Original scientific paper
UDC 338.5:665.6]:336.7

Revisiting the impacts of oil price increases on monetary policy implementation in the largest oil importers*

Nurtac Yildirim[1], *Oguzhan Ozcelebi*[2], *Seval Oral Ozkan*[3]

Abstract

The aim of this paper is to test the impacts of oil price increases on monetary policy implementation in the largest oil importers. For that purpose, we estimate structural vector error correction (SVEC) models to show the impacts of oil price increases on industrial production, consumer prices and immediate interest rates which are the elements of Taylor rule for the four largest oil importers (the USA, the EU, China and Japan). Our results indicate that oil price increases transmit to output and inflation and lead to fluctuations in industrial production, consumer prices and immediate interest rates which in turn influence the monetary policy stance in the following periods. The basic conclusion of research is that the channels through which oil prices affect output, inflation and interest rates should be identified by the monetary policy authorities of the USA, the EU, China and Japan. We also emphasize the importance of the determination of the optimal monetary policy framework to eliminate the negative consequences of oil price increases.

Key words: *Oil-importing countries, oil price increases, inflation, monetary policy, SVEC model*

JEL classification: *E31, E32, E37, Q4*

* Received: 23-03-2015; accepted: 10-06-2015

[1] *PhD, Research Assistant, Faculty of Economics, Department of Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turkey. Scientific affiliation: monetary economics, international economics, macroeconomics, political economy. Phone: +90 212 4400 000 (11789), Fax: +90 212 5208 682. E-mail: nurtacy@istanbul.edu.tr.*

[2] *Associate Professor, Faculty of Economics, Department of Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turkey. Scientific affiliation: monetary economics, international economics, macroeconomics, microeconomics, DSGE modeling. Phone: +90 212 4400 000 (11789), Fax: +90 212 5208 682. E-mail: ogozc@istanbul.edu.tr.*

[3] *PhD Candidate, Faculty of Economics, Department of Labor Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turkey. Scientific affiliation: macroeconomics, microeconomics, labor economics. Phone: +90 212 4400 000 (11789), Fax: +90 212 5208 682. E-mail: sevaloral@yahoo.com.*

1. Introduction

Since the stagflation in the 1970s attributed to the increase in oil prices, the relationship between the global crude oil price and the real economic activity in the world economy has attracted the attention of academic researchers (Darby, 1982; Hamilton, 1983; Burbidge and Harrison, 1984; Gisser and Goodwin, 1986; Barsky and Kilian, 2001). Oil price inflation may even worsen the negative consequences of the economic crisis; thus, the contributions to the literature investigating the effects of changes in oil prices on the real economy have rapidly increased since the 2008–2009 financial crisis (Hamilton, 2009a, 2009b; Kilian and Hicks, 2009; Du et al., 2010; Tang et al., 2010; Kilian and Vigfusson, 2011; Qianqian, 2011; Ou et al., 2012; Fang and You, 2014). On the other hand, the interaction between monetary policy and commodity prices- most notably oil prices- has long been argued by policy makers and scholars since the most serious fluctuations in commodity prices were acknowledged as a signal for the direction of monetary policy as well as monetary policy has impacts upon commodity prices. The fluctuations in oil prices in 1970s and 1980s are generally attributed to the second causality, namely changes in monetary policy driving the demand for oil and its price upwards while developments in recent years indicate reverse causality from changes in oil prices to monetary policy actions (Kilian, 2009a; Bodenstein et al., 2012).

The analysis of the factors underlying in the change in oil prices is a major concern for policy makers to develop appropriate policy responses since each kind of them should be treated with different policy tools (Kilian, 2008). By using the interest rate tool, central banks aim to make inflation and demand move together, however, a policy rate to reduce inflation may cause a further decline in economic performance producing more difficulty in conducting the monetary policy. In an attempt to counteract the demand effects of higher oil prices, expansionary monetary policy may be appropriate with a cost of rising inflation. When the policy maker aims to offset the supply effects of higher oil prices, contractionary monetary policy is required which would reduce the output level. That being the case, a policy maker needs to realize completely the tradeoff between policy actions, underlying factors and effects of changes in oil prices so that a possible response of policy maker may not be directed to the price of oil but to the demand and supply shocks impelling the oil prices (Barsky and Kilian, 2001; Kilian, 2009a; Bodenstein et al., 2012).

The main aim of this research is to analyze the interactions between oil prices and macroeconomic variables included in the monetary policy reaction function for the four largest oil importers in the world economy, namely the USA, the EU, China and Japan. More precisely, we investigate the impacts of oil price increases on GDP, inflation and short-term interest rates, similar to Balke et al. (1999), Bernanke et al. (1997, 2004), Cologni and Manera (2008), Du et al. (2010), Hamilton and Herrera (2004), Herrera and Pesavento (2009), Lee et al. (2001) and Ou et al. (2012). On the other hand, in order to detect and clarify the channels through which oil prices may transmit to macroeconomic variables and lead to changes in monetary policy, theoretical assumptions[4] can be needed. Our study contributes to the existing literature by imposing some theoretical assumptions into the estimation process of structural vector error correction (SVEC) models regarding to the relationship between monetary policy and oil prices. More precisely, considering the Taylor rule principle as the monetary policy formulation, short and long-term restrictions derived from economic theory are imposed in the estimation process of SVEC models. Within this theoretical and empirical framework, the main hypothesis of this paper is to test whether increases in oil prices may have impact on real economic activity, price level and short-term interest rates and thus lead to changes in monetary policy stance by using impulse response functions (IRFs) and forecast error variance decompositions (FEVDs).

For testing our hypothesis, the remainder of the paper is structured as follows: Section II reviews the relevant theoretical and empirical studies. Section III presents the methodological issues and empirical model proposed here to investigate the relationship between oil prices, industrial production, consumer prices and short term interest rates in the most oil importers. Empirical data and analysis are presented in Section IV. Section V discusses results and policy implications and Section VI concludes the paper.

2. Literature review

A wide variety of studies have analyzed the impacts of oil price changes on macroeconomic variables for many countries with different economic characteristics since global financial integration has become widely prevalent. For many European countries, Cunado and Garcia (2003) found that an oil price increase had permanent effects on inflation and asymmetric effects on production growth rates. For the case of China, Tang et al. (2010) showed that increases in oil prices affected output and investment negatively, whereas the inflation rate and interest rate were positively influenced. Similarly, Qianqian (2011) revealed that rising oil prices would cause the real output to decline and the prices to ascend in China. Parallel results were also obtained for the US economy by Kilian (2008) and Kilian and Vigfusson (2011), who detected a negative impact of oil price increases on the real GDP and inflation. According to Balke et al. (1999), increases in oil prices influenced the output via interest rates in the US; more precisely, oil prices influenced the interest rates asymmetrically before they affected the output asymmetrically. Jiménez-Rodríguez and Sánchez (2010) stated that oil price increases prompt to a decrease in industrial production and higher inflation based on their study for Japan during the period of 1976:I-2008:II.

[4] Our theoretical assumptions determining the short and long-run restrictions imposed into the estimation process of SVEC models are explained in section 3.2.

The effects of oil price changes on economic activity may also differ depending on whether the country is an oil importer or an oil exporter. According to Mendoza and Vera (2010), there have been asymmetric effects of oil price increases on output growth in oil exporters, thus the unexpected rise in oil prices impacts the economy positively. Jiménez-Rodríguez and Sánchez (2004) found that increases in oil price had a negative impact on economic activity in importing countries, except for Japan, whereas the oil price increases affected the UK negatively and Norway positively. The effects of oil price changes on macroeconomic variables may also differ according to the level of economic development. Kazi (1989) studied the 1973 and 1979 oil price changes' effects on the developed and developing countries. The findings of this study implied that low income countries were affected more seriously than countries with high income. Also, they explained that the effect varies according to the level of dependency on energy sources, development degree and capital intensity degree of the economy. Eryigit (2012) stated that changes in oil prices mostly affect emerging economies rather than developed economies. In other words, they emphasized that there is a correlation between oil price changes and industrial development. Eryigit (2012) asserted that the reason of this relation stems from greater environmental consciousness of the developed countries which are well-endowed with using alternative energy sources or switching their production methods. Conversely, Vlahinić-Dizdarević and Žiković (2010) found that in the case of Croatia the causality ran from real GDP growth to energy consumption, production and import similar to developed countries. Vlahinić-Dizdarević and Žiković (2010) also emphasized the role of strong transition depression in Croatia during the 1990s and the process of deindustrialization that had led to a sharp industrial decline which decreased the country's energy demand. Investigating the effect of energy price changes on developing countries, Cantore et al. (2012) showed that energy importers are reversely affected by energy price increase, whereas energy exporters may be positively affected. Moreover, by using the Computable General Equilibrium modelling, they came to the conclusion that African countries are vulnerable due to the higher input costs and lower oil demand. Similar to Cantore et al. (2012), Moshiri and Banihashem (2011) stated that increases in oil prices have asymmetric effects on oil exporting developing countries. They also emphasized that oil price increases do not lead to a sustained economic growth in these countries, whereas reduces in oil prices prompt to recession in the economies of oil exporting countries. On the other hand, oil price increases do not always lead to negative consequences for oil importing countries because of the recycle of petrodollars. A surge in oil prices has a reducing effect on purchasing power in oil importing countries, however using the revenues from oil sales of oil exporters in order to buy goods and services from oil importing countries reduces this negative effect on growth. (Higgins et al., 2006: 1). Rasmussen and Roitman (2011) stated that increase in exports and other income flows can compensate the negative outcomes of the rise in oil prices. Beck and Kamps (2009) examined this relation with the rising revenue generating effect of oil price increases through the trade channel led by high imports and the financial channel led by an increase in net external asset position. Stating the differences in how petrodollars have been recycled, Higgins et al. (2006) pointed out that Europe and China have better petrodollars recycle because of the increase in sales of goods and services to oil exporters and so the rise in payments return home rapidly.

Although there have been numerous studies related to the oil price increases and their effects on the economy, there is still no agreement on the transmission channels of this relation which have changed over time (Lescaroux and Mignon, 2008:11). As stated by Baumeister et al. (2009) and Schneider (2004), this impact seems to reduce nowadays as compared to the effects of oil price increases on inflation rates and lower economic growth in the 1970s. Schneider (2004) identified the sources of these changes over time as technological innovation, cost-effective alternative sources of energy, sectoral and structural changes in the oil market. According to Jbir, Zouari-Ghorbel (2009), control of energy policy, development of other energy sources and technological innovation has affected this relation. Blanchard and Gali (2008) investigated that the increases in oil prices has had an impact on prices, wages, output and employment since the 1970s and they explained these changes by reduction in real wage rigidities, improvements in monetary policy and decrease in oil price consumption and production share in total.

When the possible interactions between oil prices and macroeconomic variables in the era of economic liberalization are considered, it may be important for a monetary policy authority aiming to achieve price stability to incorporate the role of oil prices in to its monetary policy decisions. In this respect, quantitative models are used to study the effects of oil prices along with monetary policy (Bernanke et al., 1997, 2004; Balke et al., 1999; Lee and Ni, 2002; Hamilton and Herrera, 2004; Jiménez-Rodríguez and Sánchez, 2004; Herrera and Pesavento, 2009). Bernanke et al. (1997) found that a substantial part of the recessionary impact of oil price increases came from the endogenous tightening of monetary policy rather than from the increase of oil prices in the US. Leduc and Sill (2004) stressed that monetary policy contributed to the drop in output following a rise in oil prices and the consequences of oil increase were not eliminated by monetary policy actions in the US. Similarly, Hamilton and Herrera (2004) revealed that the aggressive Federal Reserve policies had no chance of eliminating recessionary consequences of an oil price increase. Conversely, Herrera and Pesavento (2009) exposed that the systematic monetary policy response dampened the fluctuations in economic activity during the 1970s in the US. For the cases of the G-7 countries, Cologni and Manera (2008) found that the effects of oil price increases transmitted to the macroeconomic variables through interest rates and they suggested that a contractionary monetary policy response should be directed towards fighting inflation. Most recently, Kormilitsina (2011) put forward the suggestion that the optimal response to an oil price increase by the central banks is to raise inflation and interest rates.

3. Methodology of analysis

3.1. Empirical model

Vector autoregression (VAR)-type models can be used to identify the transmission mechanism of oil price changes to economic activity empirically. In this study, we employ SVEC modeling[5] with quarterly data from 2000:01 to 2013:03[6]. Within this framework, we impose long and short-term restrictions deriving from economic theory into the estimation process and thus the effects of oil price increases are analyzed[7]. Our effort differs from Kilian and Vigfussion (2011) by ignoring the difference between the effects of positive and negative oil price shocks (oil price increases and decreases) and not decomposing positive and negative oil price shocks in our VAR-type of models. Hereby, the main objectives of our study are to determine the role of oil price increases on monetary policy in the USA, the EU, China and Japan and to make inferences on this basis. As for the empirical exercise, the following variables are used: industrial production indices[8] in logarithms: ind_t^{usa}, ind_t^{eu}, ind_t^{chi}, ind_t^{jp}, consumer price indices[9] in logarithms: pri_t^{usa}, pri_t^{eu}, pri_t^{chi}, pri_t^{jp}, immediate interest rates for central banks:[10] irt_t^{usa}, irt_t^{eu}, irt_t^{chi}, irt_t^{jp} and the West Texas intermediate spot oil price in logarithms: $oilpr_t$. All the series are seasonally-adjusted with the method ARIMA X12 and they are derived using the statistical database of

[5] SVEC models have some important advantages in systems with stochastic trends and cointegration and it is generally accepted that impulse responses from SVEC are more precise than VAR that may lead to exploding impulse response estimates, see Cologni and Manera (2008).

[6] We determined our sample the period from the first quarter of 2000 and to the third quarter of 2013 to consider the relatively high oil prices of the 2000s and due to data availability. There exists no censoring since the value of a measurement or observation is only fully known.

[7] In VAR-type of models, positive shocks or positive innovations may refer to the one unit increase in an endogenous variable measured by the innovation in unobservable error terms. In this study, we make inferences by detecting the impacts of shocks in oil prices, namely the oil price increases In a sense, responses of variables to negative innovations can be computed as; the responses to positive innovations) × -1 since we did not specify some form of non-linearity in our VAR equations (interact the endogenous variables with a dummy, indicating a negative change in lagged policy variable). Despite differences between positive and negative oil price may exist, the actual difference between these two responses seems fairly small, it is hard pressed to make the case for using the asymmetric model on economic grounds, see Kilian and Vigfussion (2011). Positive oil price shocks, namely the increases in oil prices can arise from the increase in oil demand or the decrease in oil supply. Also, we compute impulse responses dropping the deterministic (a constant, a trend and dummy variables) terms and exogenous terms.

[8] The industrial production index data with the base year (2005 = 100) exclude construction activity.

[9] The consumer price index data have the base year (2005 = 100).

[10] Immediate interest rates are less than 24 hours and refer to rates such as policy rates set by central banks, the rate at which central banks lend or discount eligible paper for deposit money banks and those that are short-term, such as the interbank/call money rate. Immediate central bank rates and call money rates are both under the influence of monetary policy decisions. We use the immediate central bank rates for the USA, China, Japan and India, while the interbank/call money rates represent the short-term interest rate for the EU due to the lack of availability of data.

the Federal Reserve Bank of St. Louis and J-MuLTi software is used to conduct the empirical exercise.

3.2. Vector error correction (VEC) model

$$y_t = D_t + x_t \tag{1}$$

where y_t is a K-dimensional vector that contains the observable variables. The deterministic part with a linear trend term is denoted by $D_t = \mu_0 + \mu_1 t$, while x_t is a stochastic process with VEC representation.[11] Within the framework of model (1), a pair of hypotheses is tested to determine the cointegrating rank of the model[12] (Lütkepohl, 2007b: 91). On the other a hand, a lag length of 1 is suggested for all VEC models by the Akaike information criterion (AIC), Hannan-Quinn (HQ) information criterion and Schwarz criterion (SC) in line with the view that greater number of lags isn't desirable due to the short time-series and furthermore selection of one time lag has its anchor in economic intuition considering the frequency of data used in our empirical exercise. To reflect the estimation variability of estimated impulse response functions (IRFs), 99% Hall's Percentage Intervals are used based on two hundred and fifty bootstrap replications with two seeds.

SVEC models are a tool to incorporate the contemporaneous and long-run shocks to be traced in an impulse response analysis of a VEC model. SVEC can be represented as in equation (2):

$$\mathrm{A}\Delta y_t = \Pi^* y_{t-1} + \Gamma_1^* \Delta y_{t-1} + \ldots + \Gamma_{p-1}^* \Delta y_{t-p+1} + \mathrm{B}\varepsilon_t \tag{2}$$

where restrictions are imposed on the matrix of long-run effects of shocks and the matrix B of contemporaneous effects of the shocks. The Π^* and $\Gamma_j^*(j = 1, ..., p-1)$ are structural form parameter matrices, while the matrix A is $(K \times K)$ and it allows the modeling of instantaneous relations among the variables in y_t.SVEC also has an MA representation as below:

$$y_t = \Xi \sum_{i=1}^{t} u_i + \Xi^*(L) u_t + y_0^* \tag{3}$$

In equation (3), if the cointegrating rank of the system is r, Ξ, denoting the long-run effects of forecast error impulse responses, has rank $K - r$, whereas $\Xi^*(L) = \Sigma_{j=0}^{\infty} \Xi_j^* L^j$ is an infinite-order polynomial in the lag operator with coefficient matrices containing the transitory effects. When u_t is replaced by $\mathrm{A}^{-1}\mathrm{B}\varepsilon_t$, we obtain

[11] The VEC model can be represented as: $\Delta x_t = \Pi x_{t-1} + \Gamma_1 \Delta x_{t-1} + ... + \Gamma_{p-1} \Delta x_{t-p+1}$, where Πx_{t-1} the term contains $I(1)$ variables and represents the long-term part of the model, that is, $I(0)$, and Γ_j the s refer to the short-term parameters.

[12] The ordering of the variables in our model is: ind_t, pri_t, $oilpr_t$, irt_t.

the orthogonalized short-run impulse responses as $\Xi_j^* A^{-1}B$, while the long-run effects of ε shocks are given by $\Xi A^{-1}B$. Accordingly, $K - r(K - r - 1)/2$ additional restrictions are needed to identify the permanent shocks and additional $r(r - 1)/2$ contemporaneous restrictions are required for the identification of transitory shocks (Breitung et al., 2007: 166–167).

For the identification of the SVEC models with two cointegrating relations, we assume that the nominal shocks attributed to the shocks to consumer price indices and immediate interest rates will not have permanent impacts. Additional restrictions are needed to identify the permanent shocks; thus, we assume that industrial production is only driven by its own shocks or the increases in technology in the long-run. On the other hand, one transitory shock is identified by the assumption that changes in the immediate interest rates have no contemporaneous effect on oil prices. Thus, the restrictions imposed on the B matrix and the long-run impact matrix ΞB can be expressed as in (4) and thus IRFs and FEVDs are estimated within this base:

$$\mathrm{B} = \begin{pmatrix} * & * & * & * \\ * & * & * & * \\ * & * & * & 0 \\ * & * & * & * \end{pmatrix}, \ \Xi\,\mathrm{B} = \begin{pmatrix} * & 0 & 0 & 0 \\ * & 0 & * & 0 \\ * & 0 & * & 0 \\ * & 0 & * & 0 \end{pmatrix} \tag{4}$$

Our theoretical assumptions are in line with Bonga-Bonga and Kabundi (2010) and Cologni and Manera (2008), implying the systematic response of monetary policy to oil price increases.

4. Empirical data and analysis

4.1. Empirical data

To specify the appropriate model, the unit root properties of the series included in the empirical model should be determined. In this respect, we adopt the most widely used test in the literature, the augmented Dickey-Fuller (ADF) test. Since the critical values of the test differ according to the selection of the inclusion of deterministic variables, the Pantula principle[13] proposed by Pantula (1989) is followed. The lag orders used in the ADF tests are selected by the AIC and SC. Table A1 in the appendix shows that all the series are integrated of order 1 – $I(1)$; thus, cointegrating relations may exist among the variables of the same case. In this

[13] The Pantula principle states that if a linear trend term is required in the test for the time series S_t, then only a constant term should be used in the test for S_t, whereas if just a constant is needed in the test for ΔS, the test for S_t is to be carried out with no deterministic term (Lütkepohl, 2007a: 55).

respect, we apply the Saikkonen and Lütkepohl cointegration test[14] based on the VEC model framework presented in section 3.1 to consider a deterministic trend term in the data generation process.

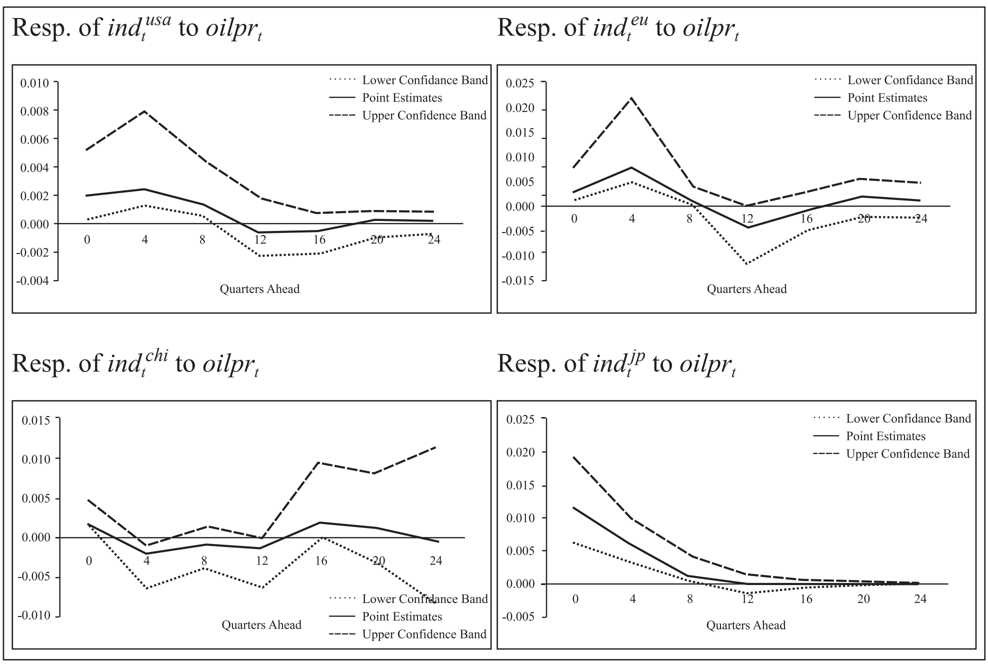
Table A2 in the appendix indicates that two cointegration relationships exist between oil prices, interest rates, inflation and industrial production for all the cases. Therefore, the possible effects of the shock in a variable on other variables in the vector can be detected with VEC modeling. However, theoretical considerations can also be adopted in the estimation process based on the VEC model; thus, we employ SVEC modeling.

4.2. Empirical Analysis

4.2.1. Impulse response analysis results

Figure 1 shows that following to an increase in oil prices, the industrial production of the USA, the EU and Japan reacts positively for the certain periods of following quarters in contrast to Aastveit (2013) and Kilian (2009b).

Figure 1: Responses of industrial production to oil price increases



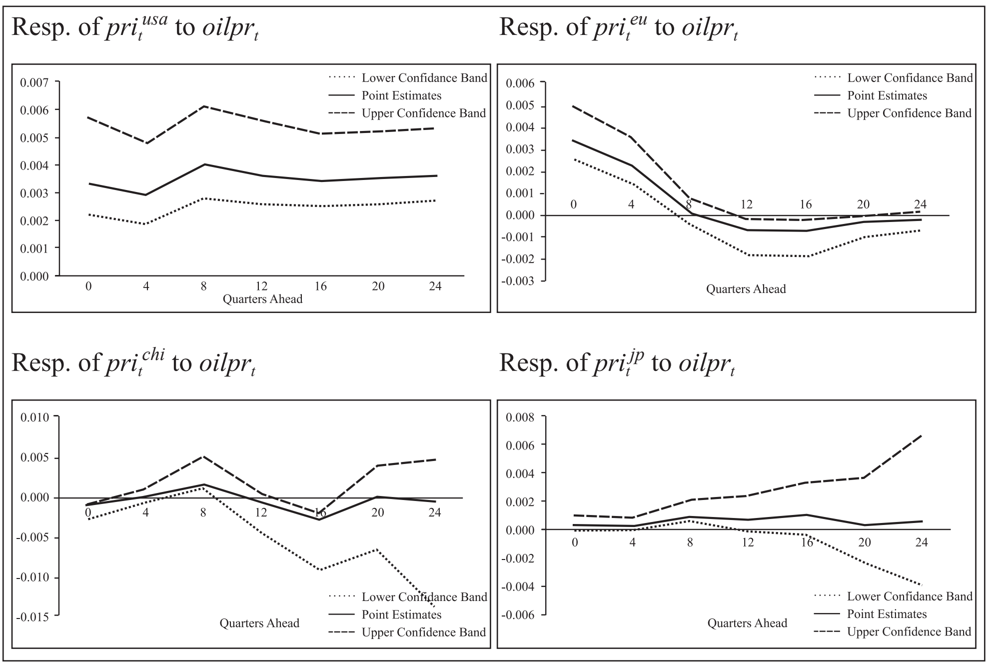
Source: Authors' calculations

[14] For the details of the Saikkonen and Lütkepohl cointegration test and the data generation process in VEC models, see Saikkonen and Luukkonen (1997) and Saikkonen and Lütkepohl (2000).

The positive impact on industrial production is short-lived in USA, the EU and Japan similar to Cunado and Garcia (2005) and Du et al. (2010), but in contrast to Cologni and Manera (2008). On the other hand, it can be inferred that no significant impact of oil price increases on industrial production, either in the short-run or in the long-run, exists for China, in line with Cologni and Manera (2008) and Lee et al. (2001), but in contrast to Du et al. (2010) and Jiménez-Rodríguez and Sánchez (2004).

According to Figure 2, oil price increases lead to inflationary pressures in the EU and Japan for certain periods of the following quarters, in line with Aastveit (2013), Balke et al. (1999), Du et al. (2010), Hamilton and Herrera (2004), Herrera and Pesavento (2009), Kilian (2008), Kilian (2009b), Kormilitsina (2011), Leduc and Sill (2004) and Ou et al. (2012).

Figure 2: Responses of consumer prices to oil price increases



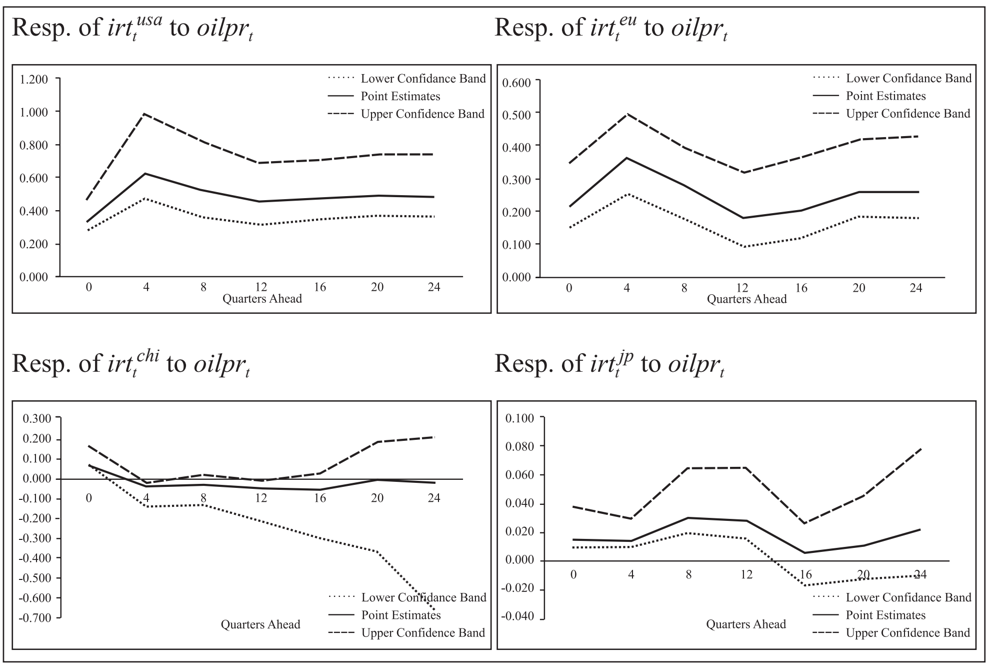
Source: Authors' calculations

A positive significant impact on consumer prices occurs up to the twelfth quarters in the EU and Japan , in contrast to Cologni and Manera (2008), whereas consumer prices react positevely to the oil price increase permanantely in the USA. Conversely, we detect no significant impact of oil price increases on consumer prices for China, similar to Cologni and Manera (2008) and Lee et al. (2001). Thus, it is implied that inflation in China may be driven by its own dynamics; more precisely, the past values of inflation may form inflationary expectations and current inflation.

Central banks in oil-importing countries may change their monetary policy stance by changing their policy rates in the case of a cost-push effect of oil price increases on inflation. In addition, changes in oil prices may influence the conditions of money markets in oil-importing countries since oil-exporting countries may acquire foreign assets of the oil importers.

Figure 3 shows that oil price increases may lead to a permanent increase in the immediate interest rates in the USA and the EU, similar to Hamilton and Herrera (2004) and Kormilitsina (2011) but in contrast to Cologni and Manera (2008), while the positive significant impact in Japan is relatively limited; immediate interest rates of Japan reacts positively to the increases in oil prices up to the following sixteenth quarters.

Figure 3: Responses of immediate interest rates to oil price increases



Source: Authors' calculations

On the other hand, the impulse response exercise reveals that the flow of funds from oil-exporting countries to China may lead to fluctuations in the immediate interest rates. On the whole, the cumulative impact on the immediate interest rates in China is not significant similar to Aastveit (2013); however, it can be interpreted as the flow of funds from oil-exporting countries to China possibly causing a fall in the short-term interest rates.

4.2.2. Forecast error variance decomposition analysis results

In the USA, the weights of the importance of oil price increases for industrial production are relatively smaller than those of the EU, China and Japan. The forecast error variance decompositions indicate that oil prices explain a small part of the variation in industrial production of the USA similar to Aastveit (2013). On the other hand, up to the twenty-fourth quarter; approximately 20% and 40% of the variation in industrial production are attributed to oil price increases in China and Japan and in the EU, respectively. Thus, it is implied that increases in oil prices may also lead to fluctuations in the employment rate (Davis and Haltiwanger, 2001). Moreover, our results show that the nominal variables that can be attributable to monetary policy are not the major source of the fluctuations in economic activity, consistent with Aguirre and Schmidt-Hebbel (2005) and Ozcelebi (2012).

Table 1: FEVDs of the industrial production

FEVD of ind_t^{usa}				
Forecast Horizon h	ind_t^{usa}	pri_t^{usa}	$oilpr_t$	irt_t^{usa}
1	0.01	0.07	0.81	0.11
6	0.82	0.01	0.15	0.02
12	0.98	0.00	0.01	0.01
18	0.96	0.00	0.03	0.01
24	0.97	0.00	0.02	0.01
FEVD of ind_t^{eu}				
Forecast Horizon h	ind_t^{eu}	pri_t^{eu}	$oilpr_t$	irt_t^{eu}
1	0.25	0.40	0.32	0.03
6	0.50	0.17	0.28	0.04
12	0.74	0.09	0.13	0.04
18	0.46	0.07	0.43	0.04
24	0.55	0.05	0.37	0.03
FEVD of ind_t^{chi}				
Forecast Horizon h	ind_t^{chi}	pri_t^{chi}	$oilpr_t$	irt_t^{chi}
1	0.08	0.65	0.27	0.00
6	0.48	0.32	0.15	0.00
12	0.63	0.15	0.21	0.01
18	0.62	0.15	0.21	0.01
24	0.74	0.07	0.18	0.01
FEVD of ind_t^{jp}				
Forecast Horizon h	ind_t^{jp}	pri_t^{jp}	$oilpr_t$	irt_t^{jp}
1	0.31	0.57	0.10	0.02
6	0.57	0.11	0.24	0.08
12	0.67	0.08	0.20	0.05
18	0.70	0.08	0.18	0.04
24	0.76	0.08	0.14	0.02

Source: Authors' calculations

Up to the twenty-fourth quarter, the consumer prices and immediate interest rates do not account for a high amount of the variation in industrial production of all countries when compared with the effects of increases in industrial production and oil prices. Nevertheless, it is revealed that the monetary policy authorities of the USA, the EU, China and Japan should determine the effects of oil prices, consumer prices and immediate interest rates on output fluctuations in detail.

Table 2: FEVDs of the consumer prices

FEVD of pri_t^{usa}				
Forecast Horizon h	ind_t^{usa}	pri_t^{usa}	$oilpr_t$	irt_t^{usa}
1	0.01	0.24	0.52	0.23
6	0.08	0.18	0.68	0.06
12	0.14	0.09	0.74	0.03
18	0.14	0.06	0.77	0.03
24	0.14	0.05	0.79	0.02
FEVD of pri_t^{eu}				
Forecast Horizon h	ind_t^{eu}	pri_t^{eu}	$oilpr_t$	irt_t^{eu}
1	0.01	0.29	0.17	0.53
6	0.14	0.29	0.13	0.44
12	0.36	0.20	0.10	0.34
18	0.37	0.17	0.15	0.31
24	0.38	0.16	0.16	0.30
FEVD of pri_t^{chi}				
Forecast Horizon h	ind_t^{chi}	pri_t^{chi}	$oilpr_t$	irt_t^{chi}
1	0.19	0.54	0.16	0.10
6	0.48	0.17	0.32	0.03
12	0.71	0.04	0.24	0.01
18	0.84	0.01	0.14	0.01
24	0.85	0.02	0.14	0.00
FEVD of pri_t^{jp}				
Forecast Horizon h	ind_t^{jp}	pri_t^{jp}	$oilpr_t$	irt_t^{jp}
1	0.30	0.53	0.07	0.10
6	0.31	0.30	0.36	0.04
12	0.36	0.11	0.51	0.02
18	0.38	0.07	0.54	0.01
24	0.38	0.05	0.56	0.01

Source: Authors' calculations

According to Table 2, oil price increase is an important source of the changes in consumer prices. Up to the twenty-fourth quarter, oil prices account for nearly 20% of the variation in consumer prices in the EU and China similar to Aastveit (2013), while the importance of oil price increases to consumer prices are higher in the USA and

Japan, explaining approximately 80% and 60% of the variation in consumer prices, in line with Du et al. (2010) and Lee et al. (2001). Our results reveal that increases in oil prices may transmit to inflation, similar to Aastveit (2013), Du et al. (2010), Herrera and Pesavento (2009), Lee et al. (2001) and Paradiso and Rao (2012).

In addition to oil price increases, we find that increases in technology attributable to the increases in industrial production have a major impact on consumer prices in all cases. Therefore, the importance of supply conditions in maintaining the price stability in the USA, the EU, China and Japan is stressed with the FEVDs. On the other hand, the FEVDs indicate that consumer prices and immediate interest rates are not major sources of the fluctuations in consumer prices when compared to supply shocks except for the EU. This finding is consistent with the theoretical assumptions imposed on matrix (4) in section 3.2, which are incorporated into the estimation process. Despite the consumer prices and immediate interest rates having a minor role in the variations in consumer prices, it may be important for the central banks of the USA, the EU, China and Japan to take into account the role of consumer prices and short-term interest rates when determining their policy.

Table 3 shows that maximum 10% of the 24-step forecast error variance of immediate interest rates is due to consumer prices and immediate interest rates, while industrial production and oil price increases account for nearly 90% of the variation in immediate interest rates up to the twenty-fourth quarter in all cases. Oil price increases explain approximately 4% and 10% of the variation in immediate interest rates in the USA and China up to the twenty-fourth quarter, respectively. On the other hand, the weights of oil price increases on short-term interest rates may be higher in the EU and Japan. Accordingly, we find that increases in oil prices may have a considerable impact on short-term interest rates, similar to Lee et al. (2001), but in contrast to Fratzscher et al. (2013).

Table 3: FEVDs of the immediate interest rates

FEVD of irt_t^{usa}				
Forecast Horizon *h*	ind_t^{usa}	pri_t^{usa}	$oilpr_t$	irt_t^{usa}
1	0.06	0.01	0.00	0.23
6	0.93	0.01	0.06	0.01
12	0.91	0.00	0.08	0.01
18	0.95	0.00	0.05	0.01
24	0.95	0.00	0.04	0.01
FEVD of irt_t^{eu}				
Forecast Horizon *h*	ind_t^{eu}	pri_t^{eu}	$oilpr_t$	irt_t^{eu}
1	0.03	0.30	0.64	0.03
6	0.13	0.10	0.67	0.10
12	0.33	0.06	0.54	0.07
18	0.35	0.05	0.53	0.07
24	0.35	0.04	0.55	0.06
FEVD of irt_t^{chi}				
Forecast Horizon *h*	ind_t^{chi}	pri_t^{chi}	$oilpr_t$	irt_t^{chi}
1	0.50	0.09	0.41	0.00
6	0.89	0.02	0.08	0.01
12	0.92	0.01	0.06	0.01
18	0.88	0.01	0.10	0.00
24	0.89	0.01	0.10	0.00
FEVD of irt_t^{jp}				
Forecast Horizon *h*	ind_t^{jp}	pri_t^{jp}	$oilpr_t$	irt_t^{jp}
1	0.28	0.31	0.27	0.14
6	0.14	0.09	0.73	0.04
12	0.18	0.04	0.77	0.01
18	0.24	0.04	0.70	0.01
24	0.26	0.04	0.69	0.01

Source: Authors' calculations

Our results are also consistent with the theoretical assumptions considered in the estimation process of the models. Nevertheless, the central banks of the USA, the EU, China and Japan should consider consumer prices and short-term interest rates in the process of making monetary policy, even if our FEVD results indicate their minimal role in explaining immediate interest rates.

5. Results and discussion

According to the impulse response analysis, we associate the positive effects of an increase in oil prices on output in the USA, the EU and Japan for the following quarters with returning "petrodollars" from oil-exporting countries to those three countries either through the trade channel via higher imports or through the financial channel via an increase in the net external asset position of oil-exporting countries (Beck and Kamps, 2009). However, impulse response analysis imply that unlike the USA, the EU and Japan, China may not take advantage of returning "petrodollars due to its less developed financial markets. The impulse response functions indicate that the increases in oil prices may lead to changes in the real economic activity of the USA, the EU and Japan in the short-run, but they do not cause a significant positive or negative effect on industrial production in the long-run for the case of China. Thus, we assert that our inferences about the effects of oil price changes on industrial production may become a considerable factor when analyzing the role of economic and political dynamics in oil price changes.

In addition, the FEVDs imply that variations in industrial production can be related to the increases in technology, while increases in oil prices may also have a major impact on the variations in output in the EU, China and Japan. Despite this finding, it can be inferred that the cumulative effect of oil price increases on output is mixed and not certain for the USA, the EU, China and Japan in the long-run, and increases in oil prices may become a crucial factor for business cycles in the USA, the EU, China and Japan, in line with Lee et al. (2001) but in contrast to Du et al. (2010). Our results imply that supply shocks may lead to flucturations in the real economic activity and employment. Accordingly, we make inference that it is critical for the monetary authorities of the USA, the EU, China and Japan aiming for price stability to identify the channels through which increases in oil prices influence output variations by considering the sectorial impacts. More precisely, we suggest that monetary policy authorities of USA, the EU, China and Japan should determine the consequences of oil price increases on each sector using oil as input.

On the other hand, IRFs' results reveal that the cost-push effects of oil price increases on producer prices may increase consumer prices in the USA, EU and Japan. Thus, it is implied that contractionary monetary policy should be implemented in the USA, EU and Japan to eliminate the negative consequences of oil price increases on inflation. According to the FEVDs, oil price increases may be an important source of the variations in consumer prices for all cases. Therefore, the monetary authorities of the USA, the EU, China and Japan should also determine the transmission mechanism of oil price changes to producer and consumer prices and also consider the effects of oil prices in analyzing the price fluctuations to formulate the optimal monetary policy for price stability. Within this context, foreign trade policy and oil price controls may be useful tools for the

USA, the EU, China and Japan especially to eliminate the negative effects of oil price increases on economic activity. We also suggest that energy policies aiming the use of alternative energy sources to oil should be developed by the USA, the EU, China and Japan to reduce the sensitivity of economic situation to increases in oil prices. Furthermore, we assert that energy policies in oil-importing countries should be conducted considering the consequences of oil price controls, subsidy reforms on the global political landscape and the climate change phenomena. Our implications related to inflation are supported by the FEVD analysis of immediate interest rates, implying that oil price increases may have a major impact on the money markets. We also find that increases in oil prices can be regarded as a cost-push factor that may influence the inflation target of the central banks of the USA, the EU and Japan negatively; thus, the immediate interest rate may be raised, in line with Balke et al. (1999), Bernanke et al. (1997), Herrera and Pesavento (2009) and Leduc and Sill (2004). Impulse response analysis examining the impacts of oil price increases on short-term interest rates for China is consistent to the fact that People's Bank of China makes instead active use of the reserve requirement ratio as a policy instrument. Within this context, the monetary authorities of the FED, ECB and Bank of Japan should also examine the effects of oil price changes on money markets in detail when determining their policy interest rate, as suggested by Bernanke et al. (1997, 2004) and Hamilton and Herrera (2004). Furthermore, considering the increased level of the interactions between commodity markets and money markets in the financial integration and development process, changes in oil prices may cause to fluctuations in interest rates. Thus, it is important to determine interactions between commodity markets and money markets by evaluating the economic, psychological and political factors of flow of funds among financial markets.

6. Conclusions

Despite the weak confirmation to our main hypothesis of IRFs which expose that oil prices have limited impacts in the following periods, FEVDs confirmed our main hypothesis with indicating that oil price should be regarded as factor leading variations in industrial production, consumer prices and immediate interest rates which is the main contribution of our findings. The IRFs expose that increases in oil prices may have temporary effects on industrial production. We find that oil price increases may influence real economic activity positively in the US, the EU and Japan for certain periods in contrast to the theoretical expectations assuming that oil price increases have asymmetric impacts on output. On the other hand, no significant influence on industrial production is detected in China. However, the FEVDs show that oil price increases may have a high amount of impact on the fluctuations in industrial production for all cases except the USA. Along with the real economic activity, the IRFs and FEVDs indicate that increases in oil prices may transmit to consumer prices and lead to changes in inflation. According to the IRFs, increases in oil prices may have significant effects on consumer prices, except for China. In addition, the FEVDs show that oil price increases can be regarded as the source of fluctuations in inflation for the USA, the EU, China and Japan. The IRFs also show that increases in oil prices may cause a rise in the immediate interest rates in the USA, the EU and Japan, whereas an insignificant impact on the short-term interest rate is shown in China. Significant limitations of this study can be twofold; (i) our sample the period is relatively limited, from the first quarter of 2000 and to the third quarter of 2013 due to data availability, (ii) differences between increases and decreases in oil prices may exist, however the actual difference between these two responses seems fairly small. As for the empirical exercise, we study the effects of increases in oil prices which can arise from the increase in oil demand or the decrease in oil supply theoretically. Our study highlights the importance of determination of the role of the trade channel and the financial channel in the analysis of oil price increases on the costs of production of goods and services and households' purchases of durable goods. We conclude that the monetary authorities of the USA, the EU, China and Japan, aiming to control economy-wide interest rates to achieve price stability, should determine the optimal theoretical and empirical framework for the evaluation of the transmission of oil price increases within dynamic stochastic general equilibrium (DSGE) framework which is also the scope of another study. In this respect, we suggest that optimal control theory can also be adapted to increase the effectiveness of monetary policy authorities in the USA, the EU, China and Japan considering the volatility generating impact of oil prices on macroeconomic variables.

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Preispitivanje utjecaja poskupljenja nafte na provođenje monetarne politike najvećih naftnih uvoznika

Nurtac Yildirim[1], *Oguzhan Ozcelebi*[2], *Seval Oral Ozkan*[3]

Sažetak

Cilj ovog rada je ispitati utjecaj poskupljenja nafte na provođenje monetarne politike najvećih naftnih uvoznika. U tu svrhu procjenjujemo modele strukturnog vektora ispravljanja pogrešaka (SVEC) da bi pokazali utjecaj poskupljenja nafte na industrijsku proizvodnju, potrošačke cijene i neposredne kamatne stope, elemente Taylorova pravila koji se odnose na četiri najveća naftna uvoznika (SAD, EU, Kina i Japan). Naši rezultati pokazuju da se rast cijena nafte prenosi na proizvodnju i inflaciju te dovodi do promjena u industrijskoj proizvodnji, potrošačkim cijenama i neposrednim kamatnim stopama koje pak utječu na monetarnu politiku u razdobljima koja slijede. Temeljni zaključak istraživanja je da bi vlasti monetarne politike u SAD-u, EU, Kini i Japanu trebale identificirati kanale kroz koje cijene nafte utječu na proizvodnju, inflaciju i kamatne stope. U radu se također naglašava važnost određivanja optimalnog okvira monetarne politike kako bi se uklonile negativne posljedice poskupljenja nafte.

Ključne riječi: *zemlje uvoznice nafte, šokovi (prouzročeni) cijenama nafte, inflacija, monetarna politika, SVEC model*

JEL klasifikacija: *E31, E32, E37, Q4*

[1] *Doktor ekonomskih znanosti, Faculty of Economics, Department of Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turska. Znanstveni interes: monetarna ekonomija, međunarodna ekonomija, makroekonomija, politička ekonomija. Tel.: +90 212 4400 000 (11789). Faks: +90 212 5208682. E-mail: nurtacy@istanbul.edu.tr.*

[2] *Izvanredni profesor, Faculty of Economics, Department of Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turska. Znanstveni interes: monetarna ekonomija, međunarodna ekonomija, makroekonomija, DSGE modeliranje. Tel.: +90 212 4400 000 (11789). Faks: +90 212 5208 682. E-mail: ogozc@istanbul.edu.tr.*

[3] *Doktorand, Faculty of Economics, Department of Labor Economics, Istanbul University. Beyazit Campus, Department of Economics, 34542 Beyazit, Istanbul, Turska. Znanstveni interes: makroekonomija, mikroekonomija, ekonomika rada. Tel.: +90 212 4400 000 (11789). Faks: +90 212 5208 682. E-mail: sevaloral@yahoo.com.*

Appendices

Table A1: Augmented Dickey–Fuller Test Results

Variables	ADF Test Statistic	Number of Lagged Differences
ind_t^{usa} (c)	-2.02	8
Δind_t^{usa}	-3.67	1
pri_t^{usa} (c,t)	-2.16	1
Δpri_t^{usa} (c)	-5.98	0
irt_t^{usa} (c)	-2.76	3
Δind_t^{usa}	-3.15	5
ind_t^{eu} (c)	-3.27	1
Δind_t^{eu}	-4.21	1
pri_t^{eu} (c,t)	-2.46	5
Δpri_t^{eu} (c)	-4.25	4
irt_t^{eu} (c)	-1.89	1
Δirt_t^{eu}	-4.30	0
ind_t^{chi} (c)	-2.18	0
Δind_t^{chi}	-5.14	3
pri_t^{chi} (c,t)	-2.79	10
Δpri_t^{chi} (c)	-2.97	8
irt_t^{chi} (c)	-2.69	0
Δirt_t^{chi}	-5.59	2
ind_t^{jp} (c)	-3.22	1
Δind_t^{jp}	-4.52	4
pri_t^{jp} (c)	-2.60	0
Δpri_t^{jp}	-6.75	0
irt_t^{jp} (c)	-2.18	2
Δirt_t^{jp}	-3.69	1
$oilpr_t$ (c,t)	-3.50	1
$\Delta oilpr_t$ (c)	-6.38	1

Notes: The 1% critical values for the ADF test with constant and trend (c,t), constant (c) and no terms are -3.96, -3.43 and -2.56, respectively. The critical values of the ADF test are from Davidson and McKinnon (1993). Δirt_t^{usa} and Δpri_t^{chi} are $I(0)$, when the number of lagged differences of the regression model of the ADF test selected by SC are as 0 and 8, respectively.

Source: Authors' calculations

Table A2: Tests for Cointegration

Series: ind_t^{usa}, pri_t^{usa}, $oilpr_t$, irt_t^{usa} No. of Included Lags (Levels): 1		
Null Hypothesis	Test Value	99% Critical Value
$r = 0$	102.18	51.45
$r = 1$	53.74	33.50
$r = 2$	13.18	19.71
Series: ind_t^{eu}, pri_t^{eu}, $oilpr_t$, irt_t^{eu} No. of Included Lags (Levels): 1		
Null Hypothesis	Test Value	99% Critical Value
$r = 0$	96.12	51.45
$r = 1$	41.81	33.50
$r = 2$	18.89	19.71
Series: ind_t^{chi}, pri_t^{chi}, $oilpr_t$, irt_t^{chi} No. of Included Lags (Levels): 1		
Null Hypothesis	Test Value	99% Critical Value
$r = 0$	81.41	51.45
$r = 1$	29.30	33.50
$r = 2$	10.57	19.71
Series: ind_t^{jp}, pri_t^{jp}, $oilpr_t$, irt_t^{jp} No. of Included Lags (Levels): 1		
Null Hypothesis	Test Value	99% Critical Value
$r = 0$	88.86	51.45
$r = 1$	41.02	33.50
$r = 2$	9.10	19.71

Source: Authors' calculations