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Testing the non-linearities of exchange rate pass-through in Somalia: does dollarization affect consumer prices?

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ABSTRACT

Over the past three decades, Somalia's economic landscape has witnessed a noticeable dependence on imported goods. The exchange rate was unregulated owing to the collapse of the country's central bank. This unregulated environment has introduced significant volatility in exchange rates, profoundly impacting consumer prices and fostering a prevalent shift towards the utilization of the US dollar in economic transactions. Hence, this undertaking delves into the asymmetric effects of exchange rates on consumer prices in the presence of dollarization in Somalia from 1995 to 2019. Employing both linear and nonlinear autoregressive distributed lag (NARDL) cointegration methodologies, we explore the short-run and long-run dynamics between exchange rates and consumer price levels. The long-run empirical results from the NARDL demonstrate asymmetrical cointegration between the unregulated exchange rate and inflation in Somalia. Both appreciation and depreciation of exchange rates exert differing impacts on consumer prices, with depreciation exhibiting a more pronounced effect. In addition, the evidence suggests that the exchange rate pass-through is incomplete in Somalia regarding its inelastic coefficient. Oil prices exhibit a substantial and statistically significant association with inflation, both in the long-run and short-run, while GDP remains inconsequential. In the short-run, the most remarkable outcome indicates that dollarization significantly contributes to mitigating inflationary pressures. Based on our empirical insights, the central bank should enhance regulatory oversight of the foreign exchange market by strictly controlling and prohibiting the issuance of counterfeit banknotes to achieve price stability.

IMPACT STATEMENT

This research comprehensively analyzes the complex dynamics between exchange rate fluctuations and consumer prices in Somalia, revealing a pronounced asymmetry. Through sophisticated modeling, the study demonstrates that exchange rate depreciations significantly impact inflation more than appreciations, a finding critical for effective monetary policy in dollarized economies like Somalia. The findings indicate the need for robust regulatory frameworks to mitigate the adverse effects of exchange rate fluctuations on the economy. This work is instrumental for policymakers, providing evidence-based recommendations to enhance regulatory measures aimed at stabilizing prices and managing inflationary pressures. Additionally, it contributes to the broader economic literature by detailing the unique challenges and strategies relevant to managing economies with significant dollarization.

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1. Introduction

Understanding domestic price changes in response to exchange rate movements has become crucial for monetary authorities to achieve price stability. The magnitude of exchange rate pass-through (ERPT) is a significant determinant of the level of exchange rates, balance of payments adjustment patterns, and

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financial stability (Delatte & López-Villavicencio, 2012). Since global trade is highly interconnected, an exchange rate shock is expected to affect the domestic price of imported goods (Abdi et al., 2023). This shift is passed on to producer and consumer prices. Even though the appreciation of local currency reduces the prices of imported goods, the weakening of the currency increases these prices, which leads to higher consumer prices (Delatte & López-Villavicencio, 2012). The nominal exchange rate affects domestic price levels of traded goods primarily through direct and indirect channels (Dobrynskaya & Levando, 2005; Jiang & Kim, 2013). The direct effect of exchange rate movements is transmitted through the prices of final goods. Whenever the proportion of the imported basket of items is larger, the influence of the exchange rate on prices is more significant (Garcia & Restrepo, 2001). The indirect channel is conveyed through the production costs of enterprises that rely on imported inputs for their final products. In this regard, the ERPT influences the company's cost structure, influencing aggregate demand levels and real incomes (Hara et al., 2015; Jiang & Kim, 2013). Correspondingly, the extent of exchange rate changes reflected in domestic inflation remains a major issue for monetary authorities in small open economies (Balcilar et al., 2019).

Typically, the degree of exchange rate pass-through to inflation ranges from zero to complete. The extent of pass-through depends on the firms' pricing behavior with respect to exchange rate changes (Helmy et al., 2018). Zero pass-through exists when foreign firms prefer to keep their markups unchanged by setting the prices of exported goods in the destination market's currency, known as local currency pricing (LCP) (Jiang & Kim, 2013). Complete pass-through, on the other hand, occurs when enterprises choose to fully transmit exchange rate variations to the selling price of their goods, especially when prices are established in the currency of the producers, referred to as producer currency pricing (PCP). Theoretically, the pass-through of the exchange rate to domestic prices is complete, that is, equal to one. On the contrary, the empirical evidence ascertains that incomplete pass-through is a common phenomenon (Aron et al., 2014; de Mendonça & Tiberto, 2017; Helmy et al., 2018; Jiang & Kim, 2013). The majority of businesses use a combination of both strategies, which is called partial pass-through because, in a competitive environment, firms cannot fully transmit ERPT to import prices (An & Wang, 2012; Delatte & López-Villavicencio, 2012). The declining degree of ERPT in many developed and developing countries can be attributed to declining inflation levels (Soon et al., 2018).

The existing empirical studies demonstrate that the disparity in the level of pass-through across different countries is mainly due to discrepancies in the monetary policies adopted. In a groundbreaking paper, Taylor (2000) contends that the extent of pass-through is minimal in an environment characterized by lower and more stable inflation. Taylor's hypotheses exhibit that ERPT results from continual price changes, which tend to decline in an inflationary environment with more credible monetary policy. The literature has documented that domestic inflation is slightly susceptible to exchange rate fluctuations in many advanced economies. Delatte and López-Villavicencio (2012) indicate that the average pass-through in developed countries is close to zero. The monetary authorities can exercise independence in the monetary policy setting, and an inflation-targeting strategy is feasible in low ERPT circumstances (Choudhri & Hakura, 2006). Unlike the experience of developed countries, inflation shocks create tremendous macroeconomic vulnerabilities in developing countries because of an unstable monetary environment, which results from increased exchange rate depreciation and capital flight (de Mendonça & Tiberto, 2017). The developing countries are vulnerable to exchange rate shocks because imported goods account for a considerable share of intermediate and consumer goods.

The Central Bank of Somalia has been the sole authority to regulate and monitor the Somali shilling (SOS), the country's *de facto* currency, which was more stable and credible before the collapse of the Somali Republic. During this time, the value of the SOS against the US dollar was maintained at around 7 shillings for roughly ten years (Nor, 2015). The SOS was pegged to the SDR instead of the US dollar in the 1980s, when the dual exchange rate system was unified (World Bank, 1983). However, following the overthrow of the central government and the collapse of the financial system in 1991, the foreign exchange market in Somalia has been operating without the regulation of the monetary authorities in the post-conflict period (Luther, 2012). This caused an increased supply of counterfeit currency and the emergence of speculators who drastically dropped or increased the value of the SOS based on their strategy to earn enormous profits (Nor, 2015). This coerced the SOS to be a volatile currency. This development implied that Somalia's inflation rate reached its highest level in 2008 when the national

currency depreciated 54 percent against the US dollar (Nor, 2012). A recent report from the Somalia National Bureau of Statistics (2022) shows that the consumer price index (CPI) increased by 6.98% in June 2022 to 134.77 against 125.97 in the same month of the preceding year.

Given the volatility of exchange rates, the depreciation of the Somali Shilling, and a prevailing lack of public confidence, local currency holders increasingly opt for the US dollar to mitigate the potential erosion of value in their domestic currency. The country's extensive use of the US dollar gained prominence during the 1990s, particularly in the aftermath of the civil war. The dollarization process in Somalia occurred gradually as businesses and individuals began to prefer using the US dollar for various transactions due to its stability and wide acceptance in international trade. In Somalia, imported goods constituted 83.5 percent of the GDP in 2020, indicating its significant dependence on foreign trade (Abdi et al., 2024). Furthermore, Musoke (2017) posits that indicators of a dollarized economy include banks offering loans and accepting deposits in dollars, goods and services priced in US dollars, and transactions predominantly conducted in dollars. This is evident in Somalia, where all government payments and financial activities are denominated in dollars. Furthermore, various transactions such as household bills, tuition fees, taxes, and government salaries are exclusively disbursed in US dollars, while the SOS remains prevalent in small-scale transactions, particularly in rural areas for livestock and agricultural markets (Nor et al., 2020). A significant factor sustaining the SOS in the economy is the impracticality of using the US dollar for small transactions due to its indivisibility.

Many studies have been conducted in various countries concentrated on the effects of central bank credibility and inflation expectations on the ERPT-inflation channel (Aron et al., 2014; Choudhri & Hakura, 2006; de Mendonça & Tiberto, 2017; Helmy et al., 2018; Juntila & Korhonen, 2012; Soon et al., 2018). According to Musoke (2017), since many developing countries face unstable monetary environments, dollarization is a significant factor that influences the exchange rate and inflation linkage. Despite the tremendous expansion of ERPT literature, no empirical study has investigated the effect of dollarization on the ERPT-inflation relationship. Given this background, this study aims to investigate the asymmetric effects of the exchange rate on inflation in Somalia from 1995 to 2019 by incorporating the role of dollarization. With a few exceptions, earlier research on the influence of ERPT on consumer prices assumed a linear interaction between exchange rate and inflation. According to the symmetric assumption, exchange rate appreciations and depreciations are passed to the final price of goods in an equivalent magnitude. Therefore, Baharumshah et al. (2017) suggest that using symmetric equations can drastically distort estimations when asymmetric pass-through is present. Using the NARDL model, they confirm that depreciation is carried through prices more than appreciation. According to Delatte and López-Villavicencio (2012), the NARDL has the benefit of allowing us to determine both the dynamic short-run and long-run asymmetries in the exchange rate-inflation connection. Another crucial advantage is that it performs better with small samples compared to other cointegration tests (Pesaran et al., 2001).

Therefore, this article contributes to the literature in various ways: First, the study examines the ERPT-inflation nexus in Somalia, presenting the first empirical evidence of the non-linear dynamic short- and long-run pass-through coefficients on consumer prices. The research sheds light on how exchange rate fluctuations impact domestic prices during the study period. Second, unlike previous research, this study delves into the impact of dollarization on the ERPT-inflation linkage. An issue that remains to be addressed is the effect of dollarization on consumer prices, which is a significant factor in countries with unstable monetary environments. Given that many developing economies are officially or unofficially dollarized, the studies investigating whether dollarization expands or dampens the ERPT-inflation pathway are limited. Third, understanding the dynamics of exchange rates, dollarization, and inflation offers valuable insights for policymakers in adjusting monetary policy properly. The findings can guide the formulation of more effective monetary policies, enabling authorities to respond appropriately to economic challenges stemming from exchange rate fluctuations and dollarization.

The remainder of the article is structured as follows: the second section provides a literature review on ERPT and inflation; the third section outlines the data and econometric methodology; the fourth section presents empirical results and discussion; and the concluding section summarizes the findings and suggests policy recommendations.

2. Literature review

The significance of the exchange rate pass-through (ERPT) mechanism for price stability has been a subject of interest for researchers in the past few decades. A large body of prior studies investigated the effects of ERPT on prices in emerging markets. The price changes are attributed to factors including changes in nominal exchange rates, GDP growth, monetary policy, and oil prices. The empirical evidence concludes with mixed findings using various estimation techniques and macroeconomic factors across different countries and regions. This section reviews the past literature investigating the connection between ERPT and inflation.

A considerable number of the prior studies present that price levels react differently to appreciations and depreciations over the short-run and long-run. Delatte and López-Villavicencio (2012) investigated the nonlinear effect of exchange rate variations on prices by adopting a markup model for prices in four particular advanced economies. The estimated findings from asymmetric cointegrating models demonstrated that prices respond disparately to appreciations and depreciation over the long-run, indicating that depreciations pass through more strongly than do appreciations in all countries in the sample. According to Baharumshah et al. (2017), consumer prices respond asymmetrically to exchange rate shifts in both the short- and long-run. The authors observed that the short-run ERPT to inflation is relatively smaller, while the long-run consumer prices respond more significantly to depreciation than appreciation. Conversely, Przystupa and Wróbel (2011) utilized the New-Keynesian Phillips Curve to assess the linearity of ERPT to price level using quarterly data between 1997 and 2008 in Poland. Their symmetric finding reveals that the ERPT tends to alter alongside the business cycle, although no evidence of an asymmetric reactions of appreciation and depreciation was observed. The estimations of consumer price reactions show that ERPT is relatively minimal amid contractions and more pronounced during expansions.

Likewise, several studies have employed panel data methodologies to investigate the ERPT phenomenon in aggregate import prices. Based on an asymmetric approach, Junttila and Korhonen (2012) observed that pass-through coefficients are dependent on the inflation policies for nine OECD countries. The authors demonstrated that pass-through is partially and favorably associated with the inflationary regime of the importing country. Correspondingly, Soon et al. (2018) found an asymmetric association among ERPT and inflation volatility for six Asian countries adopting quarterly data from 1980 to 2014. The study confirmed major disparities in the ERPT levels between the Asian countries that use inflation targeting (IT) and those that do not. The pass-through is almost complete when inflation volatility is higher. Ben Cheikh and Rault (2016) presented a significant and favorable connection between pass-through and the average inflation rate across 12-euro area (EA) economies. The evidence suggests that the monetary union process has resulted in a certain degree of macroeconomic homogeneity across the EA countries. On the contrary, An (2006) tested the level of ERPT at different distribution stages for eight major industrial countries. Based on the distribution chain, the rate of pass-through decreases, and the amount of time required for full pass-through prolongs. Moreover, the study discovered that a smaller economy with a higher import ratio, steady exchange rates, more apparent monetary shocks, an expanding inflation rate, and low volatile economic growth is associated with a higher pass-through coefficient.

Monetary policy is considered worthwhile in determining the relationship between ERPT and price changes. Under the inflation-targeting regime, the literature asserts that ERPT to inflation from import prices is incomplete. For instance, Aron et al. (2014) examined the impact of ERPT on import prices in South Africa using monthly data spanning from 1980 to 2009. The study discovered the existence of lower pass-through under the inflation-targeting regime using various cointegration methodologies. Furthermore, pass-through decreases with exchange rate volatility and increases with small appreciations. de Mendonça and Tiberto (2017) suggest that a substantial level of price stability in emerging economies is attributable to the credibility of their central banks. Once monetary authorities commit to fixing inflation expectations, they earn credibility, eliminating the pass-through effect on inflation. By the same token, Balcilar et al. (2019) compared ERPT to prices in Nigeria and South Africa, revealing that ERPT is complete in Nigeria but partial in South Africa. Notably, prices in South Africa were stickier, indicating the influence of inflation targeting and central bank credibility on ERPT. The impact of output growth and oil prices varied between the two countries. Furthermore, Bangura et al. (2012), Helmy et al. (2018), and Jiang and Kim (2013) employed the Structural Vector Autoregression (SVAR) model to estimate the pass-through effects of exchange rate changes on inflation using different price indices. The findings emphasize that the pass-through to prices

was significant for the various price indices; however, it was incomplete. These studies outlined that exchange rate depreciation is a potential and prominent source of inflation for Egypt, Sierra Leone, and China, respectively, which necessitates the implementation of a monetary targeting framework.

Moreover, a substantial body of literature explores whether a shift toward a low-inflation environment results in a reduction in the extent to which exchange rate movements pass-through to consumer prices (Bailliu & Fujii, 2004; Jimborean, 2013; Junttila & Korhonen, 2012; López-Villavicencio & Mignon, 2017). Even though studies employed diverse techniques across different regions, the outcomes indicate that the ERPT to producer and consumer price levels has decreased, attributable to stabilization policies, in numerous emerging and advanced economies. According to Bailliu and Fujii (2004), ERPT decreases when the monetary policy regime changes and the environment becomes low-inflationary. Correspondingly, López-Villavicencio and Mignon (2017) augmented the traditional bivariate to analyze the extent of pass-through on price level by accounting for the monetary stability of 14 developing countries. Consumer prices are a better choice than import prices to gauge the impact of the inflation environment since the consequences of ERPT on consumer prices are more significant than import prices. Shintani et al. (2013) present that the ERPT decreases in the 1980s and 1990s are related to decreased inflation. Additionally, Jimborean (2013) explores whether the exchange-rate pass-through estimates have decreased in response to a shift in the inflation environment for 10 Central and Eastern European countries. The author concluded that a decline in ERPT exists only in the short-run for import prices.

Recent evidence suggests that pass-through disparately affects inflation during higher or lower exchange rate volatility periods. As an illustration, Ozkan and Erden (2015) employed diverse econometric approaches to analyze the relationship between ERPT and inflation across various countries. They found a significant decrease in ERPT since the mid-1990s, with ERPT responding positively to inflation and the inflation rate volatility but negatively to exchange rate volatility, openness, and the output gap. In parallel, da Silva Correay and Minellaz (2010) utilized a Phillips curve with a threshold and found that short-run pass-through is more notable when the economy experiences a rapid expansion, the exchange rate depreciates beyond a specific threshold, and the exchange rate volatility is low. Similarly, Osabuohien et al. (2018) employed GARCH and VECM methodologies to assess the degree of exchange rate volatility and the impact of official and parallel exchange rates on inflation in Nigeria, utilizing monthly data from 2006 to 2015. Their analysis indicates that long-run exchange rate volatility substantially and positively affects inflation. Specifically, the parallel exchange rate exerts a short-run pass-through effect on the price level, while the official exchange rate influences inflation in the long-run.

Further studies presented that factors such as output growth, oil prices, policy shocks, and inflation expectations affect the ERPT and inflation mechanism. For example, Garcia and Restrepo (2001) applied linear quadratic adjustment cost (LQAC) models to measure ERPT and price level using quarterly data for Chile from 1986 to 2001. The findings state that ERPT depends positively on the output gap. This suggests that a negative output gap has compensated for the inflationary effects of exchange-rate depreciation. Additionally, productivity lowers inflation and unit labor costs, whereas wages and foreign exchange rates raise inflation. Regarding inflation targeting, Nasir et al. (2020) used monthly data to explore the ERPT to inflation expectations in the Czech Republic. The results from the NARDL framework reveal that ERPT has substantial effects on inflation expectations. Correspondingly, Comunale and Kunovac (2017) employed VAR models to investigate the ERPT in the euro area. They show that pass-through is not constant over time and can be impacted by the distribution of economic shocks that control exchange rate movement. The pass-through to import prices is higher than consumer prices in the euro area. Furthermore, Hara et al. (2015) used quarterly data between 1982 and 2014 to explore whether changing ERPT in Japan indicates changing pricing behavior. The estimations indicate that ERPT to consumer and producer price indices has increased since the late 2000s, primarily attributed to the heightened reliance on imports in production. A significant portion of this rise is attributed to the heightened responsiveness of inflation to marginal costs.

Even though the growing literature debated the central role of the macroeconomic environment, the central bank's credibility, and inflation-targeting policies on the ERPT mechanism, they ignored the effect of dollarization on consumer prices. The economic activities of many developing countries, including Somalia, are dollarized mainly due to the depreciation of the local currency. Little is known about whether dollarization increases or decreases the ERPT-inflation nexus. Hence, the present study will

adopt an asymmetric technique to fill the gap in the literature. It will pave the way for the monetary authorities to formulate a sound macroeconomic policy to control the effect of ERPT on inflation.

3. Methodology

3.1. Data and variables

The study used annual time series data from 1995 to 2019 to evaluate the ERPT hypothesis in the context of Somalia. The sample period was selected because of the following reasons. First, the dramatic depreciation of the exchange rate during this period can be attributed to the collapse of Somalia's financial institutions following the ousting of the military government in 1991. In addition, the country's foreign exchange market became unregulated. Second, the economy became highly reliant on imported goods, which comprised a significant share of the overall economic activity. Third, due to the massive depreciation of the local currency, the economy became dollarized during this period. Hence, capturing the consequences of dollarization on consumer prices in Somalia is necessary. The data employed in this study were sourced from the United Nations Statistical Division (UNSD), the Food Security and Nutrition Analysis Unit (FSNAU), and Federal Reserve Economic Data (FRED).

The explained variable is the consumer price index (CPI), a proxy of inflation, whereas the explanatory variables are the unregulated nominal exchange rate, output growth, oil price, and dollarization. The oil price and output growth are measured for the Brent crude oil price (Warsame, 2022) and real gross domestic product (Warsame et al., 2022). The study also utilizes the nominal exchange rate as a proxy of the exchange rate, consistent with ample previous studies (Helmy et al., 2018; Przystupa & Wróbel, 2011; Soon et al., 2018). Dollarization is created as a dummy variable. It was given values of "1", which shows the presence of dollarization, and "0", which indicates the absence of dollarization (Park & Son, 2020). Somalia's economy became dollarized in 2000. Before 2000, the dummy variable of dollarization was given "0"; from 2000 onwards, it was given "1". Table 1 summarizes the description of the variables, units of measurement, and their sources. To interpret the study results as elasticities, we converted all the variables into natural logarithms except for dollarization.

3.2. The econometric model

Numerous empirical studies have utilized a Phillips curve model, with minor adjustments, to investigate the empirical relationship between exchange rate fluctuations and inflation. Considering this, the model specification employed in this study aligns with previous research by Balcilar et al. (2019) and Baharumshah et al. (2017), incorporating nominal exchange rate, output growth, and oil price variables. Additionally, to incorporate dollarization into the model, this study follows the approach outlined by Park and Son (2020). Therefore, the model specification of the study is expressed as follows.

$$CPI_t = \beta_0 + \beta_1 ER_t + \beta_2 GDP_t + \beta_3 OIL_t + \beta_4 DOL_t + \mu_t \quad (1)$$

where CPI, ER, GDP, OIL and DOL represent the consumer price index, nominal exchange rate, real GDP, oil price, and dollarization, respectively. μ_t signifies the error term. Except for dollarization, we converted all scrutinized variables into a natural logarithm, as shown in Eq. (2), to avoid the occurrence of heteroskedasticity problems and to ease our interpretation in a percentage form.

Table 1. Variable descriptions and sources.

Variable	Symbol	Unit of measurement	Source
Inflation	CPI	Consumer price index	FSNAU
Nominal exchange rate	ER	Somali shilling per 1 US dollar	IMF
Real GDP	GDP	Gross domestic product (GDP) (constant 2015 US\$)	UNSD
Oil prices	OIL	International Brent crude oil price in US dollar per barrel	FRED
Dollarization	DOL	It is a dummy variable. It takes a value of '1' during the dollarization period, and a value of '0' otherwise.	

$$\ln CPI_t = \beta_0 + \beta_1 \ln ER_t + \beta_2 \ln GDP_t + \beta_3 \ln OIL_t + \beta_4 DOL_t + \mu_t \quad (2)$$

3.3. Nonlinear autoregressive distributed lag (NARDL) model

The non-linear ARDL technique proposed by Shin et al. (2014) consistently captures the long-run and short-run non-linearities between variables. This approach is suitable for analyzing macroeconomic and financial variables affected by unforeseen events. The NARDL cointegration approach outperforms other traditional cointegration techniques because it estimates variables regardless of whether they are stationary at level $I(0)$, at first difference $I(1)$, or a mixed integration. However, it is not suitable for higher orders of integration. Additionally, it is credible and appropriate to estimate the asymmetric cointegration of a small sample size. Besides this, recent empirical studies indicated that utilizing the linear ARDL model cannot best explain the relationship between variables with asymmetric association in nature. The symmetric ARDL assumes that the magnitude of exchange rate appreciation and depreciation affect consumer prices equally. The recent literature confirmed the presence of asymmetric cointegration between exchange rate and inflation (Baharumshah et al., 2017; da Silva Correay & Minellaz, 2010; Delatte & López-Villavicencio, 2012). Therefore, this study utilizes the NARDL model of Shin et al. (2014) to check the asymmetric relationship between exchange rates and inflation by following the previous empirical studies of Balcilar et al. (2019), Baharumshah et al. (2017), and Park and Son (2020). Thus, our NARDL model is specified under the conditional version as follows:

$$\begin{aligned} \Delta \ln CPI_t = & \alpha_0 + \beta_1 \ln CPI_{t-1} + \beta_2^+ \ln ER_{t-1}^+ + \beta_3^- \ln ER_{t-1}^- + \beta_4 \ln GDP_{t-1} + \beta_5 \ln OIL_{t-1} + \beta_6 DOL_{t-1} + \sum_{i=1}^p \gamma_1 \Delta \ln CPI_{t-i} \\ & + \sum_{i=1}^q \gamma_2^+ \Delta \ln ER_{t-i}^+ + \sum_{i=1}^q \gamma_3^- \Delta \ln ER_{t-i}^- + \sum_{i=1}^q \gamma_4 \Delta \ln GDP_{t-i} + \sum_{i=1}^q \gamma_5 \Delta \ln OIL_{t-i} + \sum_{i=1}^q \gamma_6 \Delta DOL_{t-i} + \varepsilon_t \end{aligned} \quad (3)$$

whereas α_0 is the intercept, γ indicates the coefficients of short-run, β represents the coefficients of long-run variables, p and q represent the lag length, the symbol Δ stands for change, and i represents the lagged values. The notations “-” and “+” of the independent variable of the exchange rate indicate the decomposition of the partial sum of negative and positive exchange rate changes, respectively. This is expressed as follows:

$$\ln ER_t^+ = \sum_{i=1}^t \Delta \ln ER_i^+ = \sum_{i=1}^t \max(\Delta \ln ER_i, 0) \quad (4)$$

$$\ln ER_t^- = \sum_{i=1}^t \Delta \ln ER_i^- = \sum_{i=1}^t \min(\Delta \ln ER_i, 0) \quad (5)$$

As for the checking for long-run asymmetric cointegration, the Wald F-test is utilized (Shin et al., 2014). The hypothesis is formulated as follows: the null hypothesis ($H_0 : \beta_0 = \beta_2^+ = \beta_3^- = 0$) suggests that the impact of exchange rate on inflation is linear (symmetric) in the long-run, whereas the alternative hypothesis ($H_a : \beta_0 \neq \beta_2^+ \neq \beta_3^- \neq 0$) states that the effect is nonlinear (asymmetric) in the long-run. To reach a conclusion on the hypothesis, the F-statistics is compared to critical values. If the null hypothesis is discarded, the presence of an asymmetric relationship between the exchange rate and inflation is valid. Besides, we estimate the short-run cumulative dynamic multiplier effect of a unit change in $\ln ER_{t-1}^+$ and $\ln ER_{t-1}^-$ using the following formula:

$$m_t^+ = \sum_{i=0}^h \frac{\partial \ln CPI_{t+k}}{\partial \ln ER_{t-1}^+}, m_t^- = \sum_{i=0}^h \frac{\partial \ln CPI_{t+k}}{\partial \ln ER_{t-1}^-}, h = 0, 1, 2, \dots \quad (6)$$

Note that $h \rightarrow \infty, m_t^+ \rightarrow \beta_2^+$ and $m_t^- \rightarrow \beta_3^-$.

4. Empirical results and analysis

Time series data often exhibits trends that violate the assumption of stationarity, potentially leading to spurious results. To address this concern, we conduct unit root tests using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Table 2 presents the results of these tests, indicating that all series exhibit a unit root at level I (0). However, upon differencing once, all variables become stationary. As a result, we proceed with the formal analysis, as all variables are stationary at the first difference I (1).

After confirming that the relevant variables have passed the unit root test, we proceeded to examine the presence of cointegration between the dependent and explanatory variables. Utilizing both linear and nonlinear ARDL methodologies, we investigated the existence of symmetric and asymmetric cointegration among the variables of interest. The results presented in Table 3 indicate that linear cointegration between inflation and the explanatory variables—namely, exchange rate, gross domestic product, oil prices, and dollarization—is inconclusive, as the bound F-statistic of 4.6828 falls between the lower and upper bound critical values. Notably, the Ramsey test suggests the presence of model misspecification, possibly due to the asymmetric nature of the relationship between inflation and exchange rates. Consequently, we proceeded to examine the presence of nonlinear associations among the variables using nonlinear ARDL. The findings, as reported in Table 3, demonstrate the existence of long-run asymmetric cointegration among the variables under scrutiny. Specifically, the bound F-statistic of 20.13 exceeds the upper bound critical value of 4.77 at a 5% significance level. Therefore, neglecting to account for the asymmetric association when modeling the relationship between inflation and the exchange rate in Somalia could lead to inconsistent results.

Following the determination of long-run cointegration among the series, the estimation of long-run coefficients becomes paramount. The long-run findings, presented in Table 4, unveil the asymmetric impact of the exchange rate on inflation in Somalia. Both appreciation and depreciation of the exchange rate exhibit significant associations with consumer prices, with depreciation exerting a stronger effect. While exchange rates asymmetrically affect consumer prices in the long run, this asymmetry is not evident in the short run, as indicated by the Wald restricted coefficients in Table 6. This suggests that currency appreciation and depreciation transmit to domestic inflation over time. Specifically, a 1% positive shock in the exchange rate (currency depreciation) leads to a long-run inflation increase of 0.52% in Somalia. Conversely, a 1% negative shock in the exchange rate (currency appreciation) reduces inflation by approximately 0.37% in the long run. The incomplete exchange rate pass-through in Somalia is attributed to its inelastic coefficient. The observed long-run asymmetric effect of exchange rate pass-through

Table 2. Result of the ADF and PP unit root tests.

Variable	ADF		PP	
	Intercept	Intercept with trend	Intercept	Intercept with trend
lnCPI	−2.628	−2.0591	−2.5874	−2.1669
ΔlnCPI	−4.3452***	−4.4109**	−4.3872***	−4.5985***
lnER	−2.1748	−2.4696	−2.204	−1.7556
ΔlnER	−3.2781**	−4.1126**	−3.2678**	−3.2261
lnGDP	−0.4128	−3.0035	−0.5157	−3.2261
ΔlnGDP	−5.3670***	−5.4838***	−5.3670***	−5.4124***
lnOIL	−1.5035	−1.3398	−1.4833	−1.3958
ΔlnOIL	−4.1872***	−4.1769**	−4.1436***	−5.1882***
DOL	−2.0867	−1.755	−2.0837	−1.7439
ΔDOL	−4.7958***	−5.0301***	−4.7959***	−5.1860**

Note. ***, **, and * represent significance level at 1, 5, and 10%. CPI, ER, GDP, OP, Dolla represent consumer price index, exchange rate, gross domestic product, oil price, and dollarization respectively. Δ stands for first difference level, and ln is the natural logarithm.

Table 3. Bounds testing.

Model specification	Lower bound	Upper bound	F-statistics	Conclusion
Linear	3.354	4.774	4.6828	Inconclusive
Nonlinear	3.354	4.774	20.1396	Cointegration

Note. The critical values are from Narayan (2005), and it is based on a 5% significance level.

Table 4. Long-run coefficient elasticities.

Variable	Coefficient
$\ln ER^+$	0.5221*** (−5.7199)
$\ln ER^-$	−0.3729** (−2.5054)
$\ln GDP$	0.5714 (−1.2998)
$\ln OIL$	0.2765*** (−7.232)
DOL	−0.0822 (−1.4983)

Note. *** denotes significant at 1%. Values in parenthesis represent t-statistic.

to domestic prices may be due to producers/importers adjusting their markup during currency appreciation periods, passing on costs to consumers during depreciation periods to mitigate losses induced by currency devaluation. Furthermore, the nonlinear effects of exchange rate pass-through may signify the presence of monopoly power. Given the unregulated nature of Somalia's exchange rate since the collapse of the military government in 1991, and the circulation of Somali shillings (SOS) without oversight from any monetary authority, the differential reactions of exchange rate appreciation and depreciation to domestic inflation are unsurprising.

In comparison to prior literature, several studies have affirmed the presence of symmetric cointegration between the exchange rate and consumer prices (Aron et al., 2014). They indicate that an increase in the exchange rate tends to elevate inflation. These studies contradict our outcome due to the non-linear relationship observed between the exchange rate and inflation in Somalia. However, our results are consistent with several previous studies that have also highlighted the non-linear nature of the relationship between the variables of interest (Delatte & López-Villavicencio, 2012; Baharumshah et al., 2017). Delatte and López-Villavicencio (2012) examined exchange rate pass-through in major economies such as the UK, USA, Japan, and Germany, discovering that currency depreciation had a more pronounced effect on inflation than appreciation. Similarly, Baharumshah et al. (2017) reported a similar outcome in their analysis of Sudan.

Regarding the control variables, the gross domestic product, as a measurement of aggregate demand, has a positive coefficient even though it is statistically insignificant. Furthermore, oil prices contribute significantly to inflation in the long-run. A 1% increase in oil prices induces inflation to rise by about 0.27% in the long-run. Oil is considered one of the essential input resources for manufacturing, production, and transportation. So, an increase in oil price renders an increase in manufacturing costs that force producers to pass these high costs on to consumers by raising the prices of the manufacturing output. A notable example of oil price shock effects in Somalia could be the famine that occurred in 2011 in Somalia. A crisis started from rain failures—causing consecutive droughts—turned into a famine partly aided by oil price hikes in 2007 and 2008 that resulted from the strong demand for energy due to stagnating world production (Hamilton, 2009). The oil price shocks not only hampered world production but also undermined Somalia's domestic consumption, where imports covered a larger portion of its domestic demand. More importantly, the high import prices due to the high production costs instigated the effects passed through to inflation through the exchange rate. For instance, the inflation rate in Somalia increased from 48.5 indexes in 2007 to 80.35 indexes in 2008. It is also noteworthy that in 2008 and onward, domestic inflation trended upward (FSNAU, 2021). Our result of the positive significant effect of oil prices on domestic inflation is corroborated by several previous studies (Choi et al., 2018; Sek & Lim, 2016). Furthermore, Somalia is characterized as a double economy, where the Somali shillings (SOS) and the US dollar are actively used to conduct transactions. Notably, the dollar is used for large transactions, whereas SOS is conducted for small transactions. Despite dollarization being accompanied by a negative coefficient, it is statistically insignificant in the long-run.

We subsequently examine the short-run association of the variables and the error correction term (ECT) after examining the long-run coefficients. The short-run results, as illustrated in Table 5, exhibit that the previous year's inflation significantly increases the current year's inflation by about 0.40% in the

Table 5. Short-run coefficients elasticities and ECT.

Variable	Coefficient
Constant	0.034 (−0.6745)
$\Delta \ln \text{CPI}_{t-1}$	0.4030*** (−3.3357)
$\Delta \ln \text{ER}^+$	0.2409* (−2.047)
$\Delta \ln \text{ER}^-$	−0.0788 (−0.3306)
$\Delta \ln \text{GDP}$	0.0212 (−0.0136)
$\Delta \ln \text{OIL}$	0.3354*** (−4.8283)
ΔDOL	−0.1802 (−2.1533)
ECT_{t-1}	−0.9597 (−5.3925)

Note. ***, ** and * represent statistical significance at 1, 5 and 10%. T-statistics are in the parenthesis (.).

Table 6. Diagnostic tests.

R^2	0.99
Serial correlation - LM test	0.8595 [0.1429]
Heteroscedasticity - BPG test	2.0661 [0.1701]
Normality - JB test	1.3871 [0.4997]
Ramsey RESET test	1.8544 [0.2064]
W_{LR}	3.844 [0.0032]
W_{SR}	1.0939 [0.2912]

P-values are in the brackets []. W_{LR} and W_{SR} are the long-run and short-run asymmetries of ER.

short-run. The short-run finding of exchange rate depreciation compromises the long-run result. A 1% increase in exchange rate depreciation induces inflation to rise by 0.24% in the short-run. Nevertheless, exchange rate appreciation is statistically insignificant in the short-run. The gross domestic product does not significantly affect inflation in the short run, which is consistent with the long-run result. The short-run finding of the oil price is in line with the long-run result, indicating that an increase in the oil price tends to increase inflation by about 0.33% in the short-run if it is increased by 1%. Interestingly, dollarization significantly contributes to the reduction of inflation by about 0.18% in the short-run, if dollarization is increased by one unit. Furthermore, Table 4 also reports the ECT, which represents the speed of adjustment. To make the variables of the model converge, the ECT should be significant and have a negative coefficient. Hence, the ECT coefficient is −0.95, which in absolute terms is 95%. It is interpreted as any disequilibrium in inflation being adjusted by 95% annually by the interesting explanatory variables.

Several diagnostic and model stability tests have been conducted to check the robustness of the study's findings. Thus, the model has passed all the diagnostic tests. The errors of the model are not correlated, as evidenced by the LM test. In addition, the Breusch-Pagan (BPG) test proved that the variance of the error terms is constant. Ramsey's RESET test confirmed that the model is correctly specified. Moreover, Jarque-Bera (J-B) has shown that the data are normally and identically distributed. Moreover, CUSUM tests—used to check the model's stability—indicate that the model is stable, as shown in Figure 1. On the other hand, the goodness fit of the model is suitable, as exhibited by the R-squared presented in Table 6. It is interpreted that 99% of the variation that happens in inflation is due to the unregulated exchange rate, gross domestic product, oil price, and dollarization. Furthermore, the dynamic multiplier effect of the exchange rate is shown in Figure 2. It takes two years to feel the full effect of the exchange rate on consumer prices. In the third year, the negative shock of the exchange rate declines, whereas the positive shock effect is stable.

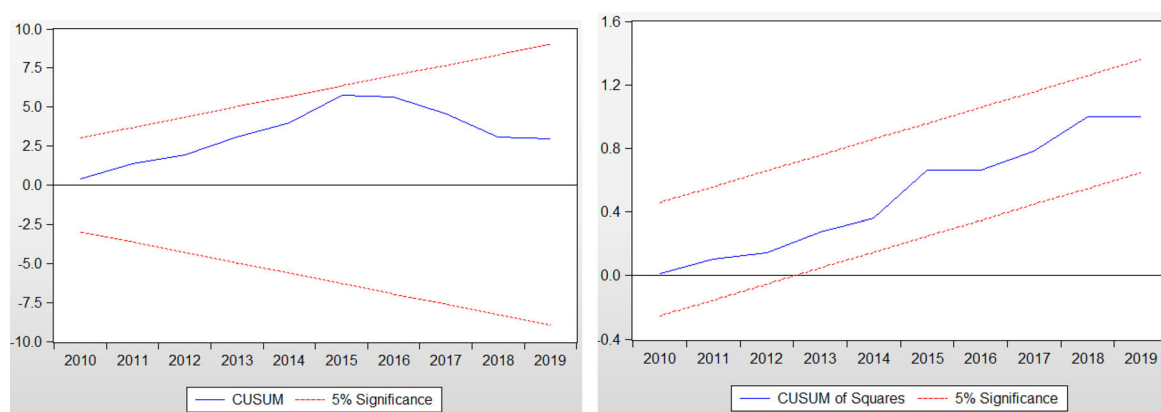


Figure 1. Stability tests.

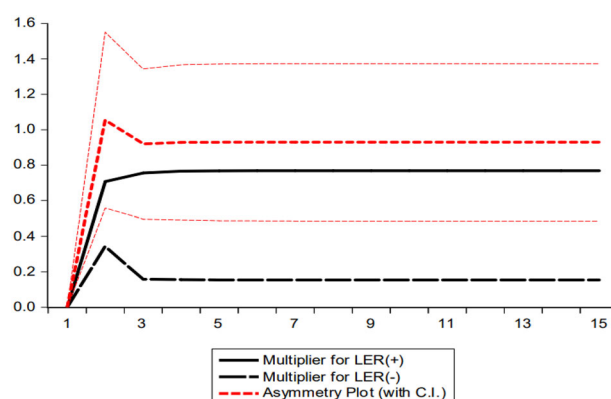


Figure 2. Dynamic multiplier effect of exchange rate.

5. Conclusion and policy insights

Exchange rate pass-through has been a hot topic in recent decades amid its importance in the monetary policy setting. It has been tested in developed and developing countries with a regulated exchange rate. These studies have produced inconclusive results, which are attributed to the nature of data, methodology, and geography of the understudied countries. To this end, this study examines the exchange rate pass-through phenomenon in Somalia. Both linear and nonlinear ARDL cointegration methods were employed to determine the long-run and short-run relationship between exchange rates and consumer prices. The empirical results demonstrate that the unregulated exchange rate is asymmetrically cointegrated with inflation in Somalia in the long-run. Both appreciation and depreciation of the exchange rate significantly and differently react to the prices, even though exchange rate depreciation has a stronger impact. Unregulated exchange rate pass-through is incomplete in Somalia due to its inelastic coefficients. Furthermore, oil prices significantly lead to an increase in inflation in the long run. However, dollarization and GDP are not different from zero, implying that they do not affect long-run inflation.

Moreover, the short-run findings reveal that the previous year's inflation significantly stimulates the current year's inflation. Exchange rate depreciation increases inflation in the short-run, even though exchange rate appreciation is statistically insignificant. In the short run, the gross domestic product has an insignificant effect on inflation, consistent with the long-run outcome. Also, our short-run results indicate that oil prices tend to increase consumer prices. The most remarkable outcome indicates that dollarization significantly contributes to the reduction of inflation in the short-run. Furthermore, the speed of adjustment term ECT coefficient is -0.95 , implying that any disequilibrium in inflation is adjusted by 95% annually by the interesting explanatory variables.

Based on the empirical findings, several policy recommendations emerge. Firstly, given the unregulated nature of Somalia's exchange rate, it is imperative for the central bank to reclaim its authority in

monitoring and controlling the foreign exchange market. This can be achieved by strictly regulating and prohibiting the issuance of banknotes by other domestic authorities or private entities, thereby consolidating the central bank as the sole issuer of banknotes. This measure would enable the central bank to manage the money supply effectively, ultimately fostering price stability. Furthermore, efforts should be directed towards enhancing the quality of economic and financial institutions. Strengthening these institutions is crucial for rebuilding public trust in public policies and the domestic currency. Instilling confidence in the economic and financial systems is likely to incentivize economic agents within dollarized economies to utilize the domestic currency for various transactions, including exchange and as a store of value. This shift towards greater reliance on the domestic currency can contribute to the overall stability and resilience of the economy.

Authors' Contributions

The authors have contributed significantly to the conception, design, and development of this article. Abdikafi Hassan Abdi was responsible for writing the first draft of the article, the introduction, and literature review, as well as reviewed and edited the manuscript. Abdimalik Ali Warsame was responsible for the data collection, analysis, writing the discussion section, reviewed and edited the manuscript. Ibrahim Abdukadir Sheik-Ali wrote the econometric methodology and data section.

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Data availability

The datasets used and/or analyzed during the current study are available on a reasonable request.

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