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Reconsidering the Relationship between Oil Prices and Industrial Production: Testing for Cointegration in some of the OECD Countries

Ibrahim Halil EKSI[*], **Berna Balci IZGI**[**], **Mehmet SENTURK** [***]

Abstract

This paper investigates the effects of crude oil prices on the industrial production for some of the OECD countries. According to it, the empirical results sign that there is statistical meaningful short term causality from crude oil price to industrial production in all countries except France. In France however, causality is from industrial production to oil price in short run. The error correction mechanism is run for US. The causality is from oil price to industrial production in long run for US. These results show us that oil prices do affect industrial production index. Another interesting finding that, similar results were observed for oil exporting and importing countries such as Saudi Arabia and Iran as well. This situation is important that firm sensitivity towards oil price shows a similarity among the countries.

Keywords: *Crude Oil Price, Industrial Production, Cointegration, VAR.*

JEL Code Classification: *D01, L60, F14.*

[*] University of Kilis 7 Aralik, Turkey E-mail: ieksi@kilis.edu.tr
[**] Corresponding Author. University of Gaziantep, Turkey. E-mail: izgi@gantep.edu.tr.
[***] University of Kilis 7 Aralik, Turkey, E-mail: msenturk@kilis.edu.tr.

1. Introduction

Crude oil is the world's most actively traded commodity both in volume and in value. Until the creation of futures markets in mid 1980s, crude oil was largely sold by producers to consumers under long term contracts. Since then the oil market has become liberal and highly liquid in which price discovery has been concentrated around three marker crudes - WTI, Brent and Dubai. These markers are considered to be the reference for all oil traded worldwide (Cuaresma, Jumah, Karbuz, 2007:1-14). In the literature OECD countries for which are studied widely - the United States, the United Kingdom, Canada, France, Germany, the Netherlands, Italy, and Japan--differ in ways which could be expected to influence their vulnerability to oil price shocks (Jones and Leiby, 1996:21). They differ in their industrial structures, their compositions of overall energy supply, their societies' and governments priorities and macroeconomic and microeconomic policies, and their labor market structures and institutions. Also, not all the data from these countries are exactly comparable, as Mork et al. (1994, pp. 25-26) note in some detail. Darby (1982, p. 741) has questioned the quality of the relevant data from France, Italy, and Japan, while Mork et al. (1994, p. 27) have raised similar questions about German GDP data as a result of their statistical performance. Accordingly one would not expect to find exactly the same response pattern to any shock across these countries.

It is widely accepted that fluctuations in price of oil have substantial real effects on macroeconomic variables (Hamilton, 1983:228-248; Loungani 1986:536-539; Peron 1989:1361-1401). Oil prices may have an impact on economic activity through various channels (Lardic and Mignon, 2008:847-855).

According to Hamilton, oil price increases seem to be one of the main cause of recessions in USA prior to 1972 (Hamilton, 1983:228-248). Within a vector autoregression (VAR) framework Hamilton (1983, 1996) have found a strong causal and negative correlation between oil price change and real U.S. GNP growth from 1948 to 1980. When the sample period is extended to 1988:2 the correlation becomes only marginally significant and that there are asymmetric effects. GNP growth has a definite negative correlation with oil price increases and an insignificant correlation with oil price decreases. Many of the quarterly oil price increases observed since 1985 are corrections to even bigger oil price decreases from the previous quarter. When one looks at the net increase in oil prices over the year, recent data are consistent with the historical correlation between oil shocks and recessions (Hamilton, 1996:215-220).

According to Darrat, Gilley and Meyer (1996) the insignificant effect of oil prices on output is not robust. First the pre- and post-1972 periods are two distinct regimes, especially for oil prices and their relationship with the economy. Second, Hamilton argues that oil prices in the post-1972 period became more volatile, and that this volatility prevented oil prices from exerting any effect on the macro economy over their original estimation period (1960:I-1993:IV). Besides this the increased volatility of oil prices in their period (1960:I-1993:IV) was found (Darrat, Gilley and Meyer, 1996:158). However, Hamilton obtained his "evidence" of a significant relationship with the real economy in his paper, that their estimation period is characterized by several major episodes of oil price changes, ranging from the hikes of the mid-1970s, to the sharp declines of the early 1980s, to the more recent spikes of the Gulf War era.

In the mid 1970s, downturns in the industrial production would probably occur at any event and the oil price increase served to deepen a recession that was already on the way (Burbidge and Harrison, 1984:459-484). Burbidge and Harrison (1984), found significant impacts of oil and energy shocks on real activity for the U.S. using annual data. They have used an unrestricted systems of equations estimated for five countries in OECD for the period 1962 to 1982 and estimated a seven-variable vector autoregression (VAR) for each. The main finding of their study was a significant difference between the effects of the 1973-1974 set of oil price shocks and those of the 1979-1980 shocks .

Mork (1989), was the first who attained the asymmetry of the oil price shocks on economic activities. He separated the real oil price variable into upward and downward movements in order to analyze the oil price increases and decreases. In Mork’s paper, the results were weaker than Hamilton’s results (Mork, 1989:740-744). However in both of the studies any oil price change regardless of direction causes some costly resource allocation. Those two effects worked against and could largely offset each other when oil prices fell while they operated in the same direction when oil prices increased. Mork and Olson (1994) again verified that there was a negative and significant relationship between an oil price increase and national output, while no statistical significance could be attributed to them when the oil price falls (Mork and Olson, 1994:19-35).

Davis and Haltiwanger (2001) used an empirical base of quarterly plant level census data from 1972:2 to 1988:4 on employment, capital per employee, energy use, age and size of plant, product durability at four digit SIC level. They used vector auto regressions to test the response of job creation and destruction to separately defined, positive and negative oil price shocks. Their test relies on response patterns of job creation and destruction to oil price changes. Aggregate channels would increase job destruction and reduce job creation in response to an oil price increase and symmetrically, decrease job destruction and increase creation in response to an oil price decrease. In contrast, allocative channels would increase both job creation and destruction asymmetrically, in response to both price increases and decreases. Thus if oil price shocks operate predominantly through aggregate channels, employment would respond roughly symmetrically to positive and negative oil price shocks. According to their study, the magnitude of effect of oil price shocks is about twice that of monetary shocks, and response of employment to oil price shocks is asymmetric, the response to postive shocks is ten times larger than that to negative shocks (Davis and Haltiwanger, 2001:465-512).

Blanchard and Gali (2007), have used structural VAR technique to analyze the effects of oil price changes on macroeconomic variables. Their results show that, the estimated response for employment and output become weaker over time, with point estimates becoming slightly positive for the most recent period. There were other adverse shocks in 1970s; the price of oil explains only part of the stagflation episodes of the 1970s (Blanchard and Gali, 2007: 1-78).

The effects of a given change in the price of oil have changed substantially over time. They explain that one of the reasons for this change is the decline in wage rigidities. According to Alper and Torul (2008), oil price increases do not significantly affect the manufacturing sector in aggregate terms, some sub-sectors are adversely affected. They have taken into account exogeneity of oil prices, extreme oil reliance and import-dependence, as well as asymmetric responses of oil product prices to world crude oil price changes (Alper and Torul, 2008). According to Blanchard and Gali (2007), it appears that there are three potential changes in economies over time. These are behavior of wages, role of monetary policy and importance of oil. The role of monetary policy has changed since 1970s. In 1970s the central banks didn’t know how to react and central banks credibility was low. In the 2000s supply shocks are no longer new, monetary policy is clearly set and credibility is much higher. Thirdly the importance of oil in the economy has declined over time. Increases in the price of oil have led to substitution away from oil, and a decrease in the relevant shares of oil in consumption and in production (Blanchard and Gali, 2007:1-78).

When analyzing the industry-level effects of oil price changes one has to understand their transmission mechanisms truly. Lee and Ni (2002) estimate the effects of exogenous oil price shocks using U.S. industry-level data. They have found that oil price shocks act mainly as supply shocks for oil-intensive industries, such as petroleum refineries, and act mainly as demand shocks for many other industries (Lee and Ni, 2002:823-852). There are also some research about the impact of oil price shocks at the industry level (Bohi, 1989; Lee and Ni 2002:823-852; Kilian and Park, 2007) . They have focused on the US with the only exception being Bohi (1989) who also explored such industry-level effects on economies other than US (specifically Germany, Japan and the UK). While Bohi (1989) and Lee and Ni (2002) analyzed the impact of oil price shocks on output in manufacturing industries. While Jimenes and Rodrigues have analyzed the effects of oil price shocks on industrial output of four European Monetary Union countries respectively (France, Germany, Italy and Spain), the UK and the US. They investigated the pattern of output responses to an oil price shock in different industries about whether these responses provide evidence on cross-industry heterogeneity of oil shock effects, as well as on cross-country heterogeneity. Rodriguez (2008), have assessed the dynamic effect of oil price shocks on the output of the main manufacturing industries in six OECD countries. The pattern of responses to an oil price shock by industrial output is diverse across the four European Monetary Union (EMU) countries under consideration (France, Germany, Italy, and Spain), but broadly similar in the UK and the US (Rodriguez, 2008:3095-3108).

Herrera,Lagalo and Wada (2010) have found that costly reallocation of factor inputs across sectors might play an important role in explaining the response of industrial production to oil price shocks, even though the response of real GDP has been shown not to be significantly asymmetric. According to Mehrara and Sarem (2009), there is a strong causality from oil price shocks to output growth for Iran and Saudi Arabia. Moreover, the oil prices–output relationship in these two countries appears more significant when asymmetric specifications are used to model the relationship between variables. In the case of Indonesia, however, none of the oil proxies have any significant effect on output both in the short and long run. The results confirm the relatively successful experience of countries such as Indonesia in the diversification of the real sector to minimize the harmful effects of oil booms and busts. Reyes and Quiros (2005) have found that raises in oil price affects in a negative and statistically significant way to stock returns and to industrial production, but the effect on stock returns is stronger than on industrial production.

2. Methodology and Data

2.1. Methodology

There is a huge literature about the effects of oil prices on macroeconomic variables. However, this study has a different aspect from the others in the sense that, it specifically deals with the effects on industrial production in a causality relationship. The relationship between variables investigated with Johansen Cointegration Approach. For cointegration testing, Johansen test is generally used (Trešl and Blatná, 2007:299).

Granger and Engle (1987) in their studies have indicated that linear combinations of two or more unstationary series may be stationary. If there is a stationary linear combination exists in this kind of unstationary series, these series are called as cointegrated. This linear stationary combination shows the longrun relationship among the variables and is called as cointegrated equation. We used cointegration tests, based on the methodology of Johansen's VAR model (Engle and Granger,1987:270). Pth VAR model is shown below:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \qquad (1)$$

In equation, yt is non-stationary vector of variables, xt is vector of deterministic variables and εt is error terms. VAR model in matrix notation is below:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \qquad (2)$$

In this equation, ıt is defined as

$$\Pi = \sum_{i=1}^{p} A_i - I \quad \text{and} \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j \qquad (3)$$

The coefficient of Π shows that if the reduced rank (r)is smaller than the endogeneous variable number (r<k if), than Π=αβ′ and β′y is I(0)and there exist kxr number of α and β matrices. r shows the number of cointegration relationship and each column of β is the cointegration vector. Two test statistics are used for testing the cointegration relationship in number r. The first one of these is called as trace test. In this test H0 investigates r and H1 investigates k number of cointegration relationship (k is the number of endogeneous variables). Trace statistics is calculated as shown below (Johansen and Juselius, 1990:170)

$$LR_{tr}(r/k) = -T \sum_{i=r+1}^{k} \log(1-\lambda_i) \qquad (4)$$

λi is the ith eigen value of Π matrice. The second test statistics is called as eigen value statistics. It investigates r+1 number of cointegration relationship against r. Eigen value statistics is calculated as shown below.

$$LR_{\max}(r/r+1) = -T \log(1-\lambda_{r+1}) \qquad (5)$$

2.2. Data

The study's data were monthly and covered from 1997:1 to 2008:12. Industrial production data were taken from OECD web site and Energy Information Administration (EIA) for the oil prices. The reason why these country groups have been used is that, some of the OECD countries have changed their index measuring in some years (Italy 1995-05, Belgium 1996-06). Such countries were not included in the analysis, instead Turkey, US, Germany, Spain, France, South Korea and Japan were included. US in one side, while Turkey, Germany, Spain and France in the other side and South Korea and Japan represent far east countries in the analysis.

The following notations were used for the above model:

LOP: Logaritmic values of oil prices(world),
LIP: Logaritmic values of index of industrial production,
ΔLOP: First log difference of oil price,
ΔLIP: First log difference of industrial production

In this study, logaritmic values of the variables were calculated and then seasonality, stationarity and autocorrelation were tested. Explanatory power of the variables was decreased with seasonal effect (Vogelvang, 2003:81). Seasonality test is actualized with X12 procedure in our analysis. Optimal lag lengths of variables were detected with the help of information criteria and Johansen Cointegration test was used for the relationship among the variables. According to the results of the cointegration analysis, standard Granger Causality test and vector error correction model is employed.

3. Results

3.1. Unit Root and Cointegration Tests Results

A cointegrating relationship exists between non-stationary series, if there is a stationary linear combination between them. Therefore, one needs to test the stationarity of the series first. Augmented-Dickey-Fuller (ADF) and Phillips-Perron (PP) tests and KPSS tests are used to determine whether or not the series are stationary.

In the Table 1 superscript a denotes significance at 1% critical level. Optimum lag lengths are set according to SC for ADF, Newey-West method for PP and KPSS.

The ADF and PP tests have the null hypothesis of existence of a unit root, rejection of which indicates stationarity. Table 1 presents the results for the unit root tests.

Table 1: Unit Root Test Results

		ADF		Philips-Perron		KPSS	
Country	Variables	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept
World	LOP level	-1.00	-2.45	-1.1	-2,81	1.25	0.134[a]
	LOP 1.df.	-10.91	-10.86[a]	-10.94[a]	-10.89[a]	0.116	0.117[a]
Germany	LIP level	-1.38	-1.18	-1.48	-1.61	1.211	0.214
	LIP 1.df.	-14.21[a]	-14.24[a]	-14.06[a]	-14.09[a]	0.168[a]	0.132[a]
USA	LIP level	-2.25	-1.31	-3.25	-2	1.165[a]	0.111[a]
	LIP 1.df.	-3.79	-4.24[a]	-12.06[a]	-12.57[a]	0.520[a]	0.136[a]
Spain	LIP level	-1.38	2.52	-1.97	0	1.09[a]	0.140[a]
	LIP 1.df.	-5.67[a]	-12.12[a]	-16.35[a]	-17.67[a]	0.359[a]	0.155[a]
France	LIP level	-3.19	-1.62	-7.69[a]	-9.9[a]	0.803	0.21
	LIP 1.df.	-23.05[a]	-23.81[a]	-39.32[a]	-48.97[a]	0.264[a]	0.007[a]
Japan	LIP level	-2.57	-1.98	-1.87	-1.98	0.765	0.22
	LIP 1.df.	-3.47[a]	-4.02[a]	-15.83[a]	-15.79[a]	0.176[a]	0.171[a]
Turkey	LIP level	-3.17	-3.29	-5.65[a]	-6.09[a]	0.742[a]	0.158[a]
	LIP 1.df.	-18.35[a]	-18.34[a]	-20.20[a]	-20.18[a]	0.188[a]	0.114[a]
Korea	LIP level	-1.57	-0.8	-1.54	-2.88	1.333	0.124[a]
	LIP 1.df.	-18.51[a]	-18.62[a]	-17.92[a]	-18.03[a]	0.214[a]	0.087[a]

While ADF and PP tests have given similar results, KPSS has given different results. Then ADF results were taken as a primary indicator. All the variables are I (1) and, a long term relationship between the crude oil price and industrial production index should be investigated for cointegration. If there is no cointegration between the variables, then OLS results would be misleading. A VAR model has established for this and optimal lags investigated with SC. Optimal lag length according to SC is determined as 4 for Germany, US, Spain and Korea and 5 for France and 2 for Japan and Turkey. Autocorrelation is tested and the results show that there is no rejection for these lag lengths. We can't find an autocorrelation for the above lag lengths. There is a long term vector between crude oil price and industrial production index in US and France.

Table 2: Cointegration Test Results

Sampling Period: 1997:01 – 2008:12 Trend Assumption: Deterministic Linear Trend							
Country	**H_0**	**H_1**	**LAGS**	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.**
Germany	R=0	R=1	4	0.058752	1.273.097	2.026.184	0.3857
	R≤1	R=2		0.030564	4.314.692	9.164.546	0.3673
USA	R=0	R=1	4	0.145897	2.769.423	2.026.184	0.0039 [a]
	R≤1	R=2		0.040685	5.773.437	9.164.546	0.2090
Spain	R=0	R=1	4	0.102915	2.456.237	2.526.184	0.1203
	R≤1	R=2		0.065836	9.066.280	9.164.546	0.1431
France	R=0	R=1	5	0.088427	1.793.105	1.549.471	0.0211 [b]
	R≤1	R=2		0.106663	3.154.523	3.841.466	0.1232
Japan	R=0	R=1	5	0.046163	8.946.187	1.549.471	0.3704
	R≤1	R=2		0.017412	2.423.996	3.841.466	0.1195
Turkey	R=0	R=1	2	0.069224	1.132.919	1.549.471	0.1920
	R≤1	R=2		0.008575	1.214.307	3.841.466	0.2705
Korea	R=0	R=1	4	0.059825	1.219.972	1.549.471	0.1476
	R≤1	R=2		0.025741	3.624.895	3.841.466	0.1169

Superscripts a and b denote rejection of the null hypothesis at the 1% and 5% levels of significance, respectively.

3.2. Granger Causality and Vector Error Correction Models

According to this approach, if two variables are cointegrated, then, there is an error correction mechanism (ECM) to revise instability in short term (Engle and Granger, 1987). ECM is used to see the speed of adjustments of the variables to deviations from their common stochastic trend. ECM corrects the deviations from the long-run equilibrium by short-run adjustments. This shows us that changes in independent variables are a function of changes in explanatory variables and the lagged error term in cointegrated regression. Granger and Engle (Granger and Engle, 1987) have showed that in case of a cointegration between the variables, there may be one way or two way Granger-causality between the variables which have stochastic error terms in I (0). Thus, regression is purified from spurious regression. Error terms are derived for France and US. ECM's of France and US are shown in Tables 3 and 4.

There seems to be no mechanism from crude oil price to industrial production index and industrial production index to oil price for France. Thus there is no long term relationship between these variables. In F-Wald test which all the independent variables are evaluated together, there is a causal relationship from industrial production index to oil prices.

Table 3: ECM for France

	Dependent Variable: ΔLOP			Causality Results	
	Variables	Prob.	Coefficient	Short Term	Long Term
France	ECT_{t-1}	0.0162	0.979072	ΔLIP → ΔLOP	No
	ΔLOP_{t-1}	0.6286	0.042674		
	ΔLOP_{t-2}	0.3882	-0.076956		
	ΔLOP_{t-3}	0.0976	0.153894		
	ΔLOP_{t-4}	0.3602	-0.086248		
	ΔLIP_{t-1}	0.0144	-0.913332		
	ΔLIP_{t-2}	0.4710	-0.412290		
	ΔLIP_{t-3}	0.1823	-0.785160		
	ΔLIP_{t-4}	0.3196	-0.523671		
	ΔLIP_{t-5}	0.4011	-0.306540		
	Constant	0.8307	0.001763		
	f-wald test	0.0903	19515 [c]		
	Dependent Variable: ΔLIP			Causality Results	
	Variables	Prob.	Coefficient	Short Term	Long Term
	ECT_{t-1}	0.0000	0.474431	No	No
	ΔLIP_{t-1}	0.0000	-0.844381		
	ΔLOP_{t-1}	0.2756	-0.029167		
	ΔLOP_{t-2}	0.1121	-0.044069		
	ΔLOP_{t-3}	0.2453	-0.032323		
	ΔLOP_{t-4}	0.6401	0.013060		
	Constant	0.7763	-0.000715		
	f-wald test	0.3078	1214499		

Table 4: ECM for US[1]

	Dependent Variable: ΔLOP			Causality Results	
	Variables	Prob.	Coefficient	Short Term	Long Term
USA	ECT_{t-1}	0.0003	0.997188	ΔLIP → ΔLOP	No
	ΔLOP_{t-1}	0.6797	0.033770		
	ΔLIP_{t-1}	0.0424	2232072		
	Constant	0.9111	0.000871		
	f-wald test	0.0424	4198239 [b]		
	Dependent Variable: ΔLIP			Causality Results	
	Variables	Prob.	Coefficient	Short Term	Long Term
	ECT_{t-1}	0.0701	-0.039827 [b]	ΔLOP → ΔLIP	ΔLOP → ΔLIP
	ΔLIP_{t-1}	0.8750	-0.013601		
	ΔLOP_{t-1}	0.0016	0.020229		
	ΔLOP_{t-2}	0.0865	0.011284		
	Constant	0.1058	0.000976		
	f-wald test	0.0017	6687886 [b]		

[1] a %1, b %5, c %10 significance level. Optimal lag number is determined according to the Schwarz (SBC). Normality of the model used for ECM is tested with Jarque-Bera test; autocorrelation is tested with LM test.

In ECM for US, there seems to be no long term relationship from industrial production index to crude oil prices so the ECM didn't work. For the f-wald test for short term, there was causality from industrial production to oil prices. Both long and short term causality was found from crude oil prices to industrial production index and ECM has worked for US. Results of the Granger causality test are shown below:

Table 5: Granger Causality Test for Selected OECD Country[2]

Country	Way of Causality	Prob
Germany	ΔLIP does not Granger Cause ΔLOP	0.03286[b]
	ΔLOP does not Granger Cause ΔLIP	0.01831[b]
Spain	ΔLIP does not Granger Cause ΔLOP	0.06860[c]
	ΔLOP does not Granger Cause ΔLIP	0.00315[a]
Japan	ΔLIP does not Granger Cause ΔLOP	0.01671[b]
	ΔLOP does not Granger Cause ΔLIP	0.00060[a]
Turkey	ΔLIP does not Granger Cause ΔLOP	0.91635
	ΔLOP does not Granger Cause ΔLIP	0.00842[a]
Korea	ΔLIP does not Granger Cause ΔLOP	0.00771[a]
	ΔLOP does not Granger Cause ΔLIP	0.00837[a]

In Granger causality test, there is a casual relationship from crude oil prices to industrial production index. A causal relation from industrial production to oil prices is valid except for Turkey.

4. Conclusion and Policy Implications

This study tried to understand the causality between industrial production indexes and crude oil prices for 7 OECD countries. Empirical findings show that, there is statistical meaningful short term causality from crude oil price to industrial production in all countries except France. In France however, causality is from industrial production to oil price in short run. The error correction mechanism is run for US. The causality is from oil price to industrial production in long run for US. These results show us oil prices do affect industrial production index. The conspicuous point here is that the relationship between these two variables makes no difference for the oil balance among these countries. In other words, similar results were observed for oil exporting and importing countries.

The causality from industrial production to oil price can be associated with oil demand. Foreseeing the oil price has crucial importance for these countries. An obvious potential direction for future research may be that the expansion of the present analysis to a multivariable (CPI, real exchange rate, energy price index may be included) context. With this way it is possible to explain the dimension and

[2] Superscripts a, b and c denote rejection of the null hypothesis at the 1%, 5% and 10% levels of significance, respectively.

existence of the relationship between the oil price and industrial production more accurately. Industrial production is very crucial for economies and especially for the manufacturing firms. The crude oil price may be the sign of ambiguity as well as a cost element. The firms are unconstrained by the volatility of oil prices. The firms could be successful as far as they can reflect those price changes to their costs. One of the most important indicators of firm behavior towards oil prices is industrial production itself.

We thus propose policy suggestions to solve the oil price effect on industrial production for these countries: foreseeing the crude oil price is still very crucial for these economies. In spite of the knowledge we have about the new energy alternatives and the decrease in usage of oil products, oil still has a vital importance on production itself. Therefore, enhancing oil supply security and guaranteeing oil supply to set up national strategic oil reserve for oil dependent industries is very crucial.

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