

Brexit Spillovers: How Economic Policy Uncertainty Affects Foreign

Direct Investment and International Trade

by Xiaoqing An^a, William A. Barnett^{b,c}, Xue Wang^{d,e}, Qingyuan Wu^{f,*}

^a*School of Economics, Jinan University, Guangzhou city, Guangdong Province, China*

^b*Department of Economics, University of Kansas, Lawrence, KS, U.S.*

^c*Center for Financial Stability, New York, NY, U.S.*

^d*Institute of Chinese Financial Studies, Southwestern University of Finance and Economics, Chengdu, China*

^e*Department of Economics, Emory University, Atlanta, GA, U.S.*

^f*School of Economics and Management, Hanshan Normal University, Chaozhou, China*

Abstract

We examine the Brexit spillovers on five major EU member states and the UK through economic policy uncertainty. Cluster analysis and TVP-VAR model are applied to data from five major EU member states and the UK to analyze the impacts of economic policy uncertainty (EPU) on foreign direct investment (FDI) and international trade (TRADE) during Brexit. The results show that the impacts of EPU in six economies are different at different stages of Brexit. The impulse responses of FDI are relatively large in the Netherlands and the UK, especially in the short-term. Moreover, in terms of strengths, the impulse responses of FDI are generally greater than those of TRADE. At the time points related to Brexit, the EPU of the Netherlands has the greatest impacts on its FDI and TRADE, followed by the UK. Furthermore, the duration of the impact of EPU on FDI is generally greater than that of EPU on TRADE. Overall, the Brexit spillovers induced by economic policy uncertainty can be grouped into three categories considering intensity: high impact for two economies (the Netherlands and the UK); medium impact for two economies (France and Spain); and low impact for two economies (Germany and Italy).

Keywords: Brexit, Economic Policy Uncertainty, Foreign Direct Investment, International Trade.

JEL Classifications: E0, F1, H0.

1. Introduction

In recent years, several major challenges have emerged, leading to increased uncertainty. Economic policy uncertainty refers to the economic risk caused by the indefiniteness of the future direction and intensity of economic policies formulated by the government. This phenomenon further makes it more difficult to predict investment prospects and affects the investment behaviour and expectations of enterprises, residents and other economic entities. At the same time, currency mismatches or changes in terms of trade may be volatile due to economic policy uncertainty, and trade between countries will decline as merchants smell risk of loss. After the 2008 global financial crisis, economic policy uncertainty increased significantly as businesses and households postponed investment and consumer spending decisions (Baker et al., 2016; Al-Thaqeb and Algharabali, 2019). Since the outbreak of COVID-19, although economies have adopted various macroeconomic policies, the world economic situation is still uncertain, and the uncertainty of macroeconomic policy has reached a new height. In fact, the view that uncertainty affects economic activities has inspired a large number of scholars to study the impact of uncertainty on investment decisions and outputs. However, most studies ignore the impact of an event on the spillover effect of uncertainty. Countries across the world are interconnected. What happens in one country can quickly affect other countries. Brexit is a significant event for EU member states and even the global economy, with an important impact on the European economy and the global economy. As a result, the impact of Brexit has become a focal point for policy-makers and academics. Previous studies have shown that the Brexit effect is largely caused by macroeconomic variables, such as foreign direct investment and international trade, which are also affected by economic policy uncertainties (Dhingra et al., 2018; Jafari and Britz, 2020).

One question worth considering is whether Brexit affects the impact of uncertainty on other variables. The uncertainty of economic policy during Brexit manifests itself as regulatory divergence, which could lead to increased foreign direct investment and trade volatility in the UK and EU member states. At this point, investors' willingness and confidence to take risks changes due to economic policy uncertainty, which may lead to inflows and outflows of capital from the European region, and both the UK and the EU will lose benefits. Although the UK may renegotiate with other partners, this takes time, and uncertainty increases, leading to frequent changes in foreign direct investment and international trade, at least in the short term. The answer to this question not only has reference significance for policy-makers in various countries to take further measures but also helps promote stable and rapid economic development and improve the ability to withstand external shocks. Moreover, it provides the basis for developing forward-looking policies.

In this paper, we use data from five major EU member states and the UK to analyse the impacts of economic policy uncertainty on foreign direct investment and international trade during Brexit through cluster analysis and the TVP-VAR model.

The TVP-VAR model can obtain the impulse response at different horizons and different time points. Therefore, we select four important time points according to the Brexit process: 2013Q1, 2016Q2, 2020Q1 and 2021Q1.

The remainder of this paper is structured as follows. Section 2 reviews the literature on the effects of economic policy uncertainty and Brexit. Section 3 introduces the empirical method. Section 4 presents data and estimation procedure. Section 5 discusses the empirical results.

2. Literature Review

Some studies related to ours have discussed the impact of economic policy uncertainty on macroeconomic variables. Scholars have not yet reached a consensus regarding the impact of economic policy uncertainty on economic growth. Some scholars believe that the impact of economic policy uncertainty on economic growth needs to be determined by the situation. In times of prosperity, economic policy uncertainty has a dampening effect on output levels, while in times of economic depression the opposite is true (Zhang and Wang, 2016). Subsequently, Istiak and Serletis (2018) take the G7 countries as a sample and find that economic policy uncertainty affects real output differently in different countries. Other scholars argue that economic policy uncertainty is not the cause of output fluctuations, but that it has a strong negative impact on price levels (Tian et al., 2017). However, most scholars believe that economic policy uncertainty is not conducive to economic growth (Cerdeira et al., 2018; Binge and Boshoff, 2020; Biljanovska et al., 2021).

In addition to affecting economic growth, uncertainty has an impact on other economic variables. Claeys (2017) argues that consumption and investment in emerging markets will suffer greater and longer-term declines as uncertainty spreads around the world. Based on the Vector Error Correction Model (VECM), Jeon et al. (2017) find that in addition to the distribution industry stock index, the Korean economic policy uncertainty index is inversely correlated with other domestic economic indicators; that is, the rise of the Korean uncertainty index means that the domestic economy will deteriorate. Meinen and Roehe (2017) report that macroeconomic uncertainty has had a significant negative impact on investment in major countries of the eurozone, which is one of the reasons for the decline in gross fixed capital formation in machinery and equipment during the Great Recession. Katayama and Kim (2018) point out that higher economic policy uncertainty has led not only to a simultaneous decline in consumption and investment, but also to an increase in the relative prices of investment goods. According to Chan and Feng (2019), companies make more corporate philanthropic contributions when political uncertainty rises.

Another topic of concern is the effect of Brexit. Long before the UK voted to leave the EU, Pain and Young (2004) ran a simulation on the National Institute model of the UK's economy (NiDEM), analysing the Brexit effects only for the UK through reducing fiscal transfers to the EU, and found that FDI would be reduced and trade barriers would be increased. Irwin (2015) analyses the impact of Brexit on the UK

and the EU from ten channels, such as trade and foreign direct investment, and finds that the economies involved would be affected to varying degrees. In addition, scholars believe that Brexit will have an impact on macroeconomic variables in the UK, such as economic growth (Crafts, 2016), tariffs (Jafari and Britz, 2020), foreign direct investment (Simionescu, 2016; Dhingra et al., 2018; Jafari and Britz, 2020), and international trade (Booth et al., 2015; Dhingra et al., 2018; Jafari and Britz, 2020).

In summary, the literature primarily suggests that foreign direct investment and international trade are not only important channels of the Brexit effect but also affected by uncertainty. Therefore, it is particularly necessary to discuss the impact of uncertainty on them in the Brexit process. In addition, previous studies have analysed the impact of Brexit on the UK, and few have considered both the UK and EU member states. Thus, this paper uses data from the UK and five major EU member states for research.

3. Time-Varying Parameter VAR Model with Stochastic Volatility

Referring to the studies of Primiceri (2005) and Nakajima (2011), this paper constructs a TVP-VAR model. We firstly consider a structural vector autoregressive model:

$$Ay_t = F_1 y_{t-1} + \dots + F_s y_{t-s} + \mu_t, \quad t = s+1, \dots, n \quad (1)$$

Where y_t refers to a $k \times 1$ vector of observed variables, A, F_1, \dots, F_s are $k \times k$ matrices of coefficients respectively, and μ_t represents a $k \times 1$ structural shock. The simultaneous relations of the structural shock are specified by recursive identification, assuming that A is lower-triangular. Equation (1) is rewritten as the following simplified VAR model:

$$y_t = B_1 y_{t-1} + \dots + B_s y_{t-s} + A^{-1} \sum \varepsilon_t, \quad \varepsilon_t \sim N(0, I_k) \quad (2)$$

where $B_i = A^{-1} F_i, i = 1, \dots, s$, $\Sigma = \text{diag}(\sigma_1, \dots, \sigma_k)$, σ_i is the standard deviation of the structural shock, for $i=1, 2, \dots, k$. β ($k^2 s \times 1$ vector) is reconstructed based on the elements of B_i , which defines $X_t = I_s \otimes (y'_{t-1}, \dots, y'_{t-s})$. Equation (2) is rewritten as:

$$y_t = X_t \beta + A^{-1} \sum \varepsilon_t \quad (3)$$

Following previous studies (Primiceri, 2005; Nakajima, 2011), equation (3) is extended to TVP-VAR model by allowing the parameters to vary with time.

$$y_t = X_t \beta_t + A_t^{-1} \sum_t \varepsilon_t, \quad t = s+1, \dots, n \quad (4)$$

where β_t , A_t and \sum_t are all time varying. Let a_t be a stacked vector of the

lower-triangular elements in A_t . The log-volatility is $h_t = (h_{1t}, \dots, h_{kt})'$ with $h_{jt} = \log \sigma_{jt}^2$, for $j=1, \dots, k$, $t=s+1, \dots, n$. It is assumed that the parameters in the TVP-VAR model follow the following random walk process:

$$\begin{aligned} \beta_{t+1} &= \beta_t + \mu_{\beta t} \\ a_{t+1} &= a_t + \mu_{at} \\ h_{t+1} &= h_t + \mu_{ht} \end{aligned} \quad , \quad \begin{pmatrix} \mu_{\beta t} \\ \mu_{at} \\ \mu_{ht} \end{pmatrix} \sim N \left(0, \begin{pmatrix} \Sigma_{\beta} & 0 & 0 \\ 0 & \Sigma_a & 0 \\ 0 & 0 & \Sigma_h \end{pmatrix} \right) \quad (5)$$

for $t = s+1, \dots, n$, where $\beta_{s+1} \sim N(\mu_{\beta 0}, \Sigma_{\beta 0})$, $a_{s+1} \sim N(\mu_{a0}, \Sigma_{a0})$ and

$h_{s+1} \sim N(\mu_{h0}, \Sigma_{h0})$. The related assumptions are consistent with Nakajima (2011).

4. Data and estimation procedure

To analyse the Brexit spillovers through economic policy uncertainty, this paper examines the impacts of economic policy uncertainty (EPU) on foreign direct investment (FDI) and international trade (TRADE) in five major EU member states and the UK in the context of Brexit. The five major EU member states include France, Germany, Italy, the Netherlands and Spain. We use a three-variable TVP-VAR model to estimate the quarterly seasonally-adjusted data from the second quarter of 2006 to the third quarter of 2021.

The variables sets of six economies are defined as $y^{FRA}_t = (FRAEPU_t, FRAFDI_t, FRATRADE_t)$, $y^{DEU}_t = (DEUEPU_t, DEUFDI_t, DEUTRADE_t)$, $y^{ITA}_t = (ITA EPU_t, ITAFDI_t, ITATRADE_t)$, $y^{NLD}_t = (NLDEPU_t, NLDFDI_t, NLDTRADE_t)$, $y^{ESP}_t = (ESPEPU_t, ESPFDI_t, ESPTRADE_t)$ and $y^{GBR}_t = (GBREPU_t, GBRFDI_t, GBRTRADE_t)$, respectively.

Table 1 explains the variable names and data sources used in the TVP-VAR model. In this paper, first-order difference processing is performed on the above variables.

Table 1. Variable description

Variable Name	Definition	Data Sources
Economic Policy Uncertainty (EPU)	Economic Policy Uncertainty Index developed by Baker et al. (2016)	http://www. policyuncertainty. com.
Foreign Direct Investment (FDI)	Net inflows of Foreign Direct Investment (% of GDP)	World Bank Database
International Trade (TRADE)	Total Imports and Exports (% of GDP)	World Bank Database

This paper estimates the TVP-VAR model using Markov Chain Monte Carlo (MCMC) algorithm. Being consistent with Nakajima (2011), the following priors are assumed for the i -th diagonals of the covariance matrices: $(\Sigma_{\beta})_i^{-2} \sim \text{Gamma}(40, 0.02)$, $(\Sigma_{\alpha})_i^{-2} \sim \text{Gamma}(40, 0.02)$ and $(\Sigma_h)_i^{-2} \sim \text{Gamma}(40, 0.02)$. For the initial state of the time-varying parameter, rather flat priors are set; $\mu_{\beta_0} = \mu_{\alpha_0} = \mu_{h_0}$, and $\Sigma_{\beta_0} = \Sigma_{\alpha_0} = \Sigma_{h_0} = 10I$.

The estimation results of selected parameters in the TVP-VAR model for six sets of variables are shown in the appendix (Table A1 to Table A6). To compute the posterior estimates, we draw $M = 20,000$ samples after the initial 2,000 samples are discarded. Every table reports the posterior means, the standard deviations, the 95 percent credible intervals (upper and lower), the Geweke values and the inefficient factors for selected parameters in the TVP-VAR model. According to Geweke (1992), all Geweke values are less than the 5 percent significance level based on the convergence diagnostics of 1.96, indicating that the null hypothesis of the convergence to the posterior distribution is not rejected. The inefficient factors are generally low. This means that the number of efficient samples used for the parameters and the stated variables are sufficient to meet the needs of posterior statistical inference. The results show that the posterior is drawn efficiently by the MCMC algorithm.

5. Empirical Results

5.1. Cluster analysis results of FDI and TRADE

The cluster analysis was performed based on the performances achieved by the twenty-seven European Union member states (EU-27 MS) and the UK in terms of foreign direct investment and international trade (Foreign direct investment, net inflows (% of GDP); Foreign direct investment, net outflows (% of GDP); Net FDI (% of GDP); Exports of goods and services (% of GDP); Imports of goods and services (% of GDP); Trade (% of GDP)), taking into account the differences between the EU-27 MS and the UK, respectively during 2000-2020 periods.

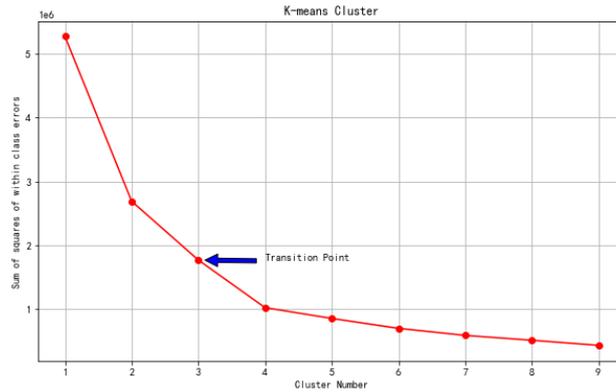


Figure 1 K-means cluster analysis

Using Elbow criterion, which is necessary for identifying K-means clusters, the transition point of the cluster number could be found as three (**Figure 1**), which would lead to a convergence for the sum of squares of within class errors.

Based on the six variables of foreign direct investment and international trade, we apply the K-means method to obtain the three clusters and obtain the results. The results are synthesised in Table 2. In order to set the number of clusters, we use machine learning methods represented by graphs. The results show three clusters shaped in EU-27 MS and the UK, and reveal the three key position of FDI and TRADE, which are defined as model centers.

Table 2. Cluster centers

Clusters	Foreign direct investment, net inflows (% of GDP)	Foreign direct investment, net outflows (% of GDP)	Foreign direct investment, net (% of GDP)	Exports of goods and services (% of GDP)	Imports of goods and services (% of GDP)	Trade (% of GDP)
1	3.44555189	2.79457163	2.41492634	37.58016308	38.42826983	76.00843291
2	15.31152223	13.29421035	4.6423946	74.04983452	71.36622812	145.4160626
3	72.05391245	71.0965411	79.19711272	148.0409937	131.8171562	279.8581499

Figure 2 shows the three clusters with a Radar chart with six labels corresponding to the six variables of FDI and TRADE. Clearly, it shows that the first two clusters have a lower share of net FDI, lower FDI inflows and outflows, respectively, compared to trade data. The model centers of the first and second clusters are far from the model center of the third cluster, and the net FDI of the second cluster is one-twentieth of that of the third cluster. In terms of trade indicators, the three major clusters account for a considerable proportion of GDP, and the model center of the third cluster has reached 279.86% of GDP.

This paper focus on the six countries including France, Germany, Italy, the Netherlands, Spain and the UK. In our analysis, the Netherlands is placed in the first cluster, which represents the lowest level for the six variables. The Netherlands is likely to benefit after Brexit, as inflows and outflows of FDI are likely to increase

over time and uncertainty is likely to decrease. Germany and France, with their prominent trade positions, fall into the second cluster and are likely to benefit from Brexit as foreign direct investment and exports increase. The other three countries are also placed in the second cluster. It is worth noting that the UK tends to be affected as uncertainty increases during Brexit.

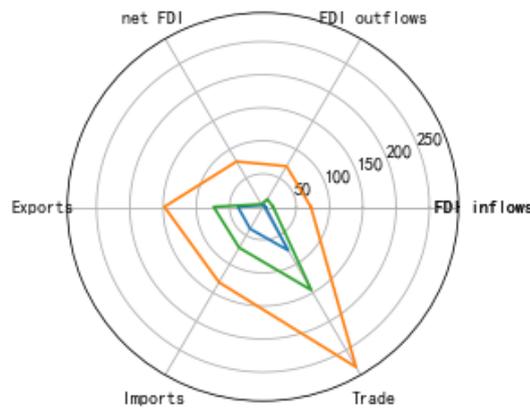


Figure 2 Three clusters with a Radar chart

5.2. Empirical results of the TVP-VAR model

Based on the TVP-VAR model, we discuss the impacts of economic policy uncertainty on foreign direct investment and international trade in the five major EU member states and the UK from two aspects.

The first aspect we consider is the time-varying effects at different time horizons. We conduct impulse response analysis of equal interval, which can simulate impulse responses more effectively (Zhou et al., 2020). And two quarters, four quarters and six quarters are selected to represent the short-term, medium-term and long-term, respectively.

The second aspect we consider is the time-varying effects at different time points. Based on the process of Brexit, we select four special time points for analysis. The first time point is 2013Q1, when Cameron officially responded to the Brexit vote. The second time point is 2016Q2, when a Brexit referendum was held. The third time point is 2020Q1, when the UK officially left the EU and entered an 11-month transition period. The fourth time point is 2021Q1, when the transition period was complete.

5.2.1. Time-varying effects at different time horizons

The TVP-VAR model serves as an innovative way in which the coefficients are time varying, the impulse responses are calculated at each date over the sample period (Nakajima et al., 2011). Figure 3 to Figure 8 show the impulse responses of foreign direct investment and international trade to a positive economic policy uncertainty shock at different time horizons in five major EU member states and the UK.

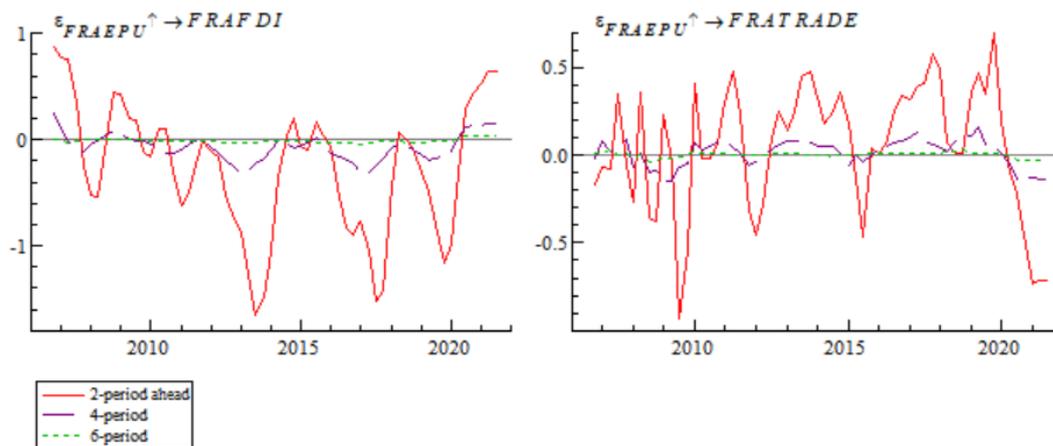


Figure 3. Time-varying responses of *FRAFDI* and *FRATRADE* to *FRAEPU* at different time horizons.

Notes: *FRAEPU*, *FRAFDI* and *FRATRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in France, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

As shown in **Figure 3**, remarkably, all of the impulse responses vary significantly over time. The impulse responses of *FRAFDI* to *FRAEPU* have a long duration of negative effects at the 2-quarter horizon. At the 4-quarter and 6-quarter horizons, the impulse responses of *FRAFDI* are still negative but remain at a low level. This implies that a benchmark *FRAEPU* shock mainly triggers short-term declines in *FRAFDI*. In terms of the strength of the impulse response, a larger negative impact occurs 2013, 2017 and 2020. Interestingly, these periods are closely related to Brexit.

The impulse responses of *FRATRADE* to *FRAEPU* have unstable directions at different time horizons. These responses are mainly positive in the period 2013-2014 and 2016-2019 and become negative when the UK officially withdraws from the EU in 2020. Since then, the negative impacts of *FRAEPU* on *FRATRADE* have increased rapidly.

Therefore, the economic policy uncertainty in France has a significant impact on its foreign direct investment and international trade in the context of Brexit.

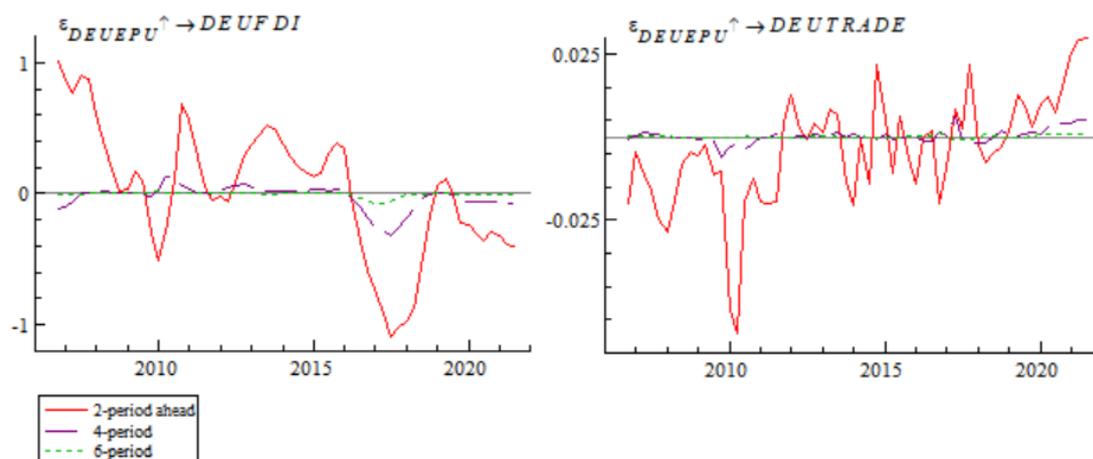


Figure 4. Time-varying responses of *DEUFDI* and *DEUTRADE* to *DEUEPU* at different time horizons.

Notes: *DEUEPU*, *DEUFDI* and *DEUTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Germany, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

As shown in **Figure 4**, at the 2-quarter horizon, *DEUEPU* mainly exerts positive impacts on *DEUFDI* in the period 2012-2015 and negative effects afterwards, implying that foreign direct investment can be controlled by economic policy uncertainty in the short term. In contrast to France, the impacts of German EPU on foreign direct investment are positive during 2013. Moreover, the impulse responses of German FDI are lower than those of French FDI.

Similarly, the impulse responses of *DEUTRADE* to *DEUEPU* present unstable directions at different time horizons, especially after the Brexit referendum was officially held. After the UK officially left the EU, the impulse responses of international trade to German EPU are positive, which is opposite to the impulse responses in Figure 3.

Therefore, the empirical results of **Figure 4** indicate that there are differences in the domestic situation between Germany and France.

For comparison, the results of the time-varying responses of *ITAFDI* and *ITATRADE* to *ITAEPU* based on the TVP-VAR model are shown in **Figure 5**. The impulse responses of *ITAFDI* to *ITAEPU* have an opposite variation to those shown in Figure 4. At the 2-quarter horizon, *ITAEPU* mainly exerts negative impacts on *ITAFDI* in the period 2011-2015. However, the impulse responses of *ITAFDI* turns positive after 2015. In addition, the impulse responses of foreign direct investment in Italy at the 4-quarter horizon are greater than those shown in Figure 4 which implies that the impacts of economic policy uncertainty in Italy on FDI will last longer.

As shown in **Figure 5**, the impulse responses of *ITATRADE* to *ITAEPU* also have unstable directions at different time horizons. In terms of the strength of the impulse response, the largest positive impacts occur around 2020. Across different time horizons, the responses of *ITATRADE* are the greatest at the 2-quarter horizon, much smaller at the 4-quarter horizon and negligible for most of the time horizons beyond 6 quarters.

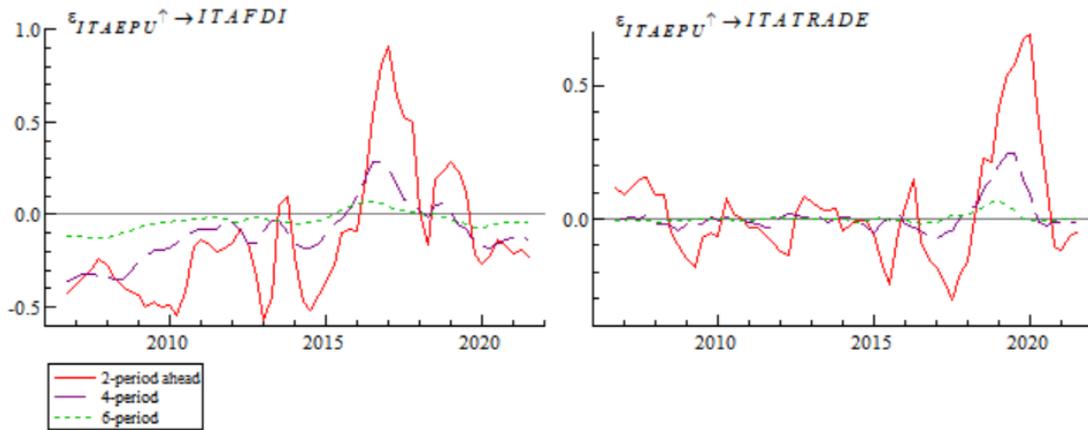


Figure 5. Time-varying responses of *ITAFDI* and *ITATRADE* to *ITAEPU* at different time horizons.

Notes: *ITAEPU*, *ITAFDI* and *ITATRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Italy, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

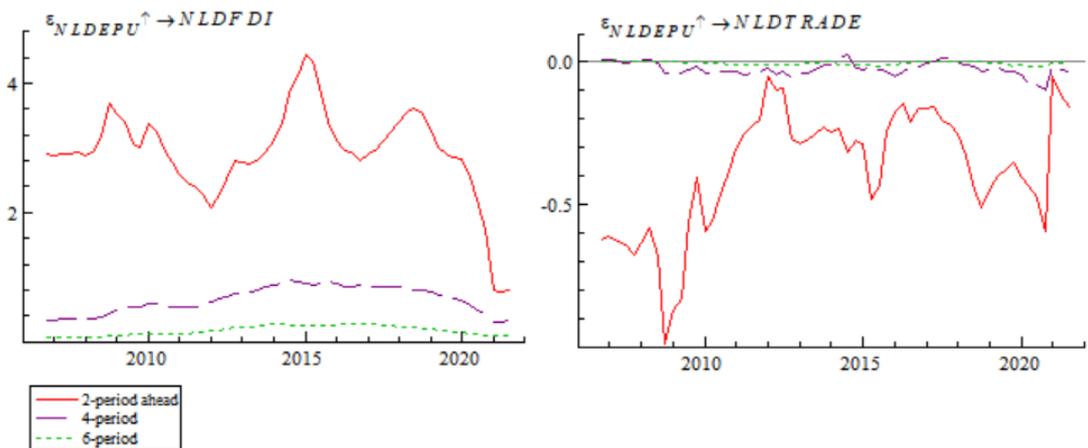


Figure 6. Time-varying responses of *NLDFDI* and *NLDTRADE* to *NLDEPU* at different time horizons.

Notes: *NLDEPU*, *NLDFDI* and *NLDTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in the Netherlands, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

Figure 6 shows the impulse responses for the set of variables (*NLDEPU*, *NLDFDI*, *NLDTRADE*), in which we can also see the significant time-varying characteristics in each impulse response. Unlike the empirical results in Figure 3 to Figure 5, the impulse responses of *NLDFDI* and *NLDTRADE* in **Figure 6** have a stable direction at different time horizons.

The impulse responses of *NLDFDI* to *NLDEPU* remain positive over all periods, although the impacts of *NLDEPU* seem to exhibit time variation. The impulse responses of *NLDFDI* begin to increase around 2013, with the official response to the

Brexit vote. However, the positive effects of economic policy uncertainty begin to decline rapidly after the UK's official withdrawal from the EU. In addition, the impulse responses of *NLDFDI* are still large in the medium term.

The impulse responses of *NLDTRADE* to *NLDEPU* remain negative over all periods, and smaller negative effects appear around 2013 and 2021. Across different time horizons, the responses of *NLDTRADE* are the greatest at the 2-quarter horizon and negligible for most of the time horizons beyond 4 quarters.

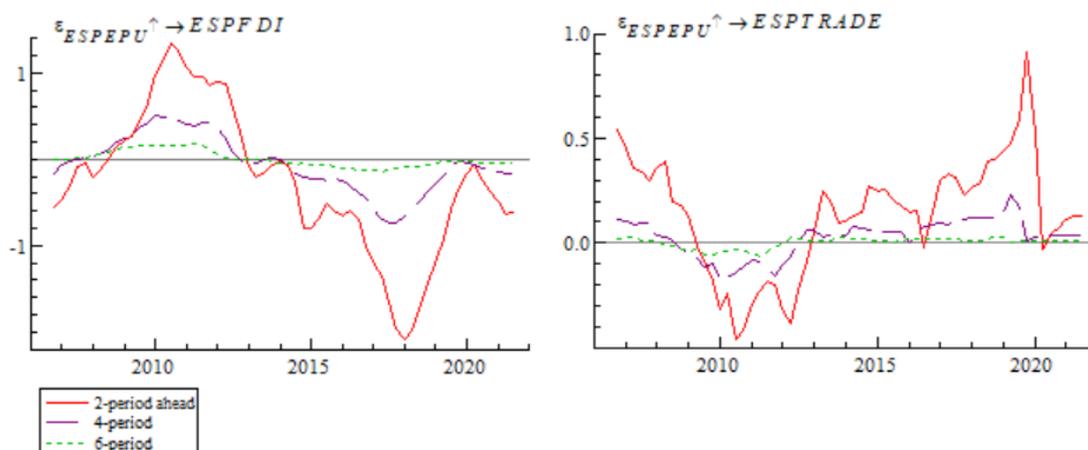


Figure 7. Time-varying responses of *ESPFDI* and *ESPTRADE* to *ESPEPU* at different time horizons.

Notes: *ESPEPU*, *ESPFDI* and *ESPTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Spain, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

Figure 7 shows the impulse responses for the set of variables (*ESPEPU*, *ESPFDI*, *ESPTRADE*), in which we can see an obvious change in direction.

The time-varying impulse responses of *ESPFDI* to *ESPEPU* remain positive until around 2013 and negative effects afterwards, which indicates that the impacts of economic policy uncertainty on foreign direct investment become negative after the official response to the Brexit vote. In terms of the function strengths, the greatest negative effects appear around 2018, and the smallest negative impacts occur around 2020. The impulse responses of *ESPFDI* at the 4-quarter horizon cannot be ignored.

The time-varying impulse responses of *ESPTRADE* to *ESPEPU* have three shifts in direction over the full sample period at three time horizons. Remarkably, the impacts of economic policy uncertainty on international trade become positive after the official response to the Brexit vote, which is different from the impulse responses of *ESPFDI*.

Figure 8 reports the impulse responses of *GBRFDI* and *GBRTRADE* to a positive *GBREPU* shock, which have unstable directions at different time horizons.

Naturally, the impulse responses of the *GBRFDI* become negative around 2013 because of the official response to the Brexit vote. In addition, the estimation result indicates that the impulse responses of the *GBRFDI* remain positive after the

referendum on Brexit and become negative around 2020, when the UK officially leaves the EU.

The impulse responses of *GBRTRADE* to *GBREPU* have a long duration of negative effects at the 2-quarter horizon, and greater negative effects appear around 2013 and 2021. Across different time horizons, the greatest effect is observed at the 2-quarter horizon, and the effects are negligible for most of the time horizons beyond 4 quarters.

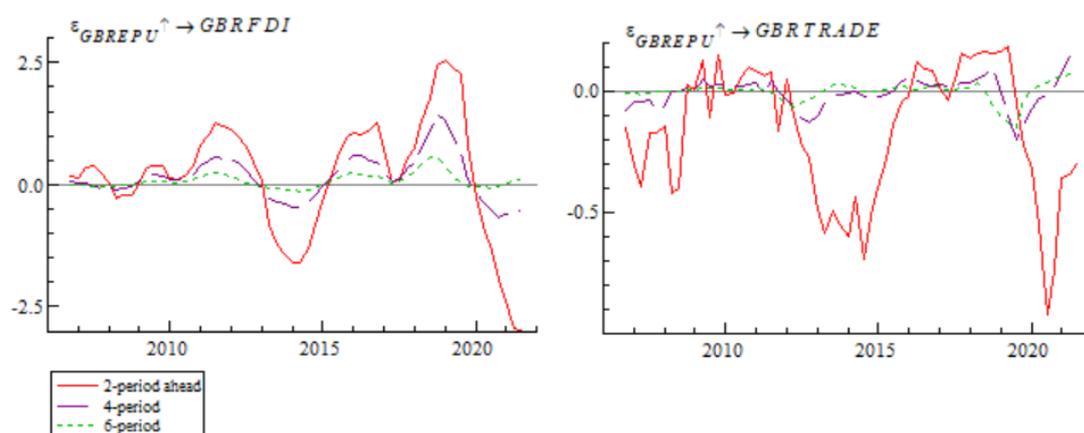


Figure 8. Time-varying responses of *GBRFDI* and *GBRTRADE* to *GBREPU* at different time horizons.

Notes: *GBREPU*, *GBRFDI* and *GBRTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in the UK, respectively. The solid line refers to time-varying impulse responses for half-year, the dashed line refers to yearly responses, and the dotted line refers to responses for six quarters.

5.2.2. Time-varying effects at different time points

It is evident from the above analyses that the impulse responses of foreign direct investment and international trade to a positive economic policy uncertainty shock are time-varying in special periods. We select four special time points related to Brexit to further analyse the impact of economic policy uncertainty: 2013Q1, 2016Q2, 2020Q1, 2021Q1. Figure 9 to Figure 14 show the impulse responses of foreign direct investment and international trade to a positive economic policy uncertainty shock at different time points in five major EU member states and the UK.

As shown in Figure 9 to Figure 14, the impulse responses of foreign direct investment and international trade are highly unstable and alternate from positive to negative frequently at different time points, which indicates that investor expectations and trade decisions are largely affected by uncertainty and international events.

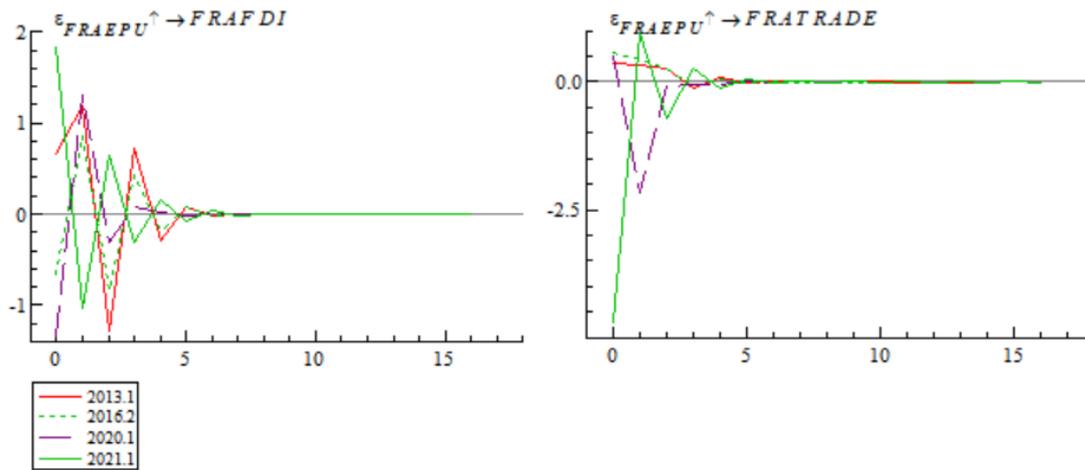


Figure 9. Time-varying responses of *FRAFDI* and *FRATRADE* to *FRAEPU* at different time points.

Notes: *FRAEPU*, *FRAFDI* and *FRATRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in France, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

Figure 9 shows that *FRAEPU* has large and volatile influences on foreign direct investment in France at four time points related to Brexit. Remarkably, the variations in impulse responses of *FRAFDI* are similar at time points 2013Q1, 2016Q2 and 2020Q1. Moreover, the responses of *FRAFDI* at 2013Q1 are greater than those at 2016Q2 and 2020Q1, which means that the official response to the Brexit vote raises the impacts of economic policy uncertainty. However, the responses of *FRAFDI* at 2021Q1 are opposite to those at other time points.

As shown in **Figure 9**, the impulse responses of *FRATRADE* at 2020Q1 and 2021Q1 are larger than those at 2013Q1 and 2016Q2, indicating that the impacts of economic policy uncertainty in France on international trade are sensitive to official withdrawal from the EU.

Figure 10 shows the impulse responses for the set of variables (*DEUEPU*, *DEUFDI*, *DEUTRADE*). At time points 2016Q2, 2020Q1 and 2021Q1, the trends of impulse responses are basically the same, and the responses of *DEUFDI* at 2021Q1 are greater. The intensity of the impulse response of *DEUFDI* implies that the impacts of economic policy uncertainty on foreign direct investment in Germany are related to the official reaction to the Brexit vote and the official exit from the EU.

Similarly, the impulse responses of *DEUTRADE* during the official withdrawal from the EU are generally larger than those during the other two time points. The responses of *DEUTRADE* are negative most of the time.

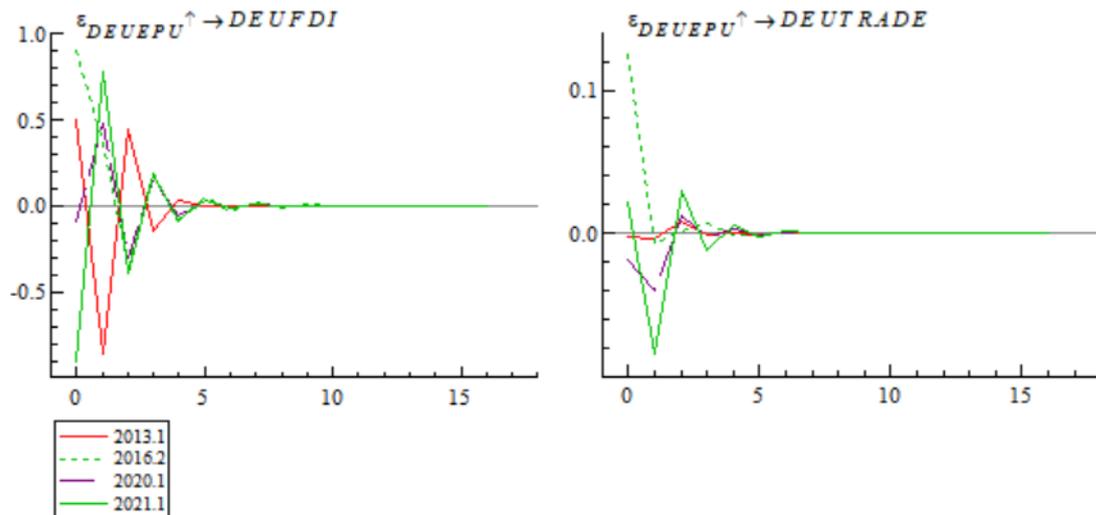


Figure 10. Time-varying responses of *DEUFDI* and *DEUTRADE* to *DEUEPU* at different time points.

Notes: *DEUEPU*, *DEUFDI* and *DEUTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Germany, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

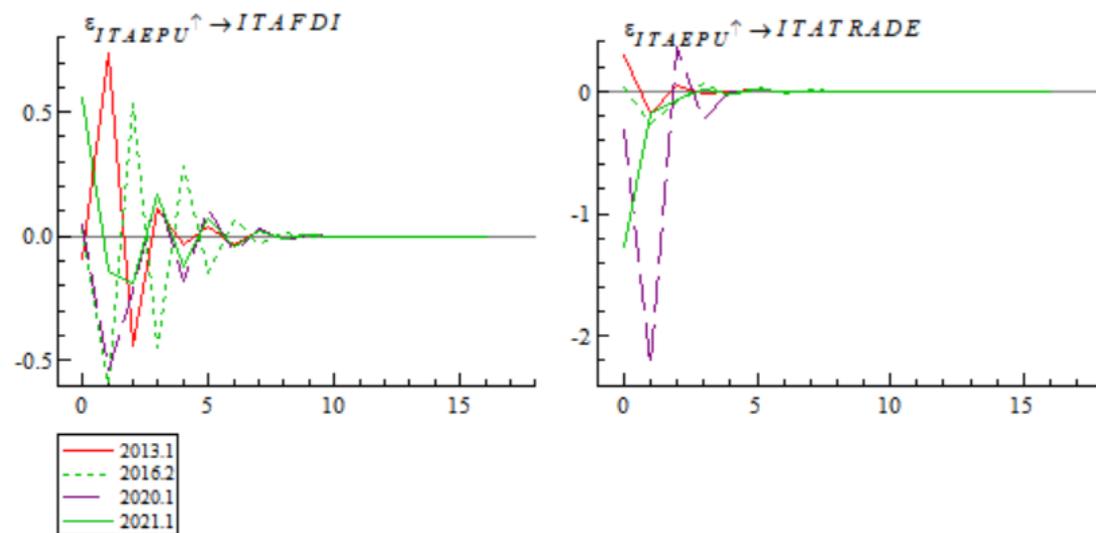


Figure 11. Time-varying responses of *ITAFDI* and *ITATRADE* to *ITAEPU* at different time points.

Notes: *ITAEPU*, *ITAFDI* and *ITATRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Italy, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

Figure 11 shows that *ITAEPU* has volatile influences on foreign direct investment in Italy at special time points. At time points 2016Q2 and 2020Q1, impulse responses of *ITAFDI* are small at the beginning and alternate from positive to

for negative the rest of the time. The effects of *ITAEPU* on *ITAFDI* are highly volatile and in uncertain directions.

As shown in **Figure 11**, the impulse responses of *ITATRADE* are still larger at the 2020Q1 and 2021Q1 time points. However, the impulse responses of *ITATRADE* during the UK's official exit from the EU and its transition period are greater than the impulse responses at the end of the transition period.

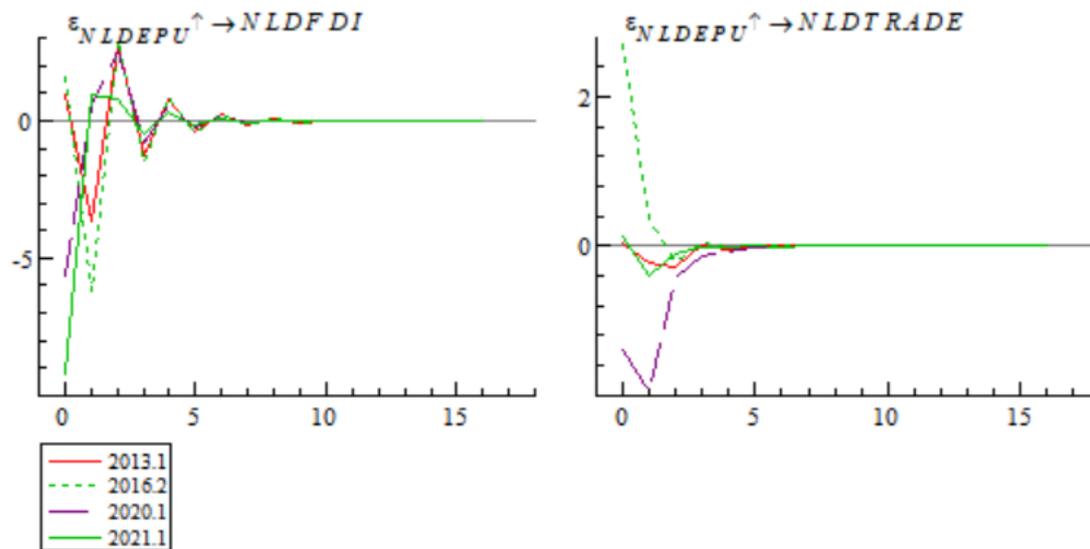


Figure 12. Time-varying responses of *NLDFDI* and *NLDTRADE* to *NLDEPU* at different time points.

Notes: *NLDEPU*, *NLDFDI* and *NLDTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in the Netherlands, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

As shown in **Figure 12**, the impulse responses of *NLDFDI* and *NLDTRADE* have similar trajectories at the four time points. Although the directions of impulse responses are different at the beginning, they gradually diminish to 0 after a period of fluctuation from negative to positive.

Furthermore, interestingly, the impulse responses of *NLDTRADE* at the 2020Q1 and 2021Q1 time points are in opposite directions. The impacts of economic policy uncertainty in the Netherlands are larger than those in other economies, which is consistent with the previous results.

Figure 13 shows that the impulse responses of *ESPFDI* and *ESPTRADE* also vary over time and have similar trajectories at the four time points. The impulse responses of *ESPFDI* at the 2021Q1 time point are significantly greater than those at other time points, indicating that the impacts of economic policy uncertainty on foreign direct investment in Spain are strongly affected by the end of Brexit. However, the largest impulse response of *ESPTRADE* occurs at the 2020Q1 time point, when the UK officially leaves the EU and enters a transition period of 11 months.

Figure 14 shows the impulse responses for the set of variables (*GBREPU*, *GBRFDI*, *GBRTRADE*). The effects of economic policy uncertainty on foreign direct investment in the UK are initially large and negative, and then change from negative to positive for the rest of the time. Compared to the impulse responses at other time points, the impulse responses at the time point of 2021Q1 are the largest, which is similar to the situation in Spain. However, the impulse responses of *GBRTRADE* are almost equal at the 2013Q1, 2020Q1 and 2021Q1 time points.

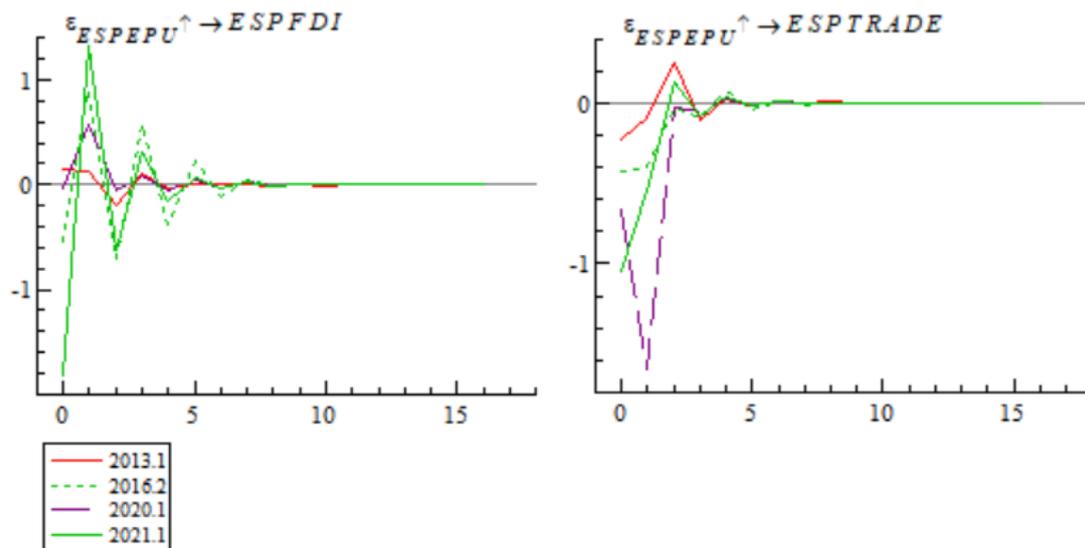


Figure 13. Time-varying responses of *ESPFDI* and *ESPTRADE* to *ESPEPU* at different time points.

Notes: *ESPEPU*, *ESPFDI* and *ESPTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in Spain, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

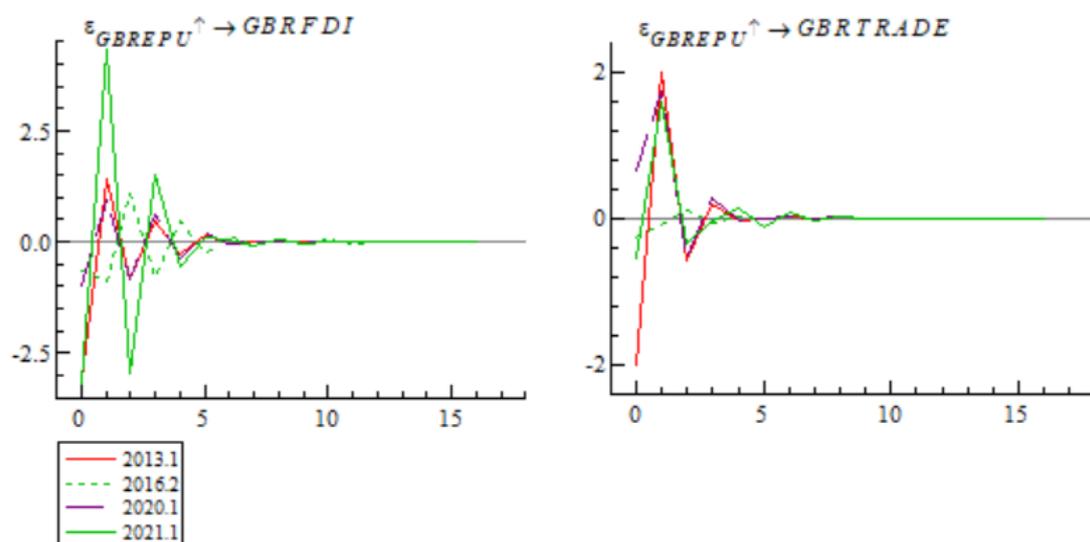


Figure 14. Time-varying responses of *GBRFDI* and *GBRTRADE* to *GBREPU* at different time points.

Notes: *GBREPU*, *GBRFDI* and *GBRTRADE* represent the economic policy uncertainty index, foreign direct investment and international trade in the UK, respectively. The red solid line refers to impulse responses at time point 2013Q1, the green dotted line refers to impulse responses at time point 2016Q2, the purple dashed line refers to impulse responses at time point 2020Q1, and the green solid line refers to impulse responses at time point 2021Q1.

6. Conclusion

We examine the Brexit spillovers on five major EU member states and the UK through economic policy uncertainty. Cluster analysis and TVP-VAR model are applied to data from five major EU member states and the UK to analyse the impacts of economic policy uncertainty (EPU) on foreign direct investment (FDI) and international trade (TRADE) during Brexit. Based on empirical results, the impulse responses of FDI and TRADE to economic policy uncertainty in six economies are different at different stages of Brexit.

Considering the impact intensity of economic policy uncertainty on foreign direct investment, the economy most affected by economic policy uncertainty is the Netherlands, which is consistent with the conclusion of Irwin (2015). The UK is the second most strongly affected by economic policy uncertainty in the Brexit-related period, and the impulse responses of foreign direct investment in France are also relatively large. From the perspective of international trade, France is the economy most affected by economic policy uncertainty, and followed by Spain.

In terms of strengths, the impulse responses of foreign direct investment are generally greater than those of international trade, which implies that economic policy uncertainty has a great impact on foreign direct investment. In addition, the time-varying impacts of economic policy uncertainty at different time horizons last for a year in France, Italy, the Netherlands, Spain and the UK.

By comparing the intensity of the impulse responses at different time points, we can see that economic policy uncertainty in the Netherlands has the greatest impact on its foreign direct investment and international trade at four time points, followed by the UK. Furthermore, the duration of the impact of economic policy uncertainty on foreign direct investment is generally greater than that of economic policy uncertainty on international trade.

Overall, the Brexit spillovers induced by economic policy uncertainty can be grouped into three categories considering intensity: high impact for two economies (the Netherlands and the UK); medium impact for two economies (France and Spain); and low impact for two economies (Germany and Italy).

References

- Al-Thaqeb, S. A., and B. G. Algharabali. 2019. "Economic Policy Uncertainty: A Literature Review." *The Journal of Economic Asymmetries* 20, e00133.
- Baker, S. R., N. Bloom, and S. J. Davis. 2016. "Measuring Economic Policy Uncertainty." *The quarterly journal of economics* 131 (4): 1593-1636.
- Biljanovska, N., F. Grigoli, and M. Hengge. 2021. "Fear Thy Neighbor: Spillovers from Economic Policy Uncertainty." *Review of International Economics* 29 (2): 409–438.
- Binge, L. H., and W. H. Boshoff. 2020. "Economic Uncertainty in South Africa." *Economic Modelling* 88: 113-131.
- Booth, S., C. Howarth, M. Persson, R. Ruparel, and P. Swidlicki. 2015. "What if...?: The Consequences, Challenges and Opportunities Facing Britain Outside EU". *Open Europe Report* 3, London.
- Cerda, R., A. Silva, and J. T. Valente. 2018. "Impact of Economic Uncertainty in a Small Open Economy: The Case of Chile." *Applied Economics* 50 (26): 2894-2908.
- Chan, K. C., and X. Feng. 2019. "Corporate Philanthropy in a Politically Uncertain Environment: Does it Bring Tangible Benefits to a Firm? Evidence from China." *The European Journal of Finance* 25 (3): 256-278.
- Claeys, P. 2017. "Uncertainty Spillover and Policy Reactions." *Ensayos sobre Política Económica* 35 (82): 64-77.
- Crafts, N. 2016. "The Growth Effects of EU Membership for the UK: A Review of the Evidence." *University of Warwick CAGE Working Paper* 280.
- Dhingra, S., G. Ottaviano, V. Rappoport, T. Sampson, and C. Thomas. 2018. "UK Trade and FDI: A Post-Brexit Perspective." *Papers in Regional Science* 97 (1): 9-24.
- Geweke, J. 1992. "Evaluating the Accuracy of Sampling-based Approaches to the Calculations of Posterior Moments." *Bayesian statistics* 4: 641-649.
- Irwin, G. 2015. "BREXIT: The Impact on the UK and the EU." *Global Counsel*, June.
- Istiak, K., and A. Serletis. 2018. "Economic Policy Uncertainty and Real Output: Evidence from the G7 Countries." *Applied Economics* 50 (39): 4222-4233.
- Jafari, Y., and W. Britz. 2020. "Brexit: An Economy-wide Impact Assessment on Trade, Immigration, and Foreign Direct Investment." *Empirica* 47 (1): 17-52.
- Jeon, J. H., H. H. Lee, and C. M. Lee. 2017. "Economic Policy Uncertainty and Korean Economy: Focusing on Distribution Industry Stock Market." *Journal of Distribution Science* 15 (12): 41-51.
- Katayama, M., and K. H. Kim. 2018. "Uncertainty Shocks and the Relative Price of Investment Goods." *Review of Economic Dynamics* 30: 163-178.
- Meinen, P., and O. Roehle. 2017. "On Measuring Uncertainty and Its Impact on Investment: Cross-country Evidence from the Euro Area." *European Economic Review* 92: 161-179.
- Nakajima, J., M. Kasuya, and T. Watanabe. 2011. "Bayesian Analysis of Time-varying Parameter Vector Autoregressive Model for the Japanese Economy and Monetary Policy." *Journal of the Japanese and International Economies* 25 (3): 225-245.
- Nakajima, J. 2011. "Time-Varying Parameter VAR Model with Stochastic Volatility: An Overview of Methodology and Empirical Applications." *IMES Discussion Paper*

Series E-9.

Pain, N., and G. Young. 2004. “The Macroeconomic Impact of UK Withdrawal from the EU.” *Economic modelling* 21 (3): 387-408.

Primiceri, G. E. 2005. “Time Varying Structural Vector Autoregressions and Monetary Policy.” *The Review of Economic Studies* 72 (3): 821-852.

Simionescu, M. 2016. “The Impact of BREXIT on the Foreign Direct Investment in the United Kingdom.” *Bulgarian economic papers* (7): 2-17.

Tian, L., J. Lin, and S. Zhang. 2017. “Is Economic Policy Uncertainty an Important Fluctuation Factor—Based on a New Mixed Identification Method.” *Finance & Trade Economics* (1): 5-20.

Zhang, Y., and Q. Wang. 2016. “The Nonlinear Macroeconomic Effect of Policy Uncertainty and Its Influencing Mechanism.” *Finance & Trade Economics* (4): 116-133.

Zhou, M. J., J. B. Huang, and J. Y. Chen. 2020. “The effects of geopolitical risks on the stock dynamics of China's rare metals: A TVP-VAR analysis.” *Resources Policy* 68: 101784.

Appendix

Table A1. Estimation results of selected parameters in the TVP-VAR model for the variable set of (*FRAEPU*, *FRAFDI*, *FRATRADE*)

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_{\beta})_1$	0.0227	0.0026	0.0183	0.0285	0.604	3.53
$(\Sigma_{\beta})_2$	0.0227	0.0026	0.0183	0.0284	0.143	3.89
$(\Sigma_{\alpha})_1$	0.0373	0.0055	0.0282	0.0495	0.783	5.19
$(\Sigma_{\alpha})_2$	0.0332	0.0045	0.0256	0.0432	0.697	19.02
$(\Sigma_h)_1$	0.1573	0.0816	0.0617	0.3762	0.223	70.78
$(\Sigma_h)_2$	0.1941	0.1152	0.0641	0.4986	0.945	84.06

Note: The estimates of $(\Sigma_{\beta})_i$ and $(\Sigma_{\alpha})_i$ are multiplied by 100.

Table A2. Estimation results of selected parameters in the TVP-VAR model for the variable set of (*DEUEPU*, *DEUFDI*, *DEUTRADE*)

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_{\beta})_1$	0.0228	0.0026	0.0185	0.0284	0.140	4.91
$(\Sigma_{\beta})_2$	0.0228	0.0026	0.0184	0.0286	0.091	4.94

$(\Sigma_{\alpha})_1$	0.0371	0.0056	0.0278	0.0496	0.428	5.13
$(\Sigma_{\alpha})_2$	0.0253	0.0030	0.0202	0.0321	0.787	17.70
$(\Sigma_h)_1$	0.1977	0.1088	0.0688	0.4793	0.591	79.80
$(\Sigma_h)_2$	0.4523	0.2341	0.1292	1.0180	0.737	92.19

Note: The estimates of $(\Sigma_{\beta})_i$ and $(\Sigma_{\alpha})_i$ are multiplied by 100.

Table A3. Estimation results of selected parameters in the TVP-VAR model for the variable set of *(ITAEPU, ITAFDI, ITATRADE)*

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_{\beta})_1$	0.0228	0.0026	0.0184	0.0285	0.629	3.66
$(\Sigma_{\beta})_2$	0.0228	0.0026	0.0184	0.0286	0.972	3.49
$(\Sigma_{\alpha})_1$	0.0393	0.0069	0.0283	0.0551	0.672	8.34
$(\Sigma_{\alpha})_2$	0.0361	0.0059	0.0266	0.0499	0.654	7.57
$(\Sigma_h)_1$	0.3526	0.1599	0.1029	0.7202	0.034	50.21
$(\Sigma_h)_2$	0.3335	0.1334	0.1505	0.6716	0.287	47.97

Note: The estimates of $(\Sigma_{\beta})_i$ and $(\Sigma_{\alpha})_i$ are multiplied by 100.

Table A4. Estimation results of selected parameters in the TVP-VAR model for the variable set of *(NLDEPU, NLDFDI, NLDTRADE)*

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_{\beta})_1$	0.0227	0.0025	0.0184	0.0282	0.666	3.89
$(\Sigma_{\beta})_2$	0.0228	0.0026	0.0183	0.0287	0.415	4.04
$(\Sigma_{\alpha})_1$	0.0716	0.0223	0.0410	0.1259	0.378	21.42
$(\Sigma_{\alpha})_2$	0.0520	0.0119	0.0342	0.0804	0.110	12.77
$(\Sigma_h)_1$	0.2967	0.1640	0.0753	0.6810	0.800	87.47

$(\Sigma_h)_2$	0.2478	0.1350	0.0782	0.5941	0.432	60.79
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Note: The estimates of $(\Sigma_\beta)_i$ and $(\Sigma_\alpha)_i$ are multiplied by 100.

Table A5. Estimation results of selected parameters in the TVP-VAR model for the variable set of $(ESPEPU, ESPFDI, ESPTRADE)$

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_\beta)_1$	0.0227	0.0026	0.0183	0.0286	0.279	2.94
$(\Sigma_\beta)_2$	0.0227	0.0026	0.0183	0.0284	0.745	3.42
$(\Sigma_\alpha)_1$	0.0462	0.0097	0.0312	0.0691	0.354	9.60
$(\Sigma_\alpha)_2$	0.0393	0.0069	0.0283	0.0551	0.517	14.51
$(\Sigma_h)_1$	0.1693	0.0947	0.0581	0.4138	0.581	52.22
$(\Sigma_h)_2$	0.1940	0.0994	0.0708	0.4471	0.817	51.67

Note: The estimates of $(\Sigma_\beta)_i$ and $(\Sigma_\alpha)_i$ are multiplied by 100.

Table A6. Estimation results of selected parameters in the TVP-VAR model for the variable set of $(GBREPU, GBRFDI, GBRTRADE)$

Parameter	Mean	St. Dev	95%L	95%U	Geweke	Inefficiency
$(\Sigma_\beta)_1$	0.0228	0.0026	0.0184	0.0287	0.532	4.25
$(\Sigma_\beta)_2$	0.0228	0.0026	0.0184	0.0287	0.118	3.09
$(\Sigma_\alpha)_1$	0.0438	0.0085	0.0304	0.0634	0.340	6.38
$(\Sigma_\alpha)_2$	0.0409	0.0071	0.0290	0.0569	0.844	13.45
$(\Sigma_h)_1$	0.4963	0.1887	0.2134	0.9409	0.594	48.49
$(\Sigma_h)_2$	0.3728	0.1690	0.1276	0.7782	0.965	51.23

Note: The estimates of $(\Sigma_\beta)_i$ and $(\Sigma_\alpha)_i$ are multiplied by 100.