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Onto Exchange Rate's Short Run Impact on Oil Prices Dynamics: An OPEC Members' perspective

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Abstract

In this paper, we study the oil price formation for the purpose of understanding price reactions of OPEC member countries to changes in the exchange rate of the US dollar and prices of other members in the short run. The results suggested that there is a partial impact of exchange rates volatility on oil prices dynamics in short runs. Moreover, the study demonstrated that Saudi Arabia behaves as a leader in the OPEC structure market while it behaves differently when linked to other reference markets. Generally, Saudi Arabia behaves more potentially and more moderately than the other OPEC members in responding to change of references markets prices.

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1- Introduction

For most countries, the real price of oil is dependent on two main factors: the value of the US dollar and the inflation rate. Since oil prices are contracted in US dollars and oil exporters import their goods from countries including the United States, a strong dollar will decrease the real oil price and a weak dollar will increase it (Melhem and Terraza, 2008). A decline in the value of the dollar will weaken an oil exporter's purchasing power since it effectively makes imports originating outside the United States more expensive and should lead the oil to be cheaper outside US (Amezegar, 1986).

Several studies have empirically examined oil exporters' reactions to changes in the exchange rate by adjusting export prices and holding import prices steady in order to maintain market shares. The degrees of exchange rate pass through depend crucially on the market structure, market share[1]…etc. These literatures provide evidence that imperfect competition may be one major explanation for the existence of an incomplete exchange rate pass through. In an attempt to fill the existing gap in the literature, Knetter (1993), Yousefi and Wirjanto (2004, 2005)[2] used the exchange rate as a determinant element in the oil price formation and they showed that the export price mark-up implies a partial exchange rate pass through. Despite a voluminous study on this subject, the question on whether and how mark-up adjustment in response to changes in exchange rates affects the import price, appears not to have been studies much in the short run. Therefore, the main objective of this paper is to analyze the reactions of OPEC countries to change in the exchange rate and changes in the price of other members in short runs.

The remaining parts of the paper are organized as follows. A section 2 develops a model for the exchange rate pass through. Section 3 presents the empirical results and section 4 concludes.

2- The model

In order to investigate the impact of exchange rate volatility on oil prices, we follow a model used in Yousefi-Wirjanto (2004), which is completed by a variance structure as specified by Froot and Stein (1991) to compute the exchange rate volatility. This modification permits us to highlight the impact of exchange rate on oil prices in the short run.

Given that the depreciation of the US dollar is expected to attract the oil price inflows at least for the following two reasons: First, the volatility of the US dollar affects the oil price trend. Second, the depreciation of the US dollar impacts on the OPEC countries assets and weakens their purchasing power. Due to its "Flexibility and uncertainty" in nature, real exchange rate volatility is assumed to consist of two parts: one is a part

[1] For an extensive studies on this subject, see Kurgman (1987), Durnbush (1987), Giovannini (1988), Froot and Klemperer (1989), Thusnelda (1996), and Also for a comprehensive survey of current studies on the exchange rate pass through, Menon (1995).

[2] For the oil market model; see Adelman (1982, 1993), Cremer and Salehi-Isfahani (1991), Griffin and Teece (1982), Johany (1980). Adams and Marquez (1984) develop a simple cartel model for OPEC to explain optimal oil price determination.

explained by the failures of establishing the law of one price and the other is an unexplained part. In order to focus on the unexplained part of the real exchange rate of USD volatility, VOL_t^{us}, we define it as the deviation of the actual value from the value explained by the failure of the law of one price:

$$VOL_t^{us} = \left| \text{var}\left(\frac{e_t^i p_t}{p_t^i} \right) - \hat{\text{var}}\left(\frac{e_t^i p_t}{p_t^i} \right) \right| \quad (1)$$

Where, $\text{var}\left(\frac{e_t^i p_t}{p_t^i} \right)$ is the actual volatility and $\hat{\text{var}}\left(\frac{e_t^i p_t}{p_t^i} \right)$ is the volatility explained by the failure of law of one price. The exchange rate $\frac{e_t^i p_t}{p_t^i}$ represents the ratio of the domestic price in time t, P_t, to the price in country i in that time. The large magnitude of VOL_t^{us} means that other factors than the failure of the law of one price play an important role in the real exchange rate volatility.

The empirical model proposed to explain prices dynamics is justified by equation (1). We assume that exchange rates variations affect the changes in the marginal cost and all export destinations prices. Therefore, changes in the exchange rate and in competitor's prices are the primary explanatory variables of the destination-specific best response function:

$$P_{i,t} = \alpha_i + \beta_i VOL_t^{us} + \gamma_i P_t + \varphi D_t + \varepsilon_{i,t} \quad (2)$$

Where $P_{i,t}$ is the logarithm of crude price charged by the source nation i to the destination market, VOL_t^{us} is the volatility of effective exchange rate of dollar, P_t is the logarithm of crude prices charged by the competitors. $\varepsilon_{i,t}$ is the random error terms assumed to be i.i.d. $(0, \sigma_i^2)$ and D_t is a dummy variable set to 1 for 2008:07 - 2008:12 and 0 otherwise.

The destination specific intercept term captures all non price determinant factors. The pricing to market can be judged from the sign and magnitude of the parameter estimate of β only. The slope coefficients as specified in the model are allowed to vary across export destination markets. Therefore, we confine our analysis in order to show the oil export price reaction to an exogenous change in exchange rates in the short run.

A highlight of the importance of the two sources of prices changes is obtained through the interpretation of the sign and magnitude of the parameters β and γ. β is the export price markup parameter. When $\beta = |1|$ exchange rates pass through does not take place because the individual producer adjusts its mark-up to absorb the full in the exchange rate to keep its export price constant. When $\beta = 0$ implies that changes in the exchange rate have no impact on the price charged by the exporting nation. When $|0 < \beta < 1|$ there

would be a partial exchange rate pass through. That is, changes to the exchange rate affect the way in which crude prices are formed. In the case where β is negative, the individual producer adjusts its mark-up to absorb the full change in the exchange rate to keep its export price constant in terms of foreign currency. In the case β is positive the individual producer does not need to adjust its mark-up because they keep its purchasing power. That is, the profit margin remains unchanged and change in the exchange rate would be fully passed on to the importing nation, net of overall price changes. The value of β provides a clear indication of the relative size of each individual exporting nation. Therefore, the large value of β indicates, close to one, for a large market, while the value can indeed deviate from one for small market.

The export price reaction to rival's price is captured by the parameter estimate of γ that measures the elasticity of the best response function of an individual exporting country. A positive sign of γ implies that reactions are strategic complements, while a negative sign indicates a strategic substitution. The value of γ provides a clear indication of the market power of each individual exporting nation. In particular, while one may expect a large value, possibly close to one, for a small exporting nation, such value can indeed deviate from one for a large exporting nation.

3- Empirical results

Before undertaking a statistical analysis that examines the reaction of spot prices for oil to the behaviour of the exchange rate, we shall describe the data using in this paper. The data we use are daily observations, over the first of January 1999 to end of Dec 2008, of the real index of the effective exchange rate of the dollar (EERD). The real index of the effective exchange rate is the price adjusted major currencies index of Dollar. The oil price series are the US dollar daily spot prices of West Texas Intermediate Crude Oil reference (WTI), North Sea Brent reference (Brent), OPEC basket price reference (OPEC), Iranian oil price reference (Iran light), the oil price of Venezuela reference (Tia Juana Light), the oil price of Saudi Arabia reference (Arab Light) and the oil price of Nigeria (Bonny Light) deflated by the US consumer price index. The variables are used in logarithmic form of first difference. The data employed are taken from the Federal Reserve's, European Central Bank, OPEC organization and Energy Information Administration (EIA).

We start our empirical examination with the unit root test by employing the augmented Dickey Fuller (1981) tests. The results are presented in table 1. We use Akaike's information criterion to select the appropriate lag lengths. For all series, we are unable to reject the unit root null hypothesis and the series are stationary in first order differencing of raw series.

Table 1 : Unit root test of ADF.

Stat-Test	WTI	Brent	OPEC	Iran	Venezuela	Saudi	Nigeria	EERD
ADF	1.56 [0.00] *	1.75 [0.00] *	2.07 [0.00] *	1.82 [0.00] *	1.59 [0.00] *	2 [0.00] *	1.77 [0.00] *	-1.37 [0.00] *
ADF(-1)	-49.5 [0.35]	-53.1 [0.42]	-42.1 [0.21]	-47 [0.37]	-48.9 [0.55]	-48 [0.43]	-47 [0.39]	-48.3 [0.57]

* The model without intercept nor trend. [] is the P-value. Null hypothesis are accepted at 5% significant level.

Table 2 reports the summary statistics of both oil series and exchange rates it shows significant difference between the standard deviations of the prices series of the WTI reference, Brent reference and those of OPEC basket (members of OPEC). We note a low variation of the OPEC member's prices series (except Nigeria) compared to those of the WTI and Brent reference. Moreover, differences appeared amongst OPEC members, with low variations of South American members (Venezuela), high variations of the African members (Nigeria) and finally the Middle East members (Arab Saudi and Iran) stayed in the middle.

Table 2: Summary Statistics

	Mean		*Min*		*Max*		*SD*		*Skew*		*Kurt*	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ	Level	Δ	Level	Δ
WTI	*39.9*	*0.0008*	*11.2*	*-0.2*	*94.6*	*0.18*	*18.3*	*0.02*	*0.7*	*-0.53*	*2.5*	*8.9*
Brent	*38.2*	*0.0009*	*9.62*	*-0.12*	*92.5*	*0.12*	*18.5*	*0.02*	*0.8*	*-0.26*	*2.4*	*5.4*
Opec	*35.9*	*0.001*	*8.09*	*-0.16*	*87.8*	*0.12*	*17.9*	*0.01*	*0.8*	*-0.33*	*2.6*	*15.1*
Iran	*35.7*	*0.001*	*8.02*	*-0.16*	*89.4*	*0.11*	*17.9*	*0.02*	*0.9*	*-0.46*	*2.7*	*6.4*
Vnzla	*33.7*	*0.0009*	*8.39*	*-0.19*	*86.8*	*0.09*	*16.2*	*0.02*	*0.9*	*-0.44*	*3.1*	*6.1*
Saudi	*35.9*	*0.0009*	*9.15*	*-0.12*	*88.1*	*0.16*	*17.3*	*0.01*	*0.9*	*-0.13*	*2.7*	*7.3*
Ngria	*38.8*	*0.001*	*9.23*	*-0.19*	*94.2*	*0.13*	*19.5*	*0.02*	*0.8*	*-0.48*	*2.5*	*7.2*
eerd	*90.1*	*-0.001*	*68.0*	*-0.01*	*111.6*	*0.017*	*10.6*	*0.01*	*0.1*	*0.07*	*1.82*	*3.7*

Δ= First difference of the logarithm

In estimating Eq. (2), we take into account the possibility that changes in crude prices charged by competitive exporters are endogenous to changes in crude price charged by the source nation. This suggests that price variables may be correlated with the equation's error term, sign of co-linearity problem between the variables. Table (3) show that the high correlation between the variables is close to one.

Table 3: price correlation matrix (level)

	WTI	*Brent*	*OPEC*	*Iran*	*Venezuela*	*Saudi*	*Nigeria*	*EERD*
WTI	**1**							
Brent	*0.99*	**1**						
OPEC	*0.99*	*0.99*	**1**					
Iran	*0.99*	*0.99*	*0.99*	**1**				
Venezuela	*0.98*	*0.98*	*0.98*	*0.99*	**1**			
Saudi Arab	*0.98*	*0.99*	*0.99*	*0.99*	*0.99*	**1**		
Nigeria	*-0.98*	*0.99*	*0.99*	*0.99*	*0.99*	*0.99*	**1**	
EERD	*0.83*	*-0.82*	*-0.83*	*-0.82*	*-0.83*	*-0.81*	*-0.82*	**1**

Table 4: comparison of the series in level and in FD with the Variance Inflation Factor VIF

	WTI	*Brent*	*OPEC*	*Iran*	*Venezuela*	*Saudi*	*Nigeria*
R_i^2 *(Level)*	*0.992*	*0.993*	*0.990*	*0.989*	*0.981*	*0.994*	*0.994*
R_i^2 *(Δ)*	*0.098*	*0.149*	*0.055*	*0.016*	*0.015*	*0.069*	*0.167*
VIF (Level)	*125*	*142*	*100*	*91*	*53*	*166*	*166*
VIF (Δ)	*1.08*	*1.17*	*1.05*	*1.02*	*1.01*	*1.07*	*1.2*

VIF= is the Variance inflation factor = 1/1- R_t^2

In order to examine this problem, we use the *variance inflation factor* to detect the presence of multi co-linearity amongst series. Table 4 establishes comparison between the series in level and in first difference; we note that VIF statistics are relatively low with the first difference (less than 2). This suggests that multi co-linearity, if it's present, is very weak and does not seem to induce serious risks. Therefore, we consider first order differencing of series, denoted, (ΔP_t) and defined by $\Delta P_t = \ln P_t - \ln P_{t-1}$ for each country.

For this reason, we use the OLS estimator to estimate the Eq. (2). The estimated exchange rate mark-up elasticities are almost statistically significant and carry negative signs while the export price reaction elasticities to rivals' prices are statistically significant and carry positive signs (reactions are strategic complements). As can be seen from table 5, the export price mark-up elasticity estimates vary between -0.011 and -0.027 implying a partial exchange rate pass through. For a 10% depreciation of the effective exchange rate of the US dollar during the sample period, for instance, export price in US dollar have been mark-up by 0.11-0.27% to partially recoup the decline in the international purchasing power of oil revenues.

The estimated exchange rate export price mark-up elasticities illustrate a pattern as they are low for the small countries and high for the bigger nations. The results show a high value for Saudi Arabia (-0.027) and a small value for Nigeria (-0.011) which indicates the size of each exporting nations market. Thus, the high export price mark-up elasticity of Saudi Arabia indicates that it has a bigger size of oil market while Nigeria has a smaller size of oil market compared to OPEC members. The answer to whether or not the

different responses are the result of the difference in the stock reserve, production capacity utilization, or the increased cost production in the oil industry caused by depreciation of the dollar cannot be inferred from our results. The results, however, provide an indication of the different reactions of OPEC members to an exogenous shock such as change in the exchange rate of USD.

Table 5: the OLS estimation for OPEC Members

	Constant	β_{eerd}	γ_{Saudi}	γ_{iran}	γ_{Venzla}	$\gamma_{Nigeria}$	$Dummy_t$
Saudi	*0.019*	*-0.027*		*0.13*	*0.23*	*0.17*	*-0.09*
(P-value)	*(0.12)*	*(0.04)**		*(0.00)**	*(0.00)**	*(0.00)**	*(0.00)**
Iran	*0.020*	*-0.026*	*0.20*		*0.135*	*0.29*	*-0.08*
(P-value)	*(0.20)*	*(0.05)**	*(0.00)**		*(0.02)**	*(0.00)**	*(0.00)**
Venzla	*0.015*	*-0.022*	*0.35*	*0.132*		*0.20*	*-0.15*
(P-value)	*(0.31)*	*(0.06)***	*(0.00)**	*(0.02)**		*(0.00)**	*(0.00)**
Nigeria	*0.016*	*-0.011*	*0.28*	*0.31*	*0.22*		*0.12*
(P-value)	*(0.30)*	*(0.06)***	*(0.00)**	*(0.00)**	*(0.00)**		*(0.00)**

** Results accepted at 5% significant level. ** Results accepted at 10% significant level. The dummy variable set equal to 1 for July 2008 to December 2008 and 0 otherwise.*

The estimated rival's prices elasticities carry the expected positive signs and are all significant at the 5% level. The results showed that the measure of the rival price elasticity estimates is as low as 0.13 for Saudi Arabia and as high 0.35 for Venezuela which indicates a substantial difference in the reactions of prices to the price changes of other members. We distinguish that the reaction of oil prices for Saudi Arabia to changes in the prices of others members are smaller others reactions of other members prices. However, we observe again that the Saudi Arabia has the biggest power/Pricing Strategy amongst member nations of OPEC.

In support of this stylized fact, we consider that the substantial difference among the estimated rival price elasticities is an indication of the different market Power/Pricing strategy of member nations of OPEC in respect of crude prices indexes of OPEC reference basket, WTI reference and Brent reference ($\gamma \cong 1$ for a small nation and the deviates from 1 for a big nation). During the period of study, table 6 suggests that estimates of new measures of rivals' price elasticities, of OPEC members related in OPEC market, range from 0.049 to 0.061 (γ_{opec}). This result indicates that a substantial difference in the reactions of prices to the prices changes of other members. The low value for Saudi Arabia export price elasticities provides big size of market power, since its reactions to the change of other member is the smallest (0.049).

Table 6: the OLS estimation for WTI, Brent and OPEC references

	Constant	β_{eerd}	γ_{wti}	γ_{Brent}	γ_{opec}	$Dummy_t$
Saudi	*0.027*	*-0.026*	*0.051*	*0.054*	*0.049*	*0.02*
(P-value)	*(0.03)**	*(0.05)**	*(0.00)**	*(0.00)**	*(0.02)**	*(0.00)**
Iran	*0.020*	*-0.016*	*0.064*	*0.17*	*0.054*	*0.08*
(P-value)	*(0.10)***	*(0.09)***	*(0.00)**	*(0.00)**	*(0.02)**	*(0.00)**
Venzla	*0.026*	*-0.013*	*0.033*	*0.12*	*0.058*	*-0.06*
(P-value)	*(0.11)*	*(0.07)***	*(0.00)**	*(0.00)**	*(0.03)**	*(0.00)**
Nigeria	*0.031*	*-0.001*	*0.021*	*0.045*	*0.061*	*-0.03*
(P-value)	*(0.07)***	*(0.02)**	*(0.03)**	*(0.02)**	*(0.03)**	*(0.00)**

** Results are accepted at 5% significative levels. ** Results are accepted at 10 % significant level. The dummy variable set equal to 1 for July 2008 to September 2008 and 0 otherwise.*

We conclude that Saudi Arabia behaves as a price leader in the OPEC market structure. Moreover, Saudi Arabia has a bigger market power and perfectly competitive market structure in respect of the OPEC price reference. This result appears as a logical fact considering the geopolitical reality of all nations, relative to production and oil export scale. To inspect the robustness of the price behavior of OPEC members, we employ alternative measures of crude oil reference price indexes from different regions of the world oil market.

Table 6 illustrate the fact that when Saudi Arabia's export price is linked to another price references (as WTI and Brent), as a result, a significant but very weak relationship was obtained for rival price elasticities, which also differs from that of OPEC reference. This means that Saudi Arabia's rival-price elasticities vary from one market to another (0.049, 0.051 and 0.054 respectively for OPEC, WTI and Brent price references). Given its rival price elasticities estimates convergence for each market reference, Saudi Arabia is considered to be more disciplined and more moderate in its reactions to changes in exchange rates, when compared to other OPEC members. Furthermore, we note that Iran's statistical elasticity estimates in respect of WTI and Brent references are high (0.064 and 0.17, respectively).

4- Conclusion

In this paper we analysed the role of US exchange rate on oil price formation in the short run, and reached a main conclusion:

The paper showed that the volatility of exchange rates influences directly daily oil exports prices. We analysed the price reactions of the selected OPEC members to responses on exchange rates changes and the price changes of other members. Specifically, our empirical results suggest that, in response to change in exchange rates, exporters adjust their prices to achieve three main interrelated objectives: a) To secure a stable international purchasing power of oil revenues. b) To avoid suppressing market

demand and losing market share. c) To geopolitical reasons. Therefore, each member of OPEC is trying to exercise some degree of market power in setting its export prices.

According to our results, Saudi Arabia seems to behave quite differently in setting its prices compared to others members of OPEC, who set their own prices without being considerably influenced by other members' prices. Thus Saudi Arabia behaves as a price leader in the OPEC structure market, while behaving differently when linked to other reference market. Furthermore, Saudi Arabia proved to be more disciplined and more moderate in its reactions to changes in exchange rates than other OPEC members markets.

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