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The role of real exchange rate in the trade balance between Turkey and Libya: Evidence from nonlinear and wavelet-based approaches

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ABSTRACT

The time-invariable models would suffer to give a clearer description to the relationship between exchange rate and trade flows. Therefore, the growing strand of literature has failed to reach a consensus. This study aims to contribute to this discussion by employing not only nonlinear model to capture the asymmetric effect, but also to detect the time frequencies and explore the lead-lag relations between real exchange rate and trade balance between Libya and its major trade partner 'Turkey' by applying both NARDL and wavelet coherence approaches, using monthly data spanning January 2013 to December 2020, selected based on data availability. The findings disclose that trade balance responds to the real exchange rate asymmetrically. The asymmetric effect is skewed more in the negative direction, as the impact of negative change is significant and greater than the positive change in long run. While the oil price shocks positively impact trade balance, economic policy uncertainty negatively affects trade balance. The wavelet coherence analysis indicates that real exchange rate and economic policy uncertainty are lagging in trade balance, while oil price leads trade balance. Among various other policy suggestions, we recommend that stable exchange rate through the intervention in the foreign exchange market will promote the trade balance at the end.

I. Introduction

Over decades, the exchange rate-trade nexus has been at the center of research interest. Since the closing of the gold standard by the United States in 1971, the academicians and policy makers started assessing the effect of exchange rate on the trade flows between countries (Bahmani-Oskooee & Arize, 2021). The unprecedented level of global economic integration accompanied by persistent trade imbalances and the resurgence of non-traditional trade restrictive measures have led to a renewed interest in the implications of exchange rates on international trade flows. The conventional theories of trade suggest that exchange rate may decrease the international trade flows, as the risk-averse exporters consider it as a sign of continuous profit uncertainty on international trade transactions (Santana-Gallego & Pérez-Rodríguez, 2019). Earlier argument documented that sharing a common currency act as a motivator to bilateral trade as it removes exchange rate uncertainty, decreases transaction costs between country pairs, and promoting the price transparency (Rose, 2000).

On the theoretical basis, some researchers have drawn an optimistic conclusion on the exchange rate uncertainty-trade flow nexus. For instance, (de Grauwe & Paulson, 2020) outlined that under some conditions the exchange rate uncertainty might benefit trade. When the exporters respond positively by increasing the exports when local currency depreciated, the higher variability in the exchange rate will increase the perceived profit. As a result, the risk-averse firms will again respond by increasing their exports. The risk neutral firms expect this positive dynamic causation to persist, given that the increase in firm's utility from increased average profits more than offsets the decline in utility from greater uncertainty of profits. Since the pioneering work of (Magee et al., 1973), and within the framework of the J-curve hypothesis, myriad research papers have investigated the effect of exchange rate on trade balance. The hypothesis basically holds that due to adjustment lags and currency contracts, currency depreciation may not impact the trade balance immediately. In the short run, the country's trade balance may persistently deteriorate due to currency devaluation before leading to an improvement in the long term, depicting a J-curve pattern (Bahmani-Oskooee et al., 2021). Precisely, this mechanism is explained by the fact that due to currency depreciation the imported goods are expected to be more expensive than the exports in the short term. The trade balance deteriorates in short run as the volume of imports and exports will not adjust sharply. In the long term, however, the volume effect sets-in and reverses the initial worsening and improves the trade balance (Halicioglu, 2008).

In the literature, an extensive debate has been made on the J-curve proposition and abundant evidence have been pointed out under different conditions. For instance, some authors (Arndt & Dorrance, 1987) earlier claimed that the J-curve effect can occur only if the local currency prices of exports are sticky. Economic theory holds that the favorable results of currency depreciation depend on the Marshall-Lerner (ML) condition, which posits that the sums elasticities of both imports and exports is greater than unity (Tunaer Vural, 2016). However, the subsequent research in this area proved that there have been cases under which the Marshall-Lerner condition was satisfied yet the trade balance continued to deteriorate. The rebound effect of 1967 British and 1971 U.S. currency devaluation also still a debatable subject in the academic and policy making circles. To this end, one can claim that there is no consensus yet to be reached on the J-curve proposition,

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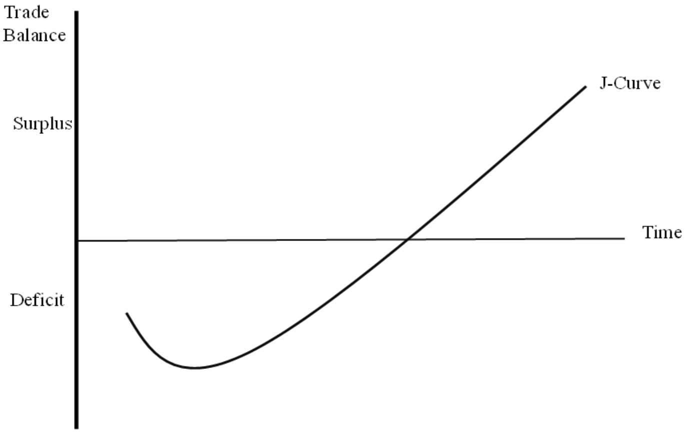
and the question of whether there still a room to improve the trade imbalance by manipulating the currency is an ongoing subject of discussion. This premise may call for a renewal research and fresh look into the topic again using the modern techniques and recently developed econometric models.

Figure 1. J-Curve pattern



Source: Author's own illustration

A glance through the literature, one can note two strands of research; the first strand of studies has relied substantially on tradition linear models to study the impact of exchange rate on trade balance. These studies have assumed that exchange rate affect trade flows symmetrically, which means that currency appreciation or depreciation have the same effect on trade balance in absolute terms (see for ex. (Bahmani-Oskooee & Gelan, 2018); (Dogru et al., 2019); (Kodongo & Ojah, 2013); (Tunaer Vural, 2016); (D. O. Olayungbo, 2019); (Sarlab & Seyed Ameri, 2021); (Serenis & Tsounis, 2014); (D. Olayungbo et al., 2011); (Senadza et al., 2018). This spectra literature has been much criticized as they ignore the factors that play a significant role in the dynamic of exchange rate-trade balance relation causing asymmetricity. Therefore, many authors have concluded that accepting the linearity assumption is equivalent to missing the asymmetric effect, which leads to partial understanding as the channels through which the volatility in exchange rate impact the trade balance is eliminated. The decision makers and other stakeholders, however, may need to understand the mechanism for the effect rather than the effect itself.

In the second strand, a growing body of literature have strived to overcome the previous limitation by modeling the exchange rate-trade balance nexus through relatively modern non-linear approaches, trying to address the link from more holistic prospective (see for instance; (Alessandria & Choi, 2021); (Baek & Jungho, 2020); (Bao & Le, 2021); (Wu et al., 2013); (Arize et al., 2017a); (Bahmani-Oskooee & Nouira, 2021); (Bahmani-Oskooee & Saha, 2019); (Xu et al., 2022); (Sambo et al., 2021); (Bahmani-Oskooee, Aftab, et al., 2017); (Shin et al., 2014). These studies have argued that exchange rate could asymmetrically affect trade balance as the traders' response to currency depreciation could be different than when it appreciated. Unlimited volume of research has been conducted focusing more on the mechanism or intuitively appealing methodological innovation to draw a clearer conclusion on the link between exchange rate and trade balance, and to solve the problems that the earlier conventional methodologies could not do so. Even though no consensus on the link has been reached. These inconclusive findings could be attributable to the econometric approaches being used or the differences in countries' characteristics. But most of the research that applied the nonlinear models have not also been far of criticism as they relied on the data between one country and its the rest of the world. This aggregation data bias has led to more concentration on the bilateral trade flows. But despite the growing numbers of studies on the subject, the actual effect of exchange rate on trade balance lacks the clarity and still an ongoing debate. Where does the current research on the subject stands? And what is missing?

Although the existing literature provided considerable outcomes which greatly contributed to policy making, these seminal works however, greatly relied on econometric models of estimation in which (a) parameter estimations are sticky and do not change over time and (b) the estimation of parameters detects at most two to three potential structural breaks of the time series. Therefore, this study, aims to contribute to this debate by introducing new methodologies not only to overcome the linearity problem but also to address the abovementioned literature shortcomings. This study utilizes Nonlinear Autoregressive Distributed Lag model (ARDL) for purposes of capturing asymmetric effect. In addition, the study employs a wavelet-based approach to address issue (a) and issue (b). This approach is expected to reveal (i) the effect of the leading variable (real exchange rate) on the lagged variable (trade balance) in the estimated model that might change over time, and/or (ii) the impact of leading variable (real exchange rate) on the lagged variables (trade balance) in the estimated model that might change from high frequency to low frequency. Since the economic theory suggests that for the real exchange rate to influence trade balance it must pass through adjustment lag. Therefore, it is believed that the wavelet-based offers unique properties to describe this dynamic effect. The wavelet technique allows us to decompose the interactive lead lag interactions in time frequency domain and to solve some practical difficulties inherent to the short sample period. This approach provides the policymakers with clearer view and more details about the possible effect and the interrelation pattern.

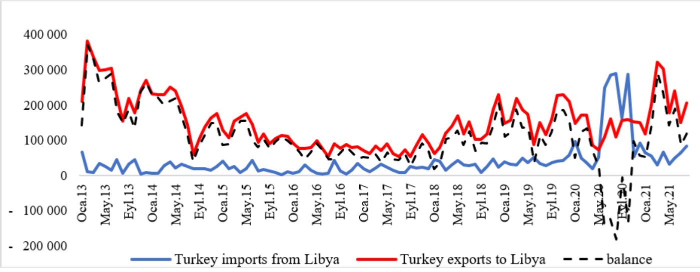
Therefore, following the J-curve proposition as the theoretical ground, this research basically aims to investigate what effect the real exchange rate possesses on the bilateral trade relations between Turkey and Libya. Turkey, which is among the twenty biggest economies in the world and 6th largest economy in Europe has experienced a dramatical exchange rate volatility, between 2020 and the first quarter of 2022, the Turkish lira depreciated by an amount never seen in its record. This dramatical currency depreciation and the anticipated impact on the country's current account and the exchange rate policy prescriptions raise academic interest in Turkish economy. Libya on the other hand, has experienced a tremendous political change since the emergence of the so-called Arab Spring over ten years ago, which later caused an endless political instability and civil war. Libya is one of the largest oil exporters and it depend heavily on oil revenues, nearly 95%. The political instability has affected the oil production (Yılmaz, 2020). Turkey is the second largest exporter to Libya after China, and the term of trade in the favor of Turkey (figure 2). The trade balance between Turkey and Libya with the average daily oil revenues of Libya demonstrate a significant cointegration. As can be seen in figure 3, both lines have almost the same trend in many periods, except between January and September 2014, and January to May 2019, which means that when the Libyan oil revenues are high, the Turkish exports to Libya getting higher and vice versa. Given all these information, Turkey-Libya trade balance offers just an interesting case of study. We believe that this research will provide considerable outcomes for policy guidance not only for Turkey and Libya policymakers but also to other policymakers in other countries with same characteristics.

The rest of the paper is structed as follows: part two reviews important literature on the topic, part three highlights the methodology, part four portrays the findings and discussion, and lastly, part five presents conclusion and policy recommendations.

2. Literature Review

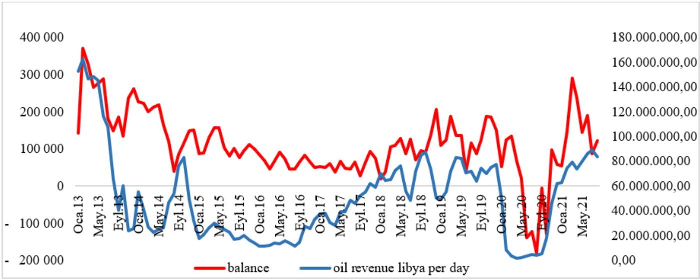
Predicting how traders behave, is a central debate on the exchange rate-trade nexus. One viewpoint asserts that the risk-averse traders react pessimistically to the unexpected change in exchange rate, consequently, the trade will decline. It is quietly argued that the risk -

Figure 2: Turkish imports and exports with Libya (Thousand dollars) Monthly



Source: Turkish Statistical Institute. https://data.tuik.gov.tr/Kategori/GetKategori?p=dis-ticaret-104&dil=2

Figure 3: Trade balance and Average daily oil revenues for Libya Monthly



Source: OAPEC Data Bank for Studies, Reports and Papers | OAPEC, (Date accessed: 20/12/2021).

averse firm operates in the environment of exchange-rate uncertainty under the floating exchange system. The subsequent literature then focused largely on incorporating uncertainty into the foreign exchange rate market, some authors have validated the proposition of negative of exchange-rate on international trade, but other researchers have documented inconclusive outcomes.

Contrarily, other view suggests that uncertainty may promote trade flows. The idea is that firm with a profit maximizing motive are expected to be more preserving and would increase their transactions to offset any decline in future revenue because of exchange rate volatility. Many researchers have reported findings in accordance with this view (Bahmani-Oskooee & Gelan, 2018). Recent debate in this area posits that the effect of exchange rate fluctuation on trade flows varies depending on whether countries are considered developed or developing. Precisely, some studies outlined that in developing countries with relatively low financial development, exchange rate volatility adversely impact the trade flows hence reduces growth. However, in developed nations with relatively high level of financial development the exchange rate volatility has no significant impact, although some empirical studies reported findings against this view (Arize et al., 2017b)

Table 1 summarized the most cited empirical studies on the possible impact of exchange rate volatility on trade balance, using different models (linear and nonlinear), and datasets. It so clear that from the prospective of emerging and developing countries, is less than a satisfactory number of empirical evidence merit conclusive inference on the nature of the link between trade flows and exchange rate fluctuation. Therefore, this literature silence necessitates fresh investigation with second generation econometric models. Therefore, in response to this literature shortcoming, this study considers the bilateral trade relation between Turkey and its major trade partner, Libya. By an in-depth search through the literature, a limited volume of research addressed the relationship between real exchange rate volatility and trade balance for Turkey. Libya on other hand, as well-known oil exporter country, depends heavily on oil revenues, and Turkey is its second largest trade partner. To our knowledge, countries with such characteristics has never been studies separately, we therefore expect this study to have a great contribution theoretically and empirically.

3. Methodology and Data

To analyze the nonlinear relationship between trade balance and real exchange rate we consider monthly data from January 2013 to December 2020. We added two control variables: economic policy uncertainty index and oil price. The full description and data sources are reported in table 2. Normally, the relationship between trade balance and exchange rate is investigated by standard time series techniques like causality, VECM, traditional ARDL and so on Tunaer Vural, (2016); Bahmani-Oskooee & Gelan, (2018). These conventional approaches are built on assumption that the relation between trade balance and real exchange rate is linear. Cointegration-based approaches can potentially examine the linear short run and long run relations; however, they are unable to examine the nonlinear relationships. Trade flows and exchange rate usually follow cycles revealing nonlinear behavior. Therefore, in this study we use the NARDL model which has been developed by (Shin et al., 2014). Unlike the standard ARDL, the NARDL bound testing cointegration approach decomposes the exchange rate into positive and negative changes to see whether the exchange rate have nonlinear effect on trade balance between Turkey and Libya within the sample period. The model allows us to detect the short run and long run asymmetric relationship between trade balance and exchange rate fluctuations.

Table 2. Definitions and the sources of the variables.

Variable	Description	Source
Trade balance (**TB**)	TB is the Turkish imports from Libya divided by the Turkish exports to Libya	Turkish statistical institution: https://data.tuik.gov.tr/Bulten/Index?p=Dis-Ticaret-Istatistikleri-Ocak-2021-37413
Real exchange rate (**REER**)	Real exchange rate between Turkish Lira and Libyan dinar	Yahoo Finance: https://finance.yahoo.com/quote/LYD%3DX/history?p=LYD%3DX
Oil price (**WTI**)	West Texas oil price index	Organization of Arab Petroleum Exporting Countries (OAPEC): https://oapecorg.org/Home/DataBank
Economic policy uncertainty index (**EPU**)	Economic Policy Uncertainty Index:	Economic Policy Uncertainty: https://www.policyuncertainty.com/global_monthly.html

Our basic model can be specified as follows:

$$\ln TB_t = \mu + \alpha_1 \ln WTI_t + \alpha_2 \ln EPU_t + \alpha_3 \ln REER_t + \varepsilon_t \qquad (1)$$

Where TB is the trade balance between Turkey and Libya; REER = Real exchange rate between Turkish Lira and Libyan dinar, and it is defined as REER = (PTUR(2003=100) ∗ NEX/ PLIB(2003=100), where NEX is the nominal exchange rate defined as number of units of Libya Dinar per Turkish Lira, PTUR is the price level in Turkey (measured by CPI(2003=100)]), and PLIB is the price level in Libya (also measured by CPI(2003=100)]). Thus, a decrease in REER reflects a real depreciation of Turkish Lira. Two other control variables have been incorporated, namely oil price (WTI is west Texas index), and economic policy uncertainty index (EPU). Since the seminal work of (Backus & Crucini, 2000) a relatively small but recently growing body of literature accentuates that studies in the previous groups rely usually on a conventional trade balance framework of (Rose & Yellen, 1989) in which the trade balance is specified as a function of exchange rates and economic sizes.

Since the price of crude oil may affect trade through macroeconomic channels, however, the exclusion of a relevant factor like oil prices by the relevant existing literature has raising questions about the validity of the results since oil prices explain a considerable variation in the balance of trade in Canada (Baek, 2020; Gnimassoun et al., 2017).

Another drawback in the attendant literature is that most, if not all, trade balance models have been predicated on the assumption that oil price changes symmetrically impact the balance of trade.

Table 1: Previous studies on the trade balance-exchange rate nexus

Author(s)	Time	Nations	Variables	Model	Conclusion
Wang et al., (2012)	2005-2009	China	TB, YF, YD, REX	Panel ECM procedure	The results support an inverted J-curve hypnotises
(Demez & Ustaoğlu, 2012)	1992 - 2010	Turkey and 5 trade partners	DS, X	Unit root test	Export is not sensitive to the structural breaks and changes in currency rates
(Tarakçı et al., 2022)	2002 - 2019	Turkey and 9 trade partners	EX, Y, REX, VOL	ARDL & NARDL	exchange rate volatility plays important role for Turkey's export
(Santana-Gallego & Pérez-Rodríguez, 2019)	1970-2016	191 countries	X, RTA, Crisis, ERR	Gravity model using PPML estimates	The exchange rate regimes, promote tared flows between countries
Bahmani-Oskooee & Gelan, (2018)	1970-2015	12 African countries	X, W, R, δ	ECM	Exchange rate volatility impact on trade flows varies among countries in terms of periods of time between short run and long run
Bahmani-Oskooee & Karamelikli, (2018)	1994-2017	U.S.-Japan	TB, YF, YD, REX	ARDL & NARDL	Findings reveal an asymmetric effects of exchange rate changes on trade balance
Bahmani-Oskooee et al., (2021)	2000-2020	Mexico - Canada	TB, YF, YD, REX	ARDL & NARDL	Findings indicate symmetric J-curve in two industries, and asymmetric inverse J-curve in nine industries
Bahmani-Oskooee, Harvey, et al., (2017)	different periods	Japan and 12 trade partners	TB, YF, YD, REX	ARDL & NARDL	The outcomes conclude that nonlinear approach is more effective than linear one, and the asymmetric effect in most cases are confirmed
Bahmani-Oskooee, Bose, et al., (2018)	2000 - 2015	China and its 21 major trade partners	TB, YF, YD, REX	ARDL & NARDL	The short-run asymmetric effects of exchange rate in some cases and short-run adjustment asymmetry in other cases are proved with a significant long-run asymmetric effect cases of five partners.
Bahmani-Oskooee, Obaidur Rahman, et al., (2018)	1985 - 2015	Bangladesh and 11 trading partners	TB, YF, YD, REX	ARDL & NARDL	non-linear models supported short-run asymmetry adjustment as well as short-run asymmetry effects of exchange rate changes in most cases
Bahmani-Oskooee & Karamelikli, (2021b)	2003-2018	Turkey-US	TB, YF, YD, REX	ARDL & NARDL	The results disclose a short-run asymmetric effects in 28 out of 45 industries.
(Bahmani-Oskooee & Karamelikli, (2021a)	1999-2019	UK-Germany	TB, YF, YD, REX	ARDL & NARDL	The findings support the symmetric J-curve effect in 12 industries, and asymmetric J-curve effect in 21 industries
Bahmani-Oskooee & Kanitpong, (2021)	1993-2019	Thailand and its 12 largest partners	TB, YF, YD, REX	ARDL & NARDL	The Thailand currency devaluation increases its outpayments to eight trading partners and increases its in-payments from seven trading partners
(Bahmani-Oskooee & Baek, 2021)	2000 - 2020	Korea-US	TB, YF, YD, REX, PU	ARDL & NARDL	In the long run, nine U.S. exporting industries are negatively affected by the Korean uncertainty measure and only five industries are affected by the U.S. uncertainty measure.
Bahmani-Oskooee & Arize, (2021)	different periods	U.S. with each of the 20 partners from Africa	TB, YF, YD, REX, V	ARDL & NARDL	Significant long-run asymmetric effects were discovered in the case of U.S. exports to 15 countries and U.S. imports from 12 countries
Tunaer Vural, (2016)	2002-2014	Turkey - Germany	TB, YF, YD, RER	ECM model	The results support the existence of J-curve effect
Nicita, (2013)	2000-2009	100 countries	X, xrate, TTRI, GDP, MR	gravity model	Study outcomes reveal that currency undervaluation promotes exports and restrict imports
Xu et al., (2022b)	2000-2020	China and 21 trade partners	TB, YF, YD, REX, V	ARDL & NARDL	Log-run significant asymmetric effects in 50% of the investigated models
(Dogru et al., 2019b)	January 1996– June 2017	USA-Canada-Mexico-UK	TOB, EXC, I	ARDL & NARDL	supporting the postulations of the ML condition and contradicting the J-curve theory
Wu et al., (2013)	1975-2010	China and G7 countries	TB, rry, rer, rop, dw, rir	Panel smooth transition regression (PSTR)	Trade balance reacts significantly to the changes in relative real income, real oil prices and import-weighted distance

TB: the trade balance; **YF:** the income of the trade partner; **YD:** the income of the country; **REX**: the real bilateral exchange rate; **X**: export volume; **W**: world income; **R:** real price rate, **δ** exchange rate volatility; **RTA**: regional trade agreement, Crisis country-specific episodes, **ERR:** bilateral exchange rate; **RER:** real effective exchange rate; **V** GARCH-based volatility of the real exchange rate; **PU:** economic policy uncertainty

This means that oil price hikes are thought of as having equally opposite effects as compared to oil price plunges. But nothing guarantees that such an assumption holds in reality. Given the effects of ups and downs in the price of crude oil on the trade balance could be different in both sign and magnitude, it would be more sensible to assume that oil price fluctuations have asymmetric impacts. Thus, to evaluate the macroeconomic impacts on the trade balance properly this study explicitly incorporates oil prices into the model. The economic policy uncertainty on the other hand captures almost all economic and political events that contribute to an uncertain situation. Since introduction of economic policy uncertainty index, researchers have assessed its impact on different macro variables, nonetheless the trade flows have been left out (Bahmani-Oskooee & Xu, 2022). In this vein, incorporating the uncertainty index to our model is of great importance and interest.

The linear ARDL models without asymmetric adjustment for the above models can be shown as follows:

$$\Delta lnTB_t = \mu + \alpha_1 lnTB_{t-1} + \alpha_2 lnWTI_{t-1} + \alpha_3 lnEPU_{t-1} + \alpha_3 lnREER_{t-1} + \sum_{i=1}^{p-1} \lambda_1 \Delta lnTB_{t-i} + \sum_{i=0}^{q-1} \lambda_2 \Delta lnWTI_{t-i} + \sum_{i=0}^{q-1} \lambda_3 \Delta lnEPU_{t-i} + \sum_{i=0}^{q-1} \lambda_4 \Delta lnREER_{t-i} + \varepsilon_t \quad (2)$$

The above equations show the symmetric cointegration relationship between the variables. Each variable was added to the model by taking its logarithmic transformations. Δ represents the first difference of the variables. λ_j and α_j show the short- and long-term coefficients of the variables (j=1,2,3) respectively. The cointegration relationship is determined based on the *F*-statistics test of the null hypothesis established as "$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$) "there is no cointegration between the variables". If there is no linear relationship between the variables, the linear ARDL model would give spurious outcomes. To avoid this problem, we propose the following asymmetric model for the long run cointegration:

$$y_t = \beta^+ x_t + \beta^- x_t + u_t \quad (3)$$

y_t represents the dependent variable at time t, x_t refers to independent variables at time t, β^+ *and* β^- represent the long-run parameters. x_t constitutes the vector of estimators defined as $x_t = x_0 + x_t^+ + x_t^-$. Here, x_0 represents the initial value *t*=0 and x_t^+ ve x_t^- positive and negative shocks, respectively. The x_t^+ positive and x_t^- negative partial sums of independent variables (real exchange rate, oil price and economic policy uncertainty) are obtained by decomposing with the following method:

$$x^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0) \quad (4)$$

$$x^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \quad (5)$$

When the positive and negative elements of the variables obtained in Equations 4 and 5 are added to the ARDL model, the NARDL model can be specified as follows.

$$\Delta lnTB_t = \mu_0 + \varphi lnTB_{t-1} + \alpha_1^+ lnWTI_{t-1}^+ + \alpha_1^- lnWTI_{t-1}^- + \alpha_2^+ lnEPU_{t-1}^+ + \alpha_2^- lnEPU_{t-1}^- + \alpha_3^+ lnREER_{t-1}^+ + \alpha_3^- lnREER_{t-1}^- + \sum_{i=1}^{p-1} \gamma \Delta lnTB_{t-i} + \sum_{i=0}^{q-1} \lambda_1^+ \Delta lnWTI_{t-i}^+ + \sum_{i=0}^{q-1} \lambda_1^- \Delta lnWTI_{t-i}^- + \sum_{i=0}^{q-1} \lambda_2^+ \Delta lnEPU_{t-i}^+ + \sum_{i=0}^{q-1} \lambda_2^- \Delta lnEPU_{t-i}^- \quad (6)$$

As in the linear model, the null hypothesis that there is no cointegration ($\varphi = \alpha_1^+ = \alpha_1^- = \alpha_2^+ = \alpha_2^- = \alpha_3^+ = \alpha_3^- = 0$) is determined by applying the F-statistics test. Acceptance or rejection of the null hypothesis are decided by comparing the calculated F-statistic value with the critical values of the upper critical test results. If the F-statistics values are greater than the upper critical bound, thus, the null hypothesis of no asymmetric cointegration relationship between the variables is rejected. However, if the F-statistics values, are lower than the lower critical bound, the null hypothesis cannot be rejected and there is no asymmetric cointegration relationship between the variables. Then, the existence of short- and long-term asymmetries is investigated using the Wald test (Shin et al., 2014).

To detect the existence of long-term nonlinearity, the null hypothesis of $\beta^+ = \beta^-$ which is established as no long-term symmetry is tested. Here, $\beta^+ = -\alpha_j^+/\varphi$ ve $\beta^- = -\alpha_j^-/\varphi$ *,j=1,2 and 3.* The presence of short-term asymmetry is $\sum_{i=0}^{q-1} \lambda_k^+ = \sum_{i=0}^{q-1} \lambda_k^-$, k=1,2 and 3. is evaluated by testing the null hypothesis established as k=1,2 and 3. Rejecting the null hypothesis means that there is no short-run asymmetry, and it is accepted that the relevant variable has short-run asymmetry.

The wavelet-based approach will also be used since the literature on the subject lacks the time frequency analysis. The time frequency analysis takes its importance from the co-movement and lead-lag properties it offers. Since the exchange rate change to influence trade balance, it must pass through an adjustment lag, the time frequency analysis is best approach to predict a clear movement through time. The wavelet approach combines the time frequency domain-based causality approaches which enables us to evaluate the degree of the co-movement concurrently at different frequencies over time. Time-frequency also deals with the change over time and shows how the relationship varies from one frequency to another. All these factors make the wavelet coherence approach the most preferable over the other causality approaches. Wavelet-based approach is relatively a new area of human knowledge, which is found to be useful for decomposing signals that have a cyclical behavior. Originally, this approach has been used in the study of a multitude of diverse physical phenomena from climate change analysis to financial issues. This study utilized Morlet wavelet function. (Adebayo, 2020) outlined that Morlet wavelet brings balance between phase and amplitude and can be specified as follows:

$$w(n) = \pi^{-\frac{1}{4}} e^{-iwn} e^{-\frac{1}{2}n^2} \quad (7)$$

w denotes the non-dimensional frequency, i refer to $\sqrt{-1\, p(\backslash)}$. By using the space and time \ = 0,1…N-1. Considering the wavelet continuous transformation of the time series, it takes following form:

$$w_{k,f}(n) = \frac{1}{\sqrt{h}} w\left(\frac{n-k}{f}\right), k, f \in \mathbb{R}, f \neq 0 \quad (8)$$

In equation 8, the k and f respectively indicate time and frequency. The continuous wavelet transformation (CWT) allows the cross-wavelet analysis to interrelate two variables and is defined in the following equation:

$$w_p(k,f) = \int_{-\infty}^{+\infty} p(n) \frac{1}{\sqrt{f}} \left(\frac{\overline{n-k}}{f}\right) dn, \quad (9)$$

In equation 10, the local variance is defined by wavelet power spectrum or shortly know as WPS. Although, there are many formulas in the literature specify the approach of wavelet coherence, but generally the specification of WTC can be given in equation 11. Where S indicates the time and scale smoothing operators with 0 ≤ $R^2(k,f)$ ≤ 0.

$$WPS_p(k,f) = \left|W_p(k,f)\right|^2 \quad (10)$$

$$R^2(k,f) = \frac{\left|S\left(f^{-1}W_{pj}(k,f)\right)\right|^2}{S\left(f^{-1}\left|W_p(k,f)\right|^2\right) S\left(f^{-1}\left|W_j(k,f)\right|^2\right)} \quad (11)$$

4. Empirical findings and discussion

In this part of the study, prior to conducting a stationarity test, cointegration and other subsequent estimations, we initially set off by introducing the summary of descriptive statistics properties through central tendencies and dispersion measures. Table 3 outlines some important descriptive statistics of our variables of interest including the trade balance, real exchange rate, oil price and economic policy uncertainty. Between January 2013 to December 2020 the trade balance varied between 0.020347 and 2.636127, with average and standard deviation of 0.307114 and 0.422581. oil shows a dramatical price movement from 16.81000 to 106.5500 with a mean and standard deviation of 61.89479 and 22.20954. Within the same sample period, real exchange rate also demonstrates a significant change ranging from 0.236772 to 0.950710, with average 0.535088 and standard deviation 0.229033. Economic policy uncertainty also demonstrates a considerable fluctuation within the sample period running from 88.56859 to 437.0496, with average and standard deviation 188.0079 and 80.28107. Overall, the economic policy uncertainty shows a highest average followed by oil price, exchange rate and trade balance. The Kurtosis and Skewness results reveal that all the variables are normally distributed except the trade balance.

Although the unit root test is not a prerequisite for the nonlinear ARDL bound testing cointegration method, however, since most time series data are not stationary in nature, it is vital to investigate the stationarity properties to avoid the presence of second-order variables. Otherwise, the model yields often spurious findings. Simply, stationarity means that the time series has a constant average and finite variance, meaning that stationary time series tends to frequently return to the mean value. Table 4 reports the findings of Augmented Dickey-Fuller (ADF) and Zivot-Andrews (ZA) unit root tests with and without structural break. The unit root with structural break is generally employed to ascertain the stationarity properties when the structural break exists. As can be seen clearly, the variables are found to be integrated at different orders, at level and first-difference as well, but none of them is integrated at the second order. Figure 4 also confirms the unit root tests, and clearly indicates that our series tends to return to its mean values. In particular, the series are found to be nonstationary when the structural breaks took place in 2018:M03, 2014:M10, 2018:M09 and 2014:M10 for lnTB, lnWTI and lnEPU respectively.

Table 3: Descriptive statistics

	Trade balance	Oil price	Real Ex. rate	EPU
Mean	0.307114	61.89479	0.535088	188.0079
Median	0.205890	54.91500	0.463370	159.9744
Maximum	2.636127	106.5500	0.950710	437.0496
Minimum	0.020347	16.81000	0.236772	88.56859
Std. Dev.	0.422581	22.20954	0.229033	80.28107
Skewness	3.763870	0.685454	0.381403	0.916549
Kurtosis	18.09324	2.385701	1.606274	2.979125

Table 4: Unit root tests without and with a structural break

Variables	ADF Intercept	ZA Intercept	Break Points	ADF Intercept and Trend	ZA Intercept and Trend	Break Points
			Level			
lnTB	-4.689	-7.780	2018:M03	-7.391***	-8.175**	2018:M09
lnWTI	-2.605	-3.692	2014:M10	-3.032	-3.649	2014:M10
lnEPU	-2.179	-5.599	2018:M09	-5.111***	-5.780***	2017:M03
lnREER	-0.613	-3.882***	2019:M06	-2.457	-4.042**	2016:M12
			1st Diffidence			
ΔlnTB	-11.616***	-7.287**	2014:M09	-11.538***	-7.420***	2018:M08
ΔlnWTI	-7.579***	-7.912*	2016:M03	-7.549***	-7.939*	2016:M03
ΔlnEPU	-12.977***	-6.917*	2017:M03	12.919***	-6.905*	2017:M03
ΔlnREER	-9.785***	-10.645***	2018:M10	-9.729***	-11.007***	2018:M10

Note: The natural logarithms of all variables are taken and Δ represents the first differences of the variables. ***, ** and * indicate 1%, 5% and 10% significance and rejected the null hypothesis at 1%, 5%, respectively. Structural break dates are those shown by Zivot–Andrews (ZA) tests

After identifying the stationarity properties, the study moves to explore the cointegration relationship among the study variables. The concept of cointegration was firstly introduced by Engle and Granger (1987) to investigate the relationship between a set of variables within a dynamic framework in long-term. (Nkoro & Uko, 2016) outline that cointegration illustrates the existence of a long run equilibrium among underlying economic time series that converges over time and provides a stronger statistical and economic foundation for empirical error correction model. Therefore, the cointegration test cannot be overlooked to confirm the long run meaningfulness of the model.

If no meaningful relationship is found, then the model is spurious and will give misleading outcomes. Table 5 summarizes both linear and nonlinear bounds testing approaches. The linear bound test's F-statistics value (4.169) exceeds the upper critical value (3.67) at 5% level of significance. The nonlinear bound test F-statistics value (15.560) is found to be greater than the upper critical value (3.99) at 1% level of significance. These findings clearly confirm the validity of applying both linear and nonlinear models. Once the long run relationship is confirmed, the analysis progresses to estimate the short run and long run linear and nonlinear models.

Figure 4: stationarity at first difference

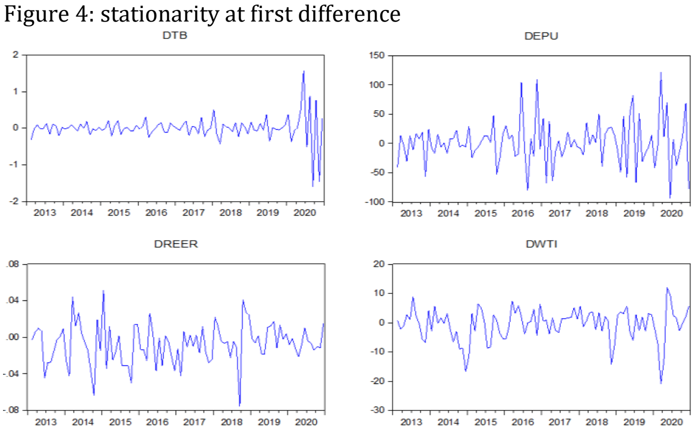


Table 6 presents the results of ARDL. The table clearly indicates that oil price (-0.589 (0.155)), economic policy uncertainty (0.690 (0.366)) and real exchange rate (-0.543 (0.316)) have no significant impacts on trade balance in the long run. This evidence may intuitively reveal that the reaction of trade balance to the leading variables in an asymmetric manner. Therefore, the asymmetric effect will be the focus of subsequent analysis.

Table 5: Cointegration Results of ARDL and NARDL testing approach

ARDL Model (4,2,6,1): $F(lnTB_t/lnWTI_t,, lnEPU_t, lnREER_t)$		
Test Statistic	Value	k
F-statistic	4.169**	3
Critical Value Bounds Significance	I(0)	I(I)
1%	3.65	4.66
5%	2.79	3.67
10%	2.37	3.2
NARDL Model: $F(lnTB_t/lnWTI_t^+, lnWTI_t^-, lnEPU_t^+\ lnEPU_t^-, lnRER_t^+, lnRER_t^-)$		
Test Statistic	Value	k
F-statistic	15.560***	6
Critical Value Bounds Significance	I(0)	I(I)
1%	2.88	3.99
5%	2.27	2.28
10%	2.88	3.99

Since the nonlinear bound test's F-statistics confirms the existence of cointegration in table 3, we employ nonlinear ARDL to disclose the short run and long run asymmetric relationship between our variables of interest. Table 7 portrays the short run and long run asymmetric results for our model. To confirm the nonlinear relationship between real exchange rate and trade balance, we decompose the real exchange rate, oil price and economic policy uncertainty into positive and negative shocks. To confirm the linearity, the impact of positive and negative shocks of the regressors on trade balance must be the same in absolute term. From table 7, the results indicate that in the long run positive shocks in exchange rate have no significant impact on trade balance 0.6052 (0.1098), while negative shocks in exchange rate significantly impact the trade balance. Precisely, a one-unit decrease in the real exchange rate will reduce the trade balance by 2.89%. This means that a negative shock in real exchange rate have a greater impact on bilateral trade between Turkey and Libya within the sample period. The model also confirms the presence of asymmetric relationship between oil price and economic policy uncertainty

We find that positive and negative shocks in oil price have significant positive coefficients in the long run, and the positive shocks have greater and long-lasting effect, a 1-unit increase in oil price brings about positive change of 0.6040 units in trade balance. Similarly, a 1-unit decrease in oil price brings a negative change of 0.2226 units in trade balance. On the other hand, we find that in the long run, positive and negative shocks in economic policy uncertainty index have significant negative coefficients. Particularly, a 1-unit increase in economic policy uncertainty index reduces trade balance by 0.2339 units in trade balance, while a 1-unit decrease in economic policy uncertainty index brings a positive change of 1.4414 units in trade balance. The adjustment coefficients of the short run dynamics show the speed of adjustments of the variables in response to a standard deviation from long run equilibrium.

Table 6: Results of ARDL

Variables	Coefficient	Std. Error	t-statistic	p-value
Long-Run Association				
C	-1.846724	2.420692	-0.762891	0.4480
$lnTB_{t-1}$	-0.601380***	0.147006	-4.090866	0.0001
$lnWTI_{t-1}$	-0.354446	0.241304	-1.468879	0.1462
$lnEPU_{t-1}$	0.415389	0.410516	1.011871	0.3149
$lnREER_{t-1}$	-0.327003	0.384978	-0.849406	0.3984
Short-Run Association				
$\Delta lnTB_{t-1}$	-0.053209	0.129942	-0.409483	0.6834
$\Delta lnTB_{t-2}$	0.006145	0.123560	0.049735	0.9605
$\Delta lnTB_{t-3}$	0.231867**	0.102745	2.256727	0.0270
$\Delta lnWTI_{t}$	0.464260	0.520843	0.891363	0.3757
$\Delta lnWTI_{t-1}$	1.186323**	0.533461	2.223822	0.0293
$\Delta lnEPU_{t}$	-0.503092	0.391849	-1.283891	0.2032
$\Delta lnEPU_{t-1}$	-0.433047	0.441713	-0.980379	0.3301
$\Delta lnEPU_{t-2}$	0.203577	0.435877	0.467053	0.6419
$\Delta lnEPU_{t-3}$	-0.169065	0.429189	-0.393918	0.6948
$\Delta lnEPU_{t-4}$	-0.492315	0.420501	-1.170784	0.2455
$\Delta lnEPU_{t-5}$	-1.221970***	0.383243	-3.188500	0.0021
$\Delta lnREER_{t}$	2.431717*	1.255691	1.936557	0.0567
ECT_{t-1}	-0.601380***	0.128237	-4.689599	0.0000
Long-term coefficients			Statistics and diagnostics	
$lnWTI$	-0.589 (0.155)		F_{PSS}	4.169**
$lnEPU$	0.690 (0.366)		χ^2_{SER}	0.520
$lnREER$	-0.543 (0.316)		χ^2_{HET}	22.973
C	-3.070 (0.438)		χ^2_{NORM}	0.3917
			χ^2_{RAMSEY}	2.403

The speed of adjustment is seen to facilitate long-run convergence among the parameters with a significant and negative sign (-2.9502), which signifies the capability of the model to witness a -2.9502% speed of adjustment to verify the tendency to equilibrium in the long-term. Table 7 also reports some important diagnostic tests outcomes such as serial correlation tests and stability test.

We use the wavelet coherence transformation (WTC) technique to figure out the co-movement and to identify the lead-lag relationship between trade balance, real exchange rate, oil price and economic policy uncertainty. Figures 5 to 10 present the WTC among the underlying variables between January 2013 and December 2020. The horizontal and vertical axis in each figure indicates the time and frequency respectively. The yellow and blue colors denote high and low dependence between the variables. The rightward and leftward arrows correspondingly show the in-phase and out-of-phase interrelations. Furthermore, the rightward-down or leftward-up indicates that the first is lagging. Whereas rightward-up (leftward-down) indicates the first series is leading. The curved lines drawn by using the Monte Carlo simulation with a 5% level of significance refers to the statistically significant region.

Figure 5 present the coherence between trade balance (TB) and real exchange rate (REER). The figure clearly indicates high correlations between two variables in the short and long term. At various frequencies, leftward-up and down arrows clearly reveal a negative relationship between trade balance and real exchange rate. The left down arrows until fourth period indicate that trade balance leads exchange rate fluctuations. This may be due to adjustment lag; the period trade flows need to response to the new exchange rate levels. But this relationship reverses in the long term after period 4, and the rightward up arrows still indicate that trade balance leads real exchange rate.

This means the real exchange rate is not the main determinant of trade balance between Turkey and Libya. Figure 6 shows the coherence between trade balance and economic policy uncertainty index. At different scales, the figure displays high correlation between two series in medium and long term. The rightward up arrows until fourth period reveal that economic policy uncertainty is lagging in trade balance. For some periods this relation takes opposite direction. For instance, until period eight, the right-down arrows indicate that economic policy uncertainty, but this relation returns and demonstrate negative correlation. Figure 7 also displays almost the same trend for some periods at given scales, until period four, the arrows show high correlation between oil price and trade balance with trade balance leading. However, until period eight, trade balance is lagging in oil price.

Table 7: Estimated long- and short-run coefficients of NARDL Results

Variable	Coefficient	Std. error	t-statistic	p- value
C	-9.9478***	1.0537	-9.4409	0.0000
$lnTB_{t-1}$	-2.9502***	0.3170	-9.3072	0.0000
$lnWTI^{+}_{t-1}$	1.7820***	0.4254	4.1892	0.0001
$lnWTI^{-}_{t-1}$	0.6568**	0.3134	2.0958	0.0413
$lnEPU^{+}_{t-1}$	-0.6903	0.4343	-1.5897	0.1183
$lnEPU^{-}_{t-1}$	-4.2526***	0.5638	-7.5429	0.0000
$lnREER^{+}_{t-1}$	1.7857	1.0750	1.6612	0.1031
$lnREER^{-}_{t-1}$	8.5263***	1.4085	6.0533	0.0000
$\Delta lnTB_{t-1}$	1.7123***	0.2653	6.4553	0.0000
$\Delta lnTB_{t-2}$	1.5143***	0.2483	6.0985	0.0000
$\Delta lnTB_{t-3}$	1.2537***	0.2224	5.6369	0.0000
$\Delta lnTB_{t-4}$	1.0932***	0.2155	5.0729	0.0000
$\Delta lnTB_{t-5}$	1.0252***	0.1877	5.4623	0.0000
$\Delta lnTB_{t-6}$	0.7302***	0.1703	4.2878	0.0001
$\Delta lnTB_{t-7}$	0.5177***	0.1312	3.9465	0.0003
$\Delta lnTB_{t-8}$	0.2466**	0.0950	2.5954	0.0124
$\Delta lnWTI^{+}_{t-3}$	-2.4689**	1.0413	-2.3710	0.0217
$\Delta lnWTI^{+}_{t-5}$	4.6752***	1.0205	4.5815	0.0000
$\Delta lnWTI^{-}_{t-2}$	-2.5098***	0.7053	-3.5586	0.0008
$\Delta lnWTI^{-}_{t-4}$	-2.4591***	0.7212	-3.4097	0.0013
$\Delta lnWTI^{-}_{t-5}$	-5.1279***	1.1179	-4.5869	0.0000
$\Delta lnWTI^{-}_{t-8}$	-2.0094***	0.7398	-2.7161	0.0091
$\Delta lnEPU^{+}_{t}$	-1.5971***	0.4605	-3.4685	0.0011
$\Delta lnEPU^{-}_{t-1}$	4.0843***	0.6460	6.3223	0.0000
$\Delta lnEPU^{-}_{t-2}$	4.2926***	0.6094	7.0437	0.0000
$\Delta lnEPU^{-}_{t-3}$	2.9102***	0.6089	4.7795	0.0000
$\Delta lnEPU^{-}_{t-4}$	2.9859***	0.5637	5.2974	0.0000
$\Delta lnREER^{+}_{t-2}$	-9.3569***	3.4185	-2.7371	0.0086
$\Delta lnREER^{+}_{t-6}$	4.8142**	2.3824	2.0207	0.0488
$\Delta lnREER^{+}_{t-7}$	8.7291***	2.1921	3.9820	0.0002
$\Delta lnREER^{-}_{t}$	4.2405***	1.3808	3.0711	0.0035
$\Delta lnREER^{-}_{t-1}$	-8.0817***	2.1267	-3.8001	0.0004
$\Delta lnREER^{-}_{t-2}$	-7.6737***	1.9472	-3.9410	0.0003
$\Delta lnREER^{-}_{t-3}$	-7.8812***	2.2658	-3.4784	0.0011
$\Delta lnREER^{-}_{t-4}$	-6.4076***	1.8255	-3.5101	0.0010
$\Delta lnREER^{-}_{t-5}$	-10.2434***	1.8965	-5.4012	0.0000
$\Delta lnREER^{-}_{t-6}$	-3.3127*	1.7568	-1.8856	0.0653
Long-run asymmetric effects				
$lnWTI^{+}$	0.6040*** (0.000)	$lnWTI^{-}$	0.2226*(0.0458)	
$lnEPU^{+}$	-0.2339*(0.099)	$lnEPU^{-}$	-1.4414***(0.000)	
$lnREER^{+}$	0.6052 (0.1098)	$lnREER^{-}$	2.8900***(0.000)	
Statistics and diagnostics				
t_{BDM}	-9.307***	R^2	0.852	
F_{PSS}	15.560***	R^2_{Adj}	0.737	
χ^2_{SER}	2.047	F_{ist}	7.849***	
χ^2_{HET}	34.017	χ^2_{RAMSEY}	2.634	
χ^2_{NORM}	3.700	Stability tests	Stable	

Note: "+" and "– "are the positive and negative partial sums of the variables, L^{+} and L^{-} estimated long-run coefficients for the positive and negative shocks, respectively, W_{LR} and W_{SR} Wald test results is used to check the short-run and long-run symmetry, respectively. ***, ** and * indicate that null hypothesis is rejected at 1%, and 5% significance level. Δ, first difference operator F_{PSS} shows the statistics from the Pesaran et al. (2001) bounds test. T_{BDM} is the BDM t-statistic showing the statistics from Banerjee et al. (1998). χ^2_{SER},χ^2_{HET},χ^2_{NORM} and χ^2_{RAMSEY} indicate Breusch-Godfrey LM autocorrelation, Breusch-Pagan variable variance and normal distribution tests and regression specification error tests, respectively. CUSUM and CUSUMSQ present Cusum and Cusum square stability tests, respectively. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. The numbers in parentheses are p-probability values. GTOS (general-to-specific approach) method was used in the model estimation and the lag lengths of the dependent and independent variables were taken as maximum p=8 and max q=8, and insignificant variables are removed from the model and the most suitable model are obtained. The lower and upper bound critical value of the F-test for cointegration when k = 6 are 3.6-4.9 at the 1%, 2.87-4 at the 5%, and 2.53-3.59 at the1%, 5% and 10% level of significance.

We use the wavelet coherence transformation (WTC) technique to figure out the co-movement and to identify the lead-lag relationship between trade balance, real exchange rate, oil price and economic policy uncertainty. Figures 5 to 10 present the WTC among the underlying variables between January 2013 and December 2020. The horizontal and vertical axis in each figure indicates the time and frequency respectively. The yellow and blue colors denote high and low dependence between the variables. The rightward and leftward arrows correspondingly show the in-phase and out-of-phase interrelations. Furthermore, the rightward-down or leftward-up indicates that the first is lagging. Whereas rightward-up (leftward-down) indicates the first series is leading. The curved lines drawn by using the Monte Carlo simulation with a 5% level of significance refers to the statistically significant region. Figure 5 present the coherence between trade balance (TB) and real exchange rate (REER). The figure clearly indicates high correlations betweem two variables in the short and long term. At various frequencies, leftward-up and down arrows clearly reveal a negative relationship between trade balance and real exchange rate. The left down arrows until fourth period indicate that trade balance leads exchange rate fluctuations. This may be due to adjustment lag; the period trade flows need to response to the new exchange rate levels. But this relationship reverses in the long term after period 4, and the rightward up arrows still indicate that trade balance leads real exchange rate. This means the real exchange rate is not the main determinant of trade balance between Turkey and Libya. Figure 6 shows the coherence between trade balance and economic policy uncertainty index. At different scales, the figure displays high correlation between two series in medium and long term. The rightward up arrows until fourth period reveal that economic policy uncertainty is lagging in trade balance. For some periods this relation takes opposite direction. For instance, until period eight, the right-down arrows indicate that economic policy uncertainty, but this relation returns and demonstrate negative correlation. Figure 7 also displays almost the same trend for some periods at given scales, until period four, the arrows show high correlation between oil price and trade balance with trade balance leading. However, until period eight, trade balance is lagging in oil price.

Figure 5. Trade balance and real exchange rate

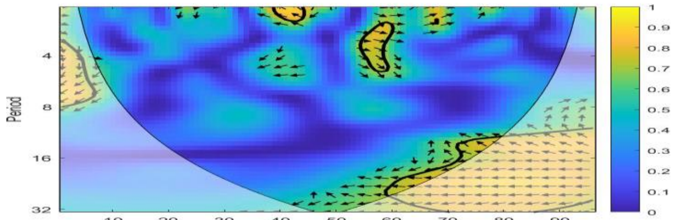


Figure 6. Trade balance and economic policy uncertainty

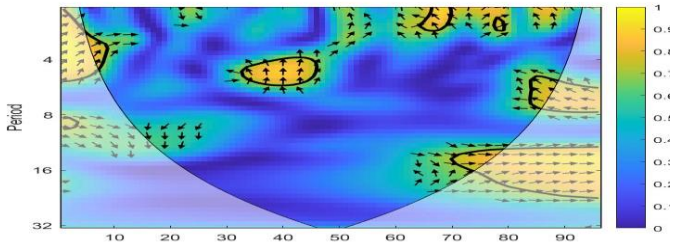


Figure 7. Trade balance and oil price

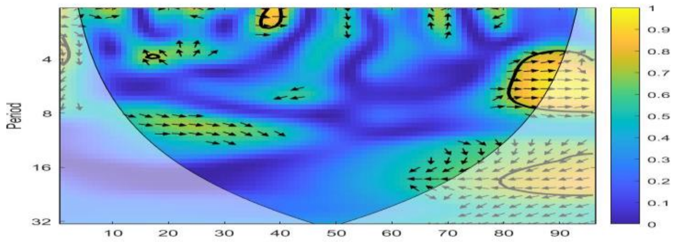


Figure 8. Economic policy uncertainty and real exchange rate

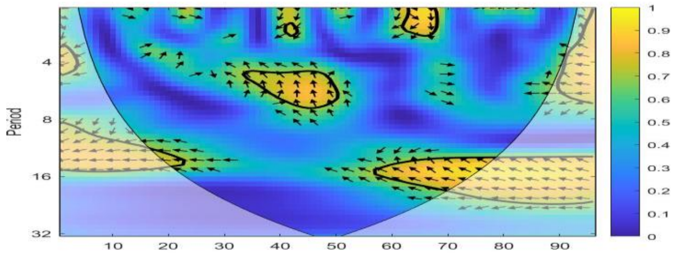


Figure 9: Real exchange rate and exports

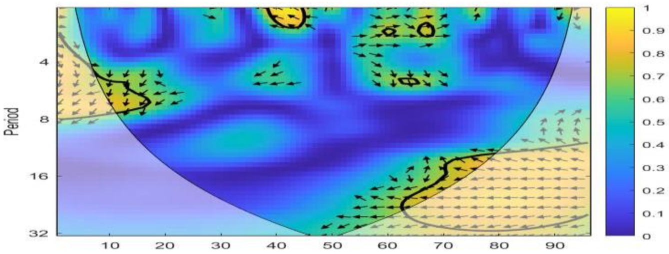
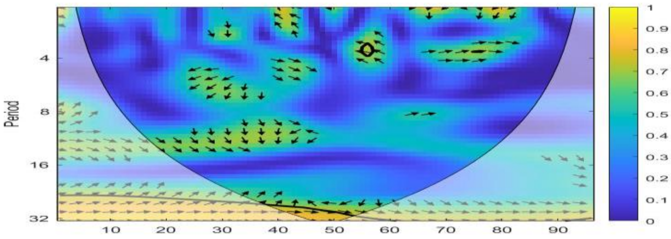


Figure 10: Real exchange rate and imports



To understand the asymmetric effect and lead-lag relationship between the trade balance and exchange rate this study uses two approaches: nonlinear ARDL and wavelet coherence. The finding of the first approach reveals the presence of a long run cointegration between trade balance, real exchange rate, oil price and economic policy and uncertainty. The nonlinear ARDL results also proved the asymmetric relationship between trade balance and real exchange rate. The asymmetric effect is skewed in the negative direction, as the impact of negative shocks in exchange rate on trade balance is significant and bigger than the positive shocks in which no significant effect was observed. This finding is consistent with results of many studies. For instance, (Bahmani-Oskooee & Gelan, 2018), studied the impact exchange rate volatility on trade balance for 12 African countries, and concluded that while exchange rate volatility affects trade flows of many of the countries in the short run, in the long-run however, the effects were restricted only on the exports of five countries and on the imports of only one country.

The possible explanation to this finding is attributed to the differences in import and export demand elasticities. (Bahmani-Oskooee, et al., 2018) also argued that the effect of exchange rate on trade balance is basically partner-specific. In case the largest partner, the trade flows may not respond to the exchange rate fluctuation instantaneously due to the adjustment lags. This view may better explain the Turkey-Libya situation, as Turkey is the second largest exporter to Libya after China. The NARDL results also confirm the asymmetric relationship between trade balance and oil price, with greater impact of positive socks in oil price. This finding is in line with those of (Commer et al., 2020; Ahad & Anwer, 2019; Baek & Jungho, 2020). Theoretically, in the oil - dependent countries the increase in oil price improves the term of trade, as the revenue will increase, this will promote the trade balance (Korhonen & Ledyaeva, 2010). This view is also explained indirectly by supply and demand effects. In supply effect, increase in oil price leads to downturn in those countries which import oil due to negative supply shock in the production process that reduce their imports that influence oil-producing countries' balance of trade. In demand effect, oil price increase creates inflation pressure on the global market that financially leads to high prices of imports in the case of both countries. This view also may provide a clear explanation to our finding as Libya is oil-dependent economy. The oil revenue constitutes more than 95% of its total revenue.

This also further proves the argument that nonlinear effect of the oil price on trade balance relationship depends on the source of the shock, for the oil exporter countries, expansion of oil supply is more important than supply disruptions, and the decrease in oil price only benefits oil importer countries if they result from supply-side shocks (Jibril et al., 2020). Lastly, the NARDL result is consistent with literature findings regarding the negative effect of economic policy uncertainty on trade balance. For instance, (Bahmani-Oskooee & Baek, 2021) applied a firm-level study and concluded that in the long run, nine U.S. exporting industries are negatively affected by the Korean uncertainty measure and only five industries are affected by the U.S. uncertainty measure. Given the news-based uncertainty policy measures, the trade-policy uncertainty nexus has become an important area of research especially after the emergence of relatively more flexible exchange rates policies undertaken by global economic organization. Regarding the oil price shocks our result contradicts the result of (Lin & Bai, 2021) who found that, the negative response to the oil price shock is greater in oil-exporter countries than that of the oil-importing ones.

The wavelet coherence technique is employed for understanding the co-movement and lead-lag relationship between trade balance and real exchange rate first; and trade balance and other control variables as the second. The results of wavelet analysis indicate that trade balance exchange rate is lagging in trade balance in all periods although the co-movement reverse between periods with high negative correlation. Since the literature lacks the time frequency analysis to the subject of trade balance-exchange rate nexus, we find no evidence to support the obtained time frequency outcomes. To overcome the data aggregation bias, we estimated the co-movement between real exchange rate and the components of trade balance separately. Although both indicators demonstrate high correlations, but their lead-lag analyses reveal opposite directions. The finding indicates that exchange rate is lagging in exports, which supports the total trade balance. On the other hand, the finding also indicates that import is lagging in exchange rate. The wavelet results also provide evidence to understand the bilateral trade relations between Turkey. The leading exports may reveal which country has the power to influence the trade relation and benefit more.

5. Conclusion and policy recommendations:

Despite voluminous empirical and theoretical research addressing the nexus between real exchange rate and trade balance, the discussion still persistent. This study adds to the existing literature on the subject by providing new evidence form more holistic prospective, not only the asymmetric effect but also the co-movement and frequency overtime between exchange rate and trade balance. The study considers trade balance between Libya and its major trade partner, Turkey. By applying nonlinear autoregressive distributed lag model (NARDL), we find that in the long run, the impact of real exchange rate on the trade balance is skewed more to negative direction, as the negative shock in real exchange is significant and greater than positive shock, which means that the negative effect is long-lasting and positive changes is faded away by large negative shocks. The results of the NARDL model also reveal considerable outcomes regarding our other control variable namely oil price and economic policy uncertainty. Particularly, the findings indicate that trade balance respond to oil price and economic policy uncertainty asymmetrically.

This study applies a unique technique to find out the frequencies and co-movement between real exchange rate and trade balance over time. This technique has been neglected completely in this area of research although it is powerful technique in detecting the frequencies between two series. Since the time is a major element in the mechanism of exchange rate-trade nexus, conducting time-variable analysis would draw a clearer view on the adjustment lag. The wavelet coherence analysis provides important information about the lead-lag between trade balance and real exchange rate.

The result indicates that trade balance leads exchange rate in all periods. The most dominant periods are fourth and eighth periods. The lead-lag analysis also reveals that trade balance is lagging in oil price. However, the trend is opposite in case of economic policy and certainty and trade balance.

Our findings provide some significant economic interpretations; First, the presence of asymmetric effect and negative direction skewness of exchange rate fluctuations on trade balance answer the question of whether depreciation or appreciation of a currency has more and long-lasting effect on trade balance between countries. As the negative shock in exchange rate is greater than positive shock, it means that positive change may be faded away by large negative change. Second, the leading of oil price may explain the paradox of why some oil-dependent countries dominate the bilateral trade but still experiencing a trade deficit. This evidence may intuitively reveal the effectiveness diverse export-oriented policies at the expense of one sector-dependence.

The results of our analysis call for important policy implications. First, as the negative shocks in the real exchange rate have a significant long run effect which adversely affect trade balance, the study recommends that stable exchange rate through the intervention in the foreign exchange market will promote the trade balance, and economic growth at the end. Second, this study recommends that the policy makers of Libya should implement a diverse export-oriented policies to overcome the long-term detrimental effect of a one sector-based economy "energy dependent economy". Third, it is suggested that an innovative public-private partnership in foreign trade sector can protect against the undesirable implications during uncertain times. Lastly, although the bilateral trade may to somewhat overcome the aggregation data bias but not completely since two countries engage in trading more than one commodity. Therefore, for the sake of more elucidation, more research on industry-level or commodity-base are required, which helps industries on how engage in foreign trade.

Declarations

Ethics approval: this study follows all ethical practices during preparation.
Competing interest: the authors of this paper declare that there is no competing interest.
Data availability statement: the full dataset (EViews and MATLAB relevant work-files) is shared in public data repository with 10.6084/m9.figshare.19312364 *and can be reached through the link* https://figshare.com/s/0086701a0cc00d39891c

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