Revisit the Nonlinear Relationship between foreign exchange rates and Energy prices: Further Evidence from Asian Energy-importing countries

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Overview

This paper applies nonlinear autoregressive distributed lag (NARDL) model to investigate the nonlinear relationships between foreign exchange rate and energy price for Asian energy-importing countries such as Japan, South Korea and Singapore. Since current account deficits and monetary policy is closely related to the international energy price such as liquid nature gas (LNG) and crude oil, we argue that the variation of energy price could have asymmetric effects on foreign exchange rate. In order to identify the existence of an asymmetric cointegration relationships between foreign exchange rate and energy price, we apply testing procedures proposed by Banerjee *et al.* (1998) and (Pesaran *et al.*, 2001) based on the NARDL-ECM. Our empirical results show that the foreign exchange rate-energy price nexus varies from countries and energy types. For example, we observe that the price of LNG and crude oil have significant asymmetric effects on foreign exchange rate, especially for Japan, while the decresing LNG price have nonlinear long run effect on foreign exchange rate in South Korea. In addition, the asymmetric effect is only detected in the short run for Singapore. Finally, the dynamic multiplier analysis suggests that the adjustment speed for foreign exchange rate to reflect energy price shock could be lagged about 6 month for Japan due to low interest rate and depreciation monetary policy.

Methods

For implementing the nonlinear autoregressive distributed lag (NARDL) model (Shin *et al.*, 2013), we specify the multivariate unrestrict error correction model(UECM) for the ARDL (p, q) bounds approach with multiple regressors as:

$$y_t = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} (\theta_j^{+'} x_{t-j}^{+} + \theta_j^{-'} x_{t-j}^{-}) + \varepsilon_t$$

(1)

Where Δ is the first-difference operator and the residual term ε_t is a white-noise disturbance. The y_t denotes for foreign exchange rate for specific country while the x_t presents energy price for coal, LNG and crude oil. The symble ϕ_j is the autoregressive parameter to be estimated while θ_j^+ and θ_j^- are the asymmetric distributed lag parameters. The subscription *t* denotes the time. Following Pesaran et al. (2001), we may rewrite Eq (1) in the NARDL-based ECM as:

$$\begin{aligned}\Delta y_t &= \rho y_{t-1} + \theta^{+'} x_{t-1}^{+} + \theta^{-'} x_{t-1}^{-} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^{+'} \Delta x_{t-j}^{+} + \varphi_j^{-'} \Delta x_{t-j}^{-}) + \varepsilon_t \\ &= \rho \xi_{t-1} + + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\varphi_j^{+'} \Delta x_{t-j}^{+} + \varphi_j^{-'} \Delta x_{t-j}^{-}) + \varepsilon_t \end{aligned} \qquad (2)$$

The NARDL model combines many of the desirable attributes of the fully-modified and the ARDL-based dynamic corrections associated respectively with Phillips and Hansen (1991) and Pesaran and Shin (1998) in a dynamic parametric framework capable of modelling both long and short-run asymmetries. Since our parameters in the model are all linear, it can be estimated by standard OLS. To investigate the existence of an asymmetric cointegrating relationship based on the NARDL-ECM, we first follow the test procedure of Banerjee *et al.* (1998) and proposed t-statistics by testing $\rho = 0$ against $\rho < 0$ in Eq.(2). If $\rho = 0$ reduces to the regression involving only first differences, implying that thereis no long-run relationship between the levels of y_t , x_t^+ and x_t^- . Next we perform the F-test of the joint null $\rho = \theta^+ = \theta^- = 0$ to identified the asymmetric long-run relationship (Pesaran *et al.*, 2001). Moreover, the asymmetric and cumulative dynamic multipliers associated with unit changes in x_t^+ and x_t^- on y_t can also be evaluated as follows:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+} = \sum_{j=0}^{h} \lambda_j^+, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-} = \sum_{j=0}^{h} \lambda_j^-, \quad h = 0, 1, 2...$$

(3)

the NARDL model in fact admits three general forms of asymmetry: (i) long-run or reaction asymmetry, associated with $\beta^+ \neq \beta^-$; (ii) impact asymmetry, associated with the inequality of the coefficients on the contemporaneous first differences Δx_t^+ and Δx_t^-; (iii) adjustment asymmetry, captured by the patterns of adjustment from initial equilibrium to the new equilibrium following an economic perturbation (i.e. the dynamic multipliers m_h^+ and m_h^-).

Results

Our empirical analysis about foreign exchange rate and energy price relationship provides several insights and implications for energy-importing countries.

1. Our empirical results show that the foreign exchange rate-energy price nexus varies from countries and energy types. For example, we observe that the price of LNG and crude oil have significant asymmetric effects on foreign exchange rate, especially for Japan. We suggest that countries adopt more flexible monetary policy could absorb shocks from energy price variation.

2. In Table 1, we find the F-tests reject the null in the cases of crude oil, LNG and coal for Taiwan, with the results of asymmetric analysis indicating strong non-linearity exists in foreign exchange rate and energy price relationship.

3. Figure 1 presents the dynamic multipliers for Japan under each of the four combinations of long-run and short-run asymmetry. We find very rapid foreign exchange market adjustment in the immediate wake of a recessionary shock, with more than 50% of the traverse to equilibrium achieved within 6 months.

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Table 1: Dynamic Asymmetric Estimation of the NTD-Energy price Relationship

Dubai			LNG			Coal		
Var.	Coeff.	p-value	Var.	Coeff.	p-value	Var.	Coeff.	p-value
NTD_{t-1}	-0.040	0.01	NTD_{t-1}	-0.051	0.00	NTD_{t-1}	-0.056	0.00
Oil^{+}	0.002	0.62	LNG^{+}	0.002	0.26	$Coal^{+}$	-0.001	0.77
Oil^{-}	0.004	0.41	LNG^{-}	0.003	0.16	$Coal^{-}$	0.001	0.91
ΔNTD_{t-1}	0.301	0.00	ΔNTD_{t-1}	0.382	0.00	ΔNTD_{t-1}	0.341	0.00
ΔNTD_{t-4}	-0.133	0.04	ΔNTD_{t-4}	-0.071	0.26	ΔNTD_{t-4}	-0.073	0.26
ΔNTD_{t-11}	-0.134	0.03	ΔLNG^{+}_{t-1}	-0.025	0.02	$\Delta Coal^{+}_{t-1}$	-0.033	0.14
ΔOil^{+}_{t-4}	-0.051	0.01	ΔLNG^{+}_{t-6}	0.024	0.02	$\Delta Coal^{+}_{t-6}$	0.049	0.03
ΔOil^{-}_{t}	-0.041	0.01	ΔLNG^{-}_{t-2}	0.022	0.03	$\Delta Coal^{-}_{t-2}$	0.024	0.28
ΔOil^{-}_{t-3}	-0.026	0.11	*Const.*	0.080	0.00	*Const.*	0.086	0.00
Const.	0.068	0.00						
L^{+}	0.040	0.65	L^{+}	0.043	0.24	L^{+}	-0.017	0.76
L^{-}	-0.090	0.49	L^{-}	-0.058	0.14	L^{-}	-0.009	0.91
R^2	0.28			0.26			0.29	
t_{BDM}	-2.54			-3.37			-3.36	
F_{PSS}	4.78			4.43			4.59	
χ^2_{SC}	31.81	0.82		37.34	0.59		41.86	0.39
χ^2_{NOR}	97.53	0.00		82.92	0.00		102.90	0.00
χ^2_{FF}	0.16	0.92		0.48	0.69		0.52	0.67
χ^2_{HET}	11.71	0.00		3.94	0.05		2.56	0.11
W_{LR}	1.34	0.25		6.66	0.01		1.18	0.28
W_{SR}	0.28	0.60		1.70	0.19		0.04	0.85
AIC	-1643.27			-1638.31			-1631.15	
BIC	-1609.61			-1608.02			-1600.86	

Table 2: Dynamic Asymmetric Estimation of the JPY-Energy price Relationship

Dubai			LNG			Coal		
Var.	Coeff.	p-value	Var.	Coeff.	p-value	Var.	Coeff.	p-value
JPY_{t-1}	-0.035	0.05	JPY_{t-1}	-0.071	0.00	JPY_{t-1}	-0.042	0.04
Oil^{+}	0.007	0.24	LNG^{+}	0.006	0.14	$Coal^{+}$	0.000	1.00
Oil^{-}	0.012	0.14	LNG^{-}	0.008	0.06	$Coal^{-}$	0.002	0.76
ΔJPY_{t-1}	0.252	0.00	ΔJPY_{t-1}	0.213	0.00	ΔJPY_{t-1}	0.271	0.00
ΔJPY_{t-5}	-0.174	0.01	ΔJPY_{t-8}	0.112	0.09	ΔJPY_{t-5}	-0.188	0.00
ΔOil^{+}_{t-4}	-0.137	0.00	ΔJPY_{t-9}	0.110	0.11	ΔJPY_{t-8}	0.178	0.01
ΔOil^{-}_{t-3}	-0.056	0.08	ΔJPY_{t-10}	0.134	0.05	ΔJPY_{t-11}	0.150	0.03
$Const.$	0.090	0.03	ΔJPY_{t-11}	0.190	0.01	$\Delta Coal^{+}_{t-1}$	-0.110	0.01
			ΔLNG^{+}_{t-3}	0.040	0.05	$\Delta Coal^{+}_{t-5}$	0.057	0.19
			$Const.$	0.149	0	$\Delta Coal^{+}_{t-8}$	-0.081	0.05
						$\Delta Coal^{-}_{t-2}$	0.141	0.001
						$\Delta Coal^{-}_{t-3}$	-0.139	0.001
						$\Delta Coal^{-}_{t-6}$	0.064	0.112
						$Const.$	0.090	0.032
L^{+}	0.191	0.34	L^{+}	0.081	0.12	L^{+}	-0.001	1.00
L^{-}	-0.337	0.24	L^{-}	-0.115	0.04	L^{-}	-0.060	0.76
R^2	0.19			0.204844			0.251455	
t_{BDM}	-1.93			-3.8119			-2.1122	
F_{PSS}	1.97			4.9726			2.046	
χ^2_{SC}	42.67	0.36		41.59	0.40		37.58	0.58
χ^2_{NOR}	5.68	0.06		5.52	0.06		0.5426	0.76
χ^2_{FF}	1.32	0.27		1.87	0.14		4.66	0.00
χ^2_{HET}	0.21	0.65		4.62	0.03		2.09	0.15
W_{LR}	2.94	0.09		20.88	0.00		1.117	0.29
W_{SR}	2.33	0.13		4.077	0.05		4.606	0.03
AIC	-1348.28			-1347.85			-1359.86	
BIC	-1321.35			-1314.19			-1312.74	

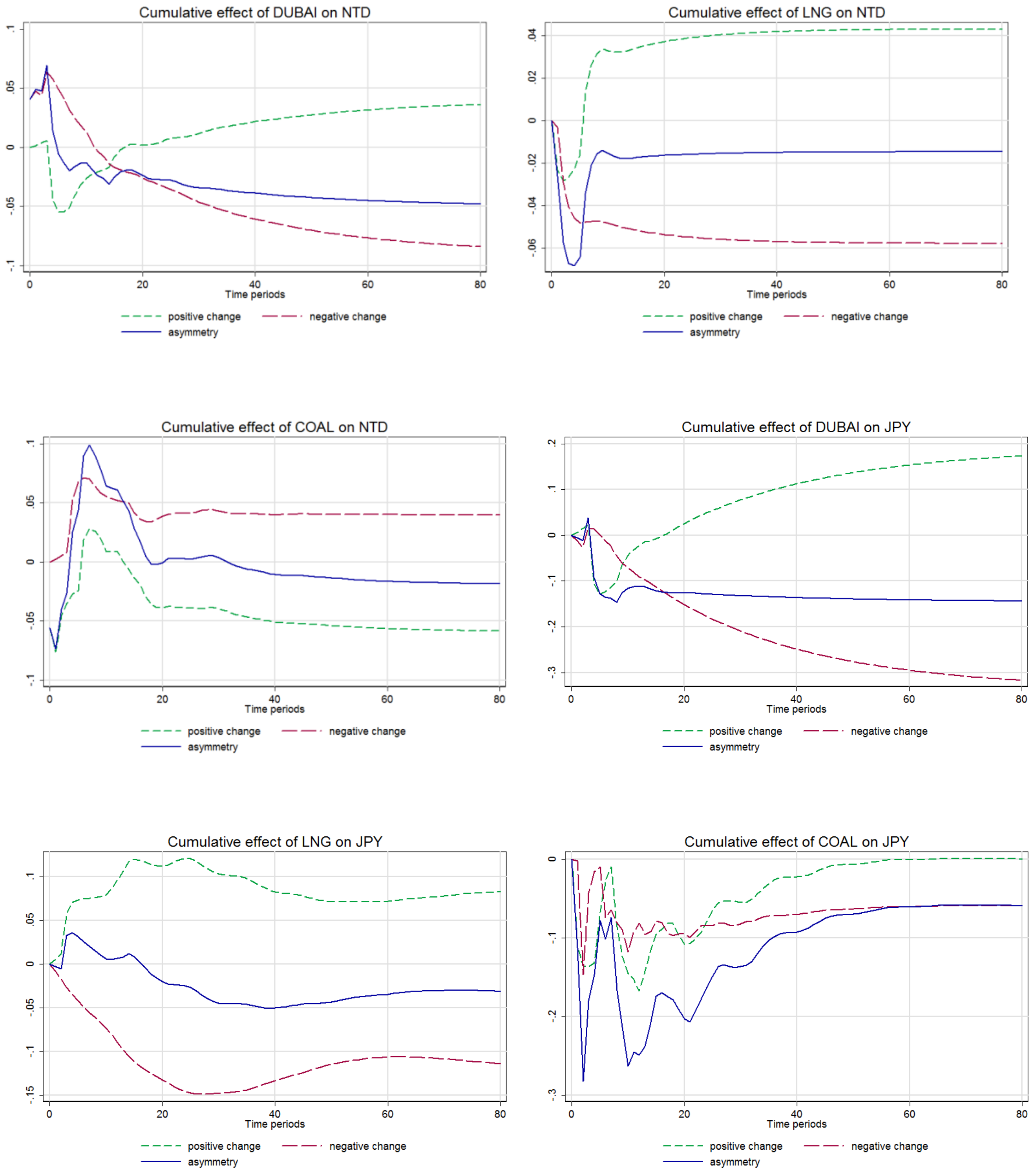

Figure 1: Dynamic Multipliers w.r.t. Energy Price and Exchange Rate Shocks