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in the G7 economies

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### ABSTRACT

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# Oil price volatility and stock returns in the G7 economies\*

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## Abstract

This study examines the relationship between oil price volatility and stock returns in the G7 economies (Canada, France, Germany, Italy, Japan, the UK and the US) using monthly data for the period 1970 to 2014. In order to measure oil volatility we consider alternative specifications for oil prices (world, nominal and real prices). We estimate a vector autoregressive model with the following variables: interest rates, economic activity, stock returns and oil price volatility taking into account the structural break in the year 1986. We find a negative response of G7 stock markets to an increase in oil price volatility. Results also indicate that world oil price volatility is generally more significant for stock markets than the national oil price volatility.

**JEL classification:** C40; G12; Q43

**Keywords:** stock returns, oil price volatility, G7 economies, Vector autoregressive (VAR) model

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## 1. Introduction

Due to the important role of oil in the world economy, there has been a large amount of research intended to capture the economic and financial consequences of changes in the price of oil. Numerous research papers indicate that there is a statistically significant and negative effect of oil price shocks on real economic activity (Hamilton, 1983, 2011; Cunado and Perez de Gracia, 2003, 2005; Herrera et al., 2011; Jo, 2014; Cunado et al., 2015).

A less extensive yet still significant amount of research has studied the effect of oil price shocks on international stock markets. The economic effect of oil price shocks should be captured by financial markets, for they are bound to affect cash flows, expected returns and investment decisions. Results from empirical studies show that oil price shocks, which are defined as oil price changes, do have a significant effect on these markets (Jones and Kaul, 1996; Sadorsky, 1999 and Cunado and Perez de Gracia, 2013). In a recent paper Jo (2014) points out that heightened volatility can deteriorate a variety of real economic activity and, using a quarterly vector autoregressive (VAR) with stochastic volatility, finds a negative effect of oil price volatility on world industrial production. Also, Elder and Serletis (2010), use a VAR that is modified to accommodate a generalized autoregressive conditional heteroskedasticity (GARCH) in order to study the macroeconomic effects of oil price volatility, finding a negative response in measures of investment, durables consumption, and aggregate output. Considering that there is, in fact, an economic impact of the oil price volatility should also be captured by financial markets.

In this context, the aim of this paper is to study the effect of changes in oil price volatility in the stock markets of the G7 economies (Canada, France, Germany, Italy, Japan, the UK and the US). Most papers referring to oil price shocks and stock markets focus on how different specifications of an oil price increase or decrease may affect stock returns. Few researches have been made to test for the effect of the volatility of oil price on stock markets. However, considering the importance of oil as a major input in production processes, it is necessary to consider how the volatility in the price of oil affects investment decisions, and reduces the efficiency of resource allocations that reflects on declining stock returns. In our research, using monthly data since 1970:01 to 2014:12 for G7 economies, we find that the effect of a change in oil price affects the stock markets not only through a price increase (or decrease) affecting cash flows or expected returns, but also because of how frequent and large oil price changes heighten volatility. Our approach measure the reaction of G7 stock markets to a shock in oil price volatility and show that, as expected, an increase in oil price volatility negatively affects the performance of stock markets in these economies.

Previous research on the macroeconomic impact of oil prices has driven economists to define several nonlinear specifications of an oil price shock. They have found that oil price increases have a more significant effect on the macroeconomic variables than oil price decreases, and that their significance is dependent on their relative difference with recent oil prices (Hamilton, 1996, 2003; Herrera et al., 2011). These nonlinear specifications have then been used for studies on the effect of oil price shocks in stock markets for the European industries (Scholtens and Yurtsever, 2012) and European countries (Park and Ratti, 2008; Cunado and Perez de Gracia, 2013), among others.

The scaled oil price increase specification by Lee et al. (1995) has been widely accepted in economic literature. This specification defines an oil price shock as the proportion of the price change relative to current oil price volatility. To identify oil price volatility, they use a GARCH (1, 1) model. However, the scaled oil price increase is still using oil price changes. To define the variance of oil returns, we also use a GARCH (1, 1) model.<sup>1</sup> Once we have defined oil price volatility, we include oil price volatility as an exogenous variable in a VAR model that also includes short-term interest rates, industrial production growth and stock returns. A time series for volatility of world, national, real and nominal oil prices is identified for each country, in order to study how the effect of an oil price volatility shock may also be influenced by changes in exchange rates or inflation. The results of the VAR model are then used to estimate impulse response functions that allow us to identify the effect of oil price volatility shocks on G7 stock markets, which we find is generally negative. The magnitude of the response of the stock markets varies by country and is most significant in Canada and Japan. We also find that the statistical significance of the shocks on all seven markets changes according to the integrated effect of exchange rates and inflation.

In earlier studies, it has been shown that there was a structural break in the relationship between oil prices and macroeconomic variables in year 1986 (Mork, 1989; Sadorsky, 1999; Cunado and Perez de Gracia, 2005 and Elder and Serletis, 2010). There was a large price drop caused by an enormous increase in supply in response to an oil price war in the year 1986. Previous studies indicate that this was due to a change in oil price behavior, which during the recent period includes larger decreases and an increased volatility (Hamilton, 1996). These huge decreases had not been seen before, and have now been followed by increases to correct a downward trend. This has contributed to a larger volatility in oil prices after 1986, which may have changed the way stock markets respond to this volatility. Following previous empirical studies, we split our sample in pre and post 1986 periods and find that G7 stock markets began reacting negatively to oil price volatility shocks after 1986.

The structure of the paper is as follows. Section 2 reviews the literature on the nexus between oil price shocks and stock returns. Section 3 presents the dataset. Section 4 covers the empirical analysis, in which we estimate the impact of oil price volatility on stock market returns. Finally, section 5 concludes.

## **2. Literature review on oil price shocks and stock returns**

Hamilton (1983) considered oil shocks as exogenous due to the finding that oil price shocks Granger-precede all other main economic variables. This has allowed for the effect of oil price shocks on stock returns to be investigated extensively. Jones and Kaul (1996) studied the effect of a linear specification of oil price shocks on stock markets in the US, Canada, the UK and Japan. They found a negative response of stock market returns to oil price shocks, and found that, while this response could be fully accounted for by the change in expected cash flows and returns in the US and Canadian stock markets, the British and Japanese markets seemed to overreact to these shocks. More research also found a negative effect of linear oil price changes in the US stock market (Miller and Ratti, 2009), and a negative effect of nonlinear and asymmetric oil price changes on the world stock market index (Driesprong et al., 2008).

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<sup>1</sup> Other studies that also approach oil price volatility with a GARCH (1, 1) are Elyasani et al. (2011) and Chen and Hsu (2012), Aye et al. (2014) and Caporale et al. (2015) and among others.

There is also research on the oil price and stock returns relationship that intends to distinguish oil supply and oil demand shocks. Most of this research identifies supply shocks through world oil production, shocks to crude oil demand induced by higher economic activity (through aggregate demand shocks), and remaining oil demand shocks as idiosyncratic (Apergis and Miller, 2009; Kilian and Park, 2009; Güntner, 2014). Güntner (2014) finds that global oil supply shocks have no significant impact on international stock markets, while an increase in global aggregate demand has the effect of rising oil prices and stock returns, which is more persistent for net oil exporters. However, idiosyncratic oil demand shocks, that is, those due to changes in the demand of oil that are independent of changes in global aggregate demand, appear to have a negative impact on stock markets of oil importing countries. Apergis and Miller (2009) find the same effect on stock markets of the G7 countries and Australia. On a different study, Cunado and Perez de Gracia (2013) define an alternative specification to disentangle oil demand and supply shocks, identified according to the sign of the correlation between oil price changes and world oil production. They find a negative and significant impact on most European stock markets.

Other studies have investigated the effect of oil price shocks at an industry level. Scholtens and Yurtsever (2012) find a negative correlation of industries and total stock market returns with oil price changes (except for oil and gas producing industries) in the Euro area for the period 1983-2007. Also, Narayan and Sharma (2011) analyze the relationship between oil price and returns for 560 US firms and find that firms belonging to the energy and transportation sector, experience a positive effect of an oil price shock, whereas the remaining sectors experience a negative effect. Also, as firm size grows, the relationship between oil prices and firm returns appears to be more negative and statistically significant.

Research by Sadorsky (1999) uses a VAR model, impulse response functions, and variance decomposition to study the effect of both oil price and oil price volatility shocks on the US stock market. He finds that oil price shocks have a negative and statistically significant impact on stock returns and that, after 1986, both oil price and oil price volatility shocks explain a larger proportion of the stock return forecast error variance than do interest rates. According to Sadorsky (1999), it is evident that oil price dynamics have changed after 1986. In this study, we analyze a full sample from 1970:01 to 2014:12, and a pre and post 1986 samples.

A different paper by Park and Ratti (2008) also studies the effect of oil price and oil price volatility shocks in stock markets of the US and 13 European countries in the period of 1986-2005. They define oil price volatility as the sum of square first log differences in daily spot or future prices, and find that increased volatility of oil prices has a negative effect on 9 out of 14 countries. Elyasani et al. (2011) measure the effect of oil price volatility on stock returns of 13 US industries, by regressing industry-level returns on oil price volatility, defined according to a GARCH (1, 1) model. Recently, Caporale et al. (2015) analyze the impact of oil price volatility on stock prices in China over the period January 1997 to February 2014 approaching oil volatility with a GARCH (1, 1) model.

Most research on the effect of oil in the economy and financial markets focuses on oil price changes. Few researches have been made to measure the effect of second moment changes of oil price in stock markets. These refer to increases or decreases in the volatility of oil prices that may affect stock markets, implying that not only a higher

(or lower) price of oil generates a reaction in the markets, but also does an increase (decrease) on the volatility of the price of oil. This would imply that a heightened volatility is bound to influence investment decisions that later reflect on stock returns. In this paper, we focus on shocks in the second moment of oil prices. Unlike other papers that examine the relationship between oil price volatility and stock market, we use a GARCH (1, 1) model in order to define the time series of oil price volatility for each country, which is then integrated into a VAR model jointly with short-term interest rates, industrial production growth, and stock returns. The effect of oil price volatility on stock markets is then identified through impulse response function generated from the VAR model.

### 3. Description of the dataset

The dataset we use consists in monthly data for all G7 economies between January 1970 and December 2014. Other papers that also use monthly data to study stock returns and oil shocks are Apergis and Miller (2009), Park and Ratti (2008), Miller and Ratti (2009) and Cunado and Perez de Gracia (2013), among others. The data are obtained from the International Financial Statistics (International Monetary Fund, 2015), FRED Economic Data (Federal Reserve Bank of St. Louis, 2015) and the US Energy Information Administration (2015). Table 1 displays the definition of the variables and sources.

< **Insert Table 1 about here** >

Following some studies on stock returns and oil price shocks, we include the following variables in the empirical analysis: interest rates, economic activity, oil prices and stock prices (Sadorsky, 1999; Miller and Ratti, 2009; Cunado and Perez de Gracia, 2013).

*-Interest rates.* Interest rate series are defined as the short-term discount rate for each country. For any missing data in the discount rate series, we complete with the money market rate and the monetary policy interest rate. Following Miller and Ratti (2009), interest rates and economic activity allow us to control for shocks affecting stock returns, but not captured by short-run oil price volatility changes. Short-interest rates are also considered by other studies such as Cunado and Perez de Gracia (2013) and Vitaly et al. (2016).

*-Economic activity.* In order to measure economic activity, we use the monthly seasonally adjusted industrial production index of each country. The total industrial production index measures real production output of manufacturing, mining, and electric and gas utilities industries. Industrial production growth is defined as the logarithm of the first difference. Additional papers that also use industrial production index are Herrera et al. (2011) and Cunado and Perez de Gracia (2013).

*-Oil prices.* We use both West Texas Intermediate (WTI) and UK Brent oil prices. We consider alternative oil specifications, including the world nominal price, the nominal national price and the real national price. We take the nominal world price to be the one given in US dollars per barrel. The nominal national price is the product of the world price and each country's exchange rate (number of units of local currency per one US dollar). The real national price is the nominal national price deflated by each country's CPI. For example, Cunado and Perez de Gracia (2005) also considered national and world oil prices.

*-Stock prices.* To measure stock returns, we use the monthly average share price index for each country. The series is deflated by each country's CPI and stock return is defined as the logarithm of the first differences of the deflated series. The definition of real stock returns is in line with the previous empirical literature such as Park and Ratti (2008) and Cunado and Perez de Gracia (2013).

#### 4. Empirical analysis

First, for each G7 country, we test for unit roots in all variables, including the different specifications of oil price (nominal and real oil price of WTI, nominal and real oil price of UK Brent).<sup>2</sup> Each variable is in natural logs with the exception of short-term interest rates. Table 2 reports the Augmented Dickey-Fuller (ADF, Dickey and Fuller, 1981) and the Phillips and Perron (PP, Phillips and Perron, 1988) unit root tests. The results show that all four variables (economic activity, short-term interest rates, stock prices and alternative oil prices) are integrated of order one, for which we can conclude that they are stationary in first differences. There are some previous related studies that confirm the unit root in economic activity, short-term interest rates, stock prices and oil prices (Cunado and Perez de Gracia, 2013).<sup>3</sup>

< Insert Table 2 about here >

Once we have checked that all the variables contain a unit root, we test for cointegration using the Johansen and Juselius test, (Johansen and Juselius, 1990). Table 3 presents the results using the trace and the maximum eigenvalue tests. We reject the null hypothesis of no cointegration (at a 10% significance level) in Canada, France, Germany, Italy, and the UK for all oil price specifications. Furthermore, the results suggest the existence of one cointegrating vector for these five countries, with the exception of Italy, where we find two cointegrating vectors when specifying oil price in Italy's local currency.

< Insert Table 3 about here >

The results suggest that there is a long-run relationship in Canada, France, Germany, Italy and the UK, between the four variables analyzed in the paper: stock prices, economic activity, short-term interest rates and oil prices. When we consider the trace statistic, we find evidence of one cointegrating vector with both world nominal oil prices -UK Brent- and national oil prices -UK Brent- in the US case. Finally, when the cointegration test assumes a model with an intercept and a linear trend, we also find one cointegration vector in the Japanese economy (column 4, Table 3).

The VAR model estimated in this paper has already been widely used for identifying the effect of several oil price shock specifications on stock market returns by Park and Ratti (2008), Güntner (2014), Cunado and Perez de Gracia (2013), among others. This VAR was initially proposed by Sims (1980).

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<sup>2</sup> Basic statistics (mean, standard deviation, skewness, kurtosis and Jarque-Bera test for normality) of the relevant series for the full sample, pre-1986 and post-1986 sub-periods are available upon author request from the authors.

<sup>3</sup> We also perform unit root tests in the pre-1986 and post-1986 sub-periods. The results are not reported here but are available upon request from the authors. The results for the pre-1986 and post-1986 sub-periods confirm that our selected variables are integrated of order one.



A VAR model of order  $p$  that includes  $k$  variables can be expressed as:

$$y_t = A_0 + \sum_{i=1}^p A_i y_{t-i} + \varepsilon_t, \quad (1)$$

where  $p$  is the number of lags,  $y_t = [y_{1t} \dots y_{kt}]'$  is a column vector of all the variables in the model (short-term interest rates, real industrial production growth, oil price volatility and real stock market returns);  $A_0$  is a column vector of constant terms;  $A_i$  is a  $k \times k$  matrix of unknown coefficients; and  $\varepsilon_t$  is a column vector of errors with the following properties:

$$\begin{aligned} E(\varepsilon_t) &= 0 & \forall t, \\ E(\varepsilon_s \varepsilon_t') &= \Omega & \text{if } s = t, \\ E(\varepsilon_s \varepsilon_t') &= 0 & \text{if } s \neq t, \end{aligned}$$

where  $\Omega$  is the variance-covariance matrix with non-zero off-diagonal elements. The lag length is selected according to the Akaike Information Criterion (AIC).

In selecting the order of variables for the VAR model, short-term interest rates are selected first because it is assumed that monetary shocks are independent of contemporaneous disturbances to other variables, but might affect oil prices and oil price volatility. This assumption is in accordance to Scholtens and Yurtsever (2012) and Sadorsky (1999).

In order to define oil price volatility, following previous studies such as Caporale et al. (2015), Aye et al. (2014), Elyasani et al. (2011) and Chen and Hsu (2012), we consider univariate GARCH (1, 1) models estimated separately for each country:

$$\begin{aligned} oil_t &= oil_{t-1} + u_t, & u_t | oil_1, \dots, oil_{t-1} &\sim N(0, h_t) \\ h_t &= \gamma_0 + \gamma_1 u_{t-1}^2 + \gamma_2 h_{t-1}, \end{aligned} \quad (2)$$

where  $oil_t$  is the price of oil at period  $t$ , and  $u_t$  is the oil price change in each period, which follows a normal distribution with mean zero and time-varying volatility  $h_t$ . The parameter  $\gamma_0$  represents long-run average variance rate of oil price,  $\gamma_1$  is a parameter that measures the sensitivity of oil price volatility to the last change in oil price and the  $\gamma_2$  parameter measures the sensitivity to all previous values of oil price variance. In equation (2)  $\gamma_0 > 0$ ,  $\gamma_1 \geq 0$ ,  $\gamma_2 \geq 0$  and  $\gamma_1 + \gamma_2 < 1$  such that GARCH model is covariance stationary. We estimate the time series of oil price conditional volatility for each oil price specification using the maximum likelihood method.

After estimating the VAR model for alternative oil price volatility specifications (world nominal -UK Brent-, national nominal -UK Brent-, national real -UK Brent-, world nominal -WTI-, national nominal -WTI- and national real -WTI-), we analyze the impact of oil price volatility shocks through generalized impulse response functions. This is done with the full sample period of 1970:01-2014:12 and the following sub-samples: 1970:01-1985:12 and 1986:01-2014:12.

Figures 1 to 6 show the generalized impulse response functions of real stock returns to the following variables: world nominal -UK Brent- oil price volatility (Figure 1); national nominal -UK Brent- oil price volatility (Figure 2); national real -UK Brent- oil price volatility (Figure 3); world nominal -WTI- oil price volatility (Figure 4);

national nominal -WTI- oil price volatility (Figure 5); national real -WTI- oil price volatility (Figure 6). The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price volatility shocks.

**< Insert Figures 1 to 3 about here >**

First, we find a significant change in how stock markets react to shocks in oil price volatility before and after January 1986. Oil price volatility has a larger negative effect on stock returns during the post-1986 period, except in the case of the UK (Figures 1, 2 and 6). These results are in accordance with Sadorsky (1999) who finds that, after 1986, oil price movements explain a larger fraction of the variance of stock returns.

Also, we can find a more significant effect of the UK Brent crude oil price volatility on G7 stock markets than that of WTI oil price.

The Canadian and Japanese stock markets are the most sensitive to oil price volatility. US and UK are less sensitive but still have diminishing stock returns related to higher oil price volatility. The French stock market reaction to changes in this volatility is mostly insignificant.

Canada is highly dependent on oil exports, and according to our findings, its stock market is more reactive to world oil price volatility, as shown in Figures 1 and 4, than it is to national real oil price volatility, as shown in Figures 2 and 5. We can also see in Figures 3 and 6 that the Canadian stock market shows a less significant reaction to real oil price volatility than it does to nominal oil price volatility.

Figures 1 and 4 also show that the French stock market only significantly reacts to a change in world oil price volatility, being most significant for the UK Brent crude (Figure 1). This structure of the French stock market corresponds to the post-1986 period, and consists in a negative reaction that is smoothly close to zero during 7 months.

In Germany, during the pre-1986 period, stock returns had an immediate reaction to oil price volatility change, recovering in the following period. For example, the German stock market presents a positive reaction to an increase in national nominal oil price volatility -WTI- for the pre-1986 period (Figure 5). Previous results are also in line with Cunado and Perez de Gracia (2013) who consider that the effect of oil price changes depend on the underlying cause of oil demand shock driven by the global economic activity. In the post-1986 period, this structure has changed into stock markets reacting mostly to nominal national oil price volatility.

In Figures 2, 3, 5 and 6, we can see that the Italian stock market shows a positive reaction to an increase in national oil price volatility. This is corrected when we use the world oil price volatility, as shown in Figures 1 and 4. Italy lacks energy resources and is entirely dependent on imports for its supply. In 1971, Italy introduced a floating exchange rate regime, and the reduction of oil prices through the devaluation of the lira enabled Italy to have an increase of exports, which have been central in the development of the Italian economy. This is a possible explanation of the positive stock return growth due to an increase in national oil price volatility, if oil price increases were in fact accompanied by the lira devaluation. However, when accounting for world oil price volatility, the Italian stock market does show a negative response in its returns.

On the other hand, Japan is also a large oil importer, and its stock markets show a significant effect due to changes in oil price volatility. Japanese stock market's sensitivity to oil price volatility corresponds only to a post-1986 period, and shows to be higher for the UK Brent (Figures 1, 2 and 3) than it is for WTI (Figures 4, 5 and 6).

Figures 1 through 3 show that the British stock market suffers a significant negative effect due to a rise in Brent crude price volatility. It is less significant when referring to WTI price volatility (Figures 4, 5 and 6). Although the British stock market already had this response before 1986, the response became more significant during the post-1986 period. Its response also shows to be equivalent across different oil price specifications (world, nominal national and real national).

Finally, although the US is the largest oil importer, its stock market is usually highly diversified, and does not show a response to oil price volatility as significant as does the Japanese stock market (also a large importer). However, we can observe that in the post-1986 period, the US stock returns began having a negative response to increases in oil price volatility. This response is not as large as other G7 economies, but is still significant. The dynamic and magnitude of its response are similar across nominal (Figures 2 and 5) and real oil price volatility variations (Figures 3 and 6).

< **Insert Figures 4 to 6 about here** >

## **5. Concluding remarks**

In this paper we analyzed whether changes in oil price volatility are captured by stock markets in the G7 countries using monthly data for the period 1970:01-2014:12. In order to estimate the impact of oil price volatility shocks on stock returns, we use an unrestricted VAR model including the following variables: short-term interest rates, economic activity, stock prices, and oil price volatility defined according to a GARCH (1, 1) model.

We consider alternative oil price specifications such as world, national and real prices expressed in both WTI and the UK Brent. Results indicate that world oil price volatility is generally more significant for stock markets than the volatility of oil price given in local currency. This is especially notable for Italy. These results are in line with Park and Ratti's (2008), who find that the effect of oil price shocks are better captured by the UK Brent index, and not by a specification that reflects the offsetting movement in the exchange rate. In other words, we find that stock market behavior is more sensitive to the information given by indicators of oil prices itself, rather than its expected impact in local currency. Also, in accordance with findings from Hamilton (2008), we do not find much difference in using real or nominal oil prices for the volatility definition. Hamilton states that this is due to the fact that in most oil shocks, the change in nominal oil prices is larger than the overall change in general prices. Considering that inflation is generally controlled by monetary policy which reduces aggregate price volatility, the results of this paper reflect the larger impact of volatility of nominal oil prices than that of inflation in stock returns.

Jo (2014) finds that an oil price volatility shock has the immediate and persistent negative effect of lowering economic activity by about 0.1%-point. Under the idea that heightened volatility can deteriorate a variety of economic activity, the overall results of

this paper suggest that oil price volatility also has a negative effect on returns of the G7 stock markets. This implies that these markets are capturing the effect that oil price volatility has on economic activity, and expected returns are impacted by a higher volatility of the price of oil. In other words, the efficiency of stock markets should be higher when there is more certainty in the price of this major input. Similar results of a negative effect of oil price volatility in stock returns are found by Park and Ratti (2008).

Also, Sadorsky (1999) stated that, after 1986, positive oil price volatility shocks explain a larger fraction of the variance of stock returns, suggesting a change in either the dynamics of oil price shocks or the structure of the economy. Cunado and Perez de Gracia (2005) also find the differential behavior before and after 1986, identifying large oil price declines and a heightened volatility. In our analysis, we use a GARCH (1, 1) model to define a time series for oil price volatility. In our empirical analysis, we can identify a heightened amount of volatility in oil prices in the post-1986 period. As the behavior of oil prices changed, the results of this paper show that G7 stock markets response to oil price volatility also changed. After 1986, G7 stock markets have reacted negatively to higher oil price volatility, which is not as significant in the pre-1986 period.

In light of these results, given that volatility of oil prices has been found to be relevant for predicting macroeconomic and financial variables, further research on this topic is needed. Additional research could focus on differential behavior, relative to price volatility, between oil importing and oil exporting countries. Also, this analysis could be extended to analyzing volatility of oil demand and oil supply shocks and to a micro-analysis at industry level.

## References

- Apergis, N., Miller, S., 2009. Do structural oil market shocks affect stock prices? *Energy Economics*, 31, 569-575.
- Aye G., Dadam, V., Gupta, R., Mamba, B., 2014. Oil price uncertainty and manufacturing production. *Energy Economics*, 43, 41-47.
- Caporale, G. M., Menla Ali, F., Spagnolo, N., 2015. Oil price uncertainty and sectoral stock returns in China: A time-varying approach. *China Economic Review*, 34, 311-321.
- Chen, S. S., Hsu, K. W., 2012. Reverse globalization: Does high oil price volatility discourage international trade? *Energy Economics*, 34, 1634-1643
- Cunado, J., Perez de Gracia, F., 2003. Do oil price shocks matter? Evidence for some European countries. *Energy Economics*, 25, 137-154.
- Cunado, J., Perez de Gracia, F., 2005. Oil prices, economic activity and inflation: Evidence for some Asian economies. *The Quarterly Review of Economics and Finance*, 45, 65-83.
- Cunado, J., Perez de Gracia, F., 2013. Oil prices shocks and stock market returns: Evidence for some European countries. *Energy Economics*, 42, 365-377.
- Cunado, J., Jo, S., Perez de Gracia, F., 2015. Macroeconomic impacts of oil price shocks in Asian economies. *Energy Policy*, 86, 867-879.
- Dickey, D. A., Fuller, W. A., 1981. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, 49, 1057-1072
- Driesprong, G. Jacobsen, B., Maat, B., 2008. Striking oil: another puzzle? *Journal of Financial Economics*, 89, 307-327.
- Elder, J., Serletis, A., 2010. Oil price uncertainty. *Journal of Money, Credit and Banking*, 42, 1137-1159.
- Elyasani, E., Iqbal, M., Odusami, B., 2011. Oil price shocks and industry stock returns. *Energy Economics*, 33, 966-974.
- Federal Reserve Bank of St. Louis, 2015. FRED Economic Data, Spot oil price: West Texas Intermediate. <<https://research.stlouisfed.org/fred2/series/OILPRICE>> [15/03/2015].
- Güntner, J. H., 2014. How do international stock markets respond to oil demand and supply shocks? *Macroeconomic Dynamics*, 18, 1657-1682.
- Hamilton, J. D., 1983. Oil and Macroeconomy since the World War II. *Journal of Political Economy*, 91, 228-248.
- Hamilton, J. D., 1996. This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics*, 38, 215-220.
- Hamilton, J. D., 2003. What is an oil shock? *Journal of Econometrics*, 113, 363-398.
- Hamilton, J. D., 2008. Oil and the macroeconomy, In: Durlauf, Steven, Blume, Lawrence (Eds.) *New Palgrave Dictionary of Economics*, 2<sup>nd</sup> edition. Palgrave McMillan Ltd.
- Hamilton, J. D., 2011. Nonlinearities and the macroeconomic effects of oil prices. *Macroeconomic Dynamics*, 15, 364-378.
- Herrera, A. M., Lagalo, L. G., Wada, T., 2011. Oil price shocks and industrial production: Is the relationship linear? *Macroeconomic Dynamics*, 15, 472-497.
- International Monetary Fund, 2015. International Financial Statistics. <<http://elibrary-data.imf.org/DataExplorer.aspx>> [15/03/2015].
- Jo, S., 2014. The effects of oil price uncertainty on global real economic activity. *Journal of Money, Credit and Banking*, 46, 1113-1135.
- Johansen, S., Juselius, K., 1990. Maximum likelihood estimation and inference on cointegration with applications to demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
- Jones, C. M., Kaul, G., 1996. Oil and the stock market. *Journal of Finance*, 51, 463-491.

- Kilian, L., Park, C., 2009. The impact of oil price shocks on the US stock market. *International Economic Review*, 50, 1267-1287
- Lee, K., Shawn, N., Ratti, R. A., 1995. Oil shocks and the macroeconomy: the role of price variability. *Energy Journal*, 16, 39-56.
- Miller, J. I., Ratti, R. A., 2009. Crude oil and stock markets: stability, instability and bubbles. *Energy Economics*, 31, 559-568.
- Mork, K. A., 1989. Oil and the macroeconomy when prices go up and down: An extension of Hamilton's results. *Journal of Political Economy*, 91, 740-744.
- Narayan, P. K., Sharma, S. S., 2011. New evidence on oil price and firm returns. *Journal of Banking and Finance*, 35, 3253-3262.
- Park, J., Ratti, R. A., 2008. Oil price shocks and stock markets in the US and 13 European countries. *Energy Economics*, 30, 2587-2608.
- Phillips, P. C., Perron, P., 1988. Testing for a unit root in time series regression. *Biometrika*, 75, 335-346.
- Sadorsky, P., 1999. Oil price shocks and stock market activity. *Energy Economics*, 21, 449-469.
- Scholtens, B., Yurtsever, C., 2012. Oil price shocks and European industries. *Energy Economics*, 34, 1187-1195.
- Sims, C.A., 1980. Macroeconomics and reality. *Econometrica*, 48, 1-48.
- Pershin, V., Molero, J. C., Perez de Gracia, F., 2016. Exploring the oil prices and exchange rates nexus in some African economies, *Journal of Policy Modeling*, forthcoming.
- US Energy Information Administration, 2015. Independent statistics & analysis, petroleum & other liquids. <[http://www.eia.gov/dnav/pet/pet\\_pri\\_spt\\_s1\\_d.htm](http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm)> [15/03/2015].

**Table 1. Variable description and sources**

Name	Description	Source
Stock returns	Share prices, end of period	International Financial Statistics (International Monetary Fund)
Economic activity	Industrial production index, seasonally adjusted	International Financial Statistics (International Monetary Fund)
CPI	CPI for all items, seasonally adjusted	International Financial Statistics (International Monetary Fund)
Interest rates	Short-term interest rate	International Financial Statistics (International Monetary Fund)
Exchange rates	Number of units of national currency per US dollar, period average	International Financial Statistics (International Monetary Fund) and FRED Economic Data (Federal Reserve Bank of St. Louis)
Oil prices	World nominal prices -UK Brent- Nominal national price -UK Brent- Real national prices -UK Brent- World nominal prices -WTI- Nominal national prices -WTI- Real national prices -WTI-	FRED Economic Data (Federal Reserve Bank of St. Louis) and US Energy Information Administration

Notes. WTI is expressed in nominal oil price, US dollars per barrel. UK Brent is expressed in nominal oil price, US dollars per barrel.

**Table 2. ADF and PP unit root tests**

	ADF test				PP test			
	Level		First difference		Level		First difference	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
<i>Economic activity</i>								
Canada	-2.113	-1.418	-4.669***	-7.018***	-2.521	-1.171	-25.410***	-25.370***
France	-2.658	-1.651	-5.380***	-5.783***	-3.315	-1.481	-30.151***	-30.006***
Germany	-3.159	-2.107	-30.121***	-30.338***	-2.866	-2.082	-29.218***	-29.534***
Italy	-4.618***	-2.713	-4.551***	-5.339***	-4.280***	-2.182	-32.439***	-34.171***
Japan	-2.868	-2.658	-13.443***	-13.488***	-2.887	-2.732	-23.718***	-23.634***
UK	-6.278***	-3.456	-21.826***	-22.938***	-6.040***	-3.404	-23.123***	-23.089***
US	-2.617	-1.697	-7.993***	-8.257***	-2.903	-1.887	-15.733***	-16.034***
<i>Interest rates</i>								
Canada	-2.161	-3.035	-27.574***	-27.553***	-2.341	-3.377	-30.227***	-30.498***
France	-1.558	-2.869	-18.600***	-18.589***	-1.589	-2.830	-18.509***	-18.497***
Germany	-2.734	-3.450	-7.533***	-7.5217***	-2.106	-2.984	-21.855***	-21.852***
Italy	-0.589	-2.073	-13.986***	-21.439***	-0.854	-2.188	-21.530***	-21.618***
Japan	-1.872	-3.612	-7.435***	-7.4298***	-1.666	-3.159	-22.501***	-22.488***
UK	-1.697	-2.205	-22.426***	-22.417***	-2.233	-2.843	-30.784***	-30.763***
US	-1.525	-2.633	-10.431***	-10.441***	-1.439	-2.519	-15.130***	-15.132***
<i>Stock prices</i>								
Canada	-1.046	-3.285	-17.294***	-17.303***	-0.939	-3.116	-17.307***	-17.313***
France	-1.530	-2.369	-19.476***	-19.468***	-1.784	-2.672	-20.068***	-20.057***
Germany	-1.077	-2.752	-21.028***	-21.022***	-1.353	-3.160	-21.071***	-21.065***
Italy	-2.535	-2.959	-10.659***	-10.663***	-2.360	-2.730	-18.592***	-18.583***
Japan	-1.992	-1.970	-16.659***	-16.650***	-1.932	-1.906	-16.595***	-16.583***
UK	-1.277	-2.724	-19.094***	-19.086***	-1.291	-2.824	-19.175***	-19.166***
US	0.192	-1.955	-19.717***	-19.781***	0.212	-2.019	-19.774***	-19.812***
<i>Nominal oil prices -UK Brent-</i>								
Canada	-2.079	-3.145	-15.686***	-15.669***	-1.630	-2.709	-15.617***	-15.600***
France	-2.416	-2.526	-16.162***	-16.171***	-2.153	-2.267	-15.586***	-15.583***
Germany	-2.500	-2.778	-16.416***	-16.404***	-2.176	-2.428	-16.309***	-16.297***
Italy	-1.776	-2.298	-16.508***	-16.528***	-1.529	-2.057	-16.011***	-15.996***
Japan	-2.665	-2.853	-15.960***	-15.945***	-2.129	-2.296	-15.835***	-15.819***
UK	-1.690	-2.469	-16.659***	-16.639***	-1.361	-2.213	-16.613***	-16.594***
US	-2.188	-3.041	-14.529***	-14.513***	-1.750	-2.637	-14.297***	-14.431***
<i>Real oil prices -UK Brent-</i>								
Canada	-2.720	-2.750	-17.672***	-17.663***	-2.499	-2.525	-17.649***	-17.640***
France	-1.988	-2.840	-19.235***	-19.235***	-1.637	-2.482	-19.099***	-19.097***
Germany	-2.703	-2.682	-18.407***	-18.399***	-2.413	-2.390	-18.274***	-18.265***
Italy	-1.625	-2.883	-19.243***	-19.247***	-1.472	-2.711	-19.199***	-19.202***
Japan	-2.657	-2.659	-18.352***	-18.334***	-2.492	-2.501	-18.341***	-18.324***
UK	-2.599	-2.564	-19.584***	-19.572***	-2.246	-2.199	-19.454***	-19.441***
US	-2.735	-2.754	-17.070***	-17.061***	-2.496	-2.515	-17.040***	-17.031***
<i>Nominal oil prices -WTI-</i>								
Canada	-2.227	-3.592	-15.520***	-15.504***	-1.529	-2.880	-15.608***	-15.592***
France	-2.327	-2.442	-15.975***	-15.984***	-2.056	-2.169	-15.362***	-15.357***
Germany	-2.633	-2.971	-15.847***	-15.835***	-2.269	-2.581	-15.803***	-15.791***
Italy	-1.739	-2.085	-16.445***	-16.463***	-1.463	-1.958	-15.920***	-15.905***
Japan	-2.758	-2.971	-15.388***	-15.372***	-2.321	-2.538	-15.467***	-15.452***
UK	-1.805	-2.808	-17.162***	-17.142***	-1.592	-2.414	-17.111***	-17.092***
US	-2.297	-3.353	-14.753***	-14.735***	-1.877	-2.851	-14.886***	-14.871***
<i>Real oil prices -WTI-</i>								
Canada	-2.770	-2.832	-16.516***	-16.507***	-2.526	-2.593	-16.574***	-16.565***
France	-1.681	-2.466	-17.640***	-17.640***	-1.419	-2.190	-17.367***	-17.361***
Germany	-2.608	-2.591	-16.946***	-16.937***	-2.332	-2.317	-16.868***	-16.858***
Italy	-1.328	-2.483	-17.654***	-17.660***	-1.091	-2.248	-17.453***	-17.409***
Japan	-2.640	-2.652	-16.650***	-16.632***	-2.483	-2.508	-16.585***	-16.567***
UK	-2.461	-2.431	-18.287***	-18.274***	-2.182	-2.151	-18.270***	-18.257***
US	-2.776	-2.820	-16.092***	-16.083***	-2.524	-2.577	-16.179***	-16.170***

Notes. (i) Constant; (ii) Constant and linear trend. \*\*\* means significant at 1%.



**Table 3. Johansen and Juselius cointegration tests (variables: oil prices -UK Brent-, economic activity, interest rates and stock prices)**

		r = 0		r ≤ 1		r ≤ 2		r ≤ 3	
		(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
<i>World nominal oil prices -UK Brent-</i>									
Canada	Trace statistic	50.307*	92.767*	18.676	33.381	8.327	14.566	2.847	5.109
	Max-eigen statistic	31.631*	59.385*	10.348	18.816	5.481	9.456	2.847	5.109
France	Trace statistic	59.171*	89.948*	17.580	33.015	8.648	18.930	3.015	5.617
	Max-eigen statistic	41.590*	56.932*	8.932	19.086	5.633	8.312	3.015	5.617
Germany	Trace statistic	73.532*	87.558*	16.699	28.608	7.408	12.005	2.152	3.170
	Max-eigen statistic	56.834*	58.950*	9.291	16.603	5.256	8.835	2.152	3.170
Italy	Trace statistic	58.662*	87.992*	22.936	44.246*	8.533	20.977	1.848	6.681
	Max-eigen statistic	35.726*	43.746*	14.403	23.269	6.685	14.296	1.848	6.681
Japan	Trace statistic	39.416	65.903*	18.149	33.242	9.736	14.012	2.258	5.728
	Max-eigen statistic	21.267	32.661*	8.413	19.230	7.478	9.284	2.258	5.728
UK	Trace statistic	60.095*	81.999*	22.105	38.719	7.255	19.404	1.651	5.601
	Max-eigen statistic	37.990*	43.280*	14.850	19.314	5.604	13.803	1.651	5.601
US	Trace statistic	31.059*	81.695*	14.738	26.774	6.340	11.805	0.662	4.093
	Max-eigen statistic	16.321	54.921*	8.398	14.969	5.678	7.711	0.662	4.093
<i>National nominal oil prices -UK Brent-</i>									
Canada	Trace statistic	51.602*	94.283*	20.172	34.311	7.957	16.105	2.533	5.138
	Max-eigen statistic	31.429*	59.972*	12.216	18.206	5.424	10.967	2.533	5.138
France	Trace statistic	49.000*	91.163*	26.323	28.982	12.310	13.754	4.370*	5.493
	Max-eigen statistic	22.678	62.181*	14.013	15.228	7.939	8.261	4.370*	5.493
Germany	Trace statistic	65.641*	82.031*	16.901	25.884	8.355	10.839	2.270	3.055
	Max-eigen statistic	48.740*	56.148*	8.546	15.045	6.084	7.783	2.270	3.055
Italy	Trace statistic	71.957*	92.353*	32.958*	43.459*	16.121*	24.698	3.373	9.938
	Max-eigen statistic	39.000*	48.893*	16.836	18.761	12.749	14.760	3.373	9.938
Japan	Trace statistic	40.277	67.439*	20.001	34.253	9.807	14.125	2.704	5.055
	Max-eigen statistic	20.276	33.186*	10.194	20.129	7.103	9.069	2.704	5.055
UK	Trace statistic	57.095*	77.164*	19.918	33.076	6.068	18.245	1.233	4.684
	Max-eigen statistic	37.177*	44.088*	13.850	14.831	4.835	13.561	1.233	4.684
US	Trace statistic	31.059*	81.695*	14.738	26.774	6.340	11.805	0.662	4.093
	Max-eigen statistic	16.321	54.921*	8.398	14.969	5.678	7.711	0.662	4.093
<i>National real oil prices -UK Brent-</i>									
Canada	Trace statistic	57.869*	100.707*	25.183	40.038	10.276	21.500	3.194	6.882
	Max-eigen statistic	32.687*	60.669*	14.906	18.538	7.082	14.619	3.192	6.882
France	Trace statistic	56.004*	93.110*	27.686	35.287	15.068	16.047	5.890*	6.846
	Max-eigen statistic	28.318*	57.824*	12.617	19.240	9.179	9.200	5.890*	6.846
Germany	Trace statistic	61.811*	80.356*	18.405	25.866	10.551	11.147	2.909	3.342
	Max-eigen statistic	43.406*	54.490*	7.853	14.718	7.642	7.806	2.909	3.342
Italy	Trace statistic	75.753*	100.044*	30.761*	49.519*	14.872	21.847	4.784*	7.174
	Max-eigen statistic	44.991*	50.525*	15.890	27.672*	10.088	14.672	4.784*	7.174
Japan	Trace statistic	42.464	69.328*	21.516	35.892	10.144	15.067	3.053	5.052
	Max-eigen statistic	20.949	33.436*	11.372	20.825	7.091	10.015	3.053	5.052
UK	Trace statistic	61.524*	78.710*	23.767	37.406	9.700	19.848	2.530	7.011
	Max-eigen statistic	37.757*	41.304*	14.066	17.558	7.170	12.838	2.530	7.011
US	Trace statistic	34.857	79.627*	17.439	29.828	8.510	13.938	0.794	5.350
	Max-eigen statistic	17.418	49.799*	8.928	15.890	7.716	8.588	0.794	5.350

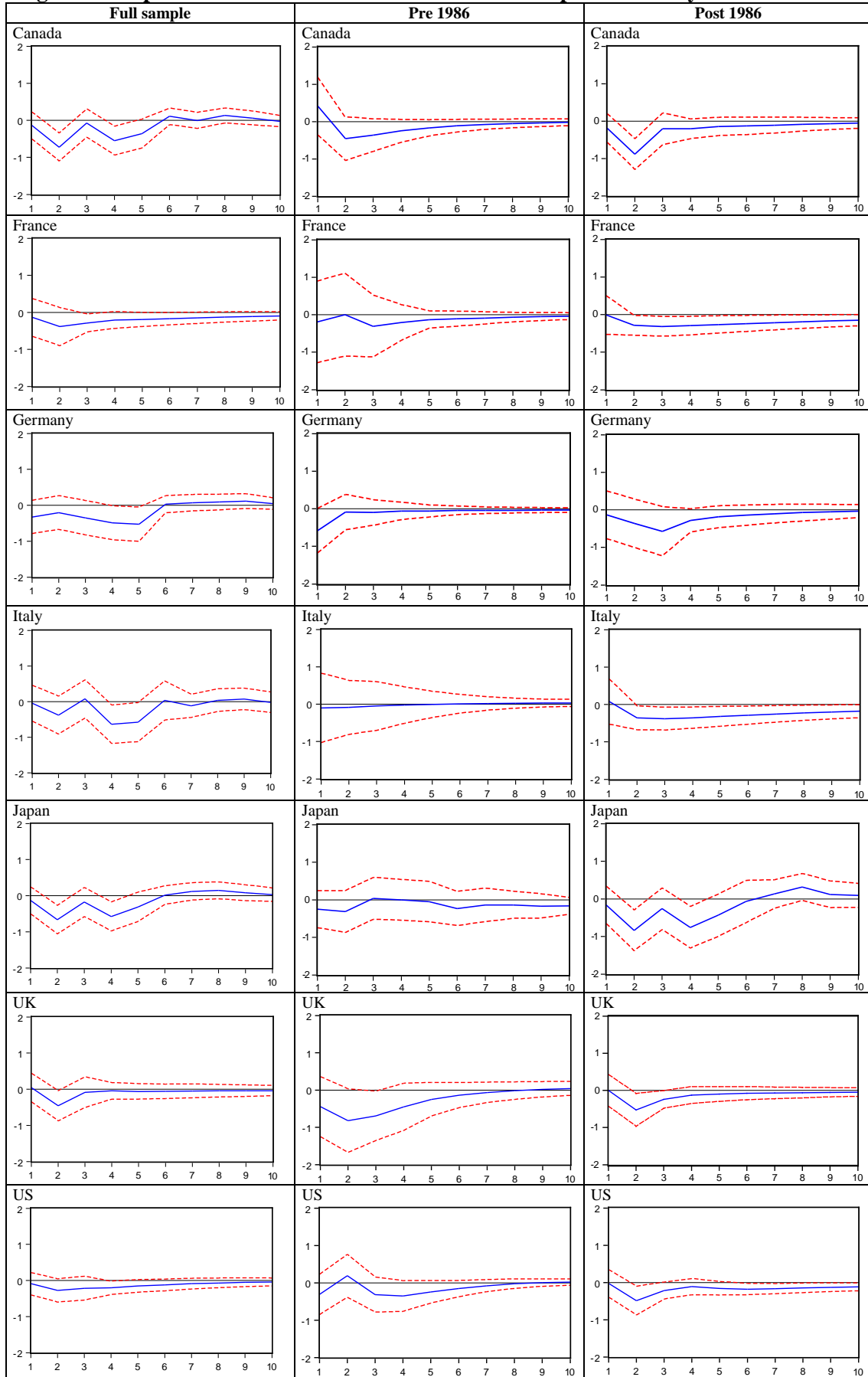
Notes. r denotes the number of cointegrating vector. \* denotes rejection of the null hypothesis at the 10% level of significance. In column 3 (r = 0) we test the null hypothesis of no cointegration against the alternative of cointegration. (i) and (ii) mean exclusion or inclusion of a linear trend in the test equation, respectively. The AIC was used for the lag determination.

**Table 3. (cont.) Johansen and Juselius cointegration tests (variables: oil prices - WTI-, economic activity, interest rates and stock prices)**

		r = 0		r ≤ 1		r ≤ 2		r ≤ 3	
		(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
<i>World nominal oil prices -WTI-</i>									
Canada	Trace statistic	52.784*	95.441*	21.238	36.365	8.851	17.267	3.000	5.012
	Max-eigen statistic	31.546*	59.076*	12.387	19.097	5.851	12.255	3.000	5.012
France	Trace statistic	60.545*	84.809*	18.761	31.649	9.681	9.884	3.479	2.549
	Max-eigen statistic	41.784*	53.160*	9.080	21.764	6.202	7.336	3.479	2.549
Germany	Trace statistic	76.223*	91.219*	17.930	31.263	8.239	12.983	2.712	3.346
	Max-eigen statistic	58.294*	59.956*	9.690	18.279	5.527	9.637	2.712	3.346
Italy	Trace statistic	60.224*	93.917*	24.347	48.733*	9.248	21.587	2.135	7.041
	Max-eigen statistic	35.877*	45.184*	15.098	27.146*	7.113	14.546	2.135	7.041
Japan	Trace statistic	41.093	69.299*	18.701	35.204	9.935	14.531	2.299	5.781
	Max-eigen statistic	22.392	34.095*	8.766	20.673	7.636	8.749	2.299	5.781
UK	Trace statistic	62.463*	86.460*	24.464	42.298	7.762	19.934	1.919	5.769
	Max-eigen statistic	37.999*	44.163*	16.702	22.364	5.843	14.166	1.919	5.769
US	Trace statistic	32.962	90.360*	15.894	28.855	7.847	12.243	0.785	4.251
	Max-eigen statistic	17.067	61.505*	8.048	16.613	7.062	7.992	0.785	4.251
<i>National nominal oil prices -WTI-</i>									
Canada	Trace statistic	54.346*	96.916*	22.993	37.576	8.440	19.334	2.686	5.046
	Max-eigen statistic	31.353*	59.340*	14.553	18.242	5.754	14.288	2.686	5.046
France	Trace statistic	49.642*	93.131*	25.972	27.600	11.904	13.506	4.278*	5.695
	Max-eigen statistic	23.671	65.531*	14.067	14.094	7.626	7.810	4.278*	5.695
Germany	Trace statistic	65.818*	82.540*	17.684	26.130	9.137	11.196	2.707	3.125
	Max-eigen statistic	48.134*	56.410*	8.547	14.933	6.431	8.071	2.707	3.125
Italy	Trace statistic	72.930*	93.696*	31.828*	42.930*	15.275	24.268	3.357	10.972
	Max-eigen statistic	41.101*	50.766*	16.553	18.662	11.918	13.296	3.357	10.972
Japan	Trace statistic	39.820	66.152*	20.237	32.875	10.157	13.965	2.592	5.340
	Max-eigen statistic	19.582	33.277*	10.081	18.910	7.565	8.625	2.592	5.340
UK	Trace statistic	59.359*	81.561*	22.164	36.351	6.700	18.795	1.606	5.078
	Max-eigen statistic	37.195*	45.211*	15.464	17.556	5.094	13.718	1.606	5.078
US	Trace statistic	32.962	90.360*	15.894	28.855	7.847	12.243	0.785	4.251
	Max-eigen statistic	17.067	61.505*	8.048	16.613	7.062	7.992	0.785	4.251
<i>National real oil prices -WTI-</i>									
Canada	Trace statistic	54.916*	96.299*	24.052	38.328	9.398	20.131	3.027	5.985
	Max-eigen statistic	30.864*	57.971*	14.654	18.197	6.371	14.146	3.027	5.985
France	Trace statistic	48.004*	87.205*	24.905	28.322	13.858	14.744	5.092*	5.917
	Max-eigen statistic	23.099	58.883*	11.047	13.578	8.766	8.827	5.092*	5.917
Germany	Trace statistic	59.667*	79.177*	17.575	24.358	9.632	9.853	2.762	2.974
	Max-eigen statistic	42.091*	54.819*	7.943	14.505	6.870	6.879	2.762	2.974
Italy	Trace statistic	67.708*	91.867*	32.063*	48.591*	16.296*	22.248	4.472*	7.439
	Max-eigen statistic	35.646*	43.276*	15.767	26.343*	11.824	14.810	4.472*	7.439
Japan	Trace statistic	39.444	65.126*	20.692	32.721	10.180	14.157	2.699	5.293
	Max-eigen statistic	18.752	32.404*	10.512	18.565	7.481	8.864	2.699	5.293
UK	Trace statistic	59.536*	76.284*	22.473	34.287	7.651	18.922	2.004	5.611
	Max-eigen statistic	37.063*	41.996*	14.823	15.365	5.647	13.311	2.004	5.611
US	Trace statistic	34.222	80.150*	17.469	29.755	8.747	13.663	1.033	5.118
	Max-eigen statistic	16.753	50.395*	8.722	16.092	7.714	8.545	1.033	5.118

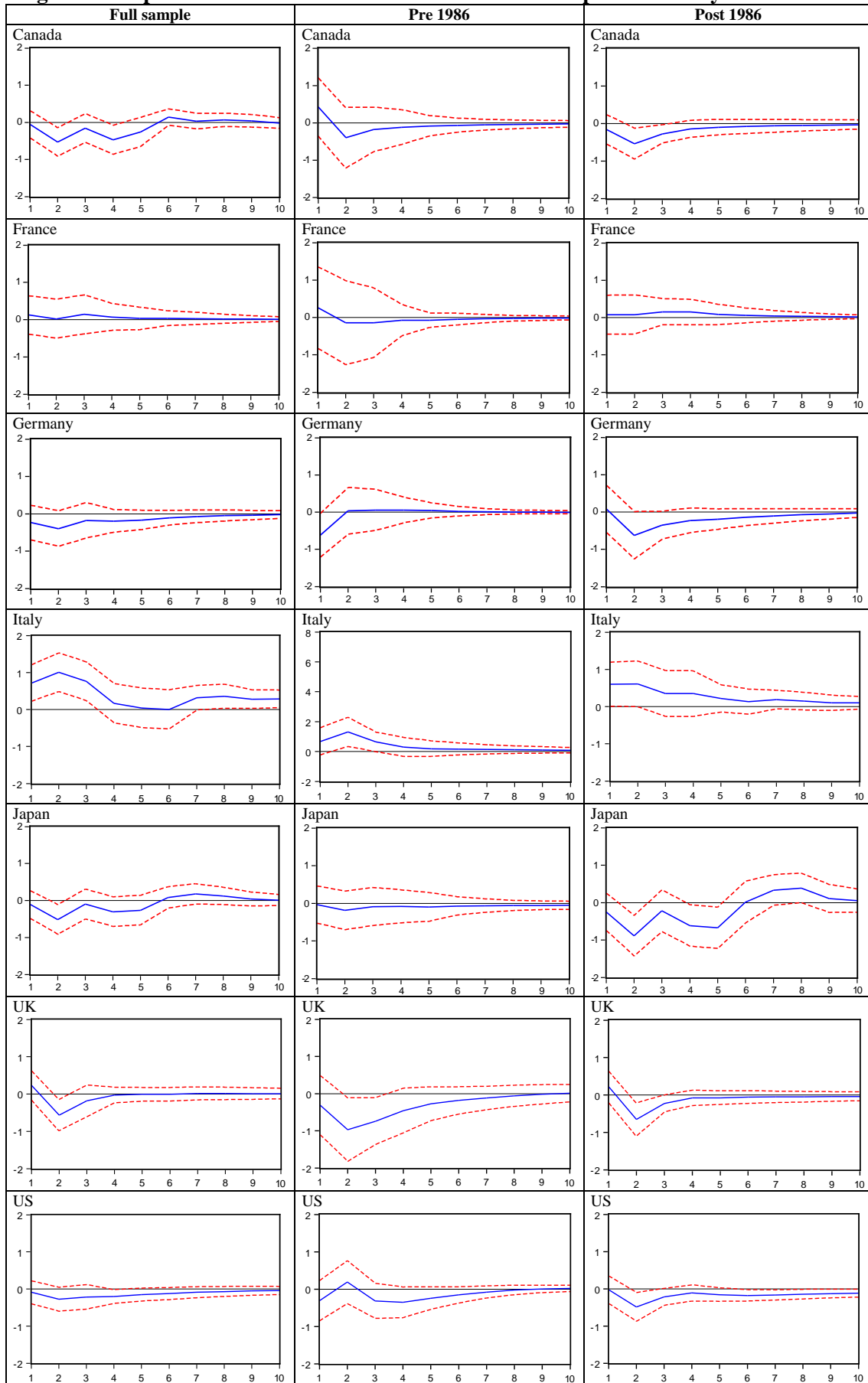
Notes. r denotes the number of cointegrating vector. \* denotes rejection of the null hypothesis at the 10% level of significance. In column 3 (r = 0) we test the null hypothesis of no cointegration against the alternative of cointegration. (i) and (ii) mean exclusion or inclusion of a linear trend in the test equation, respectively. The AIC was used for the lag determination.

**Figure 1. Response of stock returns to world nominal oil price volatility -UK Brent-**



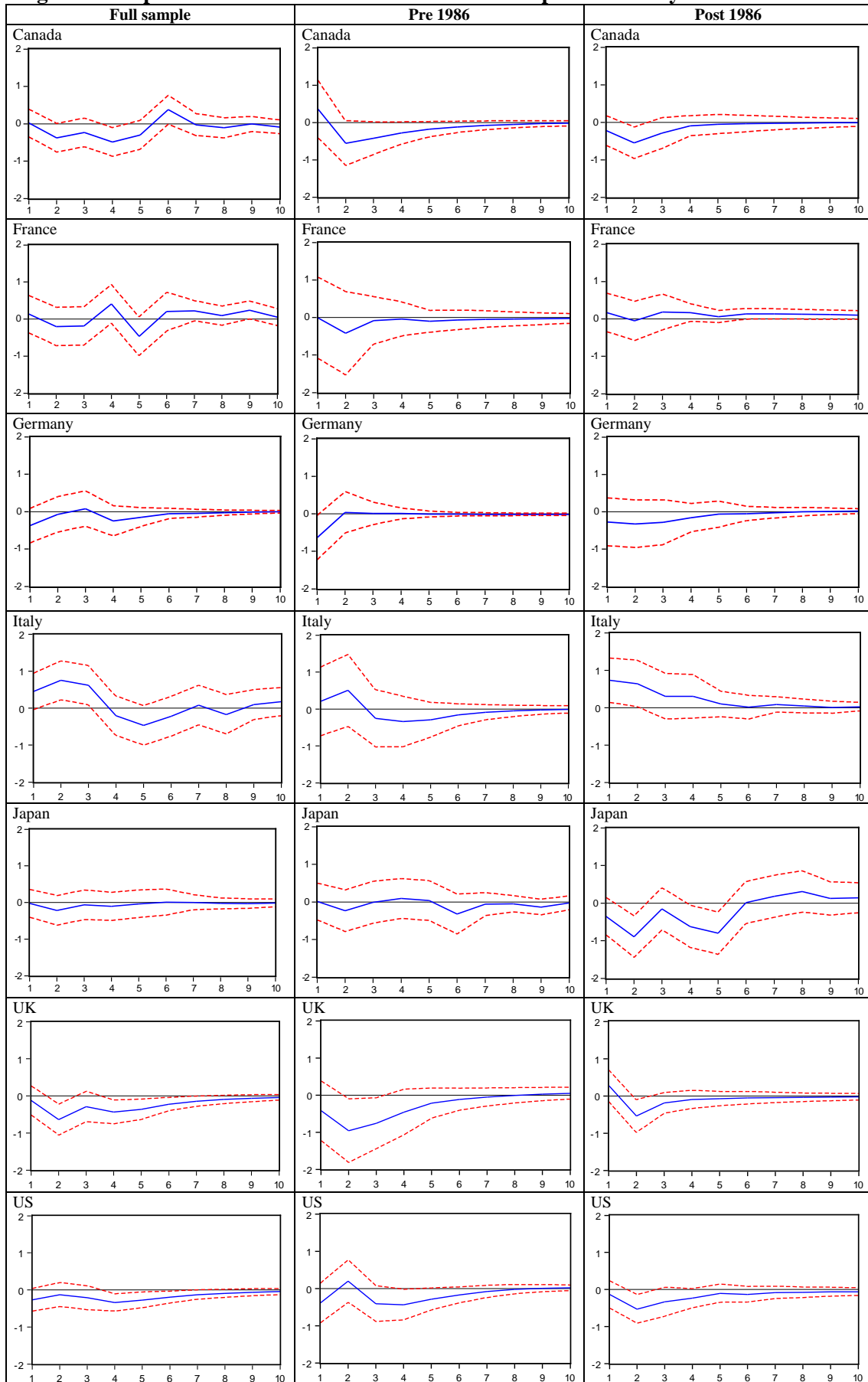
Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.

**Figure 2. Response of stock returns to national nominal oil price volatility -UK Brent-**



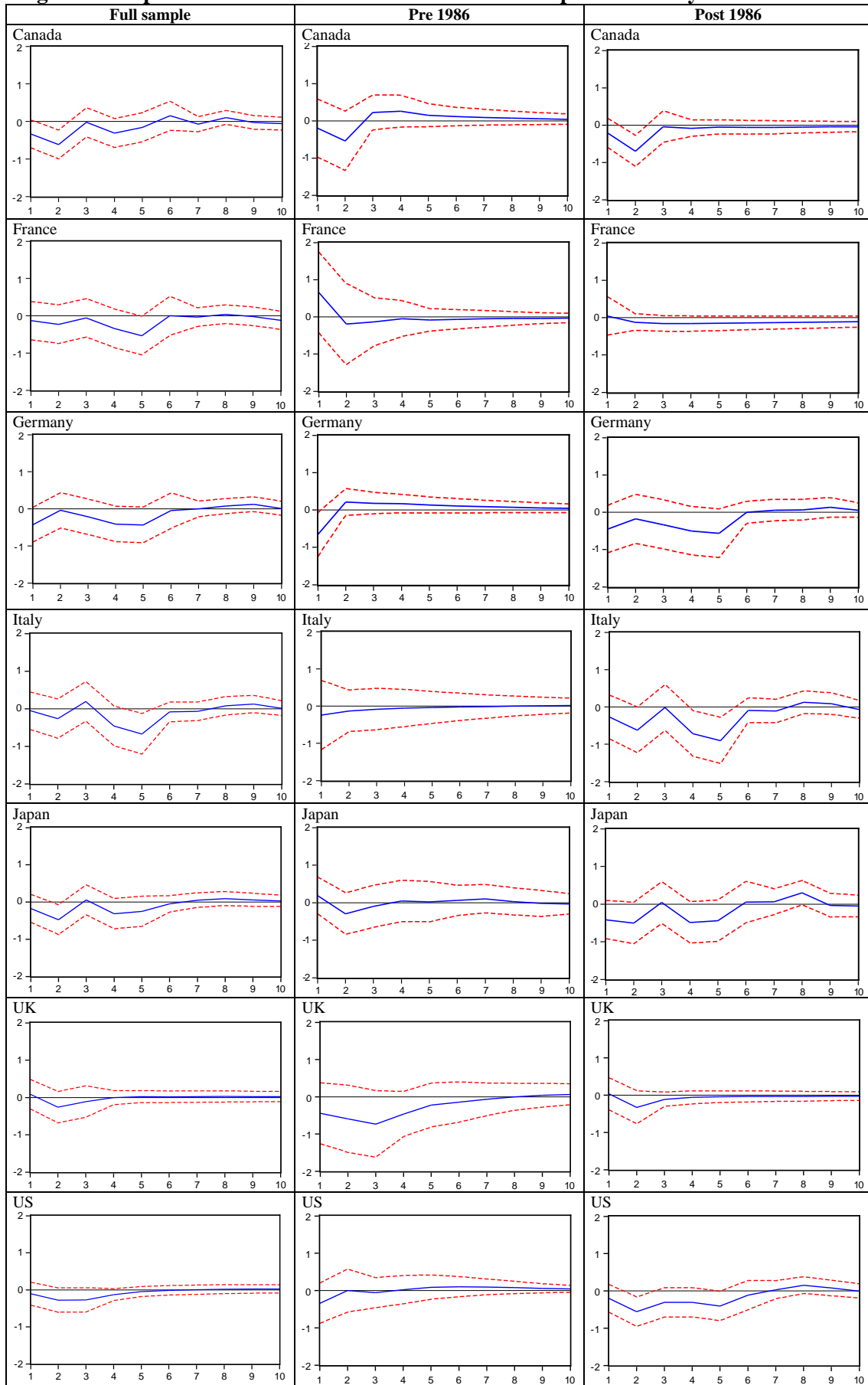
Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.

**Figure 3. Response of stock returns to national real oil price volatility -UK Brent-**



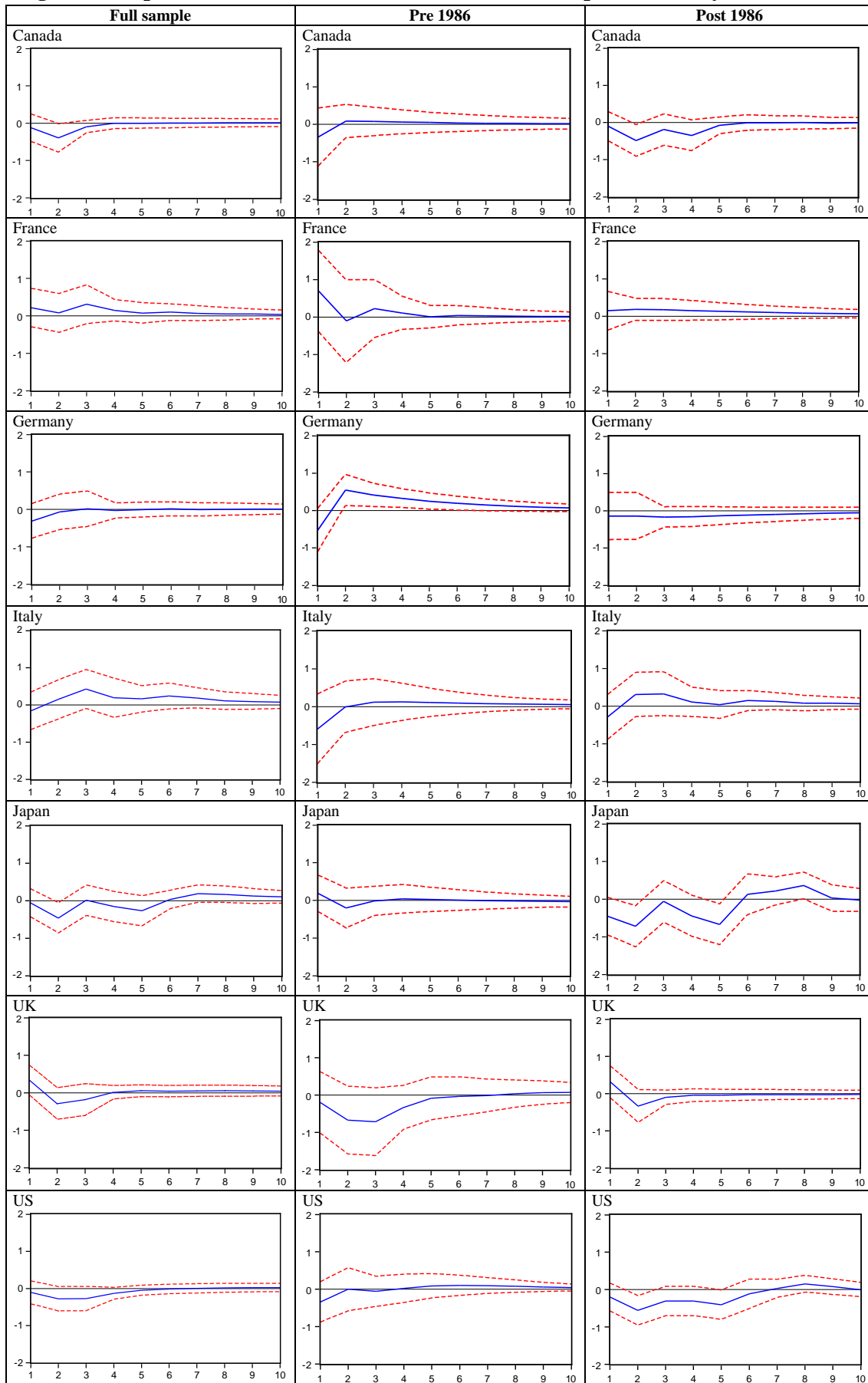
Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.

**Figure 4. Response of stock returns to world nominal oil price volatility -WTI-**



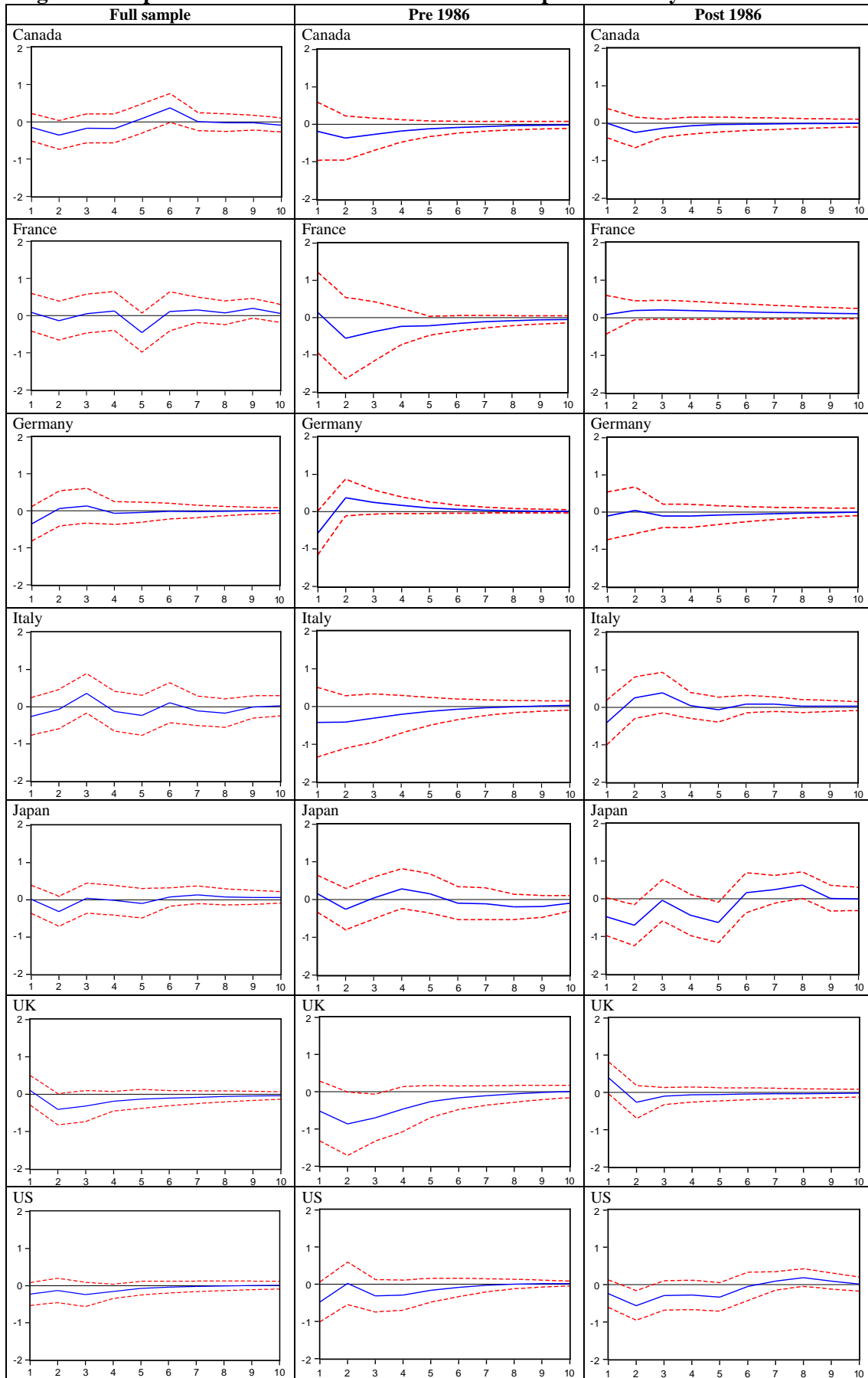
Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.

**Figure 5. Response of stock returns to national nominal oil price volatility -WTI-**



Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.

**Figure 6. Response of stock returns to national real oil price volatility -WTI-**



Notes. The dashed lines represent the 95% confidence intervals for the response of stock returns to oil price uncertainty shocks.