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Asymmetric Dynamics Between Exchange Rates and Crude Oil Prices: A Cross-Country Assessment

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ABSTRACT

This study examines whether there exists nonlinearity between exchange rates and crude oil prices for two developing economies (i.e., Pakistan and Sri Lanka) by taking data from January 2010 to March 2024. To identify structural break (asymmetry), Zivot-Andrews unit root test has been utilized. Further, nonlinear and linear Granger Causality tests have been practiced to inspect the symmetry and asymmetry between unrefined oil prices and exchange rates. A unidirectional symmetry causality has been recognized between prices of unrefined oil and exchange rates while no asymmetry causality has been identified. These results advocate that swings in crude oil prices do not forecast potential shifts in these two nations' currency rates in a nonlinear way, and vice versa. The lack of nonlinear causation may reflect the complexities of the mutual influence between oil prices and currency rates, in which other aspects such as monetary policy, external shocks, or market processes may act more importantly in shaping their dynamic linkages.

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1. Introduction

Oil, a significant source of volatility, plays a vital role within the financial advancement of countries around the globe. The rising demand of oil in both developed and developing nations has accelerated a sharp hike in its cost. Moreover, this growing demand is placing pressure on the current account balance, especially for oil-importing economies. Oil price fluctuations have both direct and indirect economic effects. Increasing oil prices directly affect the manufacturing costs of products and services. An increase in oil prices elevates the manufacturing costs of goods and services, in the manner leading to inflation. In turn, this inflation adversely affects the economic scenario of countries by lowering consumers' purchasing power which in turn causes a fall in income and overall welfare.Rising oil prices impact national income by redistributing wealth from countries that import oil to those that export it, as reflected in trade imbalances. It has been noted that the recurrent trade measures implemented due to the imbalances in the balance of payments, as the trade deficits and surpluses get rebalanced, tend to create variations in the exchange rates. It is noted that the price of oil and its cyclical nature has a lot to do with currency rates in both oil importing and oil exporting economies. Developing nations, like Pakistan and Sri Lanka, are especially sensitive to this relationship. It is no surprise that both Sri Lanka and Pakistan are at risk of rising oil prices because their economies are dependent on imported oil. Like India, oil imports make it possible for most of the people in Pakistan and Sri Lanka to meet their energy requirements. Consequently, since both countries are such import-dependent nations, Sri Lanka and Pakistan are also susceptible to variances in worldwide crude oil prices which adversely impacts their trade equilibrium and exchange rates.

A true exchange rate shock may also cause variations in oil prices worldwide. By limiting major rise and fall in the exchange rate, both Pakistan and Sri Lanka keep an equitable, business-weighted effective exchange rate regime that promotes substantial amounts of global trade and financial system stability. Pakistan determines its effective exchange rate by using a mix of crucial currencies including the British pound, US dollar, and euro. Similarly Sri Lanka's exchange rate regime aims at maintaining stability against the currencies of key trading partners in order to facilitate the movement of goods, capital and services without any hindrance. This method enables Pakistan and Sri Lanka to successfully manage external shocks and promote economic growth. In comparison, nations such as India and China have more diverse baskets that comprise currencies from many trading partners (Zhang, Shi, & Zhang, 2011). Different economists recorded different channels through which oil prices altogether impact macroeconomic factors such as net household items, intrigued rates, cash supplies, stock costs, and trade rates (e.g., (Hayat & Narayan, 2011; Hotelling, 1931; Narayan & Sharma, 2011). Hotelling (1931) theorized that resource value grounded will compel oil producers to make a decision regarding their rate of extraction based on changing interest rates and oil prices. Dohner (1981) examined price increases, financial flows, and changes in energy prices, and concluded that upsurges in oil prices invariably due to inflationary pressures. In general, the studies by Narayan and Sharma (2011, 2014) evaluated the association between the volatility of oil prices and stock market returns. By utilizing NYSE firm-level information, they found that prices of oil influenced firm’s returns in an unexpected way depending on the segments. In their study, Narayan and Sharma (2011) examined the involvement of supply and demand volatility in driving variations in the oil stock of the United States. Narayan and Sharma (2014), by utilizing day to day information from the NYSE, concluded that oil prices influence stock return’s instability, by finding that the effect is sector-specific which for most firms is that an increment in oil prices by and large diminishes stock return instability.

A number of investigations have shown varied results regarding a causal association between prices of oil and currency rates. Benhmad (2012); Chaudhuri and Daniel (1998); Chen and Chen (2007); Lizardo and Mollick (2010); Tiwari, Mutascu and Albulescu (2013); Zhang et al. (2008), and Amano and Van Norden (1998) have summarized that prices of oil does Granger cause exchange rates. Similarly, Huang and Guo (2007); Reboredo (2012); Zhang and Wei (2010), and Sadorsky (2000) have discovered that trade rate developments may Granger cause changes in unrefined oil prices, in this manner refined oil price changes. Blomberg and Harris (1995) and Krugman (1980); Krugman (1982) have given an inclusive explanation of the intuitive among exchange rates and prices of oil, recommending that the US dollar does not provide value in relation to other currencies, international oil consumers are encouraged to spend more US dollars for the purchase of oil., thereby reinforcing the belief that oil prices dictates the movements of exchange rates. Drawing upon the findings from the related literature available, this research investigates the presence of nonlinear association linking exchange rates and prices of crude oil in two prominent emerging markets, Pakistan and Sri Lanka. In spite of the fact that most experimental thinks about on causality emphasize a straight relationship, there's developing evidence of the nonlinear elements of exchange rates, oil prices and other money related time-series indicators. This becomes more apparent when analyzing nonlinear causation in time series data. A few noticeable studies claim that the conventional test for causality test, which is planned to distinguish straight causality, is ineffectual at revealing certain nonlinear causal connections. Subsequently, they suggest utilizing of nonlinear causality tests (i.e., (Baek & Brock, 1992; Benhmad, 2012; Chen et al., 2004; Diks & Panchenko, 2005; Hiemstra & Jones, 1994; Hiemstra & Kramer, 1997; Li, 2006; Péguin-Feissolle, Strikholm, & Teräsvirta, 2013; Péguin-Feissolle & Terasvirta, 1999; Skalin & Teräsvirta, 1999; Wang & Wu, 2012).

This paper highlights four basic components. To begin with, both Pakistan and Sri Lanka are driving developing economies, with strongly expanding demand for crude oil compared to the joined together states, which moreover positions profoundly in worldwide oil utilization. Measurements demonstrate that oil demand in Pakistan and Sri Lanka has been persistently rising. Secondly it calls attention to the impact of rising oil prices that directly increase production costs, fueling inflation, and reducing consumer purchasing power which in turn negatively impacts income and welfare of nations. Thirdly it highlights the redistribution of this oil price volatility by redistributing wealth from oil-demanding countries to oil-selling countries, as reflected in their trade balances and exchange rates, and hence effecting their overall macroeconomic stability. Lastly it reveals a complex interplay among oil prices, exchange rates, and other economic variables, highlighting both linear and non-linear causality. By focusing on these two emerging markets, this research aims to spotlight oil price variations and exchange rates dynamic interactions by considering both short-term volatility and long-term trends, as historical analyses underscore the long-term effects of oil price fluctuations on inflation, trade, and currency stability. This paper is expected to offer insights into the macroeconomic adjustments and policy strategies required to lessen the adverse effects of oil price shocks on these oil import-dependent economies. The remains of the paper are structured as follows: Part 2 covers prior literature related to this issue, part 3 details the data sources and analytical techniques used in this paper, part 4 is about empirical findings, and discussions and part 5 sums up the main findings and policy recommendations.

2. Review of Prior Studies

Hussain et al. (2022) studied the outcome of structural currency rates devaluation and oil prices on Pakistan inflation from 1980 to 2020. They also found that inflation is influenced by currency rates and crude oil prices. Such sources of inflation are exports, money supply and gross fixed capital formation. They recommended that central banks must regulate fiscal and monetary policies to control inflation. Bhatia (2021) considered the sustainability of crude prices of oil and exchange rates with respect to COVID-19 from 1999 to 2020. For that reason, the paper compared normal and COVID-19 periods using an OLS model as well as a DCC-GARCH. The results indicated that BRICS exchange rates bear a significant cause-and-effect relationship with crude oil prices, while there exists non-linear correlation among the variables of exchange rates, prices of oil and bigger values of variables. There was equilibrium volatility from prices of crude oil to exchange rates, but short-run volatility was lacking. Volatility was less persistent in exchange rates than in unrefined oil prices. Muhammad et al. (2021) utilized cointegration technique for regression analysis and observed the impact of crude oil prices and exchange rate volatility on inflation in Pakistan from 2004 to 2019. However, studies add that inflation is largely determined by commodity prices; particularly oil and exchange rate. In their research work, Route et al (2015) utilized the cointegration model and error correction mechanism to try and analyze the long run dynamics of exchange rates, prices of oil and inflation among the three underdeveloped economies and also originate that increasing oil prices and currency exchange rates are considerably correlated.Sheikh et al. (2020) examined asymmetrical connection among prices of oil, stock prices, gold prices, and currency exchange rates during the worldwide financial disaster from 2004 to 2018. They used the NARDL (nonlinear autoregressive distributed lag) model to analyze the pre- and post-2008 economic crises. They argued that, before the crisis, investors responded inversely to oil and gold prices, and the post-crisis tendency saw them respond variably to macroeconomic changes. Nevertheless, they found that oil price had disproportionate affect on stock price before the financial crisis.

Ullah et al. (2019) used monthly time series data to analyze the dynamic connection between oil price, KMI-30 index, and currency rate between 2009 and 2016. They found no cointegration among exchange rates, the KMI-30 index, and prices of oil. Furthermore, while prices of oil had an immediate effect on the KMI-30 index, they had no long-term effect. The exchange rate did not have a causal relationship with the KMI-30 index. Ahmed, Qaiser and Yaseen (2016) undertook an analysis of possible associations amid movements in oil prices and fluctuations in exchange rate for Pakistan in the dated from 1983 to 2014 using the EGARCH models. They reported that shock of oil price volatility existed, and oil prices negative shock had a bigger effect on exchange rate volatility. The paper by Shahbaz, Tiwari and Tahir (2015) explores the relationship between stock markets with respect to oil prices in Pakistan from 1986 to 2009 through the use of wavelet analysis. It was shown that the effective exchange rate in real terms and oil prices correlate inversely over time. It is proposed that the fluctuations in the real effective exchange rate may have temporary opposing effects on the prices of oil. The study's overall result revealed an unbroken unfavorable link between real effective currency rates and oil prices. (Ikram & Waqas, 2014) set out the survey to check the influence of the prices of oil with respect to the agriculture productivity growth in Pakistan between years 1980 to 2013. Using the Johnson co-integration approach, they ascertained that the increase in water availability and real effective exchange rates have a beneficial impact on agriculture productivity growth whereas high oil prices and overuse of fertilizers have a negative effect.

(Brahmasrene, Huang, & Sissoko, 2014) inspected the volatility connection between unrefined oil prices and currency exchange rates from 1996 to 2009 using the VAR model. They presented evidence about the crashed exchange rates due to extreme price instability in June 2008. The study also used a Granger causality test with the results indicating the impact of oil prices on currency rates.
(Ansar & Asghar, 2013) investigated the influence of oil prices on the CPI and stock market index in Pakistan for the period of 2007 to 2012. Applying the Johansen co-integration test they

demonstrated that changes in oil price influence CPI and the stock market. Their study established the presence of an upward lean between CPI and oil prices and the KSE 100 Index. Indeed, higher oil prices have obvious adverse effects on the stock market index and inflation also negatively impacts the returns from the stock market.

2.1. Linkage between Exchange Rate and Oil Price

It is clear that the relationship between prices of oil and currency exchange rates warrants study on two grounds. First, there are considerable changes in terms of trade especially when it comes to oil prices. The development of the model which distinguishes between one sector of non-tradable goods and another of tradable goods sector is that of Amano and Van Norden (1998). In their framework, each sector employs both non-tradable (labor) and tradable (for example oil) inputs. Though the production price is constant worldwide, the exchange rate which is in the actual market is determined by the output price of the non-tradable sector. Suppose there is an external factor that reduces the price of labor. In that case, the price of oil has to rise to sustain competitiveness within the tradable sector. When the tradable sector is less energy usage sector relative to the non-tradable sector, this shock will bring about an increase in its output prices leading to appreciation of the real exchange rate. In the same way, when the tradable sector is more energy usage sector, its price level must be lower to sustain competitiveness, leading to the depreciation of the real currency exchange rate. Therefore, the impact of oil price shocks is conditioned by the oil usage intensity of both sectors of relevant countries.

Secondly, the work of Golub (1983) and Krugman (1980) centered on balance of payments and assumed that increasing prices of oil leads to a net capital movement out of oil importers to oil exporters. For a limited time, this shifting of wealth alters the exchange value of currencies by affecting which investments oil-importing countries make. But in the longer run, it is these countries' import patterns that will determine currency value. However, in the long term, exchange rates are affected by the import preferences of these nations. Further, they found that oil-exporting nations particularly OPEC countries, prefer dollar-denominated assets over U.S. goods, leading to short-term dollar appreciation subsequent a hike in the oil price, but not in the long run. The association between oil prices and other economic factors has been researched on and off ever since the oil embargoes which rocked the world in the year 1973.Rafiq, Salim and Bloch (2009) prospected the existing literatures and emphasized on (1) Recognizing oil as a significant factor in the production process, (2) discussing the effects of oil price shocks on inflation, investment, employment, trade, output, interest, and exchange rate and (3) examining that the costs that derive from increase in oil prices are higher than the advantages that can be gained from decreasing the oil prices. Zhang et al. (2008) asserted that oil price and the United States dollar exchange rates have a long run relationship in the international market but do not affect the oil price markets considerably in short run. A well-articulated idea is provided by Chen and Chen (2007) who argue that this is particularly true for oil deficient economies. In such economies, even an increase of real oil prices in the least amount can eventually lead to increase all other tradable goods prices norms within the economy than in the foreign market and cause the downgrading of the home currency. Likewise, studies by Kutan and Wyzan (2005); Rautava (2004) and Darby (1982) indicated that negative shocks in oil prices led to the devaluation of home currencies in Kazakhstan, Russia, and G7 countries. In contrast, Benhmad (2012); Huang and Guo (2007); Narayan, Narayan and Prasad (2008); Olomola and Adejumo (2006) and Amano and Van Norden (1998) concluded that shocks in prices of oil accelerated the appreciation of exchange rates in Fiji, Sri Lanka, Nigeria, and U.S., during the study period.

Ghosh (2011) examined the association between prices of oil and exchange rate in the context of Indian economy and observed that rising oil prices tend to fall in the value of Indian Rupee, expressed in dollars, and even on the volatility of the exchange rates in the long run. Zhou (1995); and Chaudhuri and Daniel (1998) addressed the significant role of oil prices in amplification of exchange rate movements. Turhan, Hacihasanoglu and Soytas (2013) examined the relationship between exchange rates and prices of oil in G20 countries over time, and pointed out that there is a negative correlation between both. Ju et al. (2014) analyzed the macroeconomic effects of oil price shocks in Sri Lanka, discovering that such shocks negatively impact Sri Lanka's exchange rate and GDP while positively affecting CPI, significantly influencing Sri Lanka's trade. Since the period beginning in 2010 marked a phase of recovery from the worldwide financial crisis of 2008, the economic policies implemented by both Sri Lanka and

Pakistan, along with global trends in oil prices, offer important insights into how these two economies adapted to global recessions and adjusted their exchange rates accordingly. There were two notable oil price shocks between 2010 and 2024, such as the 2014 oil price crash and the consequences of the COVID-19 pandemic on global energy demand and supply. Examining how the currency rates of Pakistan and Sri Lanka responded to these shocks can shed light on their ability to adapt and make macroeconomic adjustments in the face of price volatility.

3. Methodology

3.1. Linear Causality Test

This research investigates the dynamic granger causality relationship between crude oil prices and currency exchange rates for Pakistan and Sri Lanka. Analysis is performed in the following manner:

$$\Delta OL_t = \theta_0 + \sum_{i=1}^{n} \theta_{1i}\,\Delta OL_{t-i} + \sum_{i=1}^{n} \theta_{2i}\,\Delta EX_{t-i} + \vartheta_t \quad (1)$$
$$\Delta EX_t = \emptyset_0 + \sum_{i=1}^{n} \emptyset_{1i}\,\Delta EX_{t-i} + \sum_{i=1}^{n} \emptyset_{2i}\,\Delta OL_{t-i} + \vartheta_t \quad (2)$$

where ΔOL_t shows change in crude oil price for Pakistan and Sri Lanka (at time t) and ΔEX_t shows variation in exchange rate for Pakistan and Sri Lanka (at time t).

3.2. Non-Linear Causality Test

The linear approach to causality evaluation has one important drawback that it cannot uncover non-linear causal relationships. Brock (2018) proposed a two-dimensional non-linear model in order to demonstrate how linear causality tests can overlook non-linear causality tests. Baek and Brock (1992) introduced a statistic theory which is not only based on parameters in order to locate non-linear structures in relations so as to resolve the forecast problems arising purely from the linear perspective. In order to identify any nonlinear dependencies existing between two time series, this technique is used to allow computation of correlation integral over time to visualize spatial probabilities.

For two stationary time series (i.e., Turhan, Hacihasanoglu and Soytas (2013) and $\{X_t\}$) where t = 1,2, … ,n, let m denote the m-length lead vector of X_t, and let Ly-length and Lx-length represent lag vectors of Y_t and X_t, represented as Y_{t-Lx}^{Lx} and X_{t-Lx}^{Lx} respectively. Moreover, for specified observations of m, both Ly and Lx ≥ 1. Y will not strictly Granger cause X for e > 0, if

$$Pr\left(\|X_t^m - X_s^m\| \prec \frac{e}{\|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\|} \prec e, \left\|Y_{t-Ly}^{Ly} - Y_{s-Ly}^{Ly}\right\| \prec e\right) = Pr\left(\|X_t^m - X_s^m\| \prec \frac{e}{\|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\|} \prec e\right) \quad (3)$$

Where || . || shows the maximum norm. In Equation (3), the left hand side (L.H.S) denotes the probability of two subjective m-length lead vectors of the processes {Xt} lying at a distance e from each other whenever the Ly-length lag vector of the process Turhan, Hacihasanoglu and Soytas (2013) and the Lx-length lag vector of the process {Xt} are also present within an extent e. The R.H.S. of Equation (3) is the probability that two subjective m-length lead vectors of {Xt} are e-close to each other given that their corresponding Lx length lag vectors are also e-close to each other. Therefore, to test the validity of Equation (3), the conditional probabilities need to be written in a form of joint probability ratios. Let C3 (m+Lx, e)/C4 (Lx, e) and C1 (m+Lx, Ly, e)/C2 (Lx, Ly, e) signify the combined probability ratios analogous to the right and left sides of Equation (3), respectively. The following statement is put forward as a strict requirement of Granger non causality. In equation (3):

$$\frac{C1(m+Lx,Ly,e)}{C2(Lx,Ly,e)} = \frac{C3(m+Lx,e)}{C4(Lx,e)} \quad (4)$$

Under stationary assumption for both $\{X_t\}$ and Turhan, Hacihasanoglu and Soytas (2013) then according to (Denker & Keller, 1983) weakly dependent and mixing conditions, if Turhan, Hacihasanoglu and Soytas (2013) does not Granger cause $\{X_t\}$, is

$$\sqrt{n}\left(\frac{C1(m+Lx,Ly,e,n)}{C2(Lx,Ly,e,n)} - \frac{C3(m+Lx,e,n)}{C4(Lx,e,n)}\right) \sim N(0,\sigma^2(m,Lx,Ly,e)) \quad (5)$$

where the estimator's variance is represented by $\sigma^2(m,Lx,Ly,e)$.

3.3. Data

This research focused on the monthly time series data from January 2010 to March 2024. Data for exchange rate is retrieved from International Financial Statistics database (IFS) and for crude oil prices, the data is retrieved from US Energy Information Administration (EIA) and US Department of Energy (DOE). This specific time frame is chosen for several important reasons, including analytical and contextual factors relevant to evaluating the relationship between currency exchange rates and crude oil prices in Pakistan and Sri Lanka. The selected period encompasses major global and regional economic events, such as fluctuations in crude oil prices due to geopolitical tensions, changes in oil supply and demand, and macroeconomic adjustments. Global oil price changes during this era had a significant influence on Pakistan and Sri Lanka in terms of economic stability, fiscal balances, and currency rate dynamics for both as net oil importers.

4. Results and Discussion

Figure 2 illustrates the changes in Pakistan's real effective exchange rate from January 2010 to March 2024, showing the month-by-month percentage fluctuations. Positive values indicate an appreciation of the real effective exchange rate (REER), potentially diminishing Pakistan's export competitiveness, while negative values suggest depreciation, which could enhance export competitiveness but increase import costs. This shows rather constant fluctuations in the early years, with major swings in late 2022 and early 2023, which are likely due to external shocks or internal policy moves in reaction to increase in global oil prices, illustrated in Figure 1. The rise in oil prices in mid-2020, driven by the COVID-19 pandemic and other disruptions, likely contributed to the instability in Pakistan's currency markets, negatively impacting the REER. Similarly, Figure 3 illustrates the REER for Sri Lanka from January 2010 to March 2024, revealing similar effects on currency competitiveness. An increase in the REER indicates appreciation, which may reduce export competitiveness, while a decrease suggests depreciation, potentially boosting exports but raising import costs. The notable fluctuations in Sri Lanka's REER during early 2022 and late 2023 align with periods of heightened oil price volatility shown in Figure 1, indicating that global oil price increase influence the currency exchange rates of both countries. Like Pakistan, Sri Lanka's REER seems to be influenced by external shocks and oil price changes, thereby exhibiting significant volatility during and after the recoveries from the COVID-19 pandemic.

Figure 1: Changes in Oil Prices

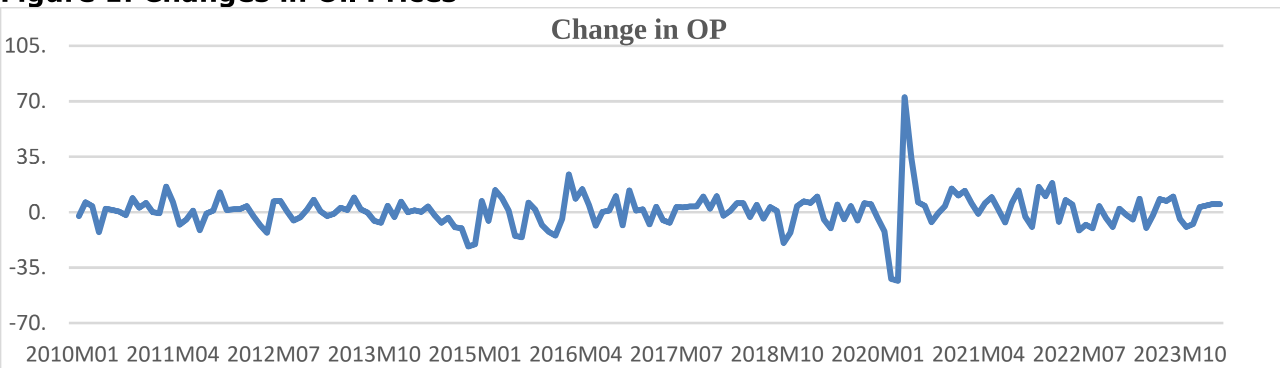

Figure 2: Changes in Pakistan's Real Effective Exchange Rate (REER)

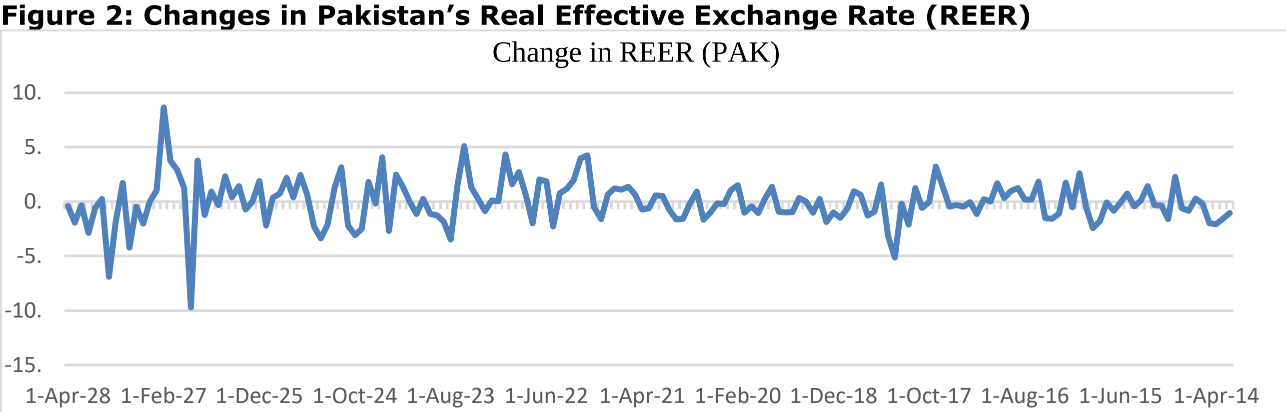

Figure 3: Changes in Sri Lanka's Real Effective Exchange Rate

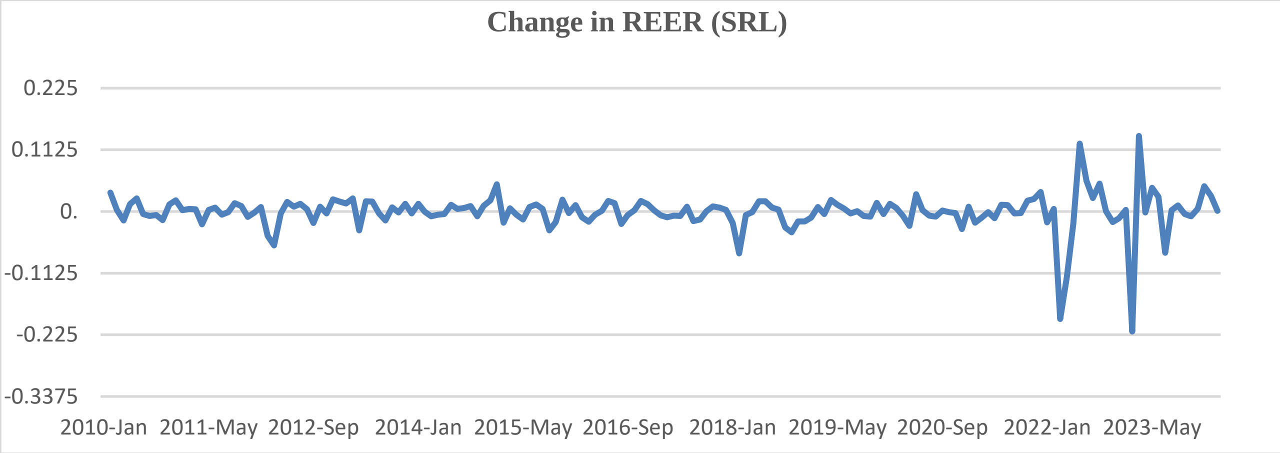

Table 1 shows the outcomes of Ng-Perron unit root test suggesting that both LOP and LREER_PAK series are unit roots under different exogenous specifications. However, from Table 2, the first differences of both LOP and LREER_PAK series reject the null hypothesis, indicating stationarity. The significant values observed in the first differences of (D(LOP) and D(LREER_PAK)) are supporting this conclusion and indicating that the series is I(1).

Table 1: Results of Ng-Perron Unit Root Test, At Level

Null Hypothesis	Exogenous	Lag-Length	MZa	MZt	MSB	MPT
LOP has a unit root	C	0	-7.828	-1.972	0.252	3.155
	C & T	2	-10.198	-2.213	0.217	9.152
LREER_PAK has a unit root	C	0	-2.802	-1.134	0.405	8.597
	C & T	0	-3.861	-1.389	0.360	23.602
LRRER_SL has a unit root	C	0	-4.701	-1.318	0.280	5.666
	C & T	0	-9.150	-2.092	0.228	10.151
Asymptotic critical values*:	1%		-13.8000	-2.58000	0.17400	1.78000
(Constant)	5%		-8.10000	-1.98000	0.23300	3.17000
	10%		-5.70000	-1.62000	0.27500	4.45000
Asymptotic critical values*:	1%		-23.8000	-3.42000	0.14300	4.03000
(Constant and Trend)	5%		-17.3000	-2.91000	0.16800	5.48000
	10%		-14.2000	-2.62000	0.18500	6.67000

C= Constant, C & T= Constant and Linear Trend *Source: Author's calculations*

Table 2: Results of Ng-Perron Unit Root Test, At 1st Difference

Null Hypothesis	Exogenous	Lag-Length	MZa	MZt	MSB	MPT
D(LOP) has a unit root	C	0	-78.853	-6.272	0.080	0.326
	C & T	1	-130.786	-8.086	0.062	0.700
D(LREER_PAK) has a unit root	C	0	-80.407	-6.340	0.079	0.306
	C & T	0	-83.155	-6.446	0.078	1.104
D(LRRER_SL) has a unit root	C	10	-0.576	-0.477	0.827	34.998
	C & T	0	-83.077	-6.442	0.077	1.1082
Asymptotic critical values*:	1%		-13.8000	-2.58000	0.17400	1.78000
(Constant)	5%		-8.10000	-1.98000	0.2330	3.17000

	10%	-5.70000	-1.62000	0.27500	4.45000
Asymptotic critical values*:	1%	-23.8000	3.42000	0.14300	4.03000
(Constant)	5%	-17.3000	2.91000	0.16800	5.48000
	10%	-14.20000	2.62000	0.18500	6.67000

C= Constant, C & T= Constant and Linear Trend *Source: Author's calculations*

Table 3 presents the output of the Zivot-Andrews unit root test. These outcomes indicate that the null hypothesis of a unit root with a structural break cannot be rejected for LOP, i.e., breaks in the trend, intercept, and both trend and intercept, suggesting non-stationarity around these structural breaks. Likewise, for LREER_PAK and LREER_SL, the null hypothesis fails to reject that there is a unit root with a structural break in trend, intercept, and both trend & intercept.

Table 3: Results of Zivot-Andrews Unit Root Test

Test	Sample Start	Sample End	Obs	Lag Length	Break Point	Z-Statistic	Prob.
LOP with Intercept Break	2010M01	2024M03	172	2	2014M10	-4.335	0.001
LOP with Trend Break	2010M01	2024M03	172	2	2016M02	-3.188	0.015
LOP with Intercept and Trend Break	2010M01	2024M03	172	2	2014M10	-4.336	0.006
LREER_PAK with Intercept Break	2010M01	2024M03	172	1	2017M12	-4.048	0.001
LREER_PAK with Trend Break	2010M01	2024M03	172	1	2015M04	-2.593	0.103
LREER_PAK with Intercept and Trend Break	2010M01	2024M03	172	1	2017M12	-3.879	0.000
LREER_SL with Intercept Break	2010M01	2024M03	172	4	2022M03	-3.994	0.001
LREER_SL with Trend Break	2010M01	2024M03	172	4	2016M11	-4.413	0.001
LREER_SL with Intercept and Trend Break	2010M01	2024M03	172	4	2014M12	-4.506	0.074

Asymptotic Critical Values With Intercept Break		With Trend Break	With Intercept and Trend Break
10% CV:	-4.58		
5% CV:	-4.93		
1% CV:	-5.34		
10% CV:	-4.11		
5% CV:	-4.42		
1% CV:	-4.80		
10% CV:	-4.82		
5% CV:	-5.08		
1% CV:	-5.57		

Source: Author's calculations

Table 4: Cointegration Test Results of Real Effective Exchange Rate and Crude Oil Prices

Series	Exogenous	Lags	Test	Statistic	CV (0.05)	Prob.	Finding
LOP, LRRER_SL	LRRER_SL	1-3	Trace	5991.792	15.49471	0	2 cointegrating equations
			Max-Eigen	4.575881	3.841466	0.0324	2 cointegrating equations
LOP, LREER_PAK	LREER_PAK	1-4	Trace	N/A	15.49471	N/A	2 cointegrating equations (based on Max-Eigen)

	Max-Eigen	4.70867	3.841466	0.03	2 cointegrating equations

Source: Author's calculations

Table 4 illustrate the results of cointegration tests of REER and crude oil prices, revealing a substantial long-term relationships between currency rates and crude oil prices for both countries. For the series LOP and LRRER_SL, both the Trace test (with a statistic of 5991.792) and the Max-Eigen test (having a statistic of 4.575881 with 0.0324 as a p-value) indicate the occurrence of two cointegrating equations. Similarly, for the series LOP and LREER_PAK, the Max-Eigen test (having a statistic of 4.70867 with 0.03 as a p-value) also specifies two cointegrating equations. However, specific values for the Trace test in this case are not available. These findings suggest robust equilibrium relationships between the LOP and the two exogenous series, LRRER_SL and LREER_PAK.

Table 5: Linear Pairwise Granger Causality Test Results

Sample	Lags	Null Hypothesis	Obs.	F-Statistic	Prob.
2010M01-2024M04	19	LREER_PAK does not Granger Cause LOP	153	1.87319	0.0228
		LOP does not Granger Cause LREER_PAK	153	1.14393	0.3186
	28	LOP does not Granger Cause LRRER_SL	144	1.69767	0.033
		LRRER_SL does not Granger Cause LOP	144	0.75224	0.8013

Source: Author's calculations

Table 5 shows the linear Granger causality output for all variables examined in this study. The findings indicate that LREER_PAK significantly Granger causes LOP, implying that LREER_PAK has predictive power over LOP. Conversely, LOP does not significantly Granger cause LREER_PAK, which suggests there is no significant predictive influence in that direction. Additionally, LOP significantly Granger causes LRRER_SL, indicating that LOP can also predict LRRER_SL. However, LRRER_SL does not Granger cause LOP, indicating no significant predictive effect. Hence these results suggest that for both exchange rates causality exists in one direction.

Table 6: Test Results of Nonlinear Granger Causality

Null Hypothesis	Granger Causality Index (GCI)	F-Statistic	p-value	Finding
lREER_PAK does not Granger Cause LOP	0.00214	0.31873	0.99518	No evidence for nonlinear causality
LREER_SL does not Granger Cause LOP	0.000000 (0)	-1.59729	1.00000	No evidence for nonlinear causality
LOP does not Granger Cause LREER_PAK	0.00389	0.58053	0.90065	No evidence for nonlinear causality
LOP does not Granger Cause LREER_SL	0.000000 (0)	-0.56437	1.00000	No evidence for nonlinear causality

Source: Author's calculations

The outcomes of nonlinear Granger causality test are given in Table 6. The results indicate no confirmation of nonlinear causality between the variables in any direction. LREER_PAK does not exhibit a nonlinear Granger causality towards LOP, nor does LREER_SL show a nonlinear Granger causality towards LOP. Likewise, LOP does not demonstrate a nonlinear Granger causality towards LREER_PAK, and LOP also does not exhibit a nonlinear Granger causality towards LREER_SL. These results suggest that there are no nonlinear causal relationships between these variables during the sample period. These data indicate that there is no nonlinear causal link at all between unrefined oil prices and real effective exchange rates for both Pakistan and Sri Lanka across the study period. Put differently, these finding suggests that swings in oil prices do not forecast potential shifts in these two nations' currency rates in a nonlinear way, and vice versa. The lack of nonlinear causation may reflect the complexities of the interactions between oil prices and currency exchange rates in which other elements like monetary policy, external shocks, or market processes may play comparatively more important role in shaping their dynamic linkages. Further study might look at potential linear linkages or other factors that might impact these characteristics.

5. Conclusion and Policy recommendations

This study investigates the presence of nonlinear relationships between exchange rates and crude oil prices for two developing economies, Pakistan and Sri Lanka, using monthly data spanning from January 2010 to March 2024, which encompasses significant global economic events and oil price shocks, such as oil price crash of 2014 and the COVID-19 pandemic. This research emphasizes their vulnerability to global oil price shocks, which exacerbate their trade imbalances and inflation. This empirical analysis conducted through various statistical tests provides valuable insights into the relationships among LOP, LREER_PAK, and LRRER_SL. The Ng-Perron test shows that the LOP and LREER_PAK series have unit roots at their respective levels, however they become stationary after the first differencing, thereby confirming that they are integrated of order one i.e., I(1). Additionally, the Zivot-Andrews test is used to test the significance of structural breaks in the series for achieving stationarity. Cointegration tests reveal strong long-term equilibrium relationships between LOP and both exogenous series (LRRER_SL and LREER_PAK), implying that even though short-term fluctuations, these variables incline to move composed over the long-run. Furthermore, linear Granger causality tests indicate that LREER_PAK significantly predicts LOP, and LOP can predict LRRER_SL, although no bidirectional predictive relationships are identified. Moreover, the nonlinear Granger causality test have not shown any evidence of nonlinear causation among the variables, suggesting that linear models adequately capture the relationships examined in this study. Given the significant cointegration relationships, policymakers should consider the long-term equilibrium dynamics when designing policies affecting the exchange rates and price levels as challenges persist due to their energy import dependence. Any interventions in the exchange rate mechanisms should account for their long-term impacts on the local price levels to maintain economic stability. For economic stability, authorities should closely monitor the LREER_PAK's impact on local price levels (LOP). Since LREER_PAK can predict LOP, maintaining a balanced and stable exchange rate could help control inflation and stabilize the economy.

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