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Chen, Chaoyi and Polemis, Michael and Stengos, Thanasis

University of Guelph, University of Piraeus, University of Guelph

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Chaoyi Chen[a], Michael Polemis[b,c], Thanasis Stengos[a*]

[a] University of Guelph, Department of Economics, Ontario, tstengos@uoguelph.ca

[b] University of Piraeus, Department of Economics, Piraeus, Greece.

[c] Hellenic Competition Commission, Athens, Greece

Abstract

We employ a pooled panel threshold model along the lines of Seo and Shin (2016) within an error correction framework to re-investigate the "*rockets and feathers*" hypothesis. The empirical results confirm the superiority of the threshold model compared to the baseline linear specifications, while attributing the asymmetric gasoline adjustment mechanism to Exchange Rate Pass Through (ERPT).

JEL classifications: C24; L16

Keywords: Gasoline asymmetry; Threshold; ERPT; Error Correction Model; EU

1. Introduction

During the last 30 years, asymmetric gasoline pricing mechanism has been thoroughly examined by researchers and practitioners (Borenstein et al., 1997; Galeotti et al., 2003; Greenwood-Nimmo and Shin, 2013).

However, existing studies fail to explain the role of exchange rate fluctuations in determining the causes of the asymmetric gasoline adjustment path (commonly known as "*rockets and feathers*" hypothesis).[1] Moreover, past studies have been methodologically restrictive in the sense that the retail gasoline short-run responses, given an input (crude) cost shock, were attributed to crude oil fluctuations. These studies would therefore be biased since a gasoline asymmetric path is usually triggered by a minimum absolute increase in the cost of raw material such as crude oil (Godby et al, 2000).

In order to overcome this problem, we build a pooled panel GMM threshold model within an error correction framework along the lines of Seo and Shin (2016). Our findings uncover that asymmetric gasoline price adjustment fluctuations can be attributed to ERPT.

2. Data and Baseline Model

The sample includes weekly observations for the 27 EU countries over the period 1994-2015. All variables are in their natural logarithms expressed in real terms. Brent crude oil price measured in USD dollars per barrel is taken from the USA Department of Energy. The exchange rate effect is quantified by two indicators: a) The Dollar trade-weighted exchange rate index (1997=100) which is drawn directly from the Federal Reserve Bank of St. Louis, and b) The

[1] This means that prices increase rapidly in response to cost increases (like a rocket) but fall only slowly in response to cost decreases (like a feather).

nominal effective Euro trade-weighted exchange rate index obtained by the European Central Bank. Summary statistics are provide in the following table.

Table 1: Descriptive statistics

Variables	Obs	Mean	St.Dev	Min	Max
ln(GasFinPrice)	19,247	6.711	1.513	-0.122	7.544
ln(GasFinPrLC)	18,150	8.004	1.604	5.894	14.59
ln(Brent)	31,813	3.704	0.746	2.245	4.949
ln(DolrTWXin)	30,218	4.681	0.0906	4.489	4.869
ln(LCtoUSD)	22,622	1.091	1.978	-1.241	7.746

Notes: GasFinPrice is the final retail gasoline price, GasFinPrLC is the final retail gasoline price in local currency, Brent is the Brent crude oil price, DolrTWXin is the trade-weighted dollar exchange rate index, LCtoUSD denotes the units of local currency to USD dollar.

Similarly to Deltas (2008), we estimate first baseline panel symmetric and asymmetric ECMs as follows:

$$\Delta\ln\left(R_{j,t}^{lc}\right) = a_j + \sum_{l=0}^{L} b_{l,j}\Delta\ln(C_{t-l}^{r}) + \sum_{l=1}^{L} c_{l,j}\,\Delta\ln\left(R_{t-l}^{lc}\right) + \sum_{l=0}^{L} b_{l,j}\Delta\ln(\,X_{t-l}^{W\$}) +$$

$$\textstyle\sum_{l=0}^{L} b_{l,j}\Delta\ln\,(X_{t-l}^{lc/\$}) + d_j\left[\ln(R_{j,t-1}) - k_j - \ m_j\ln(C_{t-1})\right] + \varepsilon_{j,t} \qquad (1)$$

where $\mathrm{R_{j,t}^{lc}}$ is the retail price of gasoline in country j and week t in local currency, $\mathrm{C_t^r}$ is the price of crude oil (common to every country) in trade-weighted real dollars (the price in dollars divided by the trade-weighted dollar index), $\mathrm{X_t^{W\$}}$ is the trade-weighted dollar exchange rate index, $\mathrm{X_t^{lc/\$}}$ is the exchange rate of local currency units per dollar, $\mathrm{R_{j,t}}$ is the retail price of gasoline in country j and week t in Euros, $\mathrm{C_{j,t}}$ is the price of crude oil (common for every country) in dollars.

3. Threshold Model

Equation (1) above can be cast in terms of threshold regression model that can be expressed as follows:

$$\Delta ln(R_t^{lc}) = \beta_1^{\mathrm{T}} X_t + \varepsilon_t, q_t \leq \gamma \tag{2}$$

$$\Delta ln(R_t^{lc}) = \beta_2^{\mathrm{T}} X_t + \varepsilon_t, q_t > \gamma \tag{3}$$

where we suppress the country index and only use time as subscript and q_t is the threshold variable, γ is the threshold level and X_t contains all the regressors of the model in a compact form, including all the lags. The two equations can be integrated into a single one written as:

$$\Delta ln(R_t^{lc}) = \beta_2^{T} X_t + \delta^{T} X_t I(q_t \leq \gamma) + \varepsilon_t \tag{4}$$

where $\delta=\beta_1-\beta_2$ and I (.) is the indication function.

To estimate equation (4) we use three different estimation strategies based on different formulations of the model namely: a) The Threshold Error Correction Model (TRECM), see Godby et al (2000) using Hansen (1999) that considers an exogenous threshold b) The Structural Threshold Error Correction Model (STR), see Kourtellos et al (2016) that allow for a parametric framework to handle an endogenous threshold and c) A GMM approach that allows for endogeneity of the threshold within a dynamic panel structure (Sheo and Shin, 2016) [2].

[2] We also looked at the Semiparametric Structural Threshold Model (SMSTR) of Kourtellos et al (2017) that allow for nonparametric endogeneity correction but conserve space the results are available from the authors.

4. Results and discussion

Nearly in all of the baseline specifications, the control variables are statistically significant with the appropriate signs (Table 2). The crude oil positive coefficients are larger than their negative counterparts and statistically significant (see columns 3-4). The relevant estimate (elasticity) for the short-run positive coefficient equals to 0.22 compared with the value of 0.17 for the negative one. Surprisingly, this outcome is fully reversed when we estimate the linear asymmetric ECM with 2SLS (see columns 5-6).

Regarding the exchange rate terms, we notice that only the positive coefficient of the real effective exchange rate term is statistically significant and negatively correlated with the final gasoline price (see columns 3 and 5). On the contrary, the nominal effective Euro trade-weighted exchange rate effect is positively correlated with the final retail gasoline price. As it is evident, the relevant estimates for the positive coefficients are larger ranging from 0.51 to 0.48. This means that a 10% appreciation (depreciation) of the Euro against the local EU currencies will increase (decrease) on average the short-run level of the final retail gasoline price (4.95% and 2.95% respectively). Lastly, the cointegration-terms are not statistically significant (see columns 2-4) and the same applies to the error correction terms (columns 5-6), indicating that the baseline model cannot capture any possible asymmetric gasoline behaviour.

Table 2: Baseline model results

Method	Symmetric	Asymmetric		Asymmetric	
		+	-	+	-
Constant	0.0017	-0.0009		-0.0028***	
	(0.1875)	(0.5221)		(0.0004)	
$\Delta\ln(C_t^r)$	0.1559***	0.2252***	0.1749***	0.1713***	0.1869***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta\ln(C_{t-1}^r)$	0.0833***	0.1573***	0.1541***	0.1315***	0.1544***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta\ln(C_{t-2}^r)$	0.08442***	0.1098***	0.0716***	0.1004***	0.0674***
	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0001)
$\Delta\ln(X_t^W)$	-0.2424***	-0.4594***	0.1013	-0.4025***	0.0425
	(0.001)	(0.0000)	(0.3366)	(0.0000)	(0.6591)
$\Delta\ln(X_{t-1}^W)$	-0.0625	0.6079***	0.6342***	0.5301***	0.5263***
	(0.3868)	(0.0000)	(0.0001)	(0.0000)	(0.0005)
$\Delta\ln(X_{t-2}^W)$	0.1556*	-0.2081	-0.9043***	-0.1809	-0.8624***
	(0.0345)	(0.2057)	(0.0000)	(0.2251)	(0.0000)
$\Delta\ln(X_t^{lc})$	0.3921***	0.5153***	0.2987***	0.4872***	0.3046***
	(0.0000)	(0.0000)	(0.0089)	(0.0000)	(0.0000)
$\Delta\ln(X_{t-1}^{lc})$	0.2468	0.0604	0.0719	0.079*	0.0763
	(0.0000)	(0.1326)	(0.3104)	(0.0416)	(0.2608)
$\Delta\ln(X_{t-2}^{lc})$	0.0985***	0.1928***	0.2527***	0.2015***	0.2508***
	(0.0005)	(0.0079)	(0.0006)	(0.0028)	(0.0001)
$\Delta\ln(R_{t-1}^{flc})$	-0.0310	-0.0819**	-0.0468	-0.1016***	-0.0321
	(0.1727)	(0.0326)	(0.2057)	(0.005)	(0.351)
$\Delta\ln(R_{t-2}^{flc})$	-0.0293	-0.0321	0.0052	-0.0465	-0.0101
	(0.1781)	(0.3091)	(0.8667)	(0.1275)	(0.7329)
$\ln(R_{t-1}^{final})$	-0.0002	-0.0003			
	(0.1679)	(0.1051)			
$\ln(C_{t-1})$	-0.0004	-0.0022			
	(0.8846)	(0.5017)			
$Error\ Correction_{t-1}$				-0.0002	-0.0003
				(0.3301)	(0.6806)
Adjusted R^2	0.346	0.381		0.374	
D-W P-Value	0.433	0.7623		0.6692	
Observations	19,247	19,247		19,247	

***Notes**:* All models include time fixed effects to control for seasonal effects. Robust standard errors are in parentheses.
*** Significance at 1% ** Significance at 5% * Significance at 10%

We carry on with the estimation of the TR model. As it is evident from Table 3, we find that the optimal threshold level of the ERPT proxied by the trade-weighted dollar exchange rate index (X_t^W) is impressively identical across the different models (≈ 4.6), revealing that the results are robust against the alterative methodologies.

Specifically, we notice that the short-run elasticity of trade-weighted dollar exchange rate ($\Delta \ln(X_t^W)$) is negative. However, this estimate is statistically significant only above the threshold (high regime). It is notably though that the magnitude of the relevant elasticity is bellow unity (in TRECM and GMM) denoting that ERPT is incomplete (Feenstra, 1989; Goldberg and Knetter, 1997).

Table 3: Threshold model results

Method	**TRECM**		**STR**		**GMM**	
Threshold	***4.6538***		***4.6502***		***4.6383***	
Regime	**Low**	**High**	**Low**	**High**	**Low**	**High**
Constant	0.002	0.0022***	-0.1437	0.1559	0.0002	0.011**
	(0.2020)	(0.0000)	(0.6237)	(0.6034)	(0.9001)	(0.0181)
$\Delta\ln(C_t^r)$	0.1965***	0.1448***	0.0293	0.0317	0.0907	0.098
	(0.0000)	(0.0000)	(0.912)	(0.7344)	(0.289)	(0.1202)
$\Delta\ln(C_{t-1}^r)$	0.1157***	0.085***	0.0308	0.419*	0.0585	0.2081
	(0.0000)	(0.0000)	(0.8565)	(0.0698)	(0.282)	(0.1151)
$\Delta\ln(C_{t-2}^r)$	0.1112***	0.0441***	-0.0295	0.3414***	0.0212	0.2439**
	(0.0000)	(0.0000)	(0.86)	(0.0044)	(0.7606)	(0.0163)
$\Delta\ln(X_t^W)$	-0.129	-0.2451***	-0.2436	-1.867*	-0.1766	-0.8141***
	(0.4324)	(0.0001)	(0.84)	(0.0651)	(0.6499)	(0.0729)
$\Delta\ln(X_{t-1}^W)$	-0.1668*	0.1004	0.1881	-0.2755	0.1868	-0.1411
	(0.0836)	(0.2136)	(0.8854)	(0.7559)	(0.6569)	(0.8303)
$\Delta\ln(X_{t-2}^W)$	-0.0569	0.6698***	-0.0255	2.6993***	0.0829	1.585***
	(0.5572)	(0.0000)	(0.9681)	(0.0010)	(0.7632)	(0.0099)
$\Delta\ln(X_t^{lc})$	0.4346***	0.1262***	0.1119	0.6595**	0.1009	0.1819
	(0.0005)	(0.0000)	(0.7804)	(0.0381)	(0.6396)	(0.462)
$\Delta\ln(X_{t-1}^{lc})$	0.2929***	0.0827***	-0.1059	-0.1035	0.1631	-3274
	(0.0000)	(0.0000)	(0.8656)	(0.7878)	(0.3396)	(0.3028)
$\Delta\ln(X_{t-2}^{lc})$	0.0706	0.1375***	-0.0112	-1.0672	-0.1051	-0.6541
	(0.1255)	(0.0000)	(0.9694)	(0.088)	(0.5011)	(0.1288)
$\Delta\ln(R_{t-1}^{flc})$	-0.0705	-0.0095*	0.2303	-0.4172	0.0237	0.1305
	(0.1343)	(0.0698)	(0.6194)	(0.1956)	(0.9091)	(0.5068)
$\Delta\ln(R_{t-2}^{flc})$	0.0017	-0.1616***	-0.1735	-0.3047	-0.0154	-0.6679***
	(0.9572)	(0.0000)	(0.4874)	(0.242)	(0.9414)	(0.0017)
$\ln(R_{t-1}^{final})$	-0.0002	-0.0004***	-0.0001	-0.0006	-0.0001	-0.0006
	(0.3189)	(0.0000)	(0.6926)	(0.1319)	(0.6587)	(0.1284)
$\ln(C_{t-1})$	-0.0055	0.0092***	0.0001	-0.0141	-0.0027	-0.0001
	(0.5653)	(0.0000)	(0.9992)	(0.7061)	(0.8886)	(0.9924)
J Statistic			9.1727		5.7919	
D-W P-Value			0.2433		0.8041	
SupWald Statistic	97.8955		51.5187		95.0121	
SupWald Boot P-Value	0.0000***		0.0000***		0.0000***	
Observations	19,247		19,247		19,247	

Notes: See Table 2 for notation.

Notably, the relevant exchange rate term seems to have a positive and statistically significant lagged-term effect only above the threshold (see columns 2, 4, 6 and 8). Regarding the GMM we observe that the lagged coefficient is estimated to 1.585, indicating that the ERPT two weeks before is complete. In addition, the (lagged) crude oil responses are positively correlated with the final retail gasoline price. It is worth mentioning that the relevant short-run (lagged) price elasticity is estimated to 0.24. In other words, a 10% increase (decrease) of the crude oil price two weeks before, will lead to a short-run increase (decrease) of the final retail gasoline price equal to 2.4%.

Lastly, the null hypothesis of no asymmetry is strongly rejected with a SupWald Bootstrapped P-value equal to 0.0000 in all of the models. One possible reason for this behaviour might be attributed to the fact that the profit function is inherently asymmetric (Godby et al, 2000). In other words, if prices are too high, the costs to profit of a sub-optimal level of sales is partly offset by the higher price (and hence profit margin) of each unit sold. When prices are low though, the firm will be selling more units, and each of them at a loss, so that the quantity and price effects on profits reinforce rather than offset each other.

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