

Relation between China's gasoline prices and international crude oil prices

Chaoqing Yuan^{a,b}, Yingjie Yang^b, Sifeng Liu^{a,c}, Zhigeng Fang^{a,c}

a College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, 211106, China

b Center for Computational Intelligence, De Montfort University, Leicester, LE1 9BH, UK

c Research Center for Scientific Development, Nanjing University of Aeronautics and Astronautics, Nanjing, 211106, China

Corresponding Author: Chaoqing Yuan, College of Economics and Management, Nanjing University of Aeronautics and Astronautics, 150 Mailbox, Jiangning District, Nanjing, China, 210016; Telephone: +86 13851878782; Email: yuanchaoqing@126.com;

Abstract

China's gasoline prices are **still** regulated by government although China's refined oil pricing mechanism has been reformed for many times. In this paper, proximity and similarity between China's gasoline prices and Brent crude oil prices **are** calculated in the different stages with China's refined oil pricing mechanism reforming, by using daily data and grey relational analysis method. The results show that there have undergone great changes of the similarity and proximity between China's gasoline prices and international crude oil prices.

Keywords: Gasoline price; Similarity; Proximity; Grey Relation; Regulation

1. Introduction

The last decade witnessed the continuous reform of China's refined oil pricing mechanism although China's gasoline prices are still regulated by **the** government. Before 1998, Chinese Gasoline prices were relatively low; and the prices were decided by the government and adjusted after a long time. In 1998, with the reorganization of China National Petroleum Corporation (CNPC) and Sinopec, came the market-oriented reforms of China's refined oil pricing mechanism. On June 3, 1998, the former State Planning Commission issued "the reform program of crude oil and refined oil prices", providing that the government referential price for gasoline and diesel oil would be implemented, while CNPC and Sinopec can determine the retail prices with an increase

or a decrease of less than 5%. In June 2000, the linkage between China's domestic refined oil price adjustment and international market price changes was established, but only Singapore gasoline prices were selected as reference at that time. In November 2001, China's refined oil prices would be adjusted according to the changes of Singapore, Rotterdam and New York gasoline prices: when these oil prices fluctuated in the range of 5%-8%, China's gasoline would be kept unchanged; if they changed over this range, the National Development and Reform Commission would [adjust](#) the benchmark prices of China's gasoline. On March 26, 2006, the National Development and Reform Commission adjusted the refined oil pricing mechanism, and China's gasoline prices [were](#) linked to international crude oil prices [because](#) ex-factory prices were included. The government would set benchmark prices for the domestic refined oil. As for the retail prices, based on ex-factory prices and with the corresponding costs, companies are allowed to determine the retail prices with an increase or a decrease within 8%. On January 1, 2009, "refined oil price tax reform program" was implemented. The international crude oil prices, domestic average processing costs, taxes, and a reasonable profit [were](#) taken into consideration in the gasoline prices. And the gasoline consumption tax rose from 0.2 RMB per liter to 1 RMB per liter, and diesel oil consumption tax rose from 0.1 RMB per liter to 0.8 RMB per liter. And the [retailers](#) just could determine the gasoline or diesel retail prices with only an additional adjustment of no [more](#) than 4%. On May 7, 2009, The "oil price control measures" released by the National Development and Reform Commission, determined that when the price increase or decrease of international crude oil was more than 4% for continuous 22 workdays, the domestic refined oil prices could be adjusted. When the international crude oil prices were below U.S. dollars 80 per barrel, the refined oil

prices would be calculated according to the normal processing margins. When above U.S. dollars 80 per barrel, the refined oil prices would be calculated by reducing processing margins until [with](#) a zero profit. When above U.S. dollars 130 per barrel, appropriate fiscal policies should be taken to ensure the production and supply of refined oil [in order to](#) maintain or increase less gasoline and diesel oil prices. On March 27, 2013, the National Development and Reform Commission adjusted the refined oil pricing mechanism again. Under the reformed refined oil pricing mechanism, the adjustment period is 10 workdays; adjustment would be started up when the anchored oil's fluctuation reaches 50 RMB per ton in continuous 10 workdays.

After China's refined oil pricing mechanism reformed, the government sets the benchmark prices not the detailed retail prices; china's refined oil prices can be adjusted more frequently with a shorter adjustment period; and now china's refined oil prices directly link to international crude oil prices.

[At the same time](#), the international oil prices increased dramatically. In 2003, the Brent crude oil prices were about 30 U.S. dollars per barrel, while in 2013 the prices are more than 100 U.S. dollars. With the soaring international oil prices, China's domestic gasoline prices have been increasing fast. In this case, it is difficult to distinguish whether it is a change in pricing mechanism or the rising international oil prices that has led to [the](#) rising of China's gasoline prices. What's more, the notion that domestic gasoline prices react quickly and more to international crude oil price increases while slowly and less to international crude oil price reductions is largely accepted among consumers, although China's refined oil pricing mechanism implies that china's gasoline prices are highly related to international crude oil prices. [And the relation between China's gasoline prices and international crude oil prices reflects the gasoline](#)

price management ability of the relevant government departments. The relation also can provide some basis for the government to reform China's refined oil pricing mechanism and to set the gasoline prices. In addition, crude oil is the most important cost of refining enterprises. If the changes of China's gasoline prices and those of international crude oil prices are consistent, the refining enterprises can pass the risk of fluctuations in crude oil prices to the vendors and the consumers; otherwise, the refining enterprises should bear the risk which can bring them income or loss. The relation between China's gasoline prices and international crude oil prices is very important for the refining enterprises to control the risk. Thus, the relation between China's Gasoline prices and international crude oil prices is very valuable to be studied.

The asymmetric impact of international crude oil prices on refined oil prices, namely the different response to price increases and decreases, have long been caught attention. Such studies began with the UK market. And asymmetry in UK market is found (Bacon, 1991; Manning,1991; Reilly and Witt, 1998; Galeotti et al, 2003; Margherita Grasso, 2007). More studies about the US oil price asymmetry have been made. Some of them didn't find asymmetry in US market (Karrenbrock, 1991; Shin,1994; Balke et al., 1998; Bachmeier and Griffin , 2003), while the others find that (Duffy-Deno, 1996; Borenstein et al.,1997; Johnson,2002; Kaufmann and Laskowski, 2005). There are also studies about some other countries such as Canada, Philippine, China and so on. And some of them didn't find evidence of asymmetric pricing behavior (Godby et al. ,2000;) while the others did (Salas,2002; Bin Tong et al., 2013; LI Zhiguo and GUO Jinggang, 2013). As for oil prices asymmetry, conclusions vary widely with different countries or markets, research methods and sets of data. Countries like US, the UK are mostly studied. And time series analysis such as co-integration and

ECM are applied. Monthly data, weekly data and daily data are all used. And these studies have mainly focused on the reaction time of gasoline price changes rather than on the fluctuation ranges of price changes, that is gasoline prices react quickly or slowly to crude oil prices.

2. Method and Material

2.1 Method

Different from the US, UK and other countries, China's refined oil prices are not entirely determined by the market and still regulated by government, although China's refined oil pricing mechanism has been reformed for several times. The government's regulation will destroy the random or stochastic distribution rules of the data which were strictly required by time series analysis. For example, even with the latest China's refined oil pricing mechanism, the anchored oil prices are required to meet rising or declining 50 RMB per ton in 10 sequential workdays before an adjustment of China's gasoline prices. In most cases, when international oil prices change, China's gasoline prices remain unchanged. In such cases, it may be hard to reveal the true relationship between the China's gasoline prices and international crude oil prices with time series analysis. And it is proved by the results of the unit root tests. Year 2003-2013 is divided into five stages according to the reform of China's refined oil pricing mechanism mentioned in section 1, as shown in table 1. In all the periods, the variables, including international oil prices and China's gasoline prices, will be tested for stationarity by ADF tests and PP tests. The results of these tests are shown in Table 1, in levels and after one differentiation (prefixed by Δ). It is shown that international crude oil prices and China's gasoline prices are co-integrated in the 2nd and 4th period, while not co-integrated in the 1st, 3rd, and 5th period.

Table 1 ADF and PP tests for stationary of the Variables

Period	Variables	Methods			
		ADF		PP	
		t-Statistic	Prob	t-Statistic	Prob
1 st : 2003.1.1-2006.3.24	COP_1	-3.656305 ^b	0.0260	-3.640797 ^b	0.0271
	GP_1	-2.813129	0.1929	-2.823836	0.1891
	ΔGP_1	-27.00305 ^a	0.0000	-26.98581 ^a	0.0000
2 nd : 2004.3.27-2008.12.31	COP_2	-0.505261	0.8847	-0.601373	0.8675
	ΔCOP_2	-28.88488 ^a	0.0000	-28.96651 ^a	0.0000
	GP_2	-1.953969	0.6247	-1.970206	0.6159
	ΔGP_2	-25.35015 ^a	0.0000	-25.35015 ^a	0.0000
3 rd : 2009.1.5-2009.5.6	COP_3	-3.732607 ^b	0.0259	-3.668917 ^b	0.0306
	GP_3	-2.221985	0.4707	-2.221985	0.4707
	ΔGP_3	-8.701980 ^a	0.0000	-8.701974 ^a	0.0000
4 th : 2009.5.7-2013.3.26	COP_4	-2.364017	0.1524	-2.331471	0.1623
	ΔCOP_4	-31.19567 ^a	0.0000	-31.19601 ^a	0.0000
	GP_4	-2.952027	0.1466	-2.954123	0.1460
	ΔGP_4	-30.44744 ^a	0.0000	-30.44789 ^a	0.0000
5 th : 2013.3.27-2013.9.12	COP_5	-3.245202 ^c	0.0812	-3.266613 ^c	0.0774
	GP_5	-1.185465	0.6789	-1.227230	0.6670
	ΔGP_5	-10.35285 ^a	0.0000	-10.35285 ^a	0.0000

Note: COP means Crude Oil Price; GP means Gasoline Price; one differentiation is prefixed by Δ .

aDenotes significance at the 1% level.

bDenotes significance at the 5% level.

c Denotes significance at the 10% level.

And China's refined oil pricing mechanism is not transparent, because it only sets the price adjustment conditions, but how to adjust is not specified. This means that China's refined oil pricing has strong grey characteristics. The grey incidence models based on similarity and nearness provide a workable solution for studying the relationship between China's gasoline prices and international crude oil prices, which include the similitude degree of grey relation model and the close degree of grey relation model. The similitude degree of grey relation model is used to measure the similar degree of geometry between sequence X_i and sequence X_j ; the close degree of grey relation model is used to measure the close degree in space between sequence

X_i and sequence X_j (Liu S. F. et al, 2011). And the grey incidence models based on similarity and nearness can reflect the relation of fluctuation ranges between sequences, not measure time response of the sequence (time series), because of the basis on shapes of the sequences.

The close degree of grey relation model of X_i and X_j , is defined as below:

$$\rho_{ij} = \frac{1}{1 + |S_i - S_j|} \quad (1)$$

And the similitude degree of grey relation model of X_i and X_j , is defined as below:

$$\varepsilon_{ij} = \frac{1}{1 + |s_i - s_j|} \quad (2)$$

Where $S_i, S_j, s_i, s_j, s_i - s_j, S_i - S_j$ were defined respectively (Liu S. F. et al, 2011).

However equation (1) and equation (2) ignore the real background of the study issue, which will lead to the failure of reflecting the relation between two variables changes in some cases. For example, when it comes to height comparison, it is a very common phenomenon that adult heights vary 5 cm; but for three year old children, 5 cm difference in height is a very big gap. So the real background of study issue should be reflected in the equations. And the models should be improved further as follows.

Definition 1 Assume sequence X_i and sequence X_j have the same length, then call

$$\varepsilon_{ij} = 1 - \frac{2|S_i - S_j|}{|S_i| + |S_j|} \quad (3)$$

the proximity of X_i and X_j .

Definition 2 Assume sequence X_i and sequence X_j have the same length, then call

$$\varepsilon'_{ij} = 1 - \frac{2|s_i - s_j|}{|s_i| + |s_j|} \quad (4)$$

the similarity of X_i and X_j .

In equation (3) and equation (4), $|S_i - S_j|$ and $|s_i - s_j|$ represent the difference between system behavior sequences; while $|S_i| + |S_j|$ 、 $|s_i| + |s_j|$ represent the real background of study issue. Correspondingly, the proximity of X_i and X_j reflects the closeness of the two sequences, and the similarity of X_i and X_j reflects the similarity of the two sequences.

2.2 Data

China's gasoline retail prices are not available because of lack of authorized investigation. So the ex-factory price of No. 93 gasoline is used because No. 93 gasoline is most consumed in China. According to the National Development and Reform Commission's reined oil price adjustment notice, related materials from the oil companies and some news reports, the China's gasoline prices sequences are obtained. Overall, there are cumulative 48 adjustments from January 1, 2003 to September 12, 2013. in recent years, the adjustment frequency is relatively high.

Before calculation, the Brent crude oil prices are converted into those of RMB per liter. And then, China's gasoline prices have same meaning, unit and magnitude with Brent crude oil prices. The sequences of China's gasoline price and Brent crude oil price can be used to calculate similarity and proximity. Excluding holidays without price or exchange rate data, a total of 2617 valid data is obtained, as shown in Fig. 1. Fig. 1 shows that the relations between the China's gasoline prices and Brent crude oil prices are not the same in the different periods.

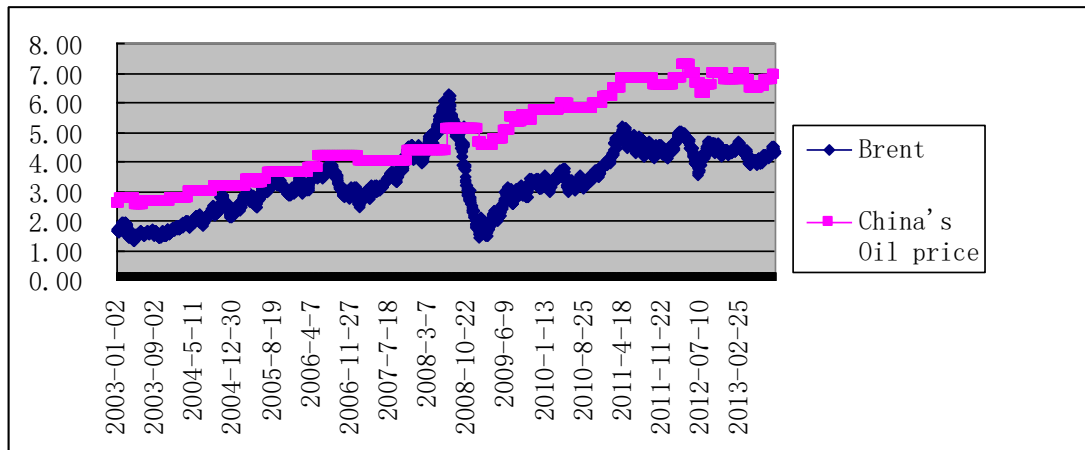


Fig. 1 China's gasoline prices and Brent crude oil prices from 2003 to 2013

3. Results and Discussion

Taking calculation method similar to that Liu S.F. et al. (2011) proposed , S_i , S_j , $S_i - S_j$, s_i , s_j , and $s_i - s_j$ are computed, then similarity and proximity of China's gasoline prices and Brent crude oil prices in the five stages are calculated according to Equation (3) and Equation (4), as shown in table 2:

Table 2 The proximity and similarity of China's gasoline price and Brent crude oil price in different periods

Period	Similarity	Sign of $s_i - s_j$	Proximity
2003.1.1-2006.3.24	0.685038	-	0.722711
2004.3.27-2008.12.31	0.981229	-	0.864281
2009.1.5-2009.5.6	0.228211	+	0.189618 0.357428 ^a
2009.5.7-2013.3.26	0.553436	+	0.547787 0.679337 ^a
2013.3.27-2013.9.12	0.653118	+	0.537712 0.662196 ^a

^a the proximity excluding the influence of gasoline consumption tax

In the first two stages, the Brent crude oil prices and China's gasoline prices both rose, and $s_i - s_j < 0$, indicating that the increase of China's gasoline prices is less than that of Brent crude oil prices. The similarity in the first stage is 0.685038, indicating that

the increase of China's gasoline prices is rather less than that of Brent crude oil prices in the first stage. The similarity in the second stage is 0.981229, almost equal to 1. Although China's gasoline prices grew stably in this period, with the Brent crude oil prices shocking, their overall changes are very close.

In the third stage, there is a declining trend in Brent crude oil prices, and $s_i - s_j > 0$, indicating that the decline of China's gasoline prices is less than that of Brent crude oil prices. In fact, the Brent crude oil prices declined in this stage while the China's gasoline prices even rose slightly, which leads to a small similarity of them, 0.228211.

In the last two stages, Brent crude oil prices have shown a rising trend, and $s_i - s_j > 0$ indicating that the increase of China's gasoline prices is more than that of Brent crude oil prices. In the fifth stage, the similarity is 0.653118, a little bit larger than 0.553436 in the fourth stage, which means that in the fifth stage China's gasoline prices changed more consistently with Brent crude oil than the fourth stage.

If similarity degree is less than 1, it indicates that the changes of China's gasoline prices and Brent crude oil prices are inconsistent, which will **certainly** change the proximity. In the first two stages, the Brent crude oil prices rose, while the similar degree is less than 1 and $s_i - s_j < 0$, **which narrows down the gap between them and intensifies the proximity**. But after 2009, **the similarity actually shows** that when international oil prices declined, there was only a small decline in China's gasoline oil prices, and when international oil prices rose, there was a larger rising in China's gasoline prices, which **caused** a significant decline in the proximity of China's gasoline prices and Brent crude oil prices.

From these results, some important findings are obtained as follows:

First, the Brent crude oil prices change according to the international market situation, while China's gasoline prices change under the regulation of the government. So the changes between them are inconsistent, which causes the different similarity and proximity of Brent crude oil prices and China's gasoline prices in the different periods.

Second, the relation between China's gasoline prices and Brent crude oil prices are influenced by China's refined oil pricing mechanism. Before 2009, China's gasoline prices raised less than the Brent crude oil prices; But after 2009, this situation was reversed. As a result, even excluding the influence of refined oil consumption tax, the proximity between the China's gasoline prices and the Brent crude oil prices has been greatly reduced. Chinese consumers' perceptions to the China's refined oil prices indeed reflect the inconsistency between China's gasoline prices changes and international crude oil prices changes.

Third, the similarity and proximity of Brent crude oil prices and China's gasoline prices vary, indicating that refining enterprises have to bear not only the price fluctuation risk of international crude oil but also the policy risk.

Forth, the government can set gasoline prices so well that changes of China's gasoline prices and those of international crude oil prices are very consistent sometimes, for example, the similarity in the second stage is 0.981229. But more often, the government can not do it well.

4. Conclusions

In general, this paper studied the relation between China's gasoline prices and international crude oil prices. The contributions of the paper include: first, China's refined oil pricing mechanism reform is summarized; Second, grey relational analysis, a new method, is introduced to study the relation between gasoline prices and crude oil

prices when time series analysis is not applicable because of the government's regulation; third, the relation between China's gasoline prices and international crude oil prices are analyzed.

Through the similarity and proximity calculated in section 3, the relation between China's gasoline prices and Brent crude oil prices has been revealed. Overall, the relation is inconsistency, which is not entirely unreasonable. In the early periods, the China's gasoline prices were lower than the Brent crude oil prices sometimes, which is clearly unreasonable and not normal. In this situation the government actually supplied refined oil subsidies. However, almost all countries in the world have taxes on refined oil instead of giving subsidies. After 2009, the proximity of the China's gasoline prices and Brent crude oil prices reduced. To some extent, it is resulted from the reduction or even canceling of government subsidies and a levy of refined oil consumption tax.

And the results show that government should not always set reasonable prices for gasoline. For example in the latter two phases, the similarity between China's gasoline prices and Brent crude oil prices is not large and China's gasoline prices rose more than the international crude oil prices. But oil market competition is highly insufficient in China. If the prices would not regulated by government while formed by the market, asymmetry between china's gasoline prices and international crude oil prices will come because of market structure as those mentioned by Michael Kendix & W.D.Walls. (2010) and Oladunjoye O. (2008). So the refined oil pricing mechanism should be further studied and reformed. More companies should be permitted to enter the oil industry at first, which will form full market competition, and then it is the time that government's regulation will be replaced by market power.

Acknowledgement

Thanks for the constructive suggestions of the anonymous referees. This work was supported by Leverhulme Trust, National Natural Science Foundation of China (71173106, 71271226, 71273131), China Postdoctoral Foundation (2012M511277), China Humanities and Social Science Fund of Ministry of Education (12YJC639276), the Fundamental Research Funds for the Central Universities (56XAA13079, 56XZA12071), Major projects for Jiangsu University Philosophy and Social Science Key Research Base (2012JDXM003), Jiangsu Natural Science Fund (BK20130785), Doctoral Fund of China Ministry of Education (20133218120036) .

Reference

Bachmeier L.J., Griffin J.M., 2003. New evidence on asymmetric gasoline price responses. *Review of Economics and Statistics*. 85. 772–776.

Bacon, R.W., 1991. Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes. *Energy economics*. 13. 211–218.

Balke N.S., Brown S.P.A., Yucel, M.K. (1998). Crude oil and gasoline prices: an asymmetric relationship? *Federal Reserve Bank of Dallas Economic Review*, First Quarter, 2–11.

Borenstein S., Cameron A.C., Gilbert R., 1997. Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics*, 112, 305–339.

Duffy-Deno K.T. (1996). Retail price asymmetries in local gasoline markets. *Energy Economics*. 18 .81–92.

Godby R.M., Lintner A., Stengos T., Wandschneider B. (2000). Testing for asymmetric pricing in the Canadian retail gasoline market. *Energy Economics*, 22, 349–368.

- Galeotti, M., Lanza, A., Manera, M. (2003). Rockets and feathers revisited: an international comparison on European gasoline markets. *Energy Economics*, 25, 175–190.
- Johnson R.N. (2002). Search costs, lags and prices at the pump. *Review of Industrial Organization*, 20, 33–50.
- Karrenbrock, J.D. (1991). The behaviour of retail gasoline prices: symmetric or not? *Federal Reserve Bank of St. Louis Review*, 73, 19–29.
- Kaufmann R.K., Laskowski C. (2005). Causes for an asymmetric relation between the price of crude oil and refined petroleum products. *Energy Policy*, 33,1587–1596.
- LI Z.G.,GUO J.G. (2013). Asymmetry between Gasoline and Crude Oil Prices in China Based on Asymmetric ECM Modeling. *Resource Science*, 35, 66-73.(In Chinese)
- Liu S.F., Xie N.M., Forrest J. (2011). Novel models of grey relational analysis based on visual angle of similarity and nearness, *Grey Systems: Theory and Application*, 1. 8-18.
- Manning, D.N. (1991). Petrol prices, oil price rises and oil price falls: some evidence for the UK since 1972. *Applied Economics*. 23. 1535–1541.
- Margherita G., Matteo M. (2007). Asymmetric error correction models for the oil–gasoline price relationship. *Energy Policy*, 35,156–177.
- Michael Kendix, W.D.Walls. (2010). Oil industry consolidation and refined product prices: Evidence from US wholesale gasoline terminals. *Energy Policy*. 38 , 3498–3507.
- Oladunjoye O. (2008). Market structure and price adjustment in the US wholesale gasoline markets. *Energy Economics*. 30(3), 937-961.
- Shin D. (1994). Do product prices respond symmetrically to changes in crude oil prices? *OPEC Review*. 18, 137–157.
- Reilly B., Witt, R., 1998. Petrol price asymmetries revisited. *Energy Economics*, 20,

297–308.

Salas J.M.I.S. (2002). Asymmetric price adjustments and a deregulated gasoline market.

Philippine Review of Economics, 9, 38–71.

Tong. B., Wu C., Zhou C.(2013). Modeling the co-movements between crude oil and refined petroleum markets. *Energy Economics*, 40, 2013, 882–897.