PRICE-RESPONSE ASYMMETRY IN DOMESTIC WHOLESALE AND RETAIL DIESEL 2 MARKETS IN PERU

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Abstract

This paper tests and confirms the hypothesis that retail and wholesale Diesel 2 prices respond more quickly to increases than to decreases in wholesale and crude oil prices, respectively. Among the possible sources of this asymmetry, we find: production / inventory adjustment lags, refining adjustments, market power of some sellers, searching costs, among others. By analyzing price transmission at different points of the distribution chain, this paper attempts to shed light on these theories for the Peruvian oil industry. Wholesale prices for Diesel 2 show asymmetry in responding to crude oil price changes, which may reflect inventory adjustment effects. Asymmetry also appears in the response that retail prices give to wholesale price changes, presumably indicating short-run local market power among retailers or the existence of searching costs.

I.- Introduction

The price asymmetry response to input price shocks is a stylized fact in several industries. In his analysis of an extensive group of American industries (242 products), Peltzman (2000) found evidence that the reply to positive shocks (increase in input prices) is twice as much as the response to negative shocks (decrease in input

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prices). These results are significant, persistent (over five months), and general (77 products basically required by final consumers and 165 products mainly required by companies).

With this general evidence, several empirical researchers, who studied the hydrocarbon industry, demonstrated that domestic fuel prices respond more quickly to increments of international fuel prices than to reductions, which means that there is an asymmetrical relationship between domestic fuel prices and international oil prices.

Borenstein, Cameron, and Gilbert (1997) evaluated the existence of asymmetric responses in gasoline prices for several production and distribution stages of the American hydrocarbon industry such as crude oil production, refining and wholesale distribution, retail distribution and fuel stations. By using weekly information for the 1986–1992 period, as well as error correction models (ECM) estimations, their research found evidence of price-response asymmetry both at wholesale level, after shocks in the crude oil market, and at retail level, after shocks in the wholesale market. In addition, their study found that the asymmetry in the response of wholesale prices to oil price shocks is consistent with adjustment costs, while the asymmetry in the response of retail prices to wholesale price shocks is consistent with the existence of market power in the short-term. Finally, as is expected in the hydrocarbon industry case, this research demonstrated that oil price volatility usually starts, principally, in the crude oil market[1].

Balke, Brown, and Yücel (1998) give a broader approach than Borenstein et al. (1997) by using various model specifications with asymmetric response and diverse weekly data sub-samples for the 1987–1996 period. Results of the research confirm some of the findings of Borenstein et al. (1997), for instance, that most part of the final price volatility has its origin in the upstream segment (that is, due to the evolution of international oil market). The authors state that the asymmetry effect is sensitive to the model specifications, but not to the selection of sub-samples. However, the authors point out that evidence of the asymmetry is strong along the whole production and distribution components of the gasoline market.

II.- Factors that would explain the asymmetric effect

Economic literature suggests different elements as possible causes for asymmetries in the reply of final prices to variations in input prices, such as the existence of focal prices in industries where there is local market power, searching costs, lags in the production process, management of fuel inventories, and refinery‘s adjustment costs.

[1] A similar applied study for the United Kingdom was made by Bacon (1991).

- **Lags in the production process and fuel stock management**

The existence of finite stocks in the oil industry is a factor for the price-response asymmetries to shocks in fuel markets. When long-term crude oil prices increase (for example, due to reduced reserves, a restricted supply or an unanticipated increase of the demand), refineries that keep stocks can raise their prices by adjusting the stock value. This situation has negative effects on the demand and positive effects on their stock value. When long-term crude oil prices decrease, companies that have stock do not decrease their prices so fast because stocks are finite –if they were not finite, sales could be quickly increased with a lower price- (Borenstein, Cameron, and Gilbert; 1997).

In other words, costs of reducing stocks in the short-term are different from costs of increasing stocks. This argument is related to the fact that a reduction in stocks can be particularly costly if the refinery does not keep enough stocks (see the following explanations). This kind of argument is valid at refinery level, but not at service station level, because they typically have a higher stock rotation.

- **Refinery's Adjustment Costs**

Refineries can also face up higher adjustment costs of production, as a result of changes in crude oil availability, due to several factors such as the automation of distillation operations and processing, as well as fixed costs that the operator has to assume if the production process stops when oil becomes scarce as it takes place in real time. This situation makes operators adjust their production slowly through the management of the refining industrial process. When crude oil supply becomes costly (as a consequence of an increase in international prices), refineries are forced to reduce their fuel production quotas, which leads to a sudden increase in ex-refinery prices. Nevertheless, when crude oil supply is normalized, refineries adjust the increase of their production quotas slowly in order to recover commercial losses caused by shocks in prices. In this way, a higher refining margin is obtained, which results in a slow lowering of fuel prices.

- **Market Power and Focal Price**

This argument usually explains why asymmetries exist in price transmission. It is based on a study developed by Green (1983) and Green and Porter (1984), amended by Tirole (2000), and then adapted for the fuel market by Borenstein, Cameron, and Gilbert (1997). According to this statement, there is a small group of dominant companies, whose reputation is quite important to keep a collusive agreement among them and that interact under a scheme of tacit collusion to keep high profit margins. If companies consider the tacit agreement and have an imperfect knowledge of the input price paid by the competitors, then each company will have a loss function with less probability to decrease its margins rather than to increase them. When the input price increases, refineries will quickly increase their prices to sustain their margins. This fact also constitutes a signal of competition. When the input price decreases, companies will reduce their prices only if they are forced to do so by a decrease in the demand or by evidence that their competitors are lowering their prices as well. Otherwise, the prevailing price is a focal point for the oligopolistic coordination (Borenstein, Cameron, and Gilbert 1997).

However, recent researchers demonstrate that there is little evidence supporting a relationship between the market structure and the asymmetric response between prices. For instance, Peltzman (2000) has found evidence of price asymmetry in diverse industries of the USA, independently of their kind of industrial organization and the number of companies that they have.

- **Searching Costs and Market Power in the commercialization phase**

The existence of searching costs incurred by consumers to find stations with lower prices can give a monopolistic power to companies in their scope of local influence. This provokes an asymmetric response in the adjustment of retail margins to changes in wholesale prices (Borenstein, Cameron, and Gilbert; 1997 and Borenstein; 1991).

In the oil industry each service station has monopolistic power in its area of influence due to its spatial segmentation at geographical level within a city, and by the product differentiation through the provision of complementary services[2]. Naturally, the gas station market power is limited by the likelihood of consumers to change the station where they buy fuel. In this way, when wholesalers increase their prices, service stations quickly increase their prices to cover their operating costs and obtain higher commercial margin; whereas when wholesale prices fall, service stations take advantage of their local market power in order to obtain higher profits by not reducing their prices automatically. Only when searching costs incurred by consumers are relatively lower than the benefits from lower prices, service stations are forced to decrease their prices gradually to competitive levels.

Taking the aforementioned factors into consideration, it is necessary to analyze briefly the features of the downstream segment in the Peruvian oil industry. In this way, we can evaluate whether the industrial organization and market conditions can determine the existence of asymmetries in fuel prices transmission.

III.- Price-response asymmetry in the Peruvian oil industry

In the oil industry, the segment called *downstream* begins with refining and finishes with the wholesale and retail commercialization of fuels to the industrial, commercial and residential final consumer.

3.1.- Refining and wholesale organization

In the refining activity, crude oil is converted into products with a high market value such as gasoline, LPG, Diesel 2[2], and other fuels[3]. Refining is an activity that involves large sunk costs and significant scope and scale economies, which can typically prevent investment in new refining assets depending on the magnitude of the demand[4].

In Peru, two refineries perform this activity: La Pampilla Refinery, operated by RELAPASA consortium and led by Repsol-YPF; and Talara Refinery, operated by PETROPERU, a public company that also operates refineries in Iquitos (Loreto), El Milagro (Amazonas), and Conchán (Lima). The first two refineries processed almost 85% of the refined fuel in Peru during 2003. Although of a smaller size, Maple Corp. is the company that operates the Pucallpa Refinery under a concession scheme and basically supplies the local demand of the rainforest region. Part of the oil products, particularly residual fuels and some types of gasoline, are exported while the rest of the production is bound for the local market.

In the case of Peru, the production of oil products is highly concentrated with a different market share per type of fuel due to different refining patterns used in refineries. For instance, PETROPERU has a strong participation in LPG production, whereas RELAPASA participates in residual production[5]. The latter mainly imports crude oil in order to refine it On the other hand, PETROPERU imports a large quantity of Diesel 2 previously processed (6.7 million barrels in 2002, more than 30% of national supply) to offer it in the local market. Diesel 2 fuel is mainly used in electricity generation, public and residential transportation, and industrial processes. For this reason, the analysis of the concentration level in the local market must be

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2 For a discussion of these elements in the Peruvian case, review Ruiz (2001).

3 Diesel 2 fuel is a specific fractional distillate of fuel oil (mostly petroleum) that is used in a diesel engine invented by German engineer Rudolf Diesel, and perfected by Charles F. Kettering. The term typically refers to fuel that has been processed from petroleum, but increasingly, alternatives such as biodiesel or biomass to liquid (BTL) or gas to liquid (GTL) diesel that are not derived from petroleum are being developed. As a hydrocarbon mixture, it is obtained in the fractional distillation of crude oil between 250 °C and 350 °C at atmospheric pressure. Diesel 2 is considered to be a fuel oil and is about 18% heavier than gasoline.

3 Refineries can also develop other related products such as lubricants, asphalt, and solvents.

4 According to Scherer (1996), in the American market, the optimal minimum scale of operation for refineries has been calculated at 200,000 barrels of processed crude oil per day. The necessary investment for a plant with these features fluctuates between US$ 800 million and US$ 2,000 million.

5 This situation has changed because of the operation of the Camisea Project, which includes a fractionating plant operated by Pluspetrol Co. See Garcia and Vasquez (2004) for further details.

performed considering imports made almost exclusively by refining companies, which modifies their participation with respect to the production indicator.

The Herfindhal–Hirschman (IHH) concentration index shows a very high level of industrial concentration. Thus, if a level of 2500 is taken as a threshold to consider the industry as highly concentrated, the average IHH for fuel sales at refinery level in Peru largely exceeds this threshold in different products[6].

TABLE 1
CONCENTRATION INDEX IN THE REFINING INDUSTRY IN PERU, 2002

Product (thousand of barrels)	PETROPERU	RELAPASA	MAPLE	TOTAL	IHH
Gasoline (%)	4 782(58)	3 540(43)	324(4)	8 303(100)	5 150
Kerosene and Turbo 1 (%)	4 709(57)	3 407(41)	132(2)	8 248(100)	4 968
Diesel (%)	5 779(43)	7 425(55)	273(2)	13 477(100)	4 878
Residual (%)	7 109(37)	12 096(63)	51(--)	19 256(100)	5 309
LPG (%)	1 681(73)	636(27)	--(--)	2 317(100)	6 017
Others (%)	829(63)	223(17)	256(20)	1 308(100)	4 691
Total (%)	24 889(47)	27 327(52)	1 036(2)	52 909(100)	4 884

Source: Monthly Report, Ministry of Energy and Mining of Peru. Own preparation.

6 The Herfindahl–Hirchman (IHH) methodology is largely used in the analysis of merger controls. The index is obtained by adding up the market share squared of each of the companies that compose the relevant market $IHH = \Sigma S_i^2$, where S_i, is the market share of the i-th company. The IHH has a maximum value of 10,000 which indicates that the market is composed of only one company with 100% market share. This index satisfies the three desirable features that an industrial concentration indicator should have (Tirole; 2000). In other words, the index is symmetric among firms: it increases before any growth in the dispersion that keeps constant the average considering identical companies (Lorenz condition), and it decreases when the number of companies increases.

The presence of high concentration level and entry barriers can be consistent with the existence of market power that companies exert. Naturally, this exercise would generate asymmetries in price transmission due to companies' commercialization policies -related to the management of refining margins- in order to maximize profits. Another reason is the operation policies to adjust refining costs when there is a sudden fall in crude oil prices, as it was mentioned in Section 2.

The following industrial activity consists of the supply of refined fuels to final consumers, other wholesale dealers, retail dealers, and service stations that sell such products to final consumers. Wholesale dealers can acquire fuel from national producers in refining plants or by direct import. Wholesalers can also export liquid fuel or other oil products.

Some wholesalers either have their own service stations or are affiliated to a trademark, being supplied on an exclusive basis. These companies also supply independent service stations and larger fuel consumers (direct consumers). Other wholesale companies do not have a trademark and supply independent stations. Wholesalers are fuel traders at a high scale; therefore, they buy and sell fuel using invoices, remittance guides, or purchase orders. Consequently, fuel trade operations are separated from the physical dispatch.

This activity does not involve significant sunk costs; therefore, we find a large number of operators and a disperse market. In this activity, there is a lower level of concentration associated with the number of companies and their market shares. On the other hand, as there are no entry barriers to this segment, a higher level of competition is expected. That is what happens in the Peruvian market. If we observe the IHH values for this segment, we find that this value is close to 1300 in the case of gasoline, kerosene, and diesel, and nearly 2120 in the case of residual oils.

In spite of the increased competition in this segment, several factors, such as the stock adjustment costs in supplying plants when there are disruptions in the fuel supply, can be sources of price-response asymmetry between wholesale and retail prices (as was mentioned by Borenstein et al; 1997).

3.2.- Evidence of asymmetry in price responses: the case of Diesel 2

3.2.1.- Retail and wholesale segments

In order to evaluate the existence and the probable degree of fuel price-response asymmetries in Peru, Diesel 2 is taken as a case study not only for its relevance in terms of national demand[7] but also for the existence of better data sources for this fuel. Figure 1 shows the evolution of Diesel 2 nominal prices. A strong relationship

7 According to DGH-MEM information, Diesel 2 had a market share of nearly 25% of liquid fuel consumption in Peru during 2002.

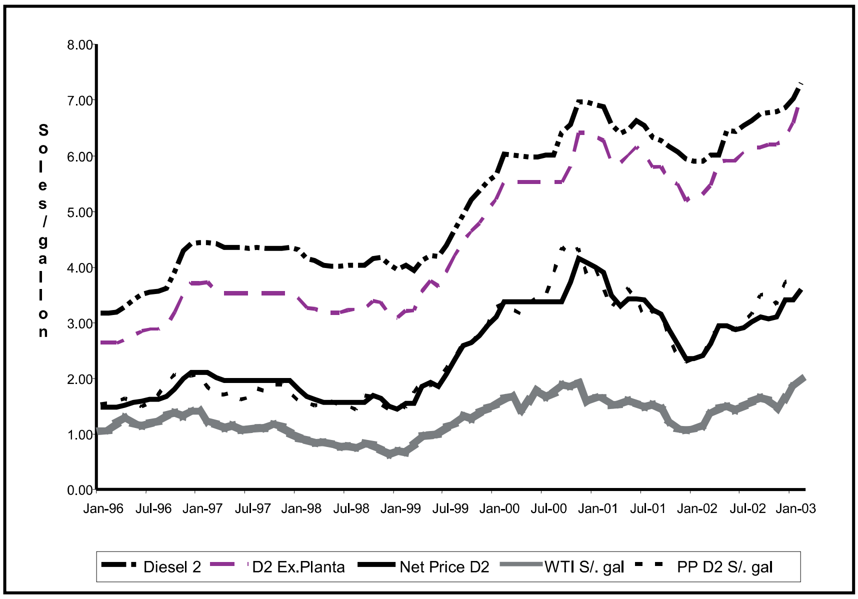
TABLE 2
CONCENTRATION INDEX IN THE FUEL WHOLESALE PHASE IN PERU, 2002

Wholesalers	Gasoline		Diesel		Kerosene		Residual	
	Bls/d 2002	Share (%)	Bls/d 2002	Share (%)	Bls/d 2002	Share (%)	Bls/d 2002	Share (%)
AMI OIL	358	2.0	1168	3.0	697	5.4	27	0.2
CMYDSA	828	4.7	828	2.2	551	4.3	113	0.8
CORCERVIZ	1442	8.2	3481	9.1	1880	14.5	157	1.1
ELITE	163	0.9	296	0.8	293	2.3	248	1.8
FERUSH	503	2.9	715	1.9	229	1.8	87	0.6
MAYCOMSA	36	0.2	58	0.2	51	0.4	19	0.1
MOBIL	2644	15.0	5238	13.7	2527	19.5	2746	20.0
PECSA	3118	17.7	6900	18.0	1470	11.4	535	3.9
PETRO OIL	914	5.2	2078	5.4	1827	14.1	25	0.2
REPSOL YPF	2163	12.3	5383	14.0	820	6.3	2501	18.2
ROMERO	793	4.5	1573	4.1	232	1.8	1302	9.5
SHELL	3196	18.2	7198	18.8	1814	14.0	4755	34.6
TEXACO	1445	8.2	3413	8.9	555	4.3	1216	8.9
Total	17603	100.0	38329	100.0	12946	100.0	13731	100.0
IHH	1237		1287		1234		2120	

Source: Monthly Report, Ministry of Energy and Minign of Peru. Own preparation.

among parity prices, refinery net prices, ex-refinery prices, wholesale prices, retail prices, and international prices is also shown. The evidence suggests that there is a significant influence of international oil prices (approximated by WTI) on the variation of domestic prices. In other words, the small size of the Peruvian economy in comparison with developed countries as well as its opening degree determines that the country is a price taker from the international oil market.

FIGURE 1
EVOLUTION OF DIESEL 2 NOMINAL PRICE



Source: Vásquez (2005).

Following the guidelines proposed by Borenstein et al (1997), and Engle and Granger (1987), an error correction model was considered in order to evaluate the presence of asymmetries in the response of Diesel 2 prices. This model links percentage variations of retail prices Δp_t^C (service stations' average list price) with the lags of percentage changes of wholesale and retail prices (Δp_{t-i}^M, Δp_{t-i}^C respectively), to a group of fictitious variables M_{t-i} and C_{t-i} that represent the asymmetry effect. M_{t-i} is 1 if lagged wholesale price p_{t-i}^M is higher than p_t^M and zero otherwise. $C_{t-I,}$ is 1 if lagged retail price p_{t-i}^C is higher than p_t^C and zero otherwise. According to the authors, there will be evidence of asymmetry if θ_i and γ_i coefficients are statistically different from zero.

The proposed model is as follows:

$$\Delta p_t^C = c_o + \alpha e_{t-1} + \sum_{i=1}^{n} \beta_i \Delta p_{t-i}^M + \sum_{i=1}^{n} \phi_i \Delta p_{t-i}^C + \sum_{i=1}^{n} \theta_i M_{t-i} + \sum_{i=1}^{n} \gamma_i C_{t-i} + \xi_t$$
$$where\ e_{t-1} = p_t^C - 0.887 * p_t^M + 1.129 \qquad (1)$$

In this equation e_{t-1} is the error-correction term, which corrects discrepancies between prices in the long-term; α is the adjustment parameter that quantifies the speed at which discrepancies are corrected (if the value is 0, there is no relationship between variables; if the value is –1, the adjustment is perfect and there are no delays in the correction of price deviations after shocks). The error-correction term is calculated through Johansen and Juselius (1990) cointegration method[8]. Through the estimates of this model, it is possible to evaluate whether there are asymmetric effects on price transmission in the Diesel 2 case. The results of the statistical test are shown in Table 3.

TABLE 3
ASSYMMETRY TEST IN WHOLESALE AND RETAIL PRICES TRANSMISSION

Statistical Test	Type of asymmetry		
	Total	Consumer price	Wholesale Price
F - Statistic	8,820	8,430	6,021
p - value	0,000	0,000	0,000

The first test is "Total", which evaluates the significance of the group of parameters θ_i and γ_i. These parameters quantify the asymmetric effect of prices on both wholesale and retail components, respectively. As it can be observed in Table 3, the F – statistic rejects the null hypothesis of non-existence of asymmetric effects. For that reason, there is strong evidence that asymmetric price responses are important in the Peruvian Diesel 2 market.

Additional tests were made in order to evaluate which the principal source of asymmetry is. The "Consumer Price" test evaluates the statistical significance of γ_i parameters that quantify the asymmetric effect on retail prices; whereas the "Wholesale Price" test evaluates the statistical significance of θ_i parameters that quantify the asymmetric effect on wholesale prices.

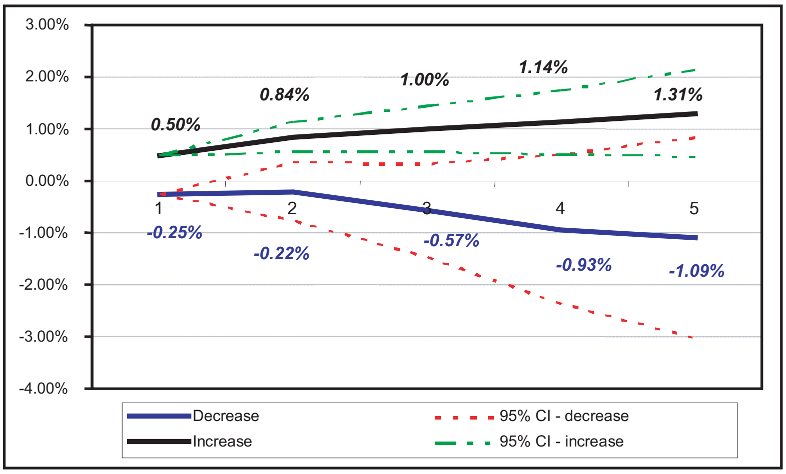
8 The number of lags used to estimate the model is 6, which was obtained by comparing Akaike and Schwartz criteria. The analysis period covers from January 1996 to February 2003. e_{t-1} is calculated from the estimated cointegrating vector shown in equation (1).

The results of these tests indicate that the sources of asymmetry in Peru would be from both segments of the oil industry. In other words, factors related to wholesale and retail distribution at the bottom of the commercialization chain of Diesel 2 account for differences in the response of the final price when there are price increases or reductions in higher segments of the fuel production chain.

It is possible to obtain complementary evidence of this fact from the analysis of the impulse response functions, which can be estimated from the model shown above. This analysis makes it possible to simulate the effect of a shock on Diesel 2 wholesale prices on retail prices.

In Figure 2, it can be observed that the Diesel 2 retail price has a strong upward reaction when there is a 1% percent increment in wholesale prices, and then it continues growing gradually. In the first month, the transmission achieves 50% of the effect of the original shock. Then, in the following months, the wholesale price continues rising until completing the shock transmission (approximately 5 months). In contrast, after a negative shock in wholesale prices, retail prices decrease slowly along several months and do not transmit the shock totally (approximately 50% after 3 months in accumulated terms). This evidence supports the idea of the existence of asymmetries in the response of Diesel 2 retail prices to shocks in the wholesale market.

FIGURE 2
ACCUMULATED EFFECT OF A SHOCK IN DIESEL 2 WHOLESALE PRICES ON RETAIL PRICES



3.2.2.- International oil market – Domestic wholesale market

Taking the guidelines proposed in the previous section to evaluate the presence of asymmetries in the response of Diesel 2 prices in wholesale and retail segments, we made a second error correction model estimation, which relates wholesale price variations in percentage terms Δp_t^M with lags of percentage changes of wholesale price to international crude oil price, represented by WTI (Δp_{t-i}^M, Δp_{t-i}^{WTI}, respectively), and a group of fictitious variables M_{t-i} and WTI_{t-I} that represent the asymmetry effect. M_{t-i} is 1 if lagged wholesale price p_{t-i}^M is higher than p_{t-i-1}^M, and zero otherwise. WTI_{t-i} is 1 if the price of lagged WTI p_{t-i}^{WTI} is higher than p_{t-i-1}^{WTI} and zero otherwise. As in the previous case, there will be an asymmetric effect if θ_i and γ_i coefficients are statistically different from zero.

The proposed model is as follows:

$$\Delta p_t^M = c_o + \alpha e_{t-1} + \sum_{i=1}^{n} \beta_i \Delta p_{t-i}^M + \sum_{i=1}^{n} \phi_i \Delta p_{t-i}^{WTI} + \sum_{i=1}^{n} \theta_i M_{t-i} + \sum_{i=1}^{n} \gamma_i WTI_{t-i} + \xi_t$$

$$\text{where } e_{t-1} = p_t^M - 0.901884 * p_t^{WTI} - 1.505997 \qquad (2)$$

Based on the estimates of this model, it is possible to evaluate if there are asymmetrical effects on transmission of crude oil shock prices toward the wholesale distribution chain in the Diesel 2 market[9]. The results of hypothesis tests are shown in Table 4.

TABLE 4
TEST OF ASYMMETRY IN WTI AND WHOLESALE PRICE TRANSMISSION

Statistical Test	Type of asymmetry		
	Total	Consumer price	Wholesale Price
F - Statistic	9,140	4,481	8,282
p - value	0,000	0,006	0,004

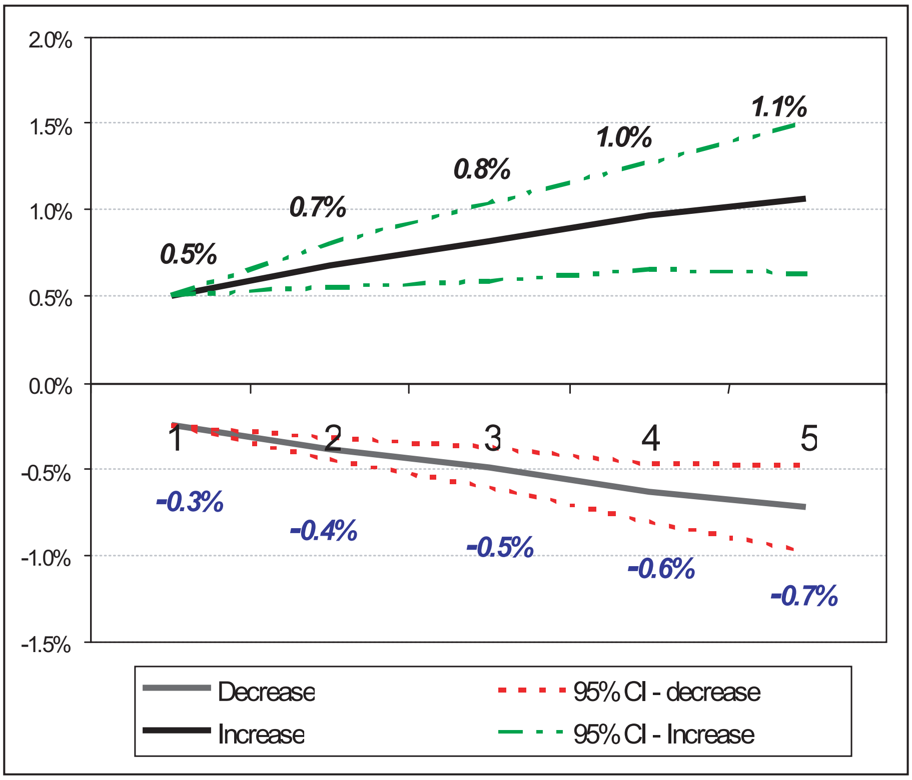
As it happened in the previous case, the first test is “Total”, which evaluates the significance of the group of parameters θ_i and γ_i. These parameters quantify

9 The number of lags used to estimate the model was 3, which was obtained by comparing Akaike and Schwartz data criteria. The analysis period covers from January 1996 to February 2003. e_{t-1} is calculated from the estimated cointegrating vector.

the asymmetric effect of price shocks in the international crude oil market on the domestic wholesale market. As it can be observed in Table 4, the F-statistic rejects the hypothesis of non-existence of asymmetric effects. Two additional tests were made in order to evaluate which the principal source of asymmetry is. The "WTI prices" evaluates the significance of γ_i parameters that quantify the asymmetric effect produced by international crude oil price fluctuations, whereas "Wholesale Price" test evaluates the statistical significance of θ_i parameters that quantify the asymmetric effect on wholesale prices.

If we calculate the impulse response functions from Model (2), it will be possible to simulate the effect of international oil price shocks over Diesel 2 wholesale prices. We could observe that the Diesel 2 wholesale price has a strong upward reaction when there is a percentage increment in the international price, and then it continues growing gradually. During the first month, the price rises by nearly 50% of the

FIGURE 3
ACCUMULATED EFFECT OF A SHOCK IN INTERNATIONAL OIL PRICES ON WHOLESALE PRICES



initial shock. Then, in the following months, it continues rising until completing the shock transmission (approximately 4 months). In contrast, after a negative oil price shock, the wholesale price decreases slowly along several months and does not transmit totally (approximately 70% after 5 months). This result also supports the evidence of the existence of asymmetries in the response of Diesel 2 prices in the wholesale segment of the fuel market (see Figure 3). The results of these tests corroborate the evidence shown in the previous section, and they allow us to state that the existence of asymmetries in price responses is an important stylized fact of the Peruvian oil industry.

IV.- Conclusions

The presence of asymmetries in price responses would be a stylized fact of structural nature in the Peruvian fuel market according to the evidence shown in this document for the Diesel 2 case. The international literature on oil industry suggests that factors such as the stock adjustment cost and the existence of production lags are relevant in the case of wholesale price-response asymmetry to changes in crude oil price. However, in the retail market, the literature suggests the existence of short-term market power. The latter fact is the result of the spatial competition among service stations.

In other cases, the literature (Peltzman, 2000) shows the presence of price-response asymmetries in a wide variety of industries (manufacturing, textile, agriculture, alcoholic drinks, recreation, electrical appliances, among others) with different types of industrial configuration (from oligopoly to competitive structures). This is to say that the price-response asymmetries are common issues in economies all over the world and usually have better explanations than just market power.

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