases, although with some minor differences. More specifically, net spillover effects between supply–side or oil specific demand shocks and economic policy uncertainty are very close zero for the pre–crisis period, whereas, for the same period, aggregate demand shocks are net transmitters of spillover effects. Notably, from 2009 onwards it is mainly the supply–side shocks that transmit spillover effects to economic policy uncertainty, although a peak in net spillovers deriving from oil specific demand shocks is observed for the latter years of the sample period. Despite the arguments put forward by Baumeister and Peersman (2013), among others, that supply–side shocks have a small role to play in the US economy, as opposed to demand–side shocks, we provide evidence that the former shocks have indeed a role to play in economic policy uncertainty developments.

In retrospect, we find that there is not one single net transmitter of spillover shocks, but rather all variables assume this character at different time periods. This is suggestive of the fact that there is no constant relationship between oil price shocks and economic policy uncertainty indices and even more this relationship varies with the type of oil price shock. In this regard, claims about the relationship between economic policy uncertainty and oil price shocks, based one static estimates, may not reveal the whole picture and, in cases, they may be misleading. Finally, distinguishing oil price shocks by virtue of their origin and investigating net spillover effects in this disaggregated framework provides a more thorough picture regarding the said relationship. On a final note, it is worth mentioning that our findings apply to both net oil–exporting and net oil–importing countries.

4. Conclusion

This paper examines the relationship between oil prices and economic policy uncertainty, using monthly data on oil and the economic policy uncertainty index produced by Baker et al. (2013), over the period 1997:01–2013:06. We examine the said relationship by extending the spillover index approach by Diebold and Yilmaz (2009, 2012) using structural decomposition. In addition, we disaggregate oil price shocks by virtue of their origin following the Kilian and Park (2009) classification, and investigate spillover effects between each of these shocks and the economic policy uncertainty indices. Sample countries include the US, Canada, China, India, the aggregate Europe, as well as, Germany, France, Italy, Spain and the UK.

According to existing literature, it is anticipated that there is bidirectional relationship between economic policy uncertainty and oil prices. On one hand, higher oil prices exert negative impacts on the economy, such as lower productivity and/or higher inflation (see, *inter alia*, Filis and Chatziantoniou, 2013; Montoro, 2012; Natal, 2012; Rahman and Serletis, 2011; Balke et al., 2010; Elder and Serletis, 2010; Tang et al., 2010; Du et al., 2010; Filis, 2010; Cologni and Manera, 2008; Cunado and Pérez de Gracia, 2005; Peter Ferderer, 1997; Hamilton, 1983). Such economic conditions put pressure on policy makers to mitigate the negative effects of increased oil prices, which in turn, raises concerns regarding the success of these policies. On the other hand, uncertainty surrounding economic policy decisions negatively affects firms' investment and output decisions (see, among others, Wang et al., 2014; Pástor and Veronesi, 2013, 2012; Fernández-Villaverde et al., 2011; Byrne and Davis, 2004). Considering that reduced investment and output levels cause a downward pressure on oil prices, we opine that economic policy uncertainty exerts an impact on oil prices.

Impulse response functions suggest that both economic policy uncertainty indices and changes in oil prices respond negatively to each others' shocks. The response from oil prices is expected, given that increased economic policy uncertainty may lead to lower productivity, and thus lower demand for oil. Decomposing oil price shocks, we observe that changes in economic policy uncertainty indices cause significantly negative responses from all types of shocks, although there is a delayed response from the supply–side shocks. The counter–intuitive response of economic policy uncertainty to changes in oil prices can be explained by the contribution of aggregate demand shocks, which is clearly evidenced once oil price shocks are disaggregated. Furthermore, we provide evidence that supply–side and oil specific demand shocks do not trigger any responses from economic policy uncertainty indices. These results are in line with Kang and Ratti (2013).

As far as total spillovers are concerned, we show that spillovers between economic policy uncertainty indices and changes in oil prices range between 10%–25% in the pre–2007 period. During the Great Recession of 2007–2009 total spillovers considerably increase reaching unprecedented heights of about 40% to 50%. With reference to the post–2009 period, total spillovers appear to revert back to the pre–2007 fluctuations patterns. Turning our attention to net spillover effects, our results reveal that for almost all countries, economic policy uncertainty is net transmitter throughout the period up until the end of the Great Recession of 2007–2009. In the post–2009 period economic policy uncertainty assumes a net receiving role. This result stands to reason, given that the global economic crisis has ended and thus uncertainty regarding future economic developments reverts to lower levels.

Once we distinguish between the different oil price shocks, we observe that total spillovers exhibit considerably different patterns and magnitudes. Prominent among our results is the finding that total spillovers occur between economic policy uncertainty and aggregate demand shocks, rather than economic policy uncertainty and supply–side or oil specific demand shocks. Net spillovers among economic policy uncertainty and the three oil price shocks reveal that any variable can assume either a net transmitting or net receiving character, depending on the time period. In this regard, we maintain that it is important to investigate this relationship in a dynamic, as opposed to a static framework.

Overall, the findings are suggestive of the fact that unless we use a disaggregated oil price shocks framework, we are not in the position to gain a thorough understanding on the relationship between economic policy uncertainty indices and oil prices. In addition, our results remain qualitatively similar for both net oil–exporting and net oil–importing countries of our sample.

These results are important for policy makers, as well as, investors who are interested in the oil market. To be more explicit it is important for investors to understand that during turbulent periods attention should be drawn to economic policy uncertainty, considering the fact that the latter affects the market in which they operate. On the other hand, policy makers should be cautious when formulating macroeconomic policies at relatively tranquil times, as oil price shocks could undermine the successful outcomes of these policies.

Furthermore, investigating the relationship between (i) financial sector uncertainty (as this is approximated by stock market volatility) and oil price shocks, (ii) business sector sentiment and oil price shocks, as well as, (iii) consumer confidence and oil price shocks, using a similar framework, could constitute potential avenues for further research. In addition, in the spirit of Balli and Balli (2011), Balli et al. (2013a) and Balli et al. (2013b) additional channels of spillover effects could be investigated, so as to show whether spillover effects from economic policy uncertainty shocks (oil price shocks) to oil prices (economic policy uncertainty) in one country can have knock on effects on relevant spillovers in other countries. Finally, future research could also examine spillover effects between oil prices and particular components of the Baker et al. EPU index, such as the public perception component or the policy making component. This approach would help identify the component which is more closely related to oil prices and thus deepen our understanding in this area.

Acknowledgements

The authors like to thank Richard S.J. Tol (Editor) and two anonymous reviewers for helpful comments on a previous version of this paper. All views expressed in this paper, and any remaining errors or omissions, remain the responsibility of the authors. The usual disclaimer applies.

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Table 1: Descriptive Statistics, 1997:01 until 2013:06

Series	Obs	Mean	Std Error	Minimum	Maximum	Skewness	Excess Kurtosis	Jarque-Bera	ADF	PP
CAN EPU	198	101.7949	39.5358	43.7017	249.2652	1.0228**	0.6428	28.736**	-4.339**	-4.139**
CHN EPU	198	109.8563	67.1629	9.0667	363.5231	1.1818**	1.1866**	43.717**	-5.413**	-5.684**
EU EPU	198	108.5708	34.5199	53.3714	213.5486	0.3745	-0.8731*	8.2701*	-3.640*	-3.085*
ESP EPU	150	104.5135	40.6360	28.3315	241.8103	0.6845**	0.4278	12.857**	-5.303**	-5.322**
FRA EPU	198	109.4032	50.3866	36.4004	303.4609	0.6546**	-0.2152	11.003**	-4.918**	-3.611**
GER EPU	198	106.2261	35.0111	42.2477	253.0389	0.9681**	1.0793**	30.713**	-5.283**	-5.299**
ITA EPU	198	108.7657	37.4112	40.0090	243.9464	0.9206**	1.0747**	28.406**	-4.636**	-5.215**
UK EPU	198	117.4592	66.6526	31.8590	297.4211	0.6553**	-0.8550*	15.300**	-3.596*	-2.992*
US EPU	198	109.8556	38.7015	57.2026	245.1263	0.5250**	-0.5026	8.4691*	-4.119**	-3.320*
IND EPU	126	101.8068	58.5598	24.9398	283.6891	1.0062**	0.5190	22.675**	-4.346**	-4.259**
Δ(OIL PRICE)	198	0.0074	0.0065	-0.3109	0.2006	-0.7429	0.9128*	24.964**	-11.555**	-11.675**
Δ(OIL PROD)	198	0.0011	0.0005	-0.0249	0.0259	-0.0600	0.9077*	6.8815*	-12.134**	-14.870**
GEA	198	0.0322	0.0202	-0.5025	0.5914	0.1336	-1.0819**	10.2451**	-4.071**	-2.929*

Note: ADF denotes Augmented Dickey Fuller test with 5% and 1% critical values of -3.44 and -4.02, respectively. PP denotes Phillip–Perron unit root test with 5% and 1% critical values of -2.88 and -3.46, respectively. * and ** indicate significance at 5% and 1% level, respectively.

Table 2: Spillover table (1997M01 – 2013M06)

	CAN			**CHN**			**EU**		
	From (j)			*From (j)*			*From (j)*		
To (i)	OIL	EPU	From others	OIL	EPU	From others	OIL	EPU	From others
OIL	89.0	11.0	11	93.9	6.1	6.1	87.0	13.0	13.0
EPU	14.2	85.8	14.2	3.5	96.5	3.5	9.0	91.0	9.0
Contr. to others	14.2	11	Tot. Spillover	3.5	6.1	Tot. Spillover	9.0	13.0	Tot. Spillover
Contr. incl. own	103.2	96.8	Index=12.6%	97.4	102.6	Index=4.8%	96	104	Index=11.0%
	ESP			**FRA**			**GER**		
	From (j)			*From (j)*			*From (j)*		
To (i)	OIL	EPU	From others	OIL	EPU	From others	OIL	EPU	From others
OIL	93.7	6.3	6.3	89.9	10.1	10.1	90.2	9.8	9.8
EPU	7.3	92.7	7.3	14.0	86.0	14.0	5.5	94.5	5.5
Contr. to others	7.3	6.3	Tot. Spillover	14.0	10.1	Tot. Spillover	5.5	98	Tot. Spillover
Contr. incl. own	101.0	99.0	Index=6.8%	103.9	96.1	Index=12.1%	15.8	104.2	Index=7.7%
	ITA			**UK**			**US**		
	From (j)			*From (j)*			*From (j)*		
To (i)	OIL	EPU	From others	OIL	EPU	From others	OIL	EPU	From others
OIL	96.4	3.6	3.6	88.1	11.9	11.9	88.6	11.4	11.4
EPU	4.9	95.1	4.9	3.9	96.1	3.9	3.6	96.4	3.6
Contr. to others	4.9	3.6	Tot. Spillover	3.9	11.9	Tot. Spillover	3.6	11.4	Tot. Spillover
Contr. incl. own	101.3	98.7	Index=4.3%	91.9	108.1	Index=7.9%	92.2	107.8	Index=7.5%
	IND								
	From (j)								
To (i)	OIL	EPU	From others						
OIL	89.2	10.8	10.8						
EPU	9.7	90.3	9.7						
Contr. to others	9.7	10.8	Tot. Spillover						
Contr. incl. own	98.9	101.1	Index=10.2%						

Note: Spillover indices, given by Equations (2)-(6), calculated from variance decompositions based on 12-step-ahead forecasts.

Table 3: Spillover table (1997M01 – 2013M06)

	CAN					**CHN**					**EU**				
	From (j)					*From (j)*					*From (j)*				
To (i)	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others
SS	82.0	8.1	5.7	4.3	18.0	84.0	7.4	6.0	2.6	16.0	80.7	7.8	5.7	5.9	19.3
ADS	3.1	79.8	2.9	14.3	20.2	1.9	57.6	3.3	37.2	42.4	3.0	84.3	2.6	10.1	15.7
OSS	6.9	9.2	74.0	9.8	26.0	6.8	7.2	78.0	7.9	22.0	7.5	8.2	69.3	14.9	30.7
EPU	3.2	7.6	14.3	74.8	25.2	3.2	2.0	4.8	89.9	10.1	4.1	9.7	2.8	83.3	16.7
Contr. to others	13.2	24.9	22.9	28.4	Tot. Spillover	12.0	16.7	14.0	47.7	Tot. Spillover	14.6	25.8	11.2	30.9	Tot. Spillover
Contr. incl. own	95.2	104.7	96.9	103.2	Index=22.3%	95.9	74.3	92.1	137.7	Index=22.6%	95.3	110.1	80.5	114.2	Index=20.6%

	ESP					**FRA**					**GER**				
	From (j)					*From (j)*					*From (j)*				
To (i)	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others
SS	72.0	11.0	2.5	14.6	28.0	81.9	7.7	5.7	4.7	18.1	80.7	9.3	5.7	4.3	19.3
ADS	5.0	87.2	5.9	1.9	12.8	3.5	84.8	3.6	8.0	15.2	2.5	91.2	3.9	2.4	8.8
OSS	10.6	10.9	73.0	5.5	27.0	6.8	7.0	75.6	10.6	24.4	6.7	9.4	73.1	10.8	26.9
EPU	3.2	30.1	2.1	64.6	35.4	7.7	4.0	11.5	76.8	23.2	7.3	12.4	5.8	74.4	25.6
Contr. to others	18.8	51.9	10.5	22.0	Tot. Spillover	18.0	18.7	20.8	23.3	Tot. Spillover	16.6	31.1	15.4	17.5	Tot. Spillover
Contr. incl. own	90.8	139.1	83.6	86.5	Index=25.8%	99.9	103.6	96.5	100.1	Index=20.2%	97.3	122.3	88.4	91.9	Index=20.2%

	ITA					**UK**					**US**				
	From (j)					*From (j)*					*From (j)*				
To (i)	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others	SS	ADS	OSS	EPU	From others
SS	82.9	9.2	6.6	1.3	17.1	77.7	11.1	5.2	6.1	22.3	78.4	9.1	6.5	6.0	21.6
ADS	2.6	77.2	5.4	14.8	22.8	2.3	76.7	2.9	18.1	23.3	2.7	80.9	4.5	11.9	19.1
OSS	6.5	9.8	79.6	4.1	20.4	8.5	9.2	71.3	10.9	28.7	5.5	7.3	74.6	12.6	25.4
EPU	7.8	4.3	1.8	86.1	13.0	1.4	4.0	1.6	93.0	7.0	2.6	2.8	3.9	90.7	9.3
Contr. to others	16.9	23.3	13.8	20.2	Tot. Spillover	12.3	24.3	9.6	35.1	Tot. Spillover	10.9	19.2	14.8	30.5	Tot. Spillover
Contr. incl. own	99.8	100.5	93.4	106.2	Index=18.5%	89.9	101.1	80.9	128.1	Index=20.3%	89.3	100	89.4	121.3	Index=18.9%

	IND				
	From (j)				
To (i)	SS	ADS	OSS	EPU	From others
SS	67.1	12.5	5.5	14.9	32.9
ADS	8.2	52.1	16.1	23.6	47.9
OSS	10.0	8.4	72.2	9.4	27.8
EPU	5.3	3.5	9.7	81.5	18.5
Contr. to others	23.5	24.4	31.3	47.9	Tot. Spillover
Contr. incl. own	90.6	76.5	103.5	129.4	Index=31.8%

Note: Spillover indices, given by Equations (2)-(6), calculated from variance decompositions based on 12-step-ahead forecasts.

Figure 1: Plots of underlying series

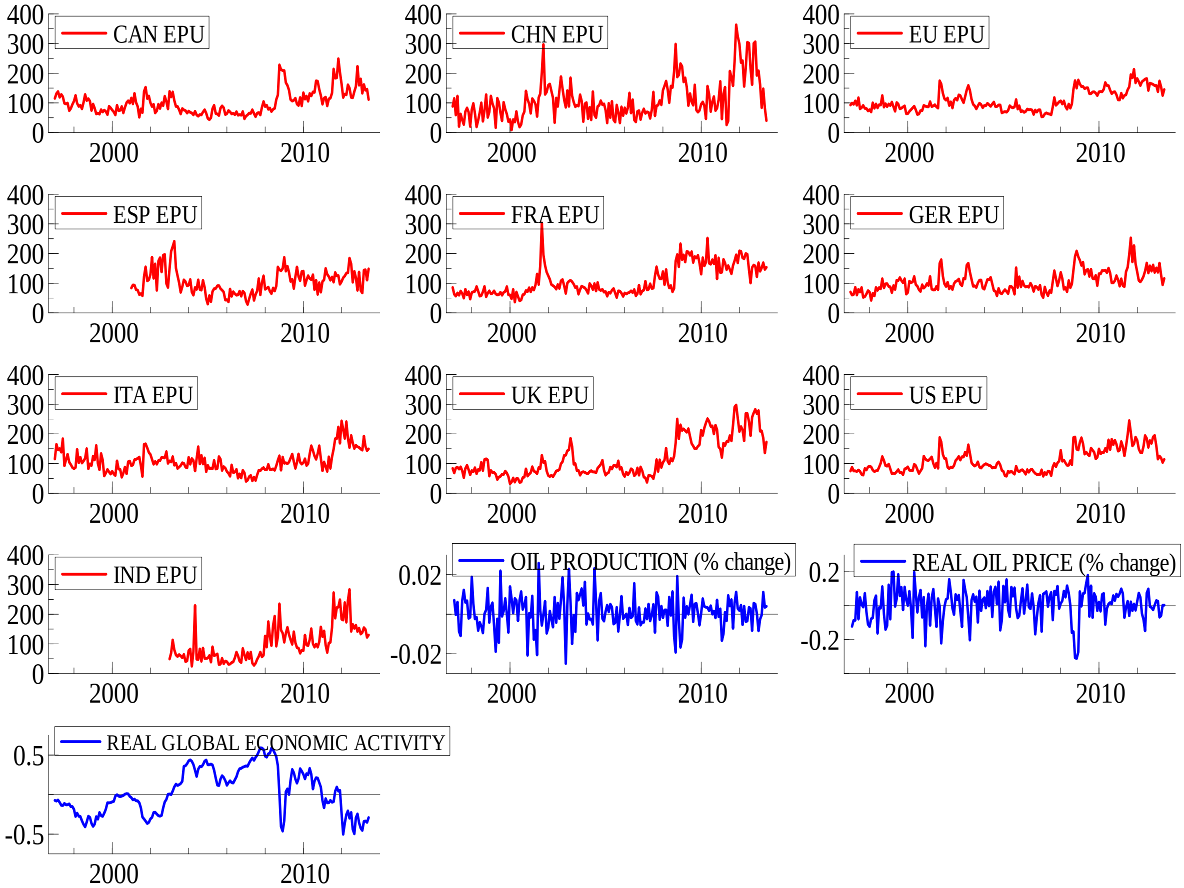
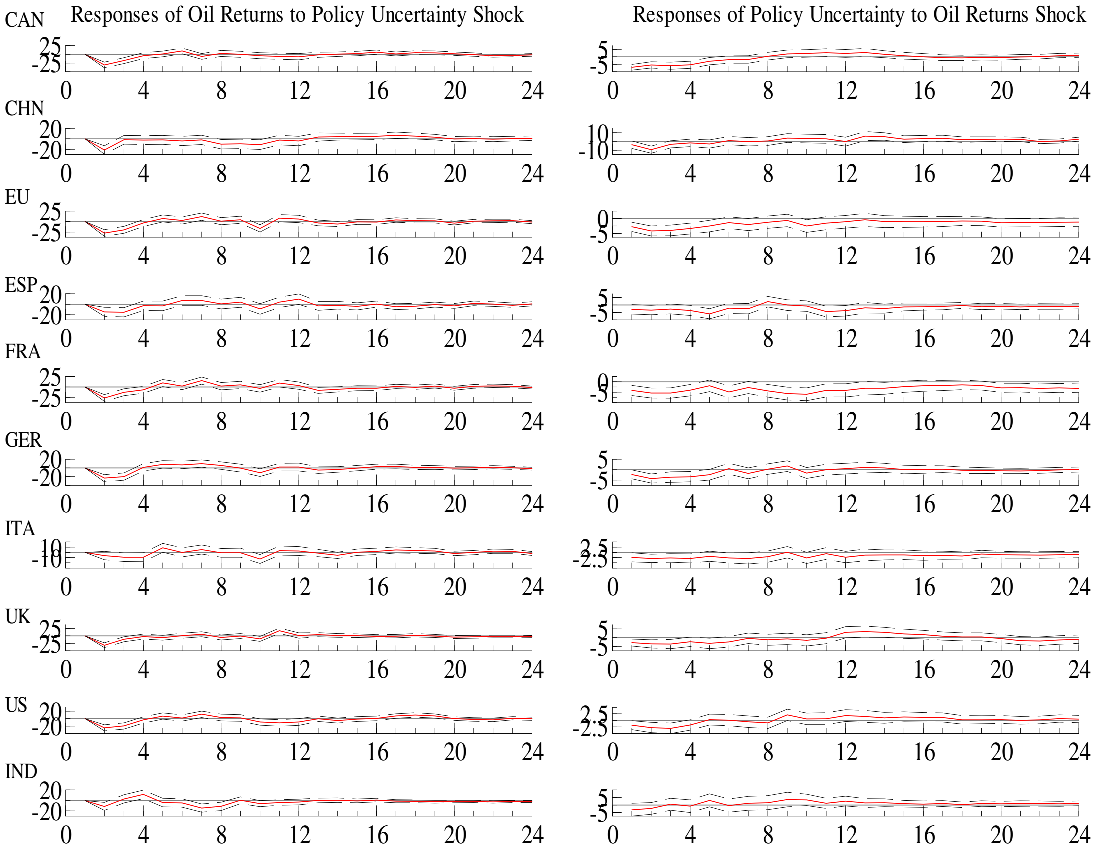
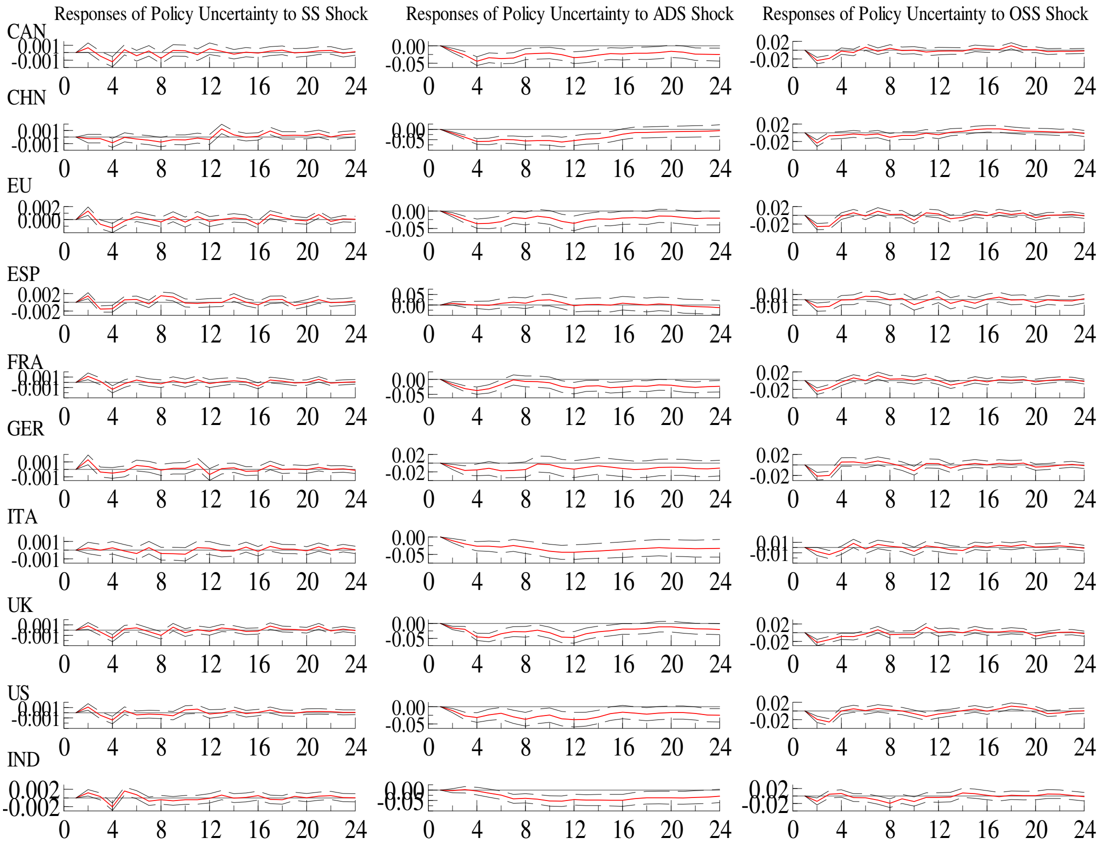


Figure 2: Structural impulse responses of oil price (economic policy uncertainty) to one standard deviation shock to economic policy uncertainty (oil price)



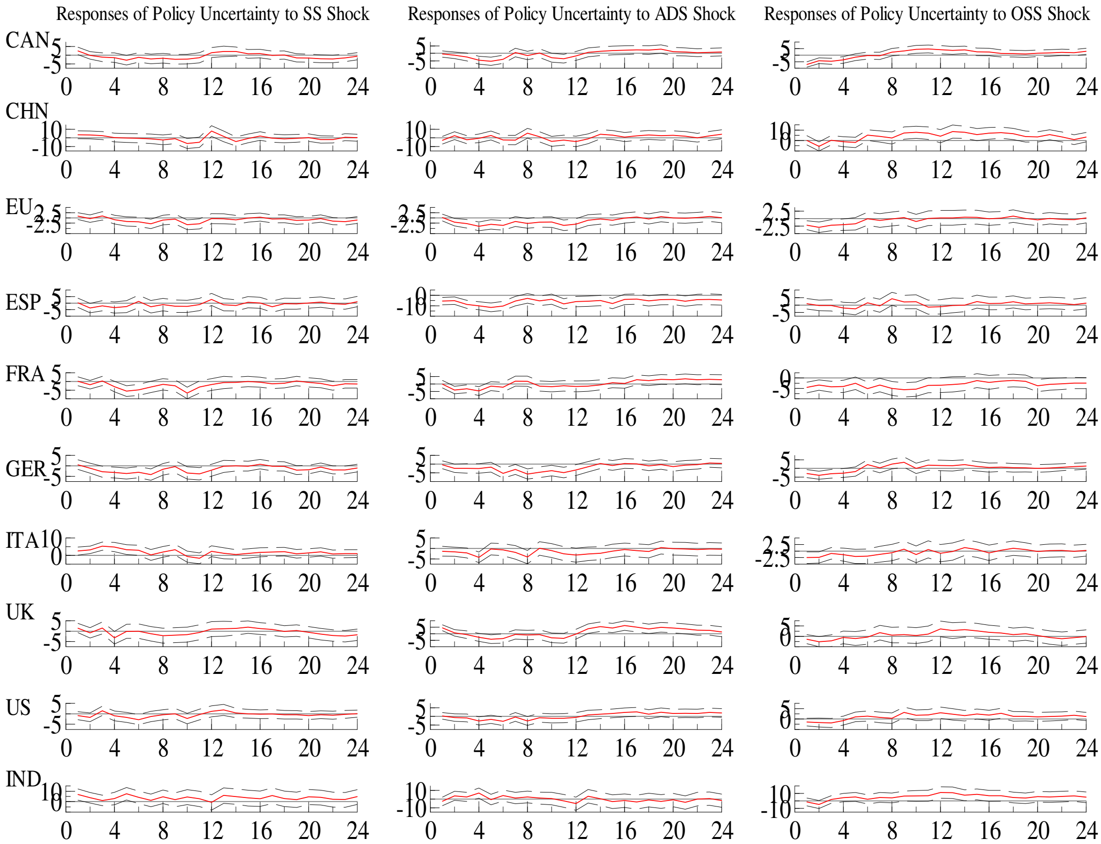
Note: Dashed lines are the one standard error bands constructed using Monte Carlo integration based on 1000 draws.

Figure 3: Structural impulse responses of SS, ADS and OSS to one standard deviation shock to economic policy uncertainty



Note: Dashed lines are the one standard error bands constructed using Monte Carlo integration based on 1000 draws.

Figure 4: Structural impulse responses of economic policy uncertainty to one standard deviation shock to SS, ADS and OSS



Note: Dashed lines are the one standard error bands constructed using Monte Carlo integration based on 1000 draws.

Figure 5: Total spillovers

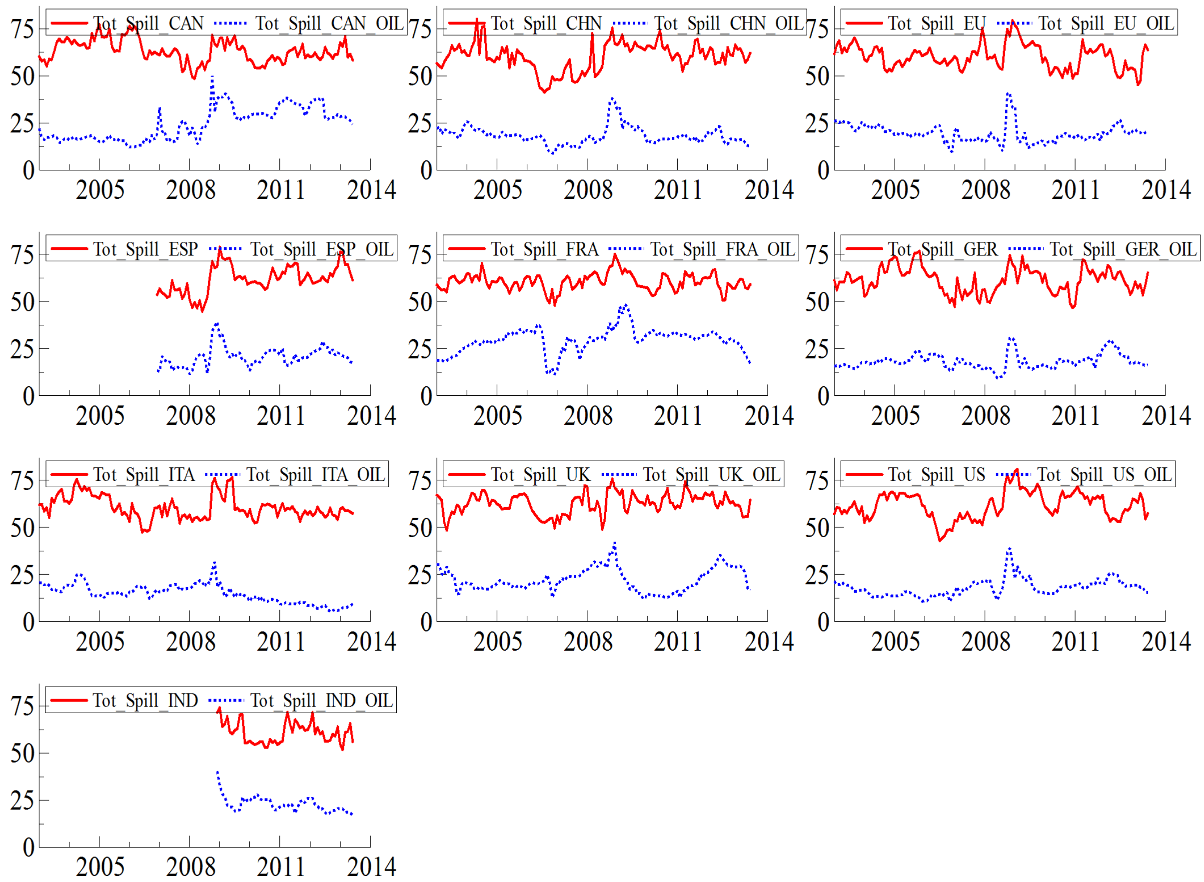


Figure 6: Net spillovers between economic policy uncertainty and oil returns

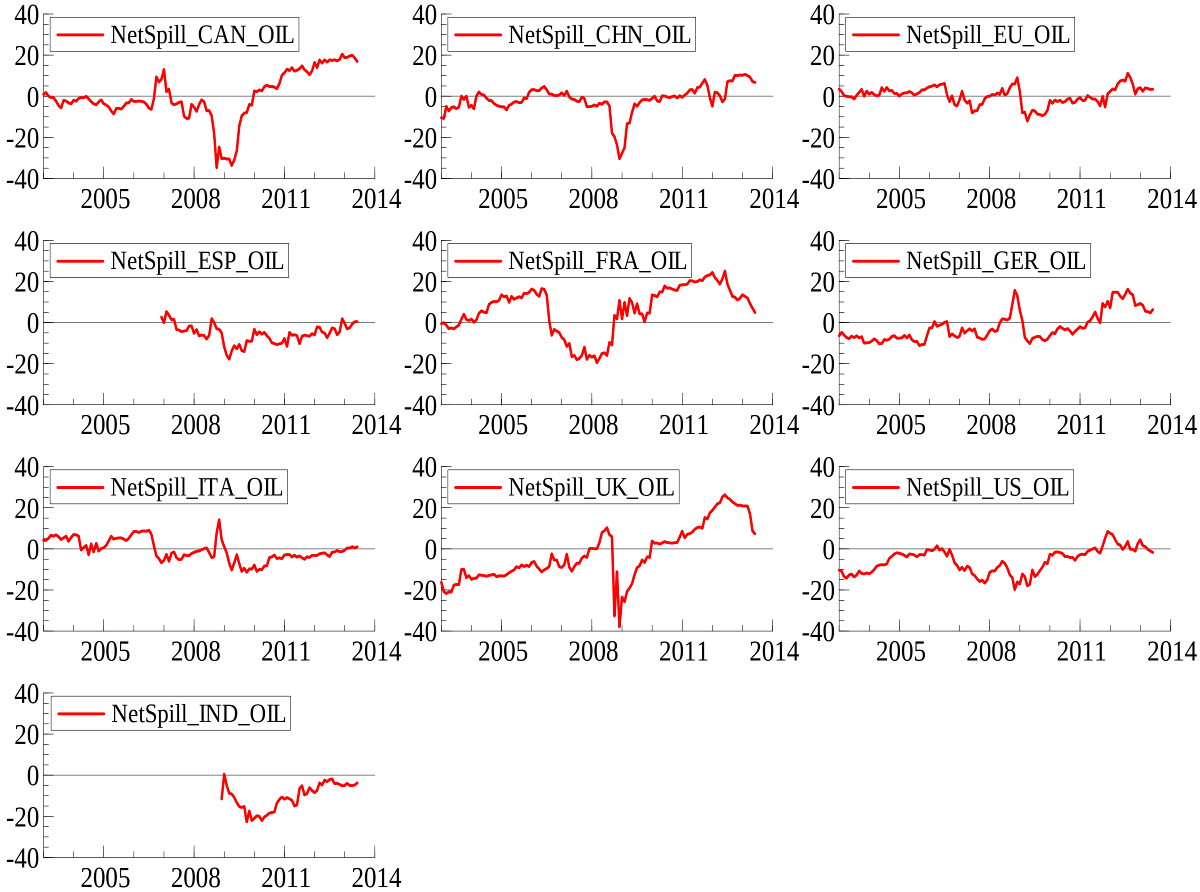


Figure 7: Net spillovers between economic policy uncertainty and oil price shocks in Canada, China and the EU

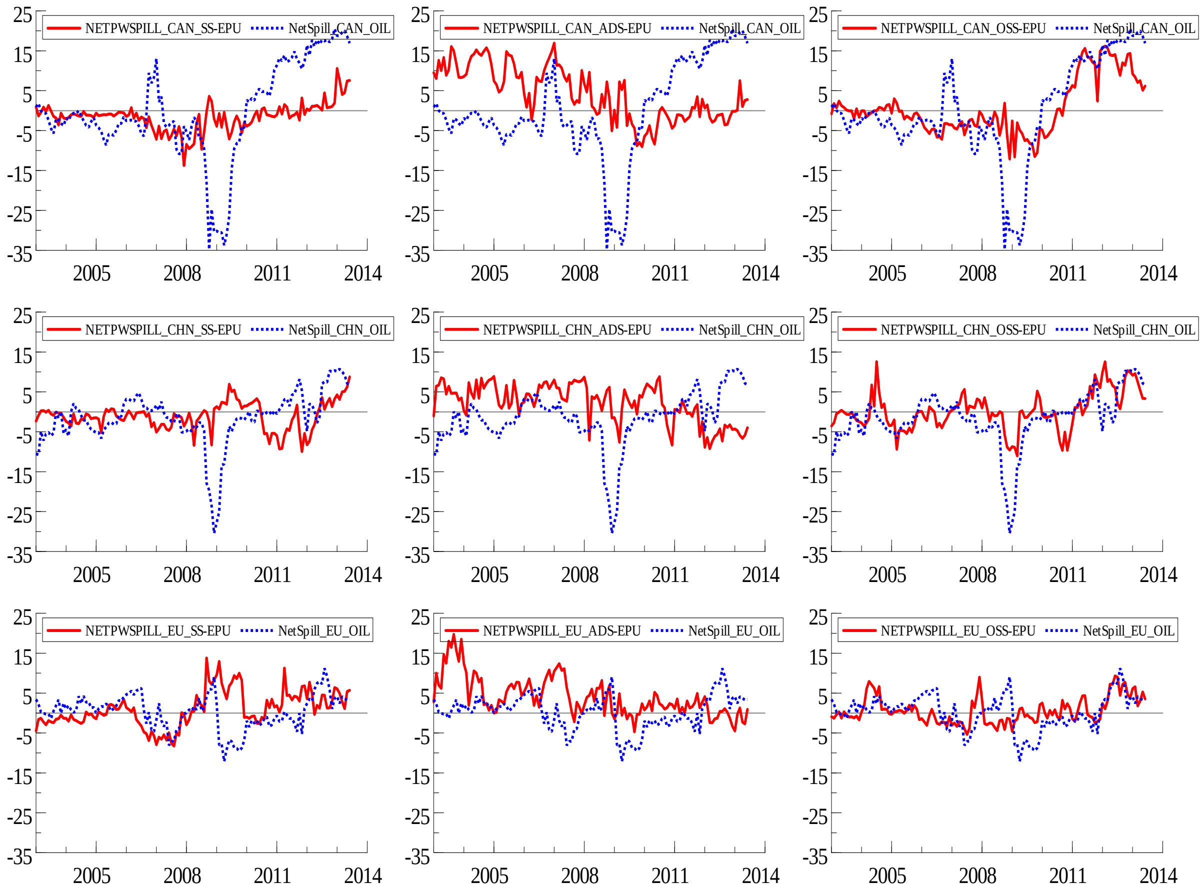


Figure 8: Net spillovers between economic policy uncertainty and oil price shocks in Spain, France and Germany

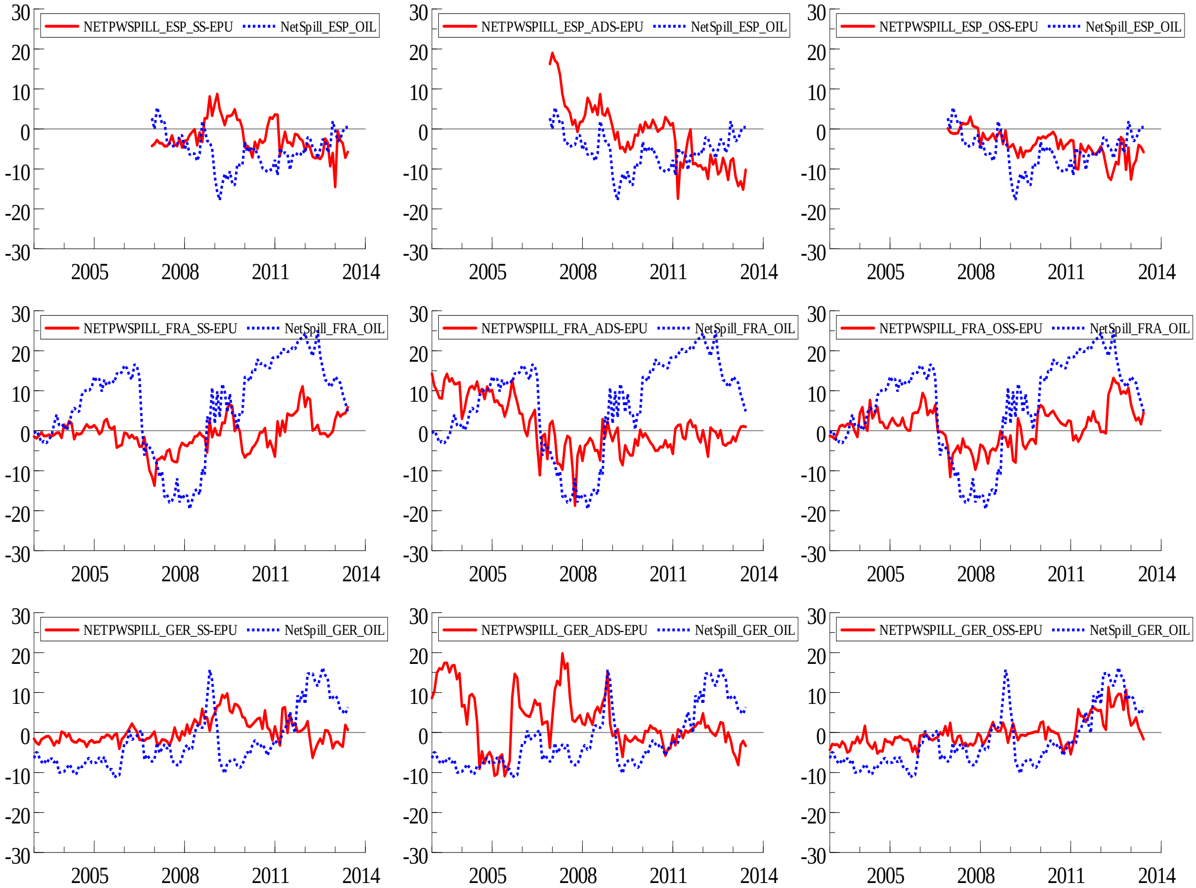


Figure 9: Net spillovers between economic policy uncertainty and oil price shocks in Italy, the UK, the US and India