Environmental Science and Pollution Research (2023) 30:48363–48374
https://doi.org/10.1007/s11356-023-25574-9

RESEARCH ARTICLE

Nexus between macroeconomic uncertainty, oil prices, and exports: evidence from quantile-on-quantile regression approach

Vishal Dagar[1] · **Sakshi Malik**[2]

Received: 6 October 2022 / Accepted: 23 January 2023 / Published online: 9 February 2023

Abstract
International trade is key to boosting the economic growth and development of an economy. Hence, it becomes critical to analyze its determinants. The present study attempts to empirically analyze the determinants of trade exports of Pakistan with its top-5 trade partners. The prior literature suffers from biased findings due to deploying the aggregate data and ignoring the likely asymmetries in the drivers of the exports. The present study has used the monthly data of oil prices and macroeconomic uncertainty in order to empirically investigate the determinants of exports. For the purpose of analysis, several advanced econometric (quantile unit root, cointegration, and granger causality) tests and (quantile-on-quantile regression) techniques are utilized to handle the issue of asymmetries in the modeled series. The findings reveal a positive and significant relationship between oil prices in Pakistan and exports. Furthermore, macroeconomic uncertainty has a significantly negative impact on the country's exports. Based on the results, key policy implications are provided.

Keywords Oil prices · Macroeconomic uncertainty · Quantile-on-quantile regression

Introduction

International trade is regarded as a key determinant of the income level and growth rate of countries. Over the past four decades, international trade has significantly increased country-level economic growth as well as the global GDP. For instance, in the year 2020, international trade contributed almost 52% to the global GDP (World Bank 2021). In addition to its contribution to the global economy, trade between nations supports technological advancements, fosters the efficient use of resources, and stimulates both domestic and foreign markets. These advantages result in maximum productivity and the development of new goods (Cui et al. 2021; Safi et al. 2021).

Responsible Editor: Arshian Sharif

✉ Sakshi Malik
sakshimalik26@gmail.com

Vishal Dagar
dagarvishal99@gmail.com; vishal.d@greatlakes.edu.in

[1] Great Lakes Institute of Management, Gurgaon 122 413, Haryana, India

[2] Jindal Global Business School, O.P. Jindal Global University, 131001, Sonipat, Haryana, India

Given the importance of international trade in boosting the global GDP, it is crucial to investigate its primary determinants. For the purpose of the analysis, the study has relied on the identification of trade exports and its determinants in the context of Pakistan. The bilateral trade of Pakistan with its top five trade partners are taken into consideration. These are the USA, China, UK, UAE, and Germany. This is because since about 50% of Pakistan's total exports is to countries. The share of trade with each of these countries for the year 2021 is depicted in Table 1.

The extensive literature body at present draws attention to the following gaps. First off, studies that use aggregate data to examine the relationship between uncertainty and oil prices suffer from aggregation bias. Second, the relevant research makes the symmetry assumption that oil prices and uncertainty have an equal impact. As far as we are aware, Baek's study (2020) is the only one to look at the asymmetric effects of oil prices on bilateral trade between Korea and its main trading partners. Because of this, the current article is motivated to investigate the dynamic effects of fluctuating oil prices and uncertainty on Pakistan's exports to its top five trading partners. The current analysis focuses on the export function because Pakistan's economy has experienced a significant trade deficit over the past 50 years (Pakistan Economic Survey, 2021).

Table 1 Top five trading partners of Pakistan

Country	Percent share in the overall trade
USA	18.63%
China	8.40%
UK	7.76%
Germany	6.27%
UAE	4.93%

Source: World Integrated Trade Solutions, 2022

The present paper contributes to the body of literature in the following ways. First, this is the first study to address the issue of aggregation bias by using monthly data to get more detailed and insightful findings. We anticipated that the monthly series, as opposed to the yearly or quarterly statistics, may more appropriately illustrate the effects of changes in certain series on Pakistan's exports. Second, this is the first study that, to the best of our knowledge, reveals the dynamic effects of oil prices and the world uncertainty index for Pakistan on Pakistan's exports to its top five trade partners. Thirdly, this analysis is the first to use Sim and Zhou's (2015) quantile and quantile (QQ) approach, which can manage the extreme values in the export function, oil prices, and world uncertainty index, in contrast to all previous studies in the relevant literature. Additionally, nonlinearities, asymmetries, and time-varying variances are all addressed by the QQ approach (Sohag et al. 2021; Adebayo 2022a, 2022b; Ahyan et al. 2022). Another advantage of the QQ approach is that it handles the problem of model misspecification by individually regressing the quantiles of the explanatory series on the quantiles of the explained series, unlike other methods like quantile regression. Finally, the study uses the quantile-on-quantile Granger causality test to further support the reliability of the results.

Literature review

The literature specific to the determinants of international trade balances can be categorized into three distinct themes. The first category deals with the identification of determinants of international trade using panel-level data. For example, Felmingham (1988) used panel data to demonstrate the necessity of this group by revealing the impact of various macroeconomic factors (such as currency rates, economic growth, etc.) on Australia's commerce with other countries. Some other studies include Mahdavi and Sohrabian (1993), and Doroodian et al. (1999).

The second category of studies deals with analyzing the bilateral trade flows of countries with their different trade partners in order to address this issue and examine how the trade balance reacts to different macroeconomic variables. The important studies in this regard are Baek (2012), (2011), Ullah et al., (2022), Adebayo et al., (2022a) Bahmani-Oskooee and Wang (2007), and Bahmani-Oskooee and Goswami (2004).

The current body of literature highlights the fact that all the researchers in the previous groups relied on the use of the traditional trade balance modeling proposed by Rose and Yellen (1989), which posited that economic growth and exchange rates are the key determinants of the trade balance. It was later discovered that crude oil has an impact on the trade balance via macroeconomic pathways. Because important determinants like oil prices were excluded from the modeling used in the previously discussed categories, the results may have been biased. Therefore, the third category of studies assesses the oil prices' macroeconomic implications on the trade balance by relying on aggregate data, contrasting one economy with the rest of the world while raising the possibility of aggregation bias. Select studies in this category are Baek et al. (2019), Gnimassoun et al. (2017), and Allegret et al. (2015). In addition to the potential aggregation bias, another issue that stands out is that all of these studies assume that oil prices have symmetrical effects, meaning that increases in oil prices have a negative influence on the trade balance and decreases will have the opposite effect. But in reality, this presumption might not be accurate. Therefore, it makes more sense to think about how oil prices affect the trade balance in asymmetrical ways.

Uncertainty is another crucial factor in determining the trade balance (Liao et al. 2021; Bernanke 1983). Uncertainty has an impact on the firm's investment choice, which then impacts the manufacturing process and, ultimately, disrupts exports and the trade balance. The majority of research, however (Jia et al. 2020; Tam 2018; Imbruno 2019), use aggregated level data of a country in comparison to its trading partners, and the result is likely to be biased by aggregation. The research on the effects of uncertainty on the trade balance and exports neglects the asymmetries in the uncertainty indices, just like the studies on oil prices. Hence, in this study, we are motivated to include the asymmetrical impact of uncertainty because of this gap.

To sum up, the extensive literature body draws attention to the following gaps. First off, studies that use aggregate data to examine the relationship between uncertainty and oil prices suffer from aggregation bias. Second, the relevant research makes the symmetry assumption that oil prices and uncertainty have an equal impact. As far as we are aware, Baek's study (2020) is the only one to look at the asymmetric effects of oil prices on bilateral trade between Korea and its main trading partners. Because of this, the current article is motivated to investigate the dynamic effects of fluctuating oil prices and uncertainty on Pakistan's exports to its top five trading partners. The current analysis focuses on the export function because Pakistan's economy has experienced a significant trade deficit over the past 50 years (Pakistan Economic Survey, 2021).

The present paper contributes to the body of literature in the following ways. First, this is the first study to address the issue of aggregation bias by using monthly data to get more detailed and insightful findings. We anticipated that the monthly series, as opposed to the yearly or quarterly statistics, may more appropriately illustrate the effects of changes in certain series on Pakistan's exports. Second, this is the first study that, to the best of our knowledge, reveals the dynamic effects of oil prices and the world uncertainty index for Pakistan on Pakistan's exports to its top five trade partners. Thirdly, this analysis is the first to use Sim and Zhou's (2015) quantile and quantile (QQ) approach, which can manage the extreme values in the export function, oil prices, and world uncertainty index, in contrast to all previous studies in the relevant literature. Additionally, nonlinearities, asymmetries, and time-varying variances are all addressed by the QQ approach (Sohag et al. 2021). Another advantage of the QQ approach is that it handles the problem of model misspecification by individually regressing the quantiles of the explanatory series on the quantiles of the explained series, unlike other methods like quantile regression. Finally, the study uses the quantile-on-quantile Granger causality test to further support the reliability of the results.

The following sections make up the rest of the article. The variables, their sources, and the approach used for analysis are explained in the second section. The findings are discussed in-depth in the third section. The final section includes a summary of the results, policy implications, and areas for improvement for future research.

Data and methodology

Data

The current study intends to examine the dynamic relationship between oil prices, macroeconomic uncertainty, and Pakistan's exports to its top five trading partners, namely the USA, China, the United Kingdom, the United Arab Emirates, and Germany, since about 50% of Pakistan's total exports is to countries. The dataset comprises monthly data from July 2003 to December 2020 for the empirical analysis. The choice of this range was made since monthly data for exports is only available as of July 2003.

Furthermore, the export figures are calculated in thousand US dollars and derived from the State Bank of Pakistan's official website (2021). Data on monthly average crude oil prices are obtained from the World Bank (2021). Additionally, in order to capture macroeconomic uncertainty, the study has used World Uncertainty Index as a proxy. This is based on the study conducted by Ahir et al. 2018). A five-step method is used (creating the report, editing, second check, sub-editing, and production) to improve the index's veracity and comparability. The index is also based on quarterly data that is translated into monthly data (2014). The quantile-on-quantile regression (QQR) method is used to calculate the hypothesized nexus among the variables.

Methodology

The following econometric analyses and methods are used for analysis. We first use the BDS test to validate the nonlinearity of the chosen series. Second, the described series' stationarity is confirmed using the ADF test, KSS asymmetric unit root testing, and quantile unit root test. Thirdly, the quantile cointegration test is used to reveal any long-term relationships between the selected series. Fourthly, we examine quantile-wise impacts using the QQR technique. Last but not least, the quantile granger causality test and a comparison of the QQR outcome with conventional quantile regression serve to demonstrate the robustness of the results.

Quantile unit root test

The presence of a unit root that results in an erroneous regression is among the time series data's most dominant characteristics. As a result, finding stationarity in the modeled series is crucial before using the econometric technique. The results of common unit root tests may be deceptive when examining the integration order since the chosen series exhibit aberrant variances due to local linearities. As a result, tests for asymmetric unit roots using KSS and the ADF are also used. In order to address the asymmetric distribution of data, Koenker and Xiao (2004) created the "quantile autoregressive (QAR) unit root test," which was later expanded by Galvao (2009). (Sohag et al. 2021). The following highlights several notable advantages of the QAR test over regular tests. First off, the Galvoa (2009) expanded version of QAR can take into account both the linear time trend and covariate stationarity. In contrast to standard unit root tests, it can also test the integration order or unit root for each quantile individually (Godil et al. 2021; Sharif et al. 2017a). Our modeled series has noticeable oscillations and temporal patterns, hence QAR is used to examine local stationarity at various quantiles. This is due to the limited global stationarity that the traditional tests offer. We use Galvao (2009) as our guide to estimate the the conditional quantile function of y as follows:

$$Q_\tau^y\left({}^{y_t}\!/\!_{I_t^y} \right) = \mu_1(\tau) + \mu_2(\tau)t + \alpha(\tau)y_{t-1} + \sum_{i=1}^{p} a_i(\tau)\Delta y_{t-i} + f_\mu^{-1(\tau)} \quad (1)$$

$f_y\left(\cdot / I_t^y\right)$ is the distribution of y_t while conditioning the I_t^y. Q_τ^y indicated the τ th quantile of y which is conditioned on I_t^y. y_t shows the stationarity of the given lag information, i.e., $I_t^y = \left(y_{t-1}, y_{t-2}, \dots, y_{t-s}\right)\acute{\epsilon}$. f_μ^{-1} is included to show the inverse of the errors of the common distribution. Additionally, QAR test uses t-statistics to detect the stationarity and the null hypothesis is $H_0(\tau)t = 1$.

Quantile cointegration

The present study has used Xiao's quantile cointegration method to analyze the long-term co-movement of the chosen series (2009). Although there are cointegration tests that identify the long-term relationship between the variables (Engle and Granger (1987)), these models treat the cointegration vectors as constants. Contrary to the conventional cointegration tests, quantile cointegration is a special advanced technique that makes the assumption that the coefficients vary in each quantile. In addition, the main goal of assuming the variable coefficients (i.e., $\beta = \beta_1, \beta_2, \dots, \beta_i$ in each quantile is to account for the effects of shock (Sharif et al. 2017b; Sharif et al. 2020a, b).

Quantile cointegration divides the error term into two parts—one with pure innovation and the other with the correlation of leads and lags in Δx_t.—is another impressive aspect of the method. In this case, $v_t = \Delta x_t$ with a zero mean stationary order of $(n + 1)$. The standard cointegration equation can be written as:

$$y_t = \alpha + \acute{\beta}_t x_t + \sum_{i=-n}^{n} \Delta \acute{x}_{t-i} \Pi_j + \varepsilon_t \tag{2}$$

In Eq. 2, introduce τ th quantile of ε_t is inserted. This term represents quantiles of y_t, conditioning the I_t^y. It can be denoted as $Q_\varepsilon(\tau)$ while $f_t = (x_t, \Delta_{t-1}, \forall_i)$. The equation will now be,

$$\left({}^{y_t}/_{I_t^x} \right) = a_1(\tau) + b_2(\acute{\tau})t + \alpha(\tau)y_{t-1} + \sum_{i=-n}^{n} \Delta \acute{x}_{t-i} \Pi_j + f_\mu^{-1_{(\tau)}} \tag{3}$$

Following Xiao (2009), Eq. 4 is introduced to check the stability of the cointegrating coefficient.

$$Q_\tau^y \left({}^{y_t}/_{I_t^x} \right) = a_1(\tau) + b_2(\acute{\tau})x_t + \gamma(\acute{\tau})x_t^2 \sum_{i=-n}^{n} \Delta \acute{x}_{t-i} \Pi_j + \sum_{i=-n}^{n} \Delta \acute{x^2} \Pi_j r_j f_\varepsilon^{-1_{(\tau)}} \tag{4}$$

The final iteration of quantile cointegration is shown by the equation above. In addition, the 1000 Monte Carlo simulation is used to obtain the critical values of $\left|\widehat{V_n}(\tau)\right|$. $\beta_\tau = \beta$ denotes the acceptance of H0, suggesting no long-lasting relationship.

QQR model

The dynamic relationship between oil prices, macroeconomic uncertainty, and Pakistan's exports to its top five trading partners is analyzed using the QQR approach proposed by Sim and Zhou (2015). The following factors serve as the basis for the application of this technique. First, the early tests show that the selected series, which includes oil prices and other macroeconomic factors, have asymmetries in their distributions. QQR is able to handle these distributions in a suitable manner. Second, this method uses non-parametric features to address OLS regression and standard quantile regression's drawbacks (Sohag et al. 2021; Meo and Karim 2021). Thirdly, to provide the slope coefficients for each quantile and to address the interdependence issue, QQR regresses the various quantiles of the predictor series on the pertinent quantile of the predicted series. This method provides comprehensive information on each quantile. Fourth, given that the majority of the selected series are asymmetrically distributed, as shown by the values of kurtosis, skewness, and Jarque–Bera, it appears that the QQR technique is appropriate for the analysis (Sohag et al. 2021; Suki et al. 2020; Khan et al. 2019).

The likelihood of model misspecification is reduced because the QQR approach is a bivariate technique in which we can only use one independent series and examine its dynamic impacts on dependent series. Thus, we can examine each of the independent series one at a time. Thus, the two variables chosen for the current article are the price of oil and macroeconomic uncertainty. Although both of these variables have recently increased, less focus has been placed on them. For analysis, the τ-quantile of $EXPUSA_t$ (Pakistan's exports to USA) is introduced, making it the function of oil prices (OP_t) that is expressed as:

$$EXPUSA_t = \beta^\tau OP_t + u_t^\tau \tag{5}$$

In Eq. 5, there are two unknown terms. Firstly, β^τ is an unknown term since its value depends on the nexus between EXPUSA and OP, which is still unknown. Secondly, u_t^τ is an error term with zero quantiles. In order to transform Eq. 1 into linear form, 1st order Tylor expansion of $\beta^\tau(,)$, around the OP_t can be written as:

$$\beta^\tau OP_t \approx \beta^\tau OP^\theta + \beta^{\acute{\tau}}\left(OP^\theta\right)\left(OP_t - OP^\theta\right) \tag{6}$$

Equation 6 demonstrates the double indexing of $\beta^\tau OP^\theta$ and $\beta^{\acute{\tau}}\left(OP^\theta\right)$ in τ and θ. It indicates that $\beta^\tau OP^\theta$ and $\beta^{\acute{\tau}}\left(OP^\theta\right)$ are the functions of τ and θ. Thus, the equation can be expressed as:

$$\beta^\tau OP_t \approx \beta_0(\tau, \theta) + \beta_1(\tau, \theta)\left(OP_t - OP^\theta\right) \tag{7}$$

To obtain the final version of the equation, we put Eq. 7 into Eq. 5 as:

$$EXPUSA_t = \underbrace{\beta_0(\tau,\theta) + \beta_1(\tau,\theta)\left(OP_t - OP^\theta\right)} + u_t^\tau \tag{8}$$

The component in $\underbrace{}$ denotes the τ th conditional quantile of $EXPUSA_t$. Additionally, the component $\underbrace{}$ expresses how exports to the USA react to oil prices, taking into account the whole distribution of both series. In addition, unlike the typical quantile regression β_0 and β_1 are indexed inτ, and θ.

We can move forward with the following equations if we perform the same exercise for EXPUSA against the second independent series, macroeconomic uncertainty (MEU):

$$EXPUSA_t = \beta^\tau MEU_t + u_t^\tau \tag{9}$$

$$\beta^\tau MEU_t \approx \beta^\tau MEU^\theta + \beta^{\acute{\tau}}\left(MEU^\theta\right)\left(MEU_t - MEU^\theta\right) \tag{10}$$

$$\beta^\tau MEU_t \approx \beta_0(\tau,\theta) + \beta_1(\tau,\theta)\left(MEU_t - MEU^\theta\right) \tag{11}$$

$$MEU_t = \underbrace{\beta_0(\tau,\theta) + \beta_1(\tau,\theta)\left(MEU_t - MEU^\theta\right)} + u_t^\tau \tag{12}$$

Similar to Eq. 8, Eq. 12 is the final iteration of the QQR model, except for the relationship between MEU and EXPUSA. To investigate the dynamic relationship between oil prices, uncertainty, and exports, QQR regression models for the other four trading partners—China, UK, UAE, and Germany—can be created using the same methodology.

Robustness check of QQR estimations

Two methods are used to assess the validity of the QQR findings. First, the results of classical quantile regression are compared with those of the QQR estimations. This is done by calculating the average QQR parameters that the conventional quantile technique is unable to obtain. The equation can be expressed mathematically as follows:

$$y_1(0) \equiv \overline{\widehat{\beta}}(0) = \frac{1}{s}\sum_\tau \widehat{\beta}_1(\tau,\theta) \tag{13}$$

In Eq. 13, $\overline{\widehat{\beta}}$ = QQR regression's parameters' average.

We use the quantile granger causality test to determine the effects of OP and MAU on exports because we believe that Pakistani policymakers and authorities may combat the fluctuations in oil prices and macroeconomic uncertainty by implementing new policies and practical measures. This technique is another measure to check the reliability of QQR results.

Results and discussion

Exports to the USA (EXPUSA), Exports to China (EXPC), Exports to Germany (EXPG), Exports to the United Kingdom (EXPUK), and Exports to the United Arab Emirates (EXPUAE) are dependent series. Oil prices (OP) and macroeconomic uncertainty (MEU) are independent series. Table 2 shows the descriptive statistics of the series. Regarding the dependent series, EXPUSA, followed by EXPC, EXPUK, and EXPUAE, has the biggest means of Pakistani exports to the USA. The lowest mean for EXPG indicates that Pakistan's major export markets are the USA and Germany, respectively. On the other hand, compared to MEU, the mean for oil prices is greater. Additionally, the kurtosis values for all the series are larger than 1, indicating a non-normal distribution. The fact that there is a significant discrepancy between the minima and maxima values of every modeled series, indicating the asymmetric distribution of the variables, is another crucial fact (Sharif et al. 2020b; Adebayo et al. 2022a, b, c). The results of the Jarque–Bera

Table 2 Descriptive statistics

	Export China	Export Germany	Export UAE	Export UK	Export USA	OP	MEU
Mean	120,513.00	87,020.81	94,167.79	113,051.80	313,490.30	942.88	878.29
Median	125,273.70	88,332.15	89,302.29	107,483.40	317,466.80	38.48	4.28
Maximum	293,031.30	145,555.10	191,587.50	183,526.80	422,390.40	1006.83	878.75
Minimum	12,960.77	37,484.65	43,235.74	59,854.09	179,772.30	81	3.92
Std. dev	69,849.12	23,878.33	24,017.09	28,346.03	39,490.12	21.48	3.92
Skewness	0.67	0.59	1.37	0.60	0.10	0.89	0.90
Kurtosis	1.37	1.87	4.03	1.82	3.40	2.07	2.79
Jarque–Bera	10.29	10.41	37.42	11.58	7.77	12.26	5.88
Sum sq. dev	1,060,000,000,000	119,000,000,000	121,000,000,000	183,000,000,000	370,000,000,000	135,763.20	5.75
Observations	210	210	210	210	210	210	210

test are also used to confirm the mistakes' normalcy. The probability/t-statistics results support the non-normal distribution of the residuals. Therefore, the QQR technique, which can handle the asymmetrical nexus among the variables, is motivated and justified by the kurtosis values, minima and maxima of the series, and the results of the Jarque–Bera test (Sharif et al. 2019; Pan et al. 2022).

Table 3 presents the results emerging from the Brock-Dechert-Scheinkman (BDS) test, which is used to confirm the non-linearity of the series All of the modeled series' BDS statistics have zero *p*-values, which indicates non-linearity. Therefore, the results of the BDS test point to the use of a method that can reveal the asymmetric nexus between the series, again supporting the application of the QQR methodology.

The results of the ADF and KSS asymmetric unit root test, are shown in Table 4. Due to the fact that all series are stationary at I, we move forward with QAR (1).

Table 5 also displays the QAR test results that agree with the outcomes of the ADF and KSS tests.

Once it is shown that none of the series are $I(2)$, we employ the quantile cointegration test suggested by Xiao (2009) to look for a long-term correlation between the variables we have chosen. The results are shown in Table 5. The results show that cointegration exists for nearly all of the quantiles. Furthermore, we see that the cointegration between each series' lower and higher quantiles and the dependent series varies. The long-term association between the regressor and regressand variables is seen to be varied, as well. Additionally, the quantile cointegration in Table 5 reveals that the long-run connection between the chosen variables is unequal.

The key findings of the QQR are provided hereby. Pakistan's exports to the USA generally have negative consequences due to the price of oil (OP). When low to high quantiles (0.01–0.99) of OP interact with moderate to high quantiles (0.3–0.9) of exports, the unfavourable nexus between the two series becomes significantly more intense. It shows that the movement of OP from a low to a high ratio sharply lowers the exports from a medium to a high ratio. It is interesting to note that the third export quantile responds positively to all OP quantiles, indicating that exporting manufacturers benefit when Pakistan's export ratio is lower than that of the USA. The negative effects are predominant, notwithstanding the varied results.

Furthermore, the exports' low quantiles (0.1–0.3) show a negative association with the low quantiles of MEU. On the other hand, MEU's entire quantile range has a positive effect (which is not significant) on the export ratio in the range of 0.2 to 0.6. It means that MEU has non-linear effects on exports. However, due to MEU, the extreme quantiles (low and high) of exports must bear the loss (Table 6).

Table 3 Brock-Dechert-Scheinkman test

	$M=2$ (BDS stat)	$M=3$ (BDS stat)	$M=4$ (BDS stat)	$M=5$ (BDS stat)	$M=6$ (BDS stat)
EXPC	0.13*	0.24*	0.36*	0.32*	0.39*
EXPUSA	0.03*	0.10*	0.15*	0.15*	0.10*
EXPUK	0.15*	0.31*	0.30*	0.34*	0.34*
EXPUAE	0.06*	0.03*	0.11*	0.16*	0.14*
EXPG	0.11*	0.23*	0.20*	0.33*	0.36*
OP	0.18*	0.28*	0.3*	0.41*	0.45*
MEU	0.18*	0.28*	0.32*	0.31*	0.31*

* indicates significance at 1%

Table 4 Unit root tests

ADF test	EXPC	EXPG	EXPUAE	EXPUK	EXPUSA	MEU	OP
At level							
	− 1.83	− 1.241	− 4.007***	− 0.846	− 3.362**	− 2.361	− 2.124**
At 1st diff							
	− 16.512***	− 13.113***	− 12.212***	− 12.130***	− 11.113***	− 7.436***	− 2.164***
KSS test							
At level							
	− 3.314***	− 0.164	− 1.982	− 1.046	− 1.529	− 0.305	− 3.444*
At 1st diff							
	− 4.323*	− 5.175	− 6.009	− 5.126	− 6.015*	− 3.266	-

*, **, *** represent significance level at 1%, 5%, and 10%, respectively

Table 5 Quantile autoregressive unit root test

Quantiles	EXPUSA		EXPC		EXPUK		EXPUAE		EXPG		OP		MEU	
	CV	*t*-stats	CV	*t*-stats	CV	*t*-stats	CV	*t*-stats	CV	*t*-stats	CV	*t*-stats	CV	*t*-stats
0.10	−2.43	3.00	−3.03	1.25	0.97	−0.60	−3.05	**−5.00**	−2.41	−0.57	−3.41	**−4.14**	−3.41	−1.25
0.20	−2.85	0.43	−3.41	0.76	0.94	−0.79	−3.41	−0.33	−2.24	**−3.93**	−3.41	**−3.19**	−3.41	−0.62
0.30	−3.29	**−3.65**	−3.41	0.05	0.94	−1.50	−3.41	−0.15	−3.03	−1.19	−3.41	−1.25	−3.26	−1.34
0.40	−3.41	−1.90	−3.41	−0.84	0.95	−1.32	−3.41	−0.22	−3.81	−2.47	−3.41	−1.43	−3.42	−1.49
0.50	−3.41	−2.20	−3.41	−4.24	0.98	**−7.64**	−3.05	**−4.93**	−3.53	−2.54	−3.41	−1.34	−3.22	−1.33
0.60	−3.41	**−4.17**	−3.41	**−5.98**	0.99	0.21	−3.41	−1.65	−3.16	**−5.70**	−3.14	−1.13	−2.03	**−3.98**
0.70	−3.14	−5.66	−3.41	−2.23	0.94	−5.22	−3.41	−1.34	−3.74	−2.50	−3.14	−1.24	−2.04	**−4.14**
0.80	−3.03	−3.95	−3.24	−0.64	0.92	−1.73	−3.32	**−6.05**	−3.25	**−4.23**	−3.41	−1.95	−3.14	−5.05
0.90	−2.62	**−4.86**	−3.81	**−7.54**	0.97	−0.06	−3.41	−2.65	−2.10	**−4.21**	−3.41	**−6.11**	−3.14	−6.29

CV: critical values; bold values indicate the presence of stationarity

In the context of China, the QQR calculations highlight that OP primarily reduces the function of exports. The OP's quantiles lead to a disruption in the exporters' ratio (0.1–0.5). Additionally, the highest quantile of exports (0.9) exhibits a negative correlation with all the quantiles of the OP. On the other hand, when we examine the relationship between the high quantile (i.e., 0.8) of the former and the quantiles of the latter, a positive relationship is observed between OP and exports. Additionally, one of the high export quantiles (0.8) has a positive relationship with OP oscillations. In terms of the impact of MEU on exports to China, the findings show that MEU consistently exhibits the negative effects on reducing exports to China. All the quantiles of MEU are directly related to one of the high quantiles (0.9) of exports. This highlights that exporting producers experience the negative effects of MEU when there is a low to high ratio of exports to China and the price of oil is also rising.

In the case of Pakistani exports to the UK the following results emerge. In relation to the relationship between OP and exports, the QQR estimates indicate substantially mixed findings. The quantiles of the 0.3 to 0.6 show that the exporters have a variable reaction to the quantiles of OP. Later, due to oscillations in all OP quantiles, these mixed effects provide noticeably favorable responses, with the mid to high quantiles of exports (0.5–0.7) benefiting greatly. The high quantiles (0.8 and 0.9) of exports, however, are notably negatively impacted by OP's mid to high quantiles (0.5–0.9).

We discover that there is a distinct response from exports to MEU from quantile to quantile regarding the relationship between MEU and exports to the UK. For instance, all of MEU's quantiles (0.1–0.9) show a significant positive impact on the two low export quantiles (0.1 & 0.2). In quantile 0.6 of exports, this substantial negative association has no effect at all. Once more, the high quantiles of exports (0.8 and 0.9) show a negative relationship with MEU. As a result, in the instance of the UK, the MEU export connections are incredibly variable and non-linear.

The results regarding Pakistan's exports to the UAE are then examined here. The moderate to high (0.5–0.9) exports quantiles are negatively impacted by all quantiles of OP. However, the second quantile of exports responds favorably to the OP's quantiles. We see both the good and negative effects of OP when we look at the low quantiles (0.1 & 0.2) of exports. According to the QQR estimations, the large gains for exporting businesses are implied by the high quantiles (0.8–0.9) of exports' interaction with MEU's quantiles.

As we turn our attention to the situation of exports to Germany, we find some interesting results. All quantiles of OP are positively but weakly correlated with the low quantiles of exports (0.1 and 0.4). It implies that changes in OP have no impact on exports to Germany during these quantiles. However, the exports' high quantiles (0.7–0.9) show that OP is having very negative effects. On the whole, OP's effects on exports continue to be inconsistent. Similarly, all of the MEU quantiles show a negligible influence on the low and high quantiles of exports (0.1–0.3 and 0.6–0.8). On the other hand, all quantiles of OP cause a large loss in low to medium quantiles (0.3–0.7) of exports.

Robustness checks

We use the causality test under the presumption that Pakistan's economic policy is in line with the direction of the State Bank of Pakistan. Table 7 lists the results of the QGC test. The results back up the QQR projections. We discover a two-way causal link. Furthermore, it is clear that fluctuations in oil prices and unpredictability considerably raise Pakistan's exports and vice versa in all circumstances, supporting our earlier conclusions.

Discussion

Based on the QQR estimations described above, we contend that our findings are unexpected and special in a number of ways. We also look at a new factor, macroeconomic

Table 6 Quantile cointegration test

Quantiles	EXPUSA VS OP	EXPUSA VS MEU	EXPC VS OP	EXPC VS MEU	EXPUK VS OP	EXPUK VS MEU	EXPUAE VS OP	EXPUAE VS MEU	EXPG VS OP	EXP VS MEU
	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$	$\beta(\tau)$
0.10	13.05*	−12.03*	−25.60	2.16	7.43	−2.21	1.46	−0.11	2.13	−1.42
0.20	22.14*	−19.96*	55.04*	−17.11**	−16.96*	15.66*	65.34*	−5.54**	−58.35**	10.98*
0.30	39.19*	−31.88*	51.29*	−18.25*	−46.35*	13.87*	12.19**	−1.24*	−59.21	0.34
0.40	36.32*	−29.86*	53.05*	−14.10*	−51.25*	16.01*	−1.96	17.86*	−43.61*	22.33*
0.50	48.19*	−22.09*	−58.81*	17.24*	−68.25*	15.11*	−4.76	1.34	−42.27*	12.54*
0.60	−39.61*	23.86*	−65.38*	26.34*	− −61.02*	18.38*	−85.34*	12.64*	33.91*	14.18*
0.70	−32.58*	33.31*	−74.66*	27.80*	−53.74*	13.54*	−72.97*	14.12*	38.54*	12.04*
0.80	−22.32*	51.43*	−59.27*	19.15*	−45.11*	19.11*	−58.17*	11.63*	38.25*	11.28*
0.90	−41.04*	38.26*	−50.81*	18.22*	−48.29*	12.42*	−51.93*	10.11*	37.11*	12.44*

uncertainty, which has a significant impact on Pakistan's exports to its top five trading partners. According to the findings about the dynamic effects of OP, Pakistan's export ratio must deal with generally significantly negative effects as a result of oscillations in OP in the case of exports to the USA, China, the United Arab Emirates, and Germany. This empirical result supports our findings and is in line with the literature (Baek et al. 2019; Le and Chang 2013; Bodenstein et al. 2011; Adebayo et al. 2022b). There are a number of ways that OP changes can reduce the ratio of the export. First off, since inflation is a relatively close channel, OP has an impact on how exports function. The exports are frequently halted by this channel, both directly and indirectly. The direct effect of an increase in oil prices is a reduction in the production of items based on petroleum due to high production costs; thus, the volume of exports is decreased by the production process reduction. The indirect result of an increase in OP is that it raises the cost of production, shipping, and heating, which lowers exports.

Second, through altering the supply and demand for raw materials, oil prices can have an impact on exports. The rationale is that unexpected spikes in oil prices raise the cost of producing raw materials since they tend to reduce their supply while simultaneously driving up their prices due to increased demand. High production costs and little exports are the results of this technique. Thirdly, agriculture accounts for the majority of Pakistan's exports. A decrease in investment in agricultural products as a result of the increase in OP leads to lower production and fewer exports.

The findings indicate that despite an increase in OP, exports to the USA and China are improving, as shown by several of the exports' quantiles. This distinguishing feature of our findings. It appears that several exporting industries hedge their bets to prevent potential losses brought on by the increase in OP. As a result, those businesses profit throughout this time. The case of the UK is another distinctive feature of the current study. In the instance of Pakistan's exports to the UK, we notice both the considerable positive and negative effects of OP.

Our study asserts that exports to the top five trading partners must suffer a large loss as a result of macroeconomic uncertainty. The identical results are also disclosed by Novy and Taylor (2020), Tam (2018), Imbruno (2019), and Feng et al. (2017)). The high price ratios, low investment, low demand for raw materials, high employment rates, low expenditures, low demand for raw materials, and low production could all be caused by uncertainty, according to one theory. This mechanism thus hinders exports while also halting economic growth. It is interesting that some export quantiles to the UK and the UAE support the advantages of uncertainty. This is a particular result of the investigation once again.

Table 7 Quantile Granger causality test

USA									
Quantiles	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
$\Delta OP_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta OP_t$	0.00	0.06	0.04	0.19	0.00	0.00	0.13	0.00	0.10
$\Delta MEU_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta MEU_t$	0.00	0.13	0.19	0.00	0.05	0.00	0.04	0.03	0.00
China									
Quantiles	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
$\Delta OP_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta OP_t$	0.07	0.12	0.01	0.00	0.02	0.00	0.00	0.00	0.00
$\Delta MEU_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta MEU_t$	0.00	0.03	0.15	0.00	0.00	0.39	0.00	0.00	0.00
UK									
Quantiles	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
$\Delta OP_t to \Delta EXP_t$	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta OP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta MEU_t to \Delta EXP_t$	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta MEU_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UAE									
Quantiles	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
$\Delta OP_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta OP_t$	0.00	0.00	0.10	0.00	0.19	0.00	0.00	0.06	0.00
$\Delta MEU_t to \Delta EXP_t$	0.05	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta MEU_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Germany									
Quantiles	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
$\Delta OP_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta OP_t$	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
$\Delta MEU_t to \Delta EXP_t$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta EXP_t to \Delta MEU_t$	0.05	0.09	0.00	0.00	0.15	0.00	0.00	0.00	0.00

Conclusion

The current study uses disaggregated (monthly) data of oil prices and uncertainty to examine their dynamic effects on Pakistan's exports to its top five trading partners for more informative and robust findings, contending that the prior literature suffers from aggregation bias as a result of using the aggregate data. The present study has several contributions to the existing literature. First, this is the first study to address the issue of aggregation bias by using monthly data to get more detailed and insightful findings. We anticipated that the monthly series, as opposed to the yearly or quarterly statistics, may more appropriately illustrate the effects of changes in certain series on Pakistan's exports. Second, this is the first study that, to the best of our knowledge, reveals the dynamic effects of oil prices and the world uncertainty index for Pakistan on Pakistan's exports to its top five trade partners. Thirdly, this analysis is the first to use Sim and Zhou's (2015) quantile and quantile (QQ) approach, which can manage the extreme values in the export function, oil prices, and world uncertainty index, in contrast to all previous studies in the relevant literature. For the analysis, we make use of a number of sophisticated econometric methods. First, according to the quantile unit root test, all of the chosen series have the integration order, and none of them are $I(2)$. Second, the quantile cointegration test's application verifies that there is long-run relationship among the modeled series. Thirdly, QQR estimations provide a range of intriguing results. According to theory and earlier research, rising oil prices (OP) lead to a decline in exports because of their inverse relationship with exports. Our research suggests that the OP has mixed and non-linear impacts, though. Although our findings support the earlier research in the bulk of the cases, including the USA, China, UAE, and Germany, a strong correlation between the two series is also seen. For instance, certain export quantiles in the USA and China show a noticeably favorable association with OP, showing that the exporting enterprises benefit in these quantiles. Beyond that, the document's most notable finding is that, in the case of the UK, exports in excess of three quantiles have a detrimental effect on OP. On the other side, because of the rise in OP, the other more than three exports quantiles benefit significantly.

Similarly, uncertainty has conflicting consequences on exports, with the exporting producers experiencing both losses and gains as a result of the uncertainty. Uncertainty is a mixed benefit for Pakistan's exports, as evidenced by the UAE, UK, and USA cases specifically. The quantile granger causality test, which validates our findings for the USA, China, UK, UAE, and Germany, identifies the bidirectional causal link among the series in all situations.

Pakistan's exports are highly susceptible to OP and uncertainty. Hence results-based strategies are advised. In most circumstances, OP decreases Pakistan's exports. The following proposal may mitigate OP's negative consequences. First, the exporting manufacturer should hedge against oil prices to reduce price risk. This policy may mitigate the OP's abrupt escalation's negative consequences on exports. Second, authorities and politicians should subsidize important exporting industries, especially when oil prices are expected to rise. The targeted subsidies may help combat OP's harmful effects. Thirdly, long-term export contracts between exporting enterprises and trading partners may reduce OP's negative consequences.

Like oil prices, macroeconomic uncertainty (MEU) always hurts exports. Global economies should address macroeconomic uncertainty since the world has become a village. The COVID-19 epidemic caused worldwide economic growth and trade to decline. In this case, these tips may help. First, "anti-globalization" beliefs may increase global uncertainty. This may hurt local economic development and worldwide trade. Thus, global governments and businesses should reject "anti-globalization" ideas that fuel MEU. Second, to address MEU-related epidemics like COVID-19, international authorities should coordinate fiscal, monetary, and capital flow policies. They also create a plan to stabilize global eco-growth and trade.

The current study also highlights limitations that may lead to new discoveries. First, this article considers Pakistan's top five trading partners. For greater direction, future study can include other trading partners. Second, adding political risk, trade policy risk, globalization, global chain values, exchange rate, and financial stress to the model should yield more intriguing results. Thirdly, the latest article focuses on Pakistani exports. Thus, researchers can use the same model for the world's largest exporters to provide policy-oriented conclusions.

Disclaimer

The authors understand that the corresponding author is the sole contact for the editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions, and final approval of proofs.

Author contribution Vishal Dagar conceptualized, conceived, designed, and wrote the paper. Sakshi Malik analyzed and interpreted the data and contributed reagents and materials. The authors confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Data Availability The data sets used during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval Not applicable.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

References

Adebayo TS (2022) Assessing the environmental sustainability corridor: linking oil consumption, hydro energy consumption, and ecological footprint in Turkey. Environ Sci Pollut Res 1–11. https://doi.org/10.1007/s11356-022-23455-1

Adebayo TS, Akadiri SS, Akpan U, Aladenika B (2022a) Asymmetric effect of financial globalization on carbon emissions in G7 countries: fresh insight from quantile-on-quantile regression. Energy & Environment, 0958305X221084290. https://doi.org/10.1177/0958305X221084290

Adebayo TS, Ibrahim RL, Agyekum EB, Zawbaa HM, Kamel S (2022) The environmental aspects of renewable energy consumption and structural change in Sweden: a new perspective from wavelet-based granger causality approach. Heliyon 8(9):e10697. https://doi.org/10.1016/j.heliyon.2022b.e10697

Adebayo TS, Saint Akadiri S, Rjoub H (2022c) On the relationship between economic policy uncertainty, geopolitical risk and stock market returns in South Korea: a quantile causality analysis. Ann Finan Econ 17(1):2250005. https://doi.org/10.1142/S2010495222500087

Ahir H, Bloom, N, Furceri D (2018) The world uncertainty index. Available at SSRN 3275033. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3275033

Allegret JP, Mignon V, Sallenave A (2015) Oil price shocks and global imbalances: lessons from a model with trade and financial interdependencies. Econ Model 49:232–247

Ayhan F, Kartal, MT, Adebayo TS, Kirikkaleli D (2022) Nexus between economic risk and political risk in the United Kingdom: evidence from wavelet coherence and quantile-on-quantile approaches. Bull Econ Reshttps://doi.org/10.1111/boer.12371

Baek J (2012) Exchange rate sensitivity of Korea-US bilateral trade: evidence from industrial trade data. J Korea Trade 3:1–21

Baek J, Ikponmwosa MJ, Choi YJ (2019) Crude oil prices and the balance of trade: asymmetric evidence from selected OPEC member countries. J Intl Trade Econ Dev 28(5):533–547

Baek J, Koo WW, Mulik K (2009) Exchange rate dynamics and the bilateral trade balance: the case of US agriculture. Agri Resour Econ Rev 38(2):213–228

Bahmani-Oskooee M, Ratha A (2004) Dynamics of the US trade with developing countries. The journal of developing areas 1–11

Bahmani-Oskooee M, Wang Y (2007) United States-China trade at the commodity level and the Yuan-dollar exchange rate. Contemp Econ Policy 25(3):341–361

Bahmani-Oskooee M, Hegerty SW (2009) Trade liberalization, the peso, and Mexico's commodity trade flows with the United States. J Dev Stud 45(5):693–725

Bernanke BS (1983) Irreversibility, uncertainty, and cyclical investment. Q J Econ 98(1):85–106

Cui X, Yao Y, Bian Y, Cui L (2021) Can better business environments promote trade partners' economic growth?. Applied Economics Letters 1–5

Donganlar M, Mike F, Kızılkaya O (2020) Testing the validity of purchasing power parity in alternative markets: evidence from the Fourier quantile unit root test. Borsa Istanbul Rev. https://doi.org/10.1016/j.bir.2020.12.004

Doroodian KHOSROW Sr, Jung C, Boyd R (1999) The J-curve effect and US agricultural and industrial trade. Appl Econ 31(6):687–695

Felmingham BS (1988) Where is the Australian J-curve? Bull Econ Res 40(1):43–56

Feng L, Li Z, Swenson DL (2017) Trade policy uncertainty and exports: evidence from China's WTO accession. J Int Econ 106:20–36. https://doi.org/10.1016/j.jinteco.2016.12.009

Galvao AF Jr (2009) Unit root quantile autoregression testing using covariates. J Econometr 152(2):165–178

Gnimassoun B, Joëts M, Razafindrabe T (2017) On the link between current account and oil price fluctuations in diversified economies: the case of Canada. Intl Econ 152:63–78

Godil DI, Yu Z, Sharif A, Usman R, Khan SAR (2021) Investigate the role of technology innovation and renewable energy in reducing transport sector CO2 emission in China: a path toward sustainable development. Sustain Dev 29(4):694–707. https://doi.org/10.1002/sd.2167

Granger CW (1969) Investigating causal relations by econometric models and cross-spectral methods. Econometrica: Journal of the Econometric Society, 424e438

Halicioglu F (2008) The bilateral J-curve: Turkey versus her 13 trading partners. J Asian Econ 19(3):236–243

Imbruno M (2019) Importing under trade policy uncertainty: evidence from China. J Comp Econ 47(4):806–826. https://doi.org/10.1016/j.jce.2019.06.004

Jia F, Huang XY, Xu XY, Sun HY (2020) The effects of economic policy uncertainty on export: a gravity model approach. Prague Economic Papers 29(5):600–622. https://doi.org/10.18267/j.pep.754

Khan SAR, Sharif A, Golpîra H, Kumar A (2019) A green ideology in Asian emerging economies: from environmental policy and sustainable development. Sustain Dev 27(6):1063–1075. https://doi.org/10.1002/sd.1958

Koenker R, Xiao Z (2004) Unit root quantile autoregression inference. Journal of the American Statistical Association 99(467), 775e787.

Le TH, Chang Y (2013) Oil price shocks and trade imbalances. Energy Econ 36:78–96

Liao J, Luo L, Xu X, Wang A (2021) Perceived macroeconomic uncertainty and export: evidence from cross-country data. Economic Research-Ekonomska Istraživanja 1–19

Mahdavi S, Sohrabian A (1993) The exchange value of the dollar and the US trade balance: an empirical investigation based on cointegration and Granger causality tests. Q Rev Econ Finance 33(4):343–358

Novy D, Taylor AM (2020) Trade and uncertainty. Rev Econ Stat 102(4):749–765. https://doi.org/10.1162/rest_a_00885

Pakistan Economic Survey (2021) http://www.finance.gov.pk/

Pan B, Adebayo TS, Ibrahim RL, Al-Faryan MAS (2022) Does nuclear energy consumption mitigate carbon emissions in leading countries by nuclear power consumption? Evidence from quantile causality approach. Energy & Environment 0958305X221112910. https://doi.org/10.1177/0958305X221112

Rafiq S, Sgro P, Apergis N (2016) Asymmetric oil shocks and external balances of major oil exporting and importing countries. Energy Economics 56:42–50

Razzaq A, Wang S, Adebayo TS, Al-Faryan MAS (2022) The potency of natural resources on ecological sustainability in PIIGS economies. Resources Policy 79:102941. https://doi.org/10.1016/j.resourpol.2022.102941

Rose AK, Yellen JL (1989) Is there a J-curve? J Monet Econ 24(1):53–68

Safi A, Chen Y, Wahab S, Ali S, Yi X, Imran M (2021) Financial instability and consumption-based carbon emission in E-7 countries: the role of trade and economic growth. Sustain Prod Consump 27:383–391

Sharif A, Afshan S, Chrea S, Amel A, Khan SAR (2020a) The role of tourism, transportation and globalization in testing environmental Kuznets curve in Malaysia: new insights from quantile ARDL approach. Environ Sci Pollut Res 27(20):25494–25509. https://doi.org/10.1007/s11356-020-08782-5

Sharif A, Baris-Tuzemen O, Uzuner G, Ozturk I, Sinha A (2020b) Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: evidence from Quantile ARDL approach. Sustainable Cities and Society 57 102138. https://doi.org/10.1016/j.scs.2020.102138

Sharif A, Jammazi R, Raza SA, Shahzad SJH (2017a) Electricity and growth nexus dynamics in Singapore: fresh insights based on wavelet approach. Energy Policy 110:686–692. https://doi.org/10.1016/j.enpol.2017.07.029

Sharif A, Raza SA, Ozturk I, Afshan S (2019) The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: a global study with the application of heterogeneous panel estimations. Renewable Energy 133:685–691. https://doi.org/10.1016/j.renene.2018.10.052

Sharif A, Saha S, Loganathan N (2017b) Does tourism sustain economic growth? Wavelet-based evidence from the United States. Tour Anal 22(4):467–482. https://doi.org/10.3727/108354217X15023805452022

Sim N, Zhou H (2015) Oil prices, US stock return, and the dependence between their quantiles. J Bank Fin 55:1–8

Sohag K, Gainetdinova A, Mariev O (2021) The response of exchange rates to economic policy uncertainty: Evidence from Russia. Borsa Istanbul Review

State Bank of Pakistan (2021) https://www.sbp.org.pk/ecodata/index2.asp

Suki NM, Sharif A, Afshan S, Suki NM (2020) Revisiting the environmental Kuznets curve in Malaysia: the role of globalization in sustainable environment. J Clean Prod 264:121669. https://doi.org/10.1016/j.jclepro.2020.121669

Tam PS (2018) Global trade flows and economic policy uncertainty. Appl Econ 50(34–35):3718–3734. https://doi.org/10.1080/00036846.2018.1436151

Ullah S, Luo R, Adebayo TS, Kartal, MT (2022) Dynamics between environmental taxes and ecological sustainability: evidence from top-seven green economies by novel quantile approaches. Sustain Dev. https://doi.org/10.1002/sd.2423

World Bank (2021) https://www.worldbank.org/en/research/commodity-markets

Xiao Z (2009) Quantile cointegrating regression. Journal of Econometrics 150(2):248e260.
Yalta AY, Yalta AT (2017) Dependency on imported oil and its effects on current account. Energy Sources Part B 12(10):859–867

The authors undersigned declare that this manuscript is original, has not been published before, and is not currently being considered for publication elsewhere.