Time-varying exchange rate pass-through to gasoline prices: evidence from Asian economies

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Abstract. This study examines exchange rate pass-through (ERPT) to domestic gasoline prices in ten Asian economies using monthly data from 2016–2024. Panel unit root tests and model diagnostics including the F-test, Breusch - Pagan LM test, and Hausman test indicate that the fixed effects model is the most appropriate specification. The empirical results show that ERPT in Asia is positive but incomplete: a 1% depreciation of the local currency increases domestic gasoline prices by only 0.184%, reflecting the presence of fuel subsidies, price regulations, and smoothing mechanisms that dampen exchange rate transmission. Brent crude oil prices exert a significant effect, with a 1% increase raising gasoline prices by 0.335%, while domestic inflation also plays a dominant role, as indicated by a CPI coefficient of 0.646. To capture time variation, an expanding-window rolling regression is employed, revealing a clear downward trend in ERPT over the sample period, with pass-through declining and stabilizing over time. This pattern suggests increasingly effective policy interventions in Asian fuel markets that mitigate the impact of exchange rate fluctuations on retail gasoline prices. Overall, the findings highlight the evolving role of exchange rates, global oil prices, and domestic policies in shaping gasoline price dynamics in Asia.

1 Introduction

Energy prices and exchange rates play a central role in shaping inflation dynamics, particularly in economies that depend heavily on imported fuels. Sharp increases in global crude oil prices most notably after the COVID-19 recovery and during geopolitical tensions have heightened concerns about the degree to which exchange rate fluctuations transmit into domestic price levels, a mechanism known as exchange rate pass-through (ERPT). Recent evidence shows that the interaction between oil prices and exchange rates has become a dominant driver of inflation across both advanced and emerging economies.

A growing body of literature highlights the importance of understanding ERPT under volatile energy markets. Ding *et al.* [1] provide evidence that the covariance between

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exchange rates and crude oil prices significantly predicts inflation in China, especially in periods of heightened commodity price volatility. Mirza *et al.* [2] show that in inflation-targeting economies, exchange rate depreciation increases domestic prices and that rising energy prices further exacerbate inflationary pressures. Evidence from the Euro area indicates that recent inflation surges are strongly linked to oil and natural gas shocks, particularly after the post-pandemic recovery [3]. Studies also document nonlinear or asymmetric dynamics in pass-through behaviour: Jammazi *et al.* [4] identify asymmetric effects of exchange rate movements on crude oil prices, while Adelakun and Ngalawa [5] argue that oil-price fluctuations materially influence ERPT in both oil-importing and oil-exporting countries.

Research further suggests that ERPT is time-varying and sensitive to macroeconomic regimes. Fedoseeva demonstrates that the relationship between oil prices and the RUB/USD exchange rate evolves substantially over time, intensifying during major oil price collapses [6]. Sekine [7] finds that ERPT has declined in several industrialised economies as inflation environments stabilized. Evidence from CIS countries also shows substantial and heterogeneous ERPT, particularly where economies rely heavily on energy imports [8]. Broader studies on energy volatility show macroeconomic impacts on output, investment, and consumption patterns [9], while general equilibrium analyses of energy price reforms reveal significant welfare effects and the potential for policy distortions [10].

Despite the extensive literature on exchange rate pass-through, relatively little attention has been paid to its effects on domestic gasoline prices, especially using cross-country panel data. Most studies focus on CPI or overall inflation, leaving a gap in understanding how exchange rate movements shape fuel prices a critical component of household budgets and public policy. Moreover, evidence comparing ERPT across different regulatory structures, subsidy systems, and energy dependencies remains limited.

This study fills these gaps by estimating exchange rate pass-through to gasoline prices using a panel regression approach with monthly data across multiple countries. By concentrating specifically on fuel markets, it offers fresh empirical insights into how currency fluctuations affect gasoline pricing information essential for policymakers, inflation targeting central banks, and energy import dependent economies.

2 Methodology

2.1 Panel unit root test

Before estimating the panel regression models, all variables were tested for stationarity to prevent spurious results. Two complementary panel unit root tests were employed: the Levin–Lin–Chu (LLC) test, , proposed by Levin *et al.* [11], which examines the presence of a common unit root process under the assumption of homogeneous autoregressive coefficients and is appropriate for the moderately balanced structure of this dataset. The test is based on the following augmented Dickey-Fuller (ADF) specification for each panel:

$$\Delta y_{it} = \alpha_i + \rho y_{it-1} + \sum_{k=1}^{n} \phi_{ik} \Delta y_{it-k} + \delta_i t + \theta_i + \varepsilon_{it}, \quad (1)$$

where Δy_{it} represents the first difference of the variable of interest, y_{it-1} is the lagged level, α_i denotes the country-specific intercept, and $\delta_i t$ captures a deterministic time trend. The lagged difference terms $\sum_{k=1}^{n} \phi_{ik} \Delta y_{it-k}$ are included to control for serial correlation in the error term ε_{it}. The key parameter of interest is ρ, which is constrained to be identical across all countries under the LLC framework. The null hypothesis of a unit root is expressed as $H_0\colon \rho = 0$, implying non-stationarity, while the alternative hypothesis is $H_1\colon \rho < 0$, indicating that all series are stationary.

The Fisher-type ADF test, developed by Maddala and Wu [12] and Choi [13], which allows for heterogeneous autoregressive dynamics across countries and aggregates individual ADF p-values using Fisher's [14] statistics:

$$P = -2 \sum_{i=1}^{N} ln(p_i) \quad (2)$$

Under the null hypothesis that all series contain a unit root (i.e., $\rho_i = 0$ for all *i*), this statistic follows a chi-square distribution with $2N$ degrees of freedom. The alternative hypothesis is more flexible than in the LLC test, it requires only that some (not necessarily all) of the individual series are stationary. This property makes the Fisher-type test particularly robust to heterogeneity and allows for the possibility that stationarity properties may differ across countries.

2.2 Panel regression model

Having established stationarity of all variables, we proceed to examine how exchange rate fluctuations affect domestic gasoline prices through panel regression techniques. The panel data structure provides substantial benefits compared to conventional cross-sectional or time-series methods, particularly in enhancing statistical efficiency, mitigating multicollinearity concerns, and addressing unobserved country level heterogeneity. To ensure our results are not driven by specific modelling choices, we compare multiple panel estimation approaches.

Our empirical strategy adopts a log-linear framework consistent with standard international economics methodology [15]. The baseline regression equation is specified as:

$$ln(Gas_{it}) = \alpha_i + \beta_1 ln(FX_{it}) + \beta_2 ln(Brent_{it}) + \beta_3 ln(CPI_{it}) + \mu_i + \lambda_t + \varepsilon_{it}, \quad (3)$$

where Gas_{it}, FX_{it}, $Brent_{it}$, and CPI_{it} denote domestic gasoline price, exchange rate, Brent crude oil price, and consumer price index, respectively, for country *i* at time *t*. The logarithmic transformation enables elasticity interpretation of the estimated coefficients. The term μ_i captures time-invariant country-specific effects, λ_t represents period-specific effects common across all countries, and ε_{it} is the idiosyncratic error component.

Our analysis considers four distinct estimation strategies. First, pooled OLS treats all observations identically without accounting for country or time dimensions. Second, the fixed effects approach incorporates country-specific intercepts to absorb time-invariant

https://doi.org/10.1051/e3sconf/202671206006

heterogeneity. Third, random effects estimation permits country-level variation while assuming such effects are orthogonal to regressors. Fourth, a parsimonious specification excludes control variables to isolate the unconditional relationship between exchange rates and gasoline prices.

2.3 Rolling Window Estimation

While the baseline panel regression provides an average estimate of exchange rate pass-through over the entire sample period, this approach implicitly assumes that the relationship remains stable over time. However, recent evidence from energy price transmission and exchange rate pass-through studies suggests that these relationships may exhibit considerable time variation [16–18]. Structural changes in fuel pricing policies, shifts in global oil market dynamics, and evolving macroeconomic conditions could all contribute to temporal instability in the pass-through coefficient. To capture these potential dynamics, we employ an expanding-window rolling regression approach.

The expanding-window methodology progressively increases the sample size by starting with an initial estimation period and sequentially adding one month at a time until the full sample is exhausted. Unlike fixed-window approaches that maintain a constant sample size by dropping early observations as new ones are added, the expanding-window technique accumulates data over time, thereby enhancing estimation precision as the window grows. This approach is particularly suitable for our analysis given the relatively short time dimension and the desire to track long-run trends in pass-through behaviour.

For each estimation window, we re-estimate the fixed effects specification:

$$ln(Gas_{it}) = \alpha_i + \beta_t ln(FX_{it}) + \gamma_t ln(Brent_{it}) + \delta_t ln(CPI_{it}) + \mu_i + \lambda_t + \varepsilon_{it}, \quad (4)$$

where the time-varying subscript t on the coefficients indicates that these parameters are allowed to vary across estimation windows. We maintain both country fixed effects (μ_i) and time fixed effects (λ_t) to control for unobserved heterogeneity and common temporal shocks. Cluster-robust standard errors are computed at the country level for each window to ensure valid inference in the presence of within-country correlation.

The initial window begins in January 2016 with a minimum of 108 months of data to ensure sufficient degrees of freedom for reliable estimation. Each subsequent window adds one additional month, such that the final window encompasses the entire sample from January 2016 to December 2024, totally 1080 months. This procedure generates a time series of coefficient estimates $\{\beta_t\}$, which we plot to visualize the evolution of exchange rate pass-through over the study period. The resulting time-varying coefficients allow us to assess whether pass-through has strengthened, weakened, or remained stable, and to identify specific periods where the transmission mechanism may have changed due to policy reforms, market disruptions, or external shocks.

3 Data

This study utilizes a monthly panel dataset spanning January 2016 to December 2024 for ten Asian economies: Japan, South Korea, China, Thailand, Indonesia, Malaysia, the Philippines, Vietnam, India, and Singapore. These countries represent a diverse mix of fuel pricing systems, exchange rate regimes, and levels of market liberalization, which provides a rich empirical context for examining exchange rate pass-through to domestic gasoline prices.

The dependent variable is the domestic retail gasoline price (Gas), measured in local currency per litter. The primary explanatory variable is the nominal bilateral exchange rate (FX), defined as units of local currency per U.S. dollar. To account for fluctuations in global energy costs, Brent crude oil prices (Brent) measured in USD per barrel are included as an external cost determinant. Additionally, the consumer price index (CPI) is incorporated as a domestic macroeconomic control capturing broader price dynamics and aggregate demand pressures. All variables are obtained from publicly accessible sources such as the World Bank, International Energy Agency (IEA), International Monetary Fund (IMF), and national statistical authorities. Monthly observations are harmonized to ensure cross-country comparability. Prior to estimation, all variables are transformed into natural logarithms to stabilize variance and allow interpretation of coefficients as elasticities. Descriptive statistics for the key variables are presented in Table 1. The Jarque–Bera statistics indicate significant departures from normality for most series, a common feature of macroeconomic and financial time series characterized by skewness and heavy tails.

Table 1. Descriptive statistics.

Statistic	Mean	Median	Max	Min	Std.Dev	Skew-ness	Kurt osis	Jarque Bera	Obs (N)
Gas	2100.65	51.14	30736.3	1.25	5784.2	2.82	6.48	3338.5***	1080
FX	2466.95	61.24	24335	1.3	6883.69	2.66	5.09	2445.5***	1080
Brent	67.71	67.25	120.08	23.34	19.24	0.19	-0.11	6.6991**	1080
CPI	106.98	100.78	196.8	83.06	20.75	1.98	4.34	1558.1***	1080

***, and ** indicate the significance levels at 1% and 5%, respectively

4 Empirical result and discussions

4.1 Panel unit root test result

Before estimating the panel regression models, panel unit root tests were conducted to verify the stationarity properties of the variables and prevent the risk of spurious regression. Two complementary tests were applied: the Levin–Lin–Chu (LLC) test, which assumes a common unit root process across countries, and the Fisher-type ADF test, which allows for heterogeneous autoregressive dynamics. The results presented in Table 2 show that all variables are stationary in levels. The LLC test strongly rejects the null hypothesis of a unit root for gasoline prices, exchange rates, and Brent crude oil prices at the 1% significance level. CPI is significant at the 10% level, providing weaker but acceptable evidence of stationarity. The Fisher-type ADF test also rejects the unit root hypothesis for all variables at conventional significance levels, confirming the robustness of the stationarity results across different testing approaches. Overall, these findings validate the use of level-form variables in the subsequent panel regression analysis and ensure that the estimated relationships are not driven by non-stationary trends.

Table 2. Panel unit root test results.

Variables	Log(Gasoline Price)	Log(Exchange rate)	Log(Brent crude oil price)	Log(Consumer Price Index)
LLC Test	-4.3061***	-3.5359***	-4.8644***	-0.14892*
Fisher-test	51.602***	49.777***	61.522***	22.316*

***, and * indicate the significance levels at 1% and 10%, respectively

4.2 Panel regression analysis

Table 3 reports the results from four panel regression specifications estimating the determinants of domestic gasoline prices across Asian economies. The specifications differ in their treatment of unobserved country heterogeneity and the inclusion of control variables. In the pooled OLS and baseline models without controls, the exchange rate coefficient is close to unity, suggesting that a 1% currency depreciation is associated with an approximately 1% increase in gasoline prices. These estimates, however, primarily reflect cross-country variation and do not identify within-country exchange rate pass-through.

Once country-specific effects are controlled for, the estimated pass-through declines substantially. The random effects model yields an exchange rate coefficient of 0.612, while the fixed effects model produces a much smaller estimate of 0.184. Table 4 model selection tests provide strong support for the fixed effects specification. The F-test for individual effects strongly rejects the pooled OLS model, indicating significant country-specific heterogeneity in domestic gasoline prices. Similarly, the Breusch–Pagan Lagrange Multiplier test rejects pooled OLS in favor of a panel estimator. The Hausman test further rejects the random effects model, implying that unobserved country-specific effects are correlated with the regressors. Taken together, these results justify the use of a fixed effects model, which appropriately controls for time-invariant cross-country structural characteristics when estimating exchange rate pass-through to gasoline prices.

Under the preferred fixed effects model, exchange rate pass-through to domestic gasoline prices is positive but incomplete: a 1% depreciation raises gasoline prices by approximately 0.18%. This limited transmission is consistent with institutional features of fuel pricing in the region, including fuel subsidies, stabilization mechanisms, and regulatory interventions that smooth retail price adjustments. The presence of fixed excise taxes and margin compression by retailers further dampens the transmission of exchange rate shocks to consumer prices.

The estimated coefficient on Brent crude oil prices is 0.335, indicating partial pass-through of international oil price movements to domestic gasoline prices. This magnitude suggests that crude oil costs account for roughly one-third of retail gasoline prices, with the remaining share reflecting refining margins, distribution costs, and taxation. The coefficient below unity is consistent with inventory adjustment, contractual pricing arrangements, and relatively stable refining margins observed in fuel markets.

Domestic inflation also plays an important role. The CPI coefficient is estimated at 0.646, indicating that gasoline prices respond strongly to changes in the general price

https://doi.org/10.1051/e3sconf/202671206006

level. This reflects the inflation sensitivity of domestic cost components such as labor, transportation, storage, and retail services, as well as the presence of ad valorem fuel taxes. The estimate remains below one, consistent with the fact that imported crude oil costs are determined externally and do not fully adjust to domestic inflation.

Overall, the results indicate that exchange rates, international oil prices, and domestic inflation significantly affect gasoline prices, but their effects are substantially moderated by policy design and market structure, resulting in persistently incomplete pass-through in Asian fuel markets.

Table 3. Panel regression parameter estimation.

Variables	Without control variables	Pooling OLS	Fixed effects	Random effects
Constant	-0.0673956*** (0.024128)	-0.0265818* (0.3603596)		-2.218557*** (0.320278)
Log (Exchange rate)	0.9968608*** (0.0048488)	0.9985587*** (0.0046915)	0.184107*** (0.058019)	0.612078*** (0.041720)
Log (Brent crude oil price)		0.3643095*** (0.0413891)	0.335071*** (0.012905)	0.311985*** (0.013281)
Log (Consumer Price Index)		-0.3366130*** (0.0748982)	0.646053*** (0.059079)	0.529188*** (0.060589)
Adj. R-squared	0.97511	0.97692	0.57972	0.59342

***, and * indicate the significance levels at 1% and 10%, respectively

Table 4. Panel Model Specification Tests.

F-test	LM test	Hausman test
F = 1450.6***	chisq = 46475***	chisq = 112.63***

*** indicates the significance levels at 1%

4.3 Rolling Window Estimation Result

The expanding-window rolling regression reveals substantial time variation in exchange rate pass-through (ERPT) to domestic gasoline prices. Figure 1 plots the evolution of the ERPT coefficient from 2017 to 2024 together with 95% confidence intervals. The estimated pass-through is relatively high at the beginning of the sample, averaging around 0.70 - 0.75 in 2017, before declining steadily and stabilizing at approximately 0.60 - 0.65 from 2020 onward.

The higher ERPT observed in the early period coincides with fuel pricing reforms implemented after the 2014 - 2016 oil price collapse, during which several Asian economies reduced fuel subsidies and allowed greater transmission of external cost shocks. As policy interventions were gradually reintroduced through subsidy programs, stabilization funds, and administrative pricing rules the sensitivity of gasoline prices to exchange rate movements declined. The stabilization of ERPT after 2020 aligns with the COVID-19 period, when widespread policy measures were adopted to shield households from fuel price volatility, resulting in more stable and uniformly incomplete pass-through across countries. Throughout the sample, the ERPT coefficient remains well below unity, confirming that exchange rate depreciation does not fully transmit to retail gasoline prices.

Overall, the rolling estimates indicate that exchange rate pass-through in Asian fuel markets is not constant but evolves in response to policy regimes and external shocks. While exchange rate movements remain relevant for gasoline pricing, their impact has weakened and become more stable over time, underscoring the importance of accounting for time-varying transmission mechanisms when assessing fuel price dynamics and inflationary pressures.

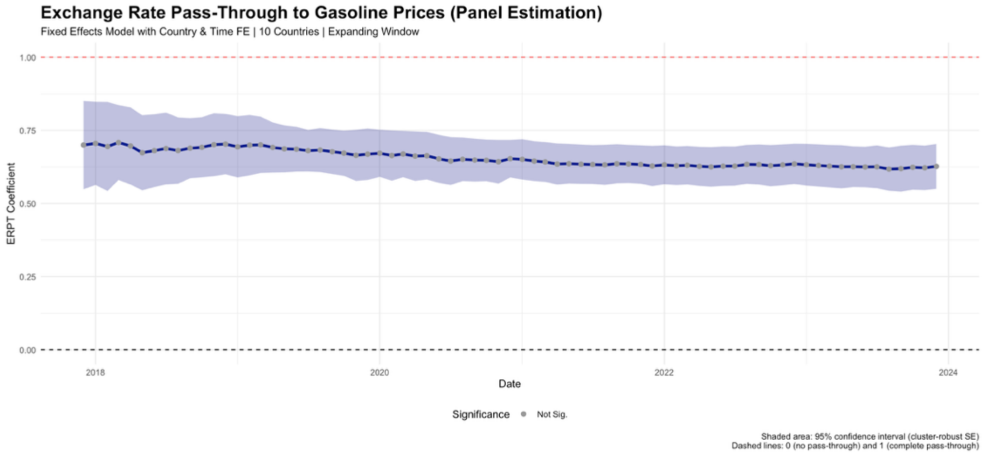

Fig. 1. Exchange rate pass-through to gasoline price.

5 Conclusion

This study investigates exchange rate pass-through (ERPT) to domestic gasoline prices in ten Asian economies using monthly data from 2016 - 2024. Panel unit root tests confirm stationarity, and model selection tests including the F-test, Breusch Pagan LM test, and Hausman test consistently indicate that the fixed effects specification is the most appropriate framework. The empirical results reveal that ERPT in Asia is positive but incomplete. The fixed effects estimate of 0.184 implies that a 1% depreciation of the domestic currency leads to only a 0.184% increase in retail gasoline prices, reflecting the widespread use of fuel subsidies, price stabilization mechanisms, tax policies, and regulatory interventions that dampen the transmission of external shocks.

From a policy perspective, the finding of positive but incomplete ERPT together with the rolling-window evidence of a declining and stabilizing pass-through indicates that fuel subsidies, price regulations, and stabilization mechanisms have been increasingly effective in moderating the transmission of exchange rate fluctuations to domestic gasoline prices. In the short run, this contributes to price stability and supports SDG 8 (Decent Work and Economic Growth) by limiting inflationary pressures and protecting household purchasing power. However, sustained insulation from external shocks entails fiscal costs, particularly during periods of prolonged currency depreciation or elevated global oil prices. Policymakers should therefore pursue gradual and transparent subsidy reforms, supported by predictable fuel pricing formulas, to maintain fiscal sustainability while avoiding abrupt price adjustments.

At the same time, the significant roles of global oil prices and domestic inflation reflected in the Brent 0.335 and CPI 0.646 coefficients suggest that fuel price stabilization must be coordinated with broader monetary and fiscal policies. In the longer term, strengthening energy security through energy diversification, renewable energy expansion, and investment in storage and refining capacity can reduce dependence on imported oil and exposure to external shocks, directly supporting SDG 7 (Affordable and Clean Energy).

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