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Is Japanese Retail Industrial Fuel Oil Price Stickier Downwards Than Upwards in Response to Oil Cost Shocks?

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Abstract
This paper examined the Japanese industrial fuel oil market for evidence of asymmetric price adjustment and rent-seeking following changes in crude oil prices. The study used the nonlinear autoregressive distributed lag (NARDL) modeling framework and monthly time series data for the period January 2005 to December 2015. The results indicate that Japanese industrial fuel oil market is fraught with sluggish speed of adjustment, which is typical of markets witnessing uncompetitive pricing and other irregular behaviours by retail firms. The results further indicate that Japanese industrial fuel oil market is bedeviled by the problem of short-run asymmetric price transmission from crude oil market, which is consistent with the rockets and fathers effect. However, the results did not show any evidence of rent-seeking since the observed short-run asymmetry is not obscured at pump. In view of the prevailing problem of rockets and feathers effect, the paper supports policies that will encourage continuous monitoring of the market in order to preserve competition and the overall social welfare.
Keywords: Rockets and Feathers effect; Rent-seeking; Asymmetric Price Adjustment; Nonlinear ARDL model; Japan
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1. Introduction

Japan is primarily dependent on the Middle East for its crude oil imports as 83% of Japanese crude oil imports originated from the Middle East in 2012. Saudi Arabia is the largest supplier of oil to Japan. Japan is one of the largest net importers of fossil fuels in the world as of 2012. Oil remains its largest source of energy. As of 2012, Japan was the third largest net importer of crude oil and petroleum products in the world after the United States and China. Hence, the ups and downs in the crude oil market is expected to impact on the prices of retail petroleum products in Japan, particularly the retail price of industrial fuel oil (henceforth fuel oil), since crude oil is the main input material in the production of fuel oil and other petroleum products. Thus, economic expectation is that for an oil-deficient economy like Japan, the retail price of fuel oil should move in tandem with the variations in the international oil market. However, there are concerns in the global economy that the recent persistent tumbling in crude oil prices which started in the last quarter of 2013 may not be reflecting at the pumps. Specifically, the concern is that the retail prices of petroleum products (such as fuel oil) may respond asymmetrically to the changes in crude oil prices.

To better understand the concerns in the foregoing paragraph, let us consider the monthly oil price statistics documented by the International Energy Agency (IEA) for eight industrialized economies, including Japan (http://www.iea.org/statistics/topics/pricesandtaxes/). This statistics indicate that while the average cost of imported crude oil in Japan declined from 113.27 US dollars per barrel in January 2014 to 110.31 US dollar per barrel in June 2014, the retail pump price of industrial fuel oil increased from 94,710 Yen per metric ton to 97,956 Yen per metric ton. This is an asymmetric pattern of price transmission from crude oil market to industrial fuel oil, suggesting that the retail price in this market may be stickier downwards than upwards in response to changes in crude oil costs. Indeed, such asymmetric pattern of retail price adjustment has become a major feature of the global energy sector. For instance, in the UK, the concern that the gasoline market may have been witnessing non competitive pricing and collusive behavior (as a result of such asymmetric pattern of price transmission) was the subject of three main investigations by the Monopolies and Mergers Commission (MMC) between1965 and 1990 (MMC, 1965, 1979, 1990). The MMC concluded that there was evidence of asymmetric response of gasoline price to changes in crude oil cost. Specifically, the MMC explained that when faced with rising input costs, sellers rapidly adjust prices upwards; but when they are faced with decreasing costs, they adjust prices downwards very sluggishly. The MMC termed this pattern of asymmetric adjustment 'rockets and feathers'. The concern in this paper is that the industrial fuel oil market in Japan may be witnessing similar asymmetric pattern of adjustment to crude oil price shocks. The objective of this study is therefore to examine the Japanese retail industrial fuel oil market for evidences of asymmetric price adjustment and rent–seeking following changes in crude oil costs.

2. An overview of the empirical literature

Several empirical studies have investigated the problem of asymmetric transmission of changes in crude oil costs to retail energy markets following the initial enquiries by the UK MMC. Though MMC failed to establish its

findings through econometric work, Bacon (1991) developed a quadratic quantity adjustment model for testing the rockets and feathers hypothesis put forward by the MMC using data from the UK retail gasoline market. Bacon econometrically established the reality of asymmetric price transmission from crude oil market to retail gasoline market as well as the prevalence of the rockets and feathers effect in the UK retail gasoline market. Using data for the period 1986 – 1992 and Error Correction Models, Borenstein Cameron and Gilbert (1997, henceforth BCG) investigated the US retail gasoline market using data for the period 1986 to 1992 to analyze price transmission at different points in the distribution chain. The results show that retail gasoline prices respond more quickly to increases than to decreases in crude oil prices.

Greenwood-Nimmo and Shin (2013, henceforth GS13) used the nonlinear ARDL framework to examine the UK gasoline, diesel, kerosene and gas oil markets over the period January 1999 to March 2013. They found evidence in support of the presumed asymmetry, which is largely obscured at pump where prices include both tax and duty suggesting the possibility of firms using tax system to conceal rent-seeking behavior. Chou, Chang and Hu (2013) estimated retail price adjustments in the gasoline and diesel markets of Taiwan, Japan, South Korea, and Singapore using monthly data between January 2004 and June 2012. The study employed an asymmetric error correction model (ECM). The results indicate that asymmetric adjustments in retail gasoline and diesel prices are common, and that the adjustments are a type of politico-economic asymmetry. Chen, Haung and Ma (2017) examined whether China's gasoline and diesel prices adjust asymmetrically to international crude oil price changes. Using monthly data on wholesale prices of gasoline and diesel products in China, and international crude oil prices from February 2006 to October 2013, they applied an asymmetric error-correction model (AECM). The findings suggest that increases and decreases in international oil prices have asymmetric effects on both wholesale prices of gasoline and diesel fuel in China, and that both increases and decreases in international oil prices have a greater effect on diesel prices than on gasoline prices in China.

Patlanakooha and Pornchaiwisetgul (2015) investigated asymmetric price transmission (APT) of gasoline price and diesel price and their causes in Thailand. Monthly data of Western Texas Instrument crude oil price, unleaded gasoline (ULG) price and high speed diesel (HSD) price, the oil fund, the stock of ULG and HSD inventories were used. The results show that APT exists for ULG but not for HSD. The oil fund does not influence the price asymmetry. Whether the oil fund is levied or otherwise, the price asymmetry is always present for ULG but not for HSD. Venditti (2010) noted that in the past decade, changes in oil prices have played a significant role in shaping inflation dynamics in the US and in the euro area, largely through their direct effect on fuel prices thereby reviving the controversy over whether the prices of petroleum products respond more promptly to positive than to negative oil price shocks. The study provides evidence on this issue for the US, the euro area and the four largest euro area countries (Germany, France, Italy and Spain), both for petrol and diesel prices. The empirical analysis shows that fuels prices respond very promptly to oil price shocks, with some heterogeneity across countries, and that no systematic evidence of asymmetries emerges.

Atil, Lahiani and Nguyen (2014) studies gasoline and natural gas markets. They used the recently developed nonlinear autoregressive distributed lag (NARDL) model to examine the pass through of crude oil prices into gasoline and natural gas prices. The short and long-run nonlinearities through positive and negative partial sum decompositions of the predetermined explanatory variables were tested using this approach. The method also offers the possibility to quantify the respective responses of gasoline oil price shocks from the asymmetric dynamic multipliers. The results show that oil prices affect gasoline prices and natural gas prices in an asymmetric and nonlinear manner, but the price transmission mechanism is not the same. Polemis and Fotis (2015) examined the asymmetric adjustment speed of gasoline price in twelve European Union (EU) countries transmitted directly in a single stage formulation using the Dynamic Ordinary Least Square (DOLS) framework. The results show strong evidence suggesting the validity of the rockets and feathers hypothesis in five out of the twelve EU countries. The findings indicates that in these countries, consumers are somewhat insulated from fluctuations in the crude oil market leaving no room for long-run rent-seeking behavior. Similarly, the null hypothesis of short-run asymmetries could not be rejected in all of the sample countries, suggesting the existence of symmetric adjustment speeds in the short-run. The study concluded that the oligopolistic structure of the local gasoline markets along with crude oil price volatility triggers the price asymmetric adjustment path. This study is consistent with Greenwood-Nimmo and Shin (2013), and sheds more light on how the manipulation of the tax system by retailers can be used to obscure asymmetry at the pump.

Polemis and Fotis (2014) explored the degree of competition in various gasoline markets and inferred possible causes of price asymmetry across the globe. The study used the Dynamic Ordinary Least Square method in order to estimate price asymmetry in twelve European countries and the United States for a sample of weekly observations which spans the period from June 1996 to August 2011. The results indicate the common perception that less competitive gasoline markets exhibit price asymmetry, while highly competitive gasoline markets follow a symmetric price adjustment path. In addition, the inclusion of taxes (VAT and excise tax) into retail gasoline prices, supports the existence of price asymmetry in many European countries.

Clerides (2010) uses data from 2000 to 2010 for several European Union (EU) countries to investigate the

response of retail gasoline and diesel prices to changes in the world oil price. The empirical findings indicate significant variation in the adjustment mechanism across countries. Kristoufek and Lunackova (2015) used weekly data between 1996 to 2014 to study gasoline price adjustments in Belguim, France Germany, Italy, Nertherlands, UK, and the USA. Using error correction model ECM, the study found no evidence of price asymmetries. Perdiguero-Garcia (2010) provides a comprehensive compilation of empirical studies on gasoline market asymmetries for 48 countries in the global economy. They observed that the analysis of price asymmetries in the gasoline market is one of the most studied in the energy economics literature.

Bagnai and Ospina (2016) studies the asymmetries in gasoline pricing using a sample of monthly data from twelve Eurozone countries running from January 1994 to December 2014. They applied nonlinear autoregressive distributed lag (NARDL) modeling framework. The results showed that while the effects of exchange rate variations display a positive asymmetry (i.e devaluation have a greater impact with respect to revaluation), crude oil price variations induce negative asymmetry (i.e. reductions in the price of crude oil have greater impact than price rises). Again, the positive asymmetry to exchange rate change is much stronger in core Eurozone countries. Wlazlowski (2003) examines the relationship between crude oil prices, the dollar-pound exchange rate and petrol prices in the UK over the period 1982-2001. The study used quantitative methods to examine the existence of long-run equilibrium and test for the presence of asymmetric patterns in the short-run responses to upstream price changes. The degree of asymmetry in the adjustment towards long-run equilibrium was also examined. The results confirm that short-run response is greater for increases in upstream prices and that the long-run equilibrium is reached faster after increase in upstream prices. Thus, the opinion held by drivers in the UK, which is the prevalence of the rockets and feathers effect, is confirmed.

da Silva et al. (2014) analyzed the existence of asymmetric transmission of prices in the Brazilian gasoline market following a regional approach, using a disaggregated data set for the period between May 2004 and February 2011. The main result finds evidence of symmetric price transmission in retail gasoline market due to price shocks arising from the distributors. However, the study stressed that all observed asymmetries following the disaggregation of the data indicate that the asymmetries do not constitute a national problem, but specific to each city and different for each of the regions in Brazil. This study suggests that interesting empirical evidences can be obtained by using disaggregated data in the study of asymmetric price adjustments in retail energy markets.

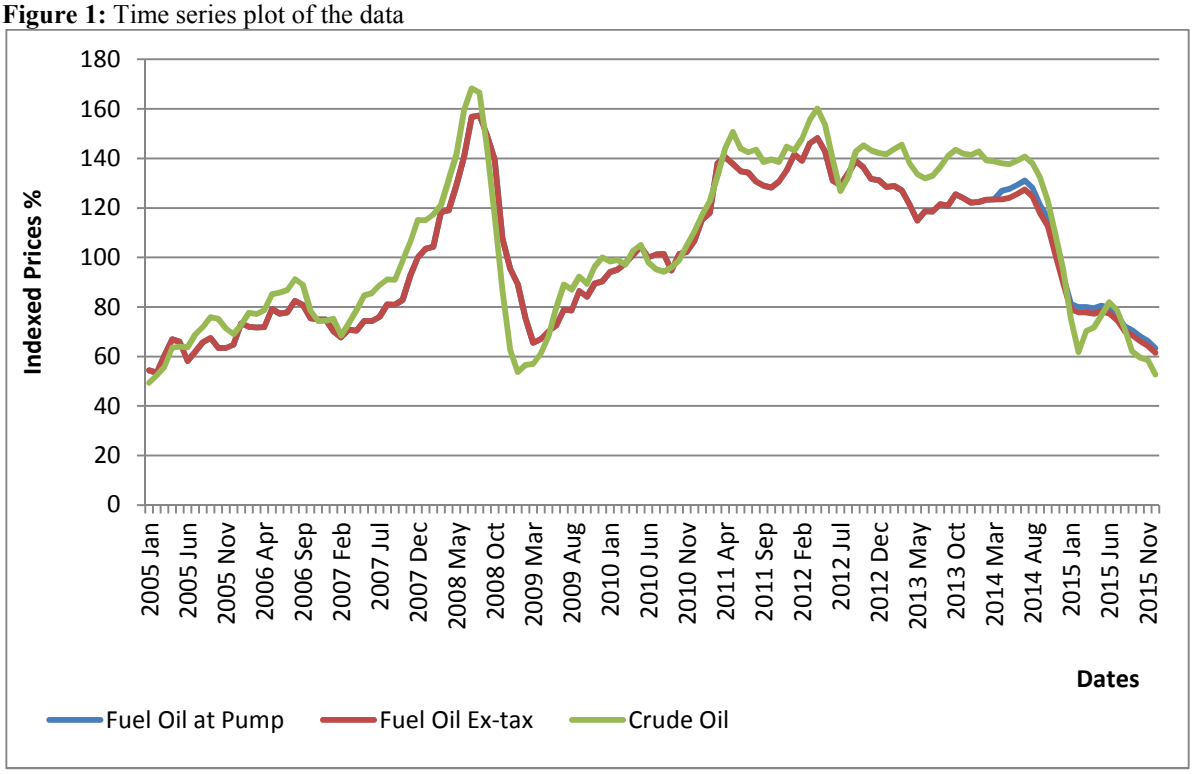
The above overview of the empirical literature shows that the extant literature is disproportionately skewed in favour of the road fuel markets, that is, the gasoline and automotive diesel markets. Most of the studies did not focus on the industrial fuel oil market. Furthermore, majority of the studies focused on the United States, United Kingdom or some selected Eurozone countries. To address these gaps, this paper contributes to the empirical literature on asymmetric price transmission of changes in crude oil costs to retail energy products with particular emphasis on Japanese industrial fuel oil market. Specifically, this study investigates the Japanese industrial fuel oil market for evidence of sluggish speed of adjustment, rockets and feathers effect, and the possibility of rent-seeking behavior by retail firms.

3. Data and methodology

The data for this study consists of monthly time series observations for the period January 2005 to December 2015, a total of 132 observations. The variables of interest are the retail prices of industrial fuel oil and the costs of imported crude oil in Japan. The retail prices are available not only at pump (i.e inclusive of tax and duty) but also exclusive of tax and duty (i.e ex-tax prices). The data were sourced from the International Energy Agency (IEA) monthly oil price statistics. To effectively track the asymmetry in the response of the retail price of industrial fuel oil to change in the cost of crude oil, this study used the crude oil cost for Japan measured in dollars per barrel. However, the retail price of industrial fuel oil that is measured in the national currency of Japan was converted to U.S dollars using the exchange rate data obtained from OECD statistics (monthly Monetary and Financial Statistics, MEI). The entire dataset was indexed to year 2010 (i.e. 2010Y = 100%). Thereafter, the data was logged prior to estimation. Figure 1 plots the data using its indexed representation. This figure indicates that the prices track themselves closely, thereby suggesting that the relationship between them might be symmetric rather than asymmetric. The plots also suggest that a stable equilibrium relationship may be existing between the prices. This study will investigate this relationship as part of the empirical analysis.

This study adopted the econometric framework applied by GS13 in modeling the asymmetric price transmission in the UK retail energy sector, which was initially advanced by Shin, Yu and Greenwood-Nimmo (2013) for modeling asymmetric cointegration and dynamic multipliers in a non-linear autoregressive distributed lag (NARDL) framework. Under this framework, short-run and long-run non-linearities were introduced through positive and negative partial sum decompositions of the explanatory variables. In the empirical literature, Webber (2000), Lee (2000), Viren (2001), Bachmeier and Griffin (2003), and BCG, among others, applied partial sum decompositions to the analysis of dynamic asymmetry with great success.

Figure 1: Time series plot of the data



Source: Authors. **Note:** Fuel oil at pump includes tax and duty, while fuel oil ex-tax is exclusive of tax and duty. The plots are based on the indexed representation of the data before they were logged for estimation.

The NARDL framework is built around the asymmetric cointegrating relationship of the form:

$$Y_t = \theta^+ X_t^+ + \theta^- X^- + u_t \quad \text{---------- (1)}$$

Where Y_t is an I(1) variable, and the explanatory variable is decomposed as follows:-

$$X_t = X_0 + X_t^+ + X_t^- \quad \text{---------- (2)}$$

Where $X_t^+ = \sum_{j=1}^{t}$ max $(\Delta X_j, 0)$ and $X_t^- = \sum_{j=1}^{t}$ min $(\Delta X_j, 0)$ are partial sum processes of positive and negative changes in X_t, while X_0 is an initial threshold value that is assumed to be zero following Shin, Yu and Greenwood-Nimmo (2013). Δ is the first difference operator while θ^+ and θ^- are the associated asymmetric long-run parameters. The NARDL (p,q) model associated with equation (1) can be written in its level form as follows:

$$Y_t = \sum_{j=1}^{P} \phi_j Y_{t-j} + \sum_{j=O}^{q} (\theta_j^+ X_{t-j}^+ + \theta_j^- X_{t-j}^-) + \varepsilon_t \quad \text{---------- (3)}$$

The underlying model in this study is derived from equation (3) following Shin, Yu and Greenwood-Nimmo (2013). This is specified in its error correction form as follows:

$$\Delta Y_t = \rho Y_{t-1} + \theta^+ X_{t-1}^+ + \theta^- X_{t-1}^- + \sum_{j=1}^{p-1} \phi_j \Delta Y_{t-j} + \sum_{j=O}^{q-1} (\pi_j^+ \Delta X_{t-j}^+ + \pi_j^- \Delta X_{t-j}^-) + \varepsilon_t \quad \text{---------- (4)}$$

Where ρ is the speed of adjustment while $\beta^+ = \frac{-\theta^+}{\rho}$ and $\beta^- = \frac{-\theta^-}{\rho}$ are the asymmetric long-run parameters.

In the above specifications, Y_t captures the retail price of industrial fuel oil in Japan, while X_t captures the crude oil costs for Japan. To ascertain the orders of integration of the variables in this study, the ADF unit root tests were used. This is to ensure that they are consistent with the underlying requirements of the nonlinear ARDL framework. The result of cointegration tests based on the bounds testing approach of Pesaran, Smith and Shin 2001 (henceforth PSS) and the t-BDM statistic of Banerjee et al (1998) are also reported in this study.

4. Empirical results and discussion

We began this empirical analysis by examining the time series properties of the data. To do this, we performed the ADF unit root test on all the variables. The results are reported in Table 1. The results indicate that all the variables are integrated of order one, I(1), which is consistent with the underlying assumptions of our model. These results suggest that the variables may be cointegrated. Thus, we include cointegration analysis as part of the nonlinear ARDL estimation results based on the bounds testing procedure of PSS and the t-BDM statistic of Banerjee et al (1998).

Table 1: ADF unit root test results

Variable	5% Critical Values	ADF Test Stat at Level	ADF Test Stat at 1st Difference	Order of Integration
Industrial fuel oil at pump	–3.445	–1.484	–7.528*	I(1)
Industrial fuel oil Ex-tax	–3.445	–1.412	–7.536*	I(1)
Crude Oil	–3.445	–2.366	–5.437*	I(1)

Source: Authors. **Notes:** Industrial fuel oil at pump denotes the retail prices that are inclusive of tax and duty; while industrial fuel oil ex-tax is the ex-tax price. * denotes significance at 5% level.

The NARDL estimation results for this study based on equation (4) are reported in Table 2. We find that the speed of adjustment is quite sluggish for both the ex-tax prices and the pump prices with values of 28% and 29%, respectively. Both speed of adjustment are highly statistically significant, even at the 1% level. Greenwood-Nimmo and Shin (2013) also found similar pattern of sluggish speed of adjustment in the UK retail petroleum products markets. Such sluggish speed of adjustment is usually associated with irregular behaviours such as weak competition and prolonged periods of mispricing. This finding raises serious anti-trust and consumer welfare issues that should not be ignored by policy makers in this economy. These results are also consistent with the dynamics of the Japanese retail industrial fuel oil and the country's profile provided by the IEA Energy Supply Security 2014. The IEA statistics indicate that Japan has negligible domestic oil production activity. Its oil import dependency ratio remained at an average of 99.7% since 1990. In fact, the high rate of oil consumption by the industrial sector is consistent with the observed sluggish speed of adjustment.

The results also show that there is significant evidence of long-run asymmetry at the 10% level only at pump. The pattern of this long-run asymmetry indicates that the pump prices respond more strongly to positive (i.e. increases) than to negative (decreases) changes in crude oil costs since the value for β^+ (i.e. 0.93) is higher than the value for β^- (which is 0.90). Furthermore, these estimated coefficients for the industrial fuel oil market are quite high (i.e. close to unity), indicating that consumers in this market are somewhat insulated to the fluctuations in the international crude oil market. Thus, at this point, our results have shown that in the long-run, retail industrial fuel oil price in Japan is stickier downwards than upwards while responding to crude oil cost shocks. In what follows, we consider if these findings are robust in the short-run.

The results indicate significant evidence of short-run additive asymmetry both for the ex-tax prices and the pump prices at the 1% level. The results indicate that crude oil price increases are passed through more strongly and rapidly than price decreases in the periods immediately following the shocks. This is because the sum of the estimated positive short-run parameters is higher than the corresponding sum of the negative short-run parameters. Indeed, these results provide clear evidence of the prevalence of the rockets and feathers effect in the Japanese retail industrial fuel oil market. Thus, our results have now shown that both in the long-run and short-run, retail industrial fuel oil price in Japan is stickier downwards than upwards while responding to crude oil cost shocks. However, we do not find evidence of rent-seeking in this market since the observed short-run asymmetry is not obscured at pump. These findings are consistent with the dynamics of the Japanese oil industry earlier highlighted in this report. For instance, the fact that Japan is an oil-deficient economy with high oil import dependency ratio predisposes its downstream sector to irregular behaviours such as mispricing and collusion. Our results therefore indicate that there is need for adequate regulation and supervision of the market to forestall these failures.

The diagnostic checks indicate that the assumptions of the underlying model have been adequately satisfied. There exists stable long-run or equilibrium relationship between the variables at 5% level. There is no evidence of autocorrelation or hetroscedastiticity problem in the results. Adjusted R^2 which indicate the values of 64% and 65% show that changes in crude oil cost shocks account substantially for variations in the industrial fuel oil market, which is consistent with economic expectation.

Table 2: NARDL Estimation Results

Dependent Variables	**Industrial Fuel Oil Ex-Tax**	**Industrial Fuel Oil at Pump**
Estimated Coefficients		
ρ	– 0.28***	–0.29***
β^{+}	0.94***	0.93***
β^{-}	0.92***	0.90***
$\sum_{j=1}^{q-1} \prod^{+j}$	0.81***	0.81***
$\sum_{j=1}^{q-1} \prod^{-j}$	0.23**	0.24**
Symmetry Tests		
$Ho = \beta^{+} = \beta^{-}$	1.13	3.00*
$Ho = \sum_{j=1}^{q-1} \prod^{+j} = \sum_{j=1}^{q-1} \prod^{-j}$	13.99***	14.81***
Diagnostics		
F_{PSS}	12.42***	13.36***
t_{BDM}	–6.05***	–6.27***
BG Test (NR^2)	15.24	14.69
ARCH Test	13.82	13.07
$\bar{R}^2$	0.64	0.65

Source: Authors. **Notes:** Industrial fuel oil at pump includes tax and duty, while industrial fuel oil ex-tax is exclusive of tax and duty. The notation for the estimated coefficients relates to the NARDL model of equation (4). The reported symmetry tests are standard Wald tests. The BG Test is the Breusch-Godfrey serial correlation test, while the ARCH Tests is the standard Heteroskedasticity Test. The BG Test and the ARCH Test were conducted at lag 12, since the dataset comprises monthly series. The relevant k = 1 critical values reported by PSS for the t_{BDM} statistic are –2.91, 3.22, and 3.82 at the 10%, 5% and 1% levels. The equivalent critical values for the F_{PSS} statistics are 4.78, 5.73 and 7.84. ***, **,** and ******* denote significance at the 10%, 5% and 1% levels, respectively.

5. Conclusion and policy implications

This paper examined the Japanese industrial fuel oil market for evidence of asymmetric price adjustment and rent-seeking following changes in crude oil prices. The study used the nonlinear autoregressive distributed lag (NARDL) modeling framework and monthly time series data for the period January 2005 to December 2015. The results indicate that Japanese industrial fuel oil market is fraught with sluggish speed of adjustment, which is typical of markets witnessing uncompetitive pricing and other irregular behaviours by retail firms. The results further indicate that Japanese industrial fuel oil market is bedeviled by the problem of short-run asymmetric price transmission from crude oil market, which is consistent with the rockets and feathers effect. However, the results did not show any evidence of rent-seeking since the observed short-run asymmetry is not obscured at pump. In view of the prevailing problem of rockets and feathers effect, the paper supports policies that will encourage continuous monitoring of the market in order to preserve competition and the overall social welfare.

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