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The Analysis of Asymmetric Prices of Crude Oil and Prices of Imported Gasoline to Iran Using TAR Model

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ABSTRACT

In economic literature, there have been numerous studies in respect to the interaction between crude oil and gasoline prices. These studies examine the relationship between prices based on linear causality relationship and VECM modeling that show there is unidirectional causality from the price of crude oil to that of gasoline. This paper investigates asymmetric relationship between Iran's crude oil and imported gasoline prices for the period 1987.1-2008.12 using threshold nonlinear model. The results of estimated ECM-TAR suggest the short-run unidirectional causality from the price of crude oil toward imported gasoline price and bidirectional causality between these variables in the long-run. Furthermore the result of TAR modeling supports co-integration and symmetry between crude oil price and imported gasoline price variables in the long-run.
KEYWORDS: petroleum and oil Market, Granger Causality, Error Correction Model.

• INTRODUCTION

The first study of the relationship between the price of crude oil and those of other oil products was done just after the Persian Gulf crisis (1991-1990) when there was sever fluctuation in the price of crude oil. Many studies were conducted by economists to assess the interaction between crude oil price changes and price changes of oil products. Most of the previous researches provide econometric support for public claims that gasoline prices rise more quickly when crude oil prices are rising than they fall when crude prices are falling. Bacon (1991) finds asymmetry for the UK gasoline market. Karrenbock (1991); French (1991); Borenstein, Cameron, and Gilbert(1997); Balke, Brown, and Yücel (1998); and in a report of the General Accounting Office(1993) all find some evidence for an asymmetric response in U.S. Gasoline markets.In contrast with the other studies, Norman and Shin (1991) find symmetric response in U.S. Gasoline markets.This study re-examines the existence of threshold cointegration between crude oil prices and prices of imported gasoline to Iran for the period 1987.1-2008.12 using threshold nonlinear method. The paper proceeds as follows: Section 2 review of literature, Section 3 introduces the empirical modeling and discusses the contribution of threshold autoregressive models to the analysis. Section 4 introduces and describes the data. Section 5 discusses the empirical findings; and section 6 concludes.

• REVIEW OF LITERATURE

An unexpected and significant increase in the price of gasoline at the local level will bring out the people's voices and similarly a period of fall will bring about complaints of asymmetric changes in the cost of gasoline. Termed the "rockets and feathers" hypothesis, it is argued that an increase in the price of crude will cause the price of gasoline at the local pumps to sky rocket upwards, but as the price of crude falls, the price of gasoline responds like a falling feather, slowly floating downwards. This hypothesis has been studied in the past, using different frequency of data and a variety of modeling techniques, sometimes resulting in conflicting findings. It has been observed that one of the most visible and comprehensive studies are that of Borenstein,Cameron, and Gilbert (1997), hereafter identified as BCG. They used weekly and biweekly data from 1986 to 1992 in a series of bi-variants of error correction models to test for asymmetry in price movements between the various stages of gasoline production and distribution—from crude oil to the refinery to the retail pumps. Enough evidence of asymmetry in all segments of the market was found.

Shin (1992) however argues that the periodicity of the data, the period under observation and the model specification would probably affect the results obtained in various studies. To examine the issues that Shin raised, Balke, Brown, and Yücel (1998), hereafter identified as BBY, conducted extensive research on the work of BCG by using several different model specifications and various subsamples of weekly data from 1987 through early1996. BBY confirmed BCG's theory that volatility in prices of gasoline originates upstream (in or

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closer to markets for crude oil) rather than downstream (in or closer to final consumer markets). They also found that asymmetry is sensitive to model specification but not relevant to the period of estimation. However, BBY found evidence that asymmetry is pervasive across the stages of gasoline production and distribution. For example, BBY found retail gasoline prices initially increased sharply after the crude oil price rises and then increased more gradually. According to Peltzman (2000) shows that the asymmetric response to output prices and changes in input prices is not specific to the gasoline market, indicating that 77 consumer and 165 producer goods and output prices tend to respond faster to input price increases than to decreases.

Godby et al. (2000) are skeptical of this view. Applying a threshold regression model, they were unable to find evidence of the asymmetric adjustment in the Canadian gasolinemarket.

However, Bachmeier and Griffin (2003) using the Engle-Granger two-step approach, along with dailydata established that there was no asymmetry in the American wholesale gasoline market during 1985-1998.

In contrast Borenstein et al. (1997), claimed that gasoline prices showed asymmetry. They estimated an ECM with daily spot gasoline and semi-monthly retail gasoline pricesalong with crude oil prices as explanatory variables over the period 1985-1998 and found evidence of asymmetry in wholesale gasoline prices.

The sources of the difference in results are twofold. While, astandard Engle-Granger two-step estimation procedure was used by Bachmeier et al, Borenstein et al. (1997) used a non-standard estimation methodology. Although, the same non-standard specifications, the use of daily rather than weekly data yields were used, little evidence of price asymmetry.

Radchenko (2005) did the following a) using a Markov switching model found the degree of asymmetry is inversely related to long and short term variations of volatility in crude oil prices') and also studied the link between oil price volatility and asymmetry. His findings suggest a robust negative relationship between them for the American retail market. However if some extra variables are introduced in the model, it could influence the final outcome.

Kaufmann and Laskowski (2005) results showed when utilization rates and the level of stocks are included in the model; the asymmetry between the price of crude oil and motor gasoline vanishes based on monthly data on the American petroleum market for the period January 1986 – December 2002. The asymmetric ECM approach was used. However,using the same specification of the model, they find asymmetries in the home heating oil market.

Noel (2007) used daily data between 2/2001 and 6/2001 and confirmed the presence of an asymmetric price response: gas prices increase faster with rising crude prices and fall slower with decreases in the price of crude.

Finally,Honarvar (2009) based on monthly data for 1982-2007 in U.S found statistical evidence of "rockets and feathers" in price behavior.

In conclusion, the above studies done on individual markets consider the lower end of the market – in which the product is distributed and sold at the pumps where the relevant prices involved are a definition of the wholesale price and retail.

• EMPIRICAL MODEL

Ever since the Box and Jenkins's Time Series Analysis: Forecasting and Control (Box & Jenkins, 1970) was appeared various nonlinear extensions of the original autoregressive moving-average (ARMA) model have been proposed (Engle, 1982; Fan & Yao, 2003; Granger & Andersen, 1978; Tong, 2003). The threshold autoregressive (TAR) model is one of these extensions which have been introduced by Tong (1983) and Tong and Lim (1980). It is appropriate for processes that are characterized by regime-switching triggered by an observed threshold variable.

TAR models have several clear characteristics that can be possibly used for general judgment and identification, such as periodic cycling, up-and-down oscillations and sudden rising or fallings. It is difficult to describe these characteristics by the conventional linear ARIMA models.

Tong (1983), dealing with the structure changes of the nonlinear time series, presented the characteristics of the delay parameter and the threshold parameter (i.e. "change point"), and subsequently he described them by the switch mechanism. From that time on, the TAR model has been established completely. Basically, the TAR model comprises several linear AR models and the switch mechanism, and the switch mechanism switches AR models in accordance with the comparison of the delay output and the threshold value.

There are two other subclasses of the TAR model (Tong & Lim,

1980). If the threshold variable is an exogenous variable, the model is called an open-loop TAR system (TARSO). If two variables serve as each other's threshold variable, the model is called a closed-loop TAR system (TARSC). Besides these subclasses, a number of extensions of the basic TAR model have been proposed, which consist of including other (lagged) variables as predictors in the equation, and incorporating moving average terms (Tong, 2003). In addition, multivariate (vector) extensions of the TAR model have been developed (Koop, Pesaran, & Potter, 1996; Tsay, 1998).

Conventional residual-based tests - co-integration (Engle and Granger, 1986) examine the existence of unit root (non- stationary) hypothesis between oil prices and gasoline prices by estimating the following model:

$$PGt = \alpha_0 + \alpha_1 POt + \varepsilon_t \text{ (1)}$$

$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\varepsilon_{t-i} + \upsilon_t \text{ (2)}$$

Where PGt the gasoline is price; POt is the oil price; ε_t is a stochastic innovation term; and α_1 is the elasticity of gasoline prices with respect to crude oil prices.

Equation (1) represents the long-run relationship between oil prices and gasoline prices. Support for the hypothesis requires that $\alpha_1 > 0$, and ε_t follow a stationary process. The later condition is satisfied if the null hypothesis of unit roots $(\rho = 0)$ in the augmented Dickey and Fuller (1979) model in equation (2) is rejected in favor of the alternative that $\rho < 0$.

An implicit assumption in tests of unit roots in (2) is symmetric adjustments of the gasoline prices to positive and negative deviations from the equilibrium. If violated, this assumption results in a model mis - specification. An alternative which allows for asymmetric adjustments is the TAR and M-TAR models as in Enders and Granger (1998), Enders (2001), and Enders and Siklos (2001) . That requires estimating the following modified ADF model:

$$\Delta\varepsilon_t = \rho^+ M_t \varepsilon_{t-1} + \rho^- (1 - M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \beta i \, \Delta\varepsilon_{t-i} + u_t \text{ (3)}$$

Where M is the Heaviside indicator; and parameters ρ^+ and ρ^- allow for asymmetric autoregressive decay.

The criteria for the Heaviside indicator differ between TAR and MTAR models. In the TAR model, it is set according to the previous value of the error term relative to an optimum threshold, τ :

$$\begin{cases} M_t = 1 & \text{if } \varepsilon_{t-1} \geq \tau \\ \quad = 0 & \text{if } \varepsilon_{t-1} < \tau \end{cases} \quad (4)$$

In contrast, in the M-TAR model, it is set according to the change in the previous value of the error term relative to an optimum threshold:

$$\begin{cases} M_t = 1 & \text{if } \Delta\varepsilon_{t-1} \geq \tau \\ \quad = 0 & \text{if } \Delta\varepsilon_{t-1} < \tau \end{cases} \quad (4)$$

Here is set endogenously using Chan (1993) method. As is clear from (3) and (4), the degree of autoregressive decay in the TAR model depends on the state of the equilibrium error.

The test procedure consists of three steps: The first step involves estimating the TAR and M-TAR models and testing for co integration. The null hypothesis of no-co integration $(H_O : \rho^+ = \rho^- = 0)$ is examined by comparing the actual values of the test statistics with their corresponding critical values (table 2). If the null hypothesis of no-co integration is rejected, then one Proceeds to the second step, which involves testing the null hypothesis of symmetry $(H_O : \rho^+ = \rho^-)$. (Table 3)

If the null hypothesis of symmetry is rejected and then there is evidence of relatively more decay in response to positive deviations from equilibrium. The third step involves estimation of the asymmetric error-correction model and tests of short-run and long-run causality. The error-correction model consists of two equations as follow:

$$\Delta PG_t = \delta_1^+ M_t \varepsilon_{t-1} + \delta_1^- (1 - M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta PG_{t-i} + \sum_{i=1}^{k} \varphi_i \Delta PO_{t-i} + u_t \text{ (5)}$$

$$\Delta PO_t = \delta_2^+ M_t \varepsilon_{t-1} + \delta_2^- (1 - M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \gamma_i^* \Delta PO_{t-i} + \sum_{i=1}^{k} \varphi_i^* \Delta PG_{t-i} + u_t^* \text{ (6)}$$

The null hypothesis of long-run non-causality from PG to PO is tested by examining the joint Significance of δ_1^+ and δ_1^- in (5). The possibility of asymmetric long-run causality is examined by individual inspection of δ_1^+ and δ_1^- . Also, null hypothesis of short-run causality from PO_t to PG_t are examined by testing for the joint significance of $\left(i=1,\ldots,k\right)$.Related tests of non-causality from PG_t to PO_t were carried out using equation (6). Finally, in the absence of co integration, tests of short-run non-causality were carried out in a VAR model with first differenced data.

• DATA

Gasoline as one of the most important energies in Iran carries a major share of total consumption of energy products. Prior to 1977, gasoline production capacity was almost equal to domestic consumption. But after the Revolution because of the war, the damage to the country's major refineries that produce gasoline led to declination of production which was not compatible with the country's gasoline consumption and for this reason the government was forced to import gasoline since 1982.Thisanalysis is based on monthly data of light crude oil price and imported gasoline prices for Iran over the period 1982:5-2008:12.

Figure 1 compare crude oil as well as gasoline prices for Iran during the sample period. The surplus supply in the world oil market brought about the decrease and adjustment in the price of oil in the beginning of 1982. The decisions made by OPEC to control oil production and prices in March 1983 trigger an unprecedented price reduction. Decrease in oil prices stopped and increased suddenly because of Iraq's invasion to Kuwait in 1990. After the Persian Gulf crisis between 1991-97, there was a relative adjustment in the prices of oil, which was because of increased production of Kuwait, Iraq's probability to enter the market and also increased level of oil reserves in USA. But following the 1998 crisis, South Asia was encountered with relative huge reduction of oil prices. The oil price started to rise but decreased in 2001 due to the September 11 attack. After that the price began to rise again until the United States attack on Iraq, until 2007.The following Factors reinforced the hike of gasoline prices in 2007:

1) reports of China's economic growth data which indicated the improve of economy and increasing oil demand in this country.
2) Reduction of light crude oil supply in West Africa
3) earthquake in Japan which suspended the world's largest nuclear powerhouse.

The variations in the gasoline price as one of the most crucial products was affected by the international changes of oil price, the trend of changes in imported gasoline price are similar to trend of changes of oil price in Iran.

• EMPIRICAL RESULTS

Table 1 report the results of tests of unit roots in gasoline prices and crude oil prices using Augmented Dickey-Fuller test. All test statistics overwhelmingly fail to reject the null hypothesis of unit roots in levels. Table 2 report the results of tests of co- integration between gasoline prices and crude oil Prices under TAR adjustments. Finally, we report tests of non-causality between crude oil prices and gasoline prices. For the Iran with co -integrated relations, we report the estimated asymmetric error-correction parameters along with F-test of long-run and short-run non-causality. The main findings are reported in Table 3 which are the results of the estimate ECM-TAR suggest the short-run unidirectional causality from the price of crude oil toward imported gasoline price and the bidirectional causality between these variables in the long-run.

Also the results of TAR models support co- integration and asymmetry between crude oil price and imported gasoline price.

Conclusion

This study investigated asymmetry relationship between Iran crude oil prices and import gasoline prices for the period 1987:1-2008:12 using threshold nonlinear series method. The difference between this study and others is importance of having threshold in relation between crude oil and import gasoline price. The results of estimating of long-run relationship and error correction model using a threshold can be summarized as follows:

1- In the first part the stationary model variables were examined then by using TAR model Co-integration and symmetry between the crude oil prices and imported gasoline prices in the long-run are confirmed.
2- According to the results of the estimating of ECM-TAR models, there is unidirectional short run causality from crude oil price to imported gasoline price, whereas there is bidirectional causality between them in long-run.

REFERENCES

Bachmeier, Lance T. And James M. Griffin, "New Evidence on Asymmetric Gasoline Price Differences," The Review of Economics and Statistics, August 2003, 772-776.

Bacon, Robert W., “Rockets and Feathers: The Asymmetric Speed of Adjustment of U.K. Retail Gasoline Prices to Cost Changes,” Energy Economics, July 1991, 211-218.

Balke, Nathan S., Stephen P.A. Brown, and Mine K. Yücel, “Crude Oil and Gasoline Prices: An Asymmetric Relationship?” Federal Reserve Bank of Dallas Economic Review, First Quarter 1998, 2-11.

Borenstein, Severin, A.Colin Cameron, and Richard Gilbert, “Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes,” The Quarterly Journal of Economics, February 1997, 305-339.

Chan, K. S. 1993. “Consistency and Limiting Distributions of the Least Squares Estimators of a Threshold Autoregressive Model,” *Annals of Statistics* 21, 520-533

Dickey, David. A., and Fuller, W.A.1979. Distribution of the Estimators of Autoregressive Time Series with a Unit Roo,Journal of the American Statistical Association74, 427-31

Enders, Walter., and Granger, C. W. J. 1998. “Unit-Root Tests and Asymmetric Adjustment with an Example Using the Term Structure of Interest Rates,” *Journal of Business and Economic Statistics* 16(3), 304-311

Engle, Robert. F. and Granger, C.W.J.1987. “Cointegration and Error Correction: Representation,Estimation, and Testing.” *Econometrica*55, 251-276

Enders, Walter.And P.L. Siklos, P.L. 2001. “Cointegration and Threshold Adjustment,” *Journal of Business and Economic Statistics* 19(2), 166-176

Enders, Walter. 2001. “Improved Critical Values for the Enders-Granger Unit-Root Test,” *Applied Economics Letters* 8, 257-261

French, Mark (1991), “Asymmetry in Gasoline Price Changes” (Washington, D.C.: Board of Governors of the Federal Reserve System, August, Draft paper).

Godby, Bob, Anastasia Lintner, ThanasisStengos, and Bo Wandschneider, “Testing for Asymmetric Pricing in the Canadian Retail Gasoline Market,” Energy Economics, June 2000, 349-368.

GAO/RCED-91-17 (Washington, D.C.: Government Printing Office, March).

Godby, Bob, Anastasia Lintner, ThanasisStengos, and Bo Wandschneider, “Testing for Asymmetric Pricing in the Canadian Retail Gasoline Market,” Energy Economics, June 2000, 349-368.

Honarvar, Afshin (2009) with monthly data for 1982-2007 in U.S. find statistical evidence of “rockets and feathers” price behavior.

Honarvar, Afshin, “Asymmetry in Retail Gasoline and Crude Oil Price Movements in the United States: An Application of Hidden Cointegration Technique,” Energy Economics, May 2009, 395-402

Johnson, Ronald. N. (2002) “Search costs, lags and prices at the pump” Review of Industrial Organization, Vol. 20. pp. 33-50.

Karrenbrock, Jeffrey, “The Behavior of Retail Gasoline Prices: Symmetric or Not?” Federal Reserve Bank of St.Louis Review, July/August 1991, 19-29.

Kaufmann, Robert. K. and Laskowski, Ch.(2005) “Causes for an asymmetric relation between the price of crude oil and refined petroleum products” Energy Policy, Vol.33 (12).Pp.1587-1596.

Mohammadi, Hassan and Jahan-Parvar, Mohammad R.2009.“Oil Prices and Exchange Rates in Oil-Exporting Countries: Evidence fromTAR and M-TAR Models”, MPRA Paper No.14578

Noel, Michael, (2007) use daily data between 2/2001 and 6/2001 and confirm the presence of an asymmetric price response: gas prices increase faster with rising crude prices and fall slower with decreases in the price of crude.

Noel, Michael, “Do Gasoline Prices Respond Asymmetrically to Cost Shocks? The Cofounding Effect of Edgeworth Cycles,” Unpublished working paper, Department Economics, University of California San Diego, http://respositories.cdlib.org/ucsdecon/2007-04.

Peltzman, Sam, “Prices Rise Faster than They Fall,” Journal of Political Economy, June 2000, 466-502.

Radchenko, Stanislav, “Oil Price Volatility and the Asymmetric Response of Gasoline Prices to Oil Price Increases and Decreases,” Energy Economics, September 2005, 708-730.

Shin, David (1992), “Do Product Prices Respond Symmetrically to Changes in Crude Oil Prices,” American Petroleum Institute Research Study no.068 (Washington,D.C.,December).U.S. General Accounting Office (1993), “Analysis of The Pricing of Crude Oil and Petroleum Products,

Appendix 1

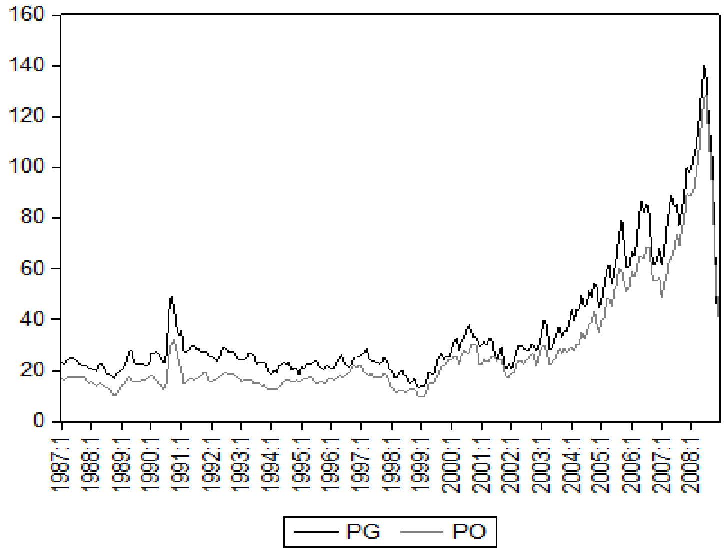

Figure 1: The Prices of Crude Oil and gasoline

Appendix 2

Table 1: Test of unit roots for crude oil price and imported gasoline price

Variable	Intercept	Intercept and trend
P_G	-	-3.496*
P_O	.3.004*	-

Notes: 1.$P_G$and$P_o$stand for gasoline prices and crude oil prices respectively.
2. Based lag-lengths are determined by SIC in brackets.
3. Significance at 5 percent level is denoted by *.

Table 2: Test of co-integration and asymmetry

$F(\rho^{-} =^{+}=0)$	H_0
16.02350 (0.000)*	$\rho^{-} = \rho^{+}=0$

*Numbers in brackets are significance levels.

Table 3: Test of asymmetry

$F(\rho^{-} = \rho^{+})$	H_0
0.733922 (0.3923)*	$\rho^{-} = \rho^{+}$

*Numbers in brackets are significance levels.

Table 4: Tests of Long-Run and Short-Run Causality

$H_0 : PO \neq> PG$				$H_0 : PG \neq> PO$			
δ_1^+	δ_1^-	$F\left(\delta_1^+ = \delta_1^- = 0\right)$	$F\left(\varphi_i = 0\right)$	δ_1^+	δ_1^-	$F\left(\delta_1^+ = \delta_1^- = 0\right)$	$F\left(\varphi_i = 0\right)$
-0.23987 (0.09231)	0.08384 (0.1038)	3.402389 [0.0345]	23.6821 [0.0000]	-0.02663 (0.0719)	0.20792 (0.0809)	3.538782 [0.0302]	0.058826 [0.8085]

Notes: Numbers in parentheses are estimated standard errors. Numbers in brackets are significance levels. Significant at 5% level is denoted by '*'. $H_0 : PO \neq> PG$ Refers to null of no-causality from crude oil prices to gasoline prices; δ_1^+ and δ_1^- are equilibrium error adjustment parameters; $F\left(\delta_1^+ = \delta_1^- = 0\right)$ and $F\left(\varphi_i = 0\right)$ are F-statistics of long-run and short-run non-causality from crude oil prices to gasoline prices