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Exchange rate volatility and export in Turkey: Does the nexus vary across the type of commodity?☆,☆☆

Doğukan Tarakçı [a,*], Fevzi Ölmez [b], Dilek Durusu-Çiftçi [c]

[a] Department of International Trade and Finance, İstanbul Aydin University, 34295, İstanbul, Turkey
[b] Department of International Trade and Business, İzmir Bakircay University, 35000, İzmir, Turkey
[c] Department of International Trade and Finance, Pamukkale University, 20070, Denizli, Turkey

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ABSTRACT

Turkey has experienced a rapid increase in exports during the last two decades. In addition, there has been a significant increase in the exchange rate and its volatility in recent years. Hence, the empirical examination of the volatility-export nexus in a comprehensive framework seems to be important to provide insights for policymakers. In this study, we investigate how the exchange rate volatility affects Turkey's exports to its major partners namely, Belgium, France, Germany, Italy, Netherlands, Russia, Spain, the UK, and the USA for the period of 2002:01–2019:12. Considering the existence of an asymmetric effect of volatility on trade, we separate positive changes of volatility from negative changes via the partial sum concept and introduce nonlinearity into the estimation and testing procedure. Our results indicate that (i) exchange rate volatility plays quite important role for Turkey's export, (ii) asymmetry matters for better understanding the volatility-export nexus, (iii) the impact of volatility is country and commodity-specific, (iv) exchange rate volatility shows higher impacts on capital and consumption goods export. Lastly, exchange rate volatility affects exports in opposite directions in the short and long-run. Both low and high volatility generally increase (decrease) Turkey's exports in the short-run (long-run). These results provide important implications for policymakers.

1. Introduction

The modern floating exchange rate era that began with the collapse of the Bretton Woods System in 1973, can be divided into two stages. The first stage was a period of adaptation to the new international monetary regime. With the liberalization of financial markets, international trade has also expanded considerably. The second stage starting from the establishment of the World Trade Organization (WTO) is called the period of "hyperfinancialization" and "hyperglobalization" (see, Obstfeld, 2018; Subramanian and Kessler, 2013).[1] In the second period, the relationship between ever-increasing international trade and the behavior of exchange rates has attracted much attention by researchers. Numerous studies focus on the twin concepts of the Marshall-Lerner (ML) condition and the J-Curve phenomenon (e.g. Bahmani-Oskooee and Zhang, 2013; Kyophilavong et al., 2013; Shahzad et al., 2017; Bahmani-Oskooee and Nasir, 2020). However, in the "hyperglobalization" era, sudden movements in exchange rates due to floating regimes also caused higher volatility. In that vein, there is another growing body of literature examining the exchange rate volatility and international trade relation starting from Ethier

☆ This study is an improved and revised version of the study titled "Asymmetric Effects of Exchange Rate Volatility on Exports of Goods Between Turkey and Major Trade Partners" that we presented at the 21st National Economics Congress (EKONTEK2021).

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* Corresponding author.
E-mail addresses: dogukantarakci@aydin.edu.tr (D. Tarakçı), fevzi.olmez@bakircay.edu.tr (F. Ölmez), dciftci@pau.edu.tr (D. Durusu-Çiftçi).
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[1] Obstfeld (2018) describes the period between the mid-1990s to end-2010s as "hyperfinancialization" in which the greater exchange rate flexibility on the part of many emerging market economies. At the same time, Subramanian and Kessler (2013) characterize developments in international trade, including rapidly expanding global value chains, as "hyperglobalization" especially after China's affiliation to the WTO.

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(1973), Clark (1973), Baron (1976), and Hooper and Kohlhagen (1978).

The theoretical literature demonstrates different impacts of exchange rate volatility on exports depending on alternative assumptions and modelling strategies. In the first group of models, the impact of exchange rate volatility on export has been largely associated with exporters' risk perception. It is expected for risk-averse exporters to be affected by exchange rate volatility in different degrees. For instance, Hooper and Kohlhagen (1978) assess the effects of exchange rate volatility on exports by incorporating both supply and demand sides. They show that increased risk aversion due to high volatility on the part of both exporters and importers will reduce the overall volume of trade. Opposing to Hooper and Kohlhagen (1978), De Grauwe (1988) argues that exchange rate volatility may have two different effects depending on whether the substitution effect or the income effect will dominate the risk-averse firm. In his theoretical model, the only source of risk for an individual producer who has the choice for producing home or foreign markets arise from the exchange rate uncertainty as it affects the total value of its revenues in domestic currency. The choice problem of the individual producer is to allocate the given amount of resources to maximize the expected utility of his total income. Herein, De Grauwe (1988) demonstrates that risk-averse producers worry about the worst possible outcome and as the volatility increases, they will export more to avoid the possibility of a drastic decrease in their revenues. In this case, income effect dominates the substitution effect and higher exchange rate volatility leads to greater export activity. His arguments are also supported theoretically by Broll and Eckwert (1999), but only for firms that are flexible enough to reallocate their products among international markets accordingly to changes in exchange rates.

The second group of models consider hedging strategies against exchange rate volatility. In general, it is accepted that developed forward markets neutralize the negative effects of volatility on trade. On the other side, Caporale and Doroodian (1994) and Obstfeld and Rogoff (1998) demonstrate that hedging generates costs that translate into higher export prices which in turn decrease export. The third set of models account for sunk costs. In this context, it is expected for export firms to invest in production facilities, marketing and distribution networks, infrastructure, R&D, etc. before they sell their products to another country. These sunk costs make firms less responsive to short-run exchange rate volatility since they adopt a “wait and see” (IMF, 2004) or “hold your breath” (Arize et al., 2017) approach and stay in the market. Besides, firms that have not yet entered the market are more likely to stay out during times of high volatility. Dixit (1989) and Krugman (1986) have explored the implications of sunk costs following the finance literature on real options. They assume that exporting firms have an option to leave the market, and firms that are not exporting have an option to enter the market in the future. The decision to enter or exit the export market involves the “cost of exercising the option”. As the volatility increases, the value of keeping the option increases as well. These set of models suggest that increased volatility would increase the inaction in entry and exit decisions.[2]

Exchange rate volatility is also particularly important for policymakers since national governments increasingly feel the effects of the volatility on monetary policies. The primary purpose of the central banks is to ensure price stability. Various monetary policy instruments are used to keep prices stable. However, the reflection of the volatility of the exchange rates on the prices of imported goods makes it difficult to control the general level of prices in the economy. These effects are especially vital for economies that implement export-led growth strategies since high volatility creates uncertainty about foreign earnings from international trade. Including the risk premium to the costs of the goods leads to higher prices, which may undermine the comparative advantage of these goods. In this context, the dependency level of a country's exports on its imports also gains importance. If a significant part of the imported goods is raw materials and capital goods, the reactions of the producers to the exchange rate volatility can be expected to affect both domestic sales and exports.[3]

The literature on exchange rate volatility and international trade nexus seems to be focusing mostly on developing economies, especially Asian and African economies (e.g. Doganlar, 2002; Poon et al., 2005; Baak et al., 2007; Chit et al., 2010; Musila and Al-Zyoud, 2012; Polodoo et al., 2016; Senadza and Diaba, 2017; Aftab et al., 2017; Thuy and Thuy, 2019; Bahmani-Oskooee and Nouira, 2020; Bahmani-Oskooee and Arize, 2020). As an emerging economy, Turkey holds a special place in this regard since both exchange rate and international trade policies have seen remarkable changes over the years. In Turkey, export-led growth and liberal economic policies began to be implemented after the 1980s but the exchange rate policy was not fully floating until 2001. After the 2001 crisis, Turkey shifted from pegged exchange rate regime to flexible exchange rate regime. Since then, the exchange rate volatility of the Turkish Lira (TL) has become one of the main determinants of Turkey's trade flows (Nazlioglu, 2013). Figs. 1–4 below, show how TL depreciated against foreign currencies (U.S. dollar, euro, pound, and ruble) over the years. Moreover, exchange rate volatility has shown an increasing trend for all currencies since 2015, except for the TL/Ruble.

Even though there are plenty of works in the literature that test the validity of the J-curve hypothesis in Turkey, the number of

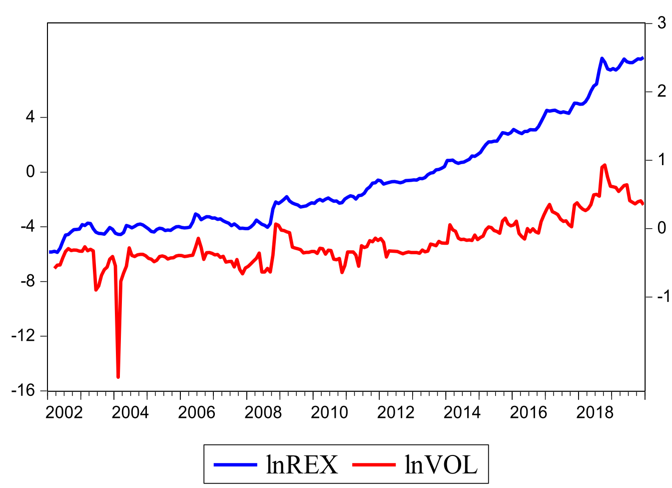

Fig. 1. Note: lnREX and lnVOL variables are calculated by authors using data from CBRT. lnRER is the log of the real exchange rate which is the nominal exchange rate multiplied by the ratio of consumer price index (CPI, 2010 = 100) of Turkey over CPI (2010 = 100) of the foreign country. lnVOL is the log of volatility, obtained by the EGARCH (1,1) method for Euro (Germany) and Pound and TGARCH (1,1) for USD and Ruble.

[2] A more detailed survey of the earlier theoretical framework can be found in Cote (1994).

[3] Exchange rate volatility also affects international portfolio investments that have been increasing with globalization. Similar to commodity trade, high volatility can discourage international investors, as high exchange rate risks reduce the expected return on foreign investment flows. Therefore, limiting the exchange rate volatility is an important goal for policymakers. Since we aim to analyze the effects of volatility on international trade, we concentrate on the former.

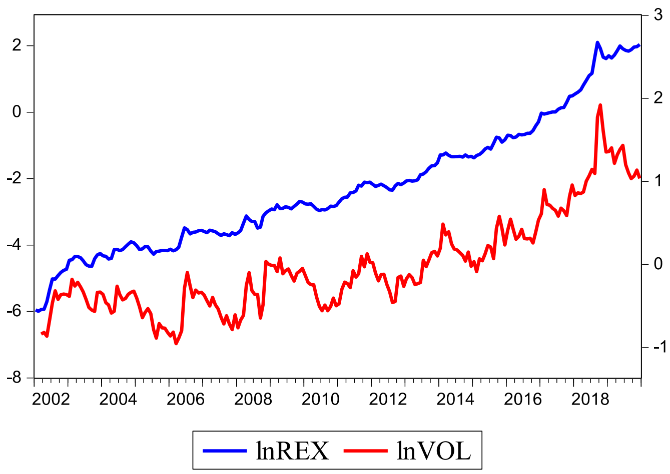

Fig. 2. Note: lnREX and lnVOL variables are calculated by authors using data from CBRT. lnRER is the log of the real exchange rate which is the nominal exchange rate multiplied by the ratio of consumer price index (CPI, 2010 = 100) of Turkey over CPI (2010 = 100) of the foreign country. lnVOL is the log of volatility, obtained by the EGARCH (1,1) method for Euro (Germany) and Pound and TGARCH (1,1) for USD and Ruble.

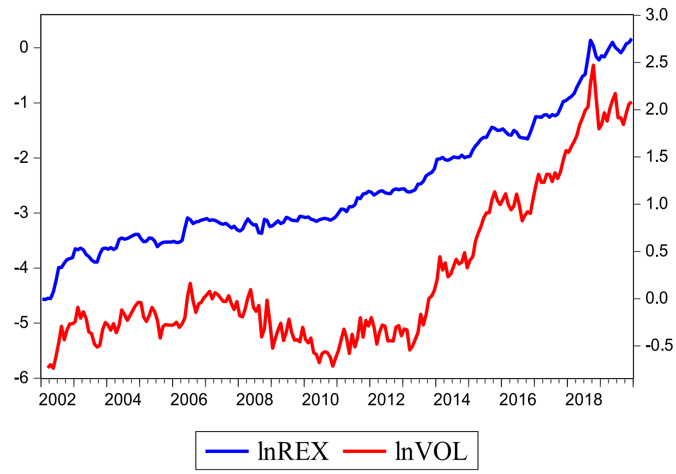

Fig. 4. Note: lnREX and lnVOL variables are calculated by authors using data from CBRT. lnRER is the log of the real exchange rate which is the nominal exchange rate multiplied by the ratio of consumer price index (CPI, 2010 = 100) of Turkey over CPI (2010 = 100) of the foreign country. lnVOL is the log of volatility, obtained by the EGARCH (1,1) method for Euro (Germany) and Pound and TGARCH (1,1) for USD and Ruble.

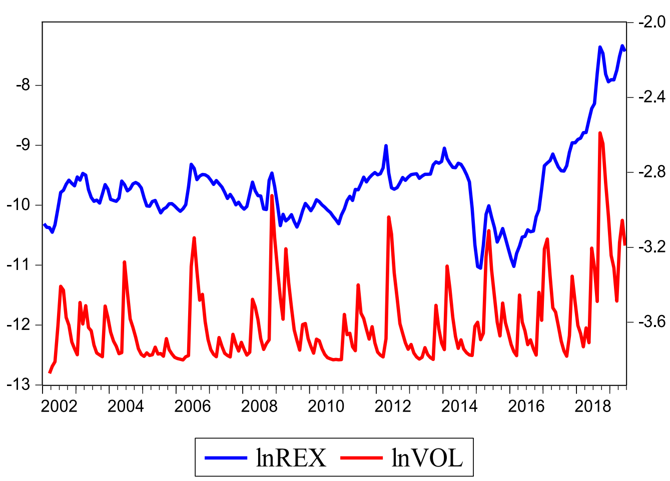

Fig. 3. Note: lnREX and lnVOL variables are calculated by authors using data from CBRT. lnRER is the log of the real exchange rate which is the nominal exchange rate multiplied by the ratio of consumer price index (CPI, 2010 = 100) of Turkey over CPI (2010 = 100) of the foreign country. lnVOL is the log of volatility, obtained by the EGARCH (1,1) method for Euro (Germany) and Pound and TGARCH (1,1) for USD and Ruble.

studies examining the effects of exchange rate volatility on trade is limited. Also, findings associated with Turkish exports are mixed. While some studies find negative effects of volatility on Turkish exports (e.g. Caballero and Corbo, 1989; Özbay, 1999; Doganlar, 2002; Saatcioğlu and Karaca, 2004; Ozturk and Acaravci, 2002; Dincer and Kandil, 2011), some others including Kasman and Kasman (2005), Altintas et al. (2011), Erdal et al. (2012), Tatliyer and Yigit (2016), Bilgili et al. (2019) find positive effects. There are also other works that find insignificant effects of volatility (e.g. Yüksel et al., 2012; Demez and Ustaoğlu, 2012; Denaux and Falks, 2013; Asteriou et al., 2016). The results of these studies also vary depending on the sample, method, and whether the export data is aggregated or disaggregated. The empirical literature on Turkey can be divided into four groups in terms of sample selection: (i) Aggregated export data to the rest of the world, (ii) disaggregated export data to the rest of the world, (iii) aggregated – bilateral export data, (iv) disaggregated – bilateral export data. It is worth noting that most of the above listed empirical works use total exports of Turkey to the rest of the world which possibly cause aggregation bias (e.g. Özbay, 1999; Kasman and Kasman, 2005; Ozturk and Acaravci, 2002; Altıntaş et al., 2011; Yüksel et al., 2012 and Bilgili et al., 2019). Secondly, some studies use disaggregated data (either ISIC or BEC classified) of Turkish exports to the rest of the world (e.g. Dincer and Kandil, 2011; Erdal et al., 2012; Nazlioglu, 2013; Bahmani-Oskooee and Durmaz, 2016). The second group may also suffer from another aggregation bias problem in that commodities of different industries traded between Turkey and her major partners may react differently to exchange rate volatility. The third group of studies uses total exports of Turkey to the selected trade partners (e.g. Vergil, 2002; Erdem et al., 2010; Demez and Ustaoğlu, 2012). Lastly, a very recent study by Bahmani-Oskooee and Karamelikli (2021) analyzes the impact of exchange rate volatility on industrial level trade between Turkey and Germany.

This study tries to contribute to the related literature in three aspects: (i) Aggregation bias is an important problem in examining the exchange rate-trade relationship. Since some types of commodities may be more elastic to the exchange rate changes while some others are inelastic. Moreover, the positive impact of volatility for some countries may be offset by its negative impact on other countries (Bahmani-Oskooee and Halicioglu, 2017).[4] Therefore, the analysis of disaggregated and bilateral data may provide a more accurate and broad perspective to policymakers. To our knowledge, except for the study of Bahmani-Oskooee and Karamelikli (2021) on Turkey-Germany bilateral trade, there is no serious effort to understand this relationship in detail for Turkey. More specifically, we use the export data according to Broad Economic Categories (BEC) classification[5] (consumption goods, capital goods, and intermediate goods) for the top export partners of Turkey (see, Table 1). (ii) Another potential problem of the earlier works may be the use

[4] As a result of exchange rate volatility, export demands of some countries may increase while export demands of others decrease. However, these increases and decreases may also be at the same level and lead to any changes in total.

[5] According to the BEC Classification of Turkish Statistical Institute, 47.2% of total Turkish exports were intermediate goods, followed by 40.2% of consumption goods and 11.9% of capital goods in 2019.

Table 1
Top exporting countries of Turkey (US billion $).

	2002	2004	2006	2008	2010	2012	2014	2016	2018	2019	2002–2019 Avg.
Germany	5.9 (16.3)	8.7 (13.8)	9.7 (11.3)	13.0 (9.8)	11.5 (10.1)	13.1 (8.6)	15.1 (9.6)	14.0 (9.8)	16.1 (9.6)	15.4 (9.0)	12.1
UK	3.0 (8.4)	5.5 (8.8)	6.8 (8.0)	8.2 (6.2)	7.2 (6.4)	8.7 (5.7)	9.9 (6.3)	11.7 (8.2)	11.1 (6.6)	10.9 (6.3)	8.0
Italy	2.4 (6.6)	4.6 (7.4)	6.8 (7.9)	7.8 (5.9)	6.5 (5.7)	6.4 (4.2)	7.1 (4.5)	7.6 (5.3)	9.6 (5.7)	9.3 (5.4)	6.7
Iraq	0 (0.0)	0.4 (2.9)	2.6 (3.0)	3.9 (3.0)	6.0 (5.3)	10.8 (7.1)	10.9 (6.9)	7.6 (5.4)	8.3 (5.0)	9.0 (5.2)	6.1
France	2.1 (5.9)	3.7 (5.8)	4.6 (5.4)	6.6 (5.0)	6.1 (5.3)	6.2 (4.1)	6.5 (4.1)	6.0 (4.2)	7.3 (4.3)	7.6 (4.5)	5.6
USA	3.4 (9.3)	4.9 (7.7)	5.1 (5.9)	4.3 (3.3)	3.8 (3.3)	5.6 (3.7)	6.3 (4.0)	6.6 (4.6)	8.3 (4.9)	8.1 (4.7)	5.4
Spain	1.1 (3.1)	2.6 (4.1)	3.7 (4.3)	4.0 (3.1)	3.5 (3.1)	3.7 (2.4)	4.7 (3.0)	5.0 (3.5)	7.7 (4.6)	7.7 (4.5)	4.2
UAE	0.5 (1.3)	1.1 (1.8)	2.0 (2.3)	8.0 (6.0)	3.3 (2.9)	8.2 (5.4)	4.7 (3.0)	5.4 (3.8)	3.1 (1.9)	3.5 (2.1)	3.9
Russia	1.2 (3.3)	1.9 (2.9)	3.2 (3.8)	6.5 (4.9)	4.6 (4.1)	6.7 (4.4)	5.9 (3.8)	1.7 (1.2)	3.4 (2.0)	3.9 (2.2)	3.9
Netherlands	1.1 (2.9)	2.1 (3.4)	2.5 (3.0)	3.1 (2.4)	2.5 (2.2)	3.2 (2.1)	3.5 (2.2)	3.6 (2.5)	4.8 (2.8)	5.4 (3.2)	3.0
Belgium	0.7 (1.9)	1.1 (1.8)	1.8 (1.6)	2.1 (1.6)	1.9 (1.7)	2.3 (1.5)	2.9 (1.8)	2.5 (1.8)	3.9 (2.3)	3.2 (1.9)	2.2

Note: Author's calculations from TURKSTAT database. The values in the parenthesis are the share of Turkey's total exports of these countries.

of reel effective exchange rate. The trend and volatility of the exchange rate may differ for different currency types. Therefore, we calculate and use Turkey's bilateral exchange rates with the relevant country in the trade models. (iii) In many of the empirical works both the short and long-run effects of exchange rate volatility are found insignificant. In recent years, it has been argued that these findings may be the result of the symmetry assumption. For example, Bahmani-Oskooee and Aftab (2017) claim that trade flows can respond asymmetrically to the exchange rate, as well as to its volatility. In other words, traders can react differently under low exchange rate volatility versus high volatility.

Theoretical literature provides several reasons for the fact that traders can show different behaviors to low and high exchange rate volatility including, various beliefs of market participants about the degree of real exchange rate misalignments (Kilian and Taylor, 2003), official exchange rate operations (Arize et al., 2017), and changes of traders' expectations, willingness to take risks and new information (Bahmani-Oskooee and Aftab, 2017). Kilian and Taylor (2003) argue that there can be heterogeneous opinions about the actual value of the nominal exchange rate because of lack of information and government restrictions, especially in emerging markets. In the long-run, market participants agree on the appropriate direction of the exchange rate movements, and accordingly, the exchange rate goes back to its latent level. Similarly, firms may react asymmetrically to low and high exchange rate volatility due to imperfect information and government restrictions. Due to increased uncertainty in high volatility, firms may decide to cut exports more than in low volatility situations. On the other hand, eliminating market distortions will reduce the uncertainties on both the level and volatility of the exchange rate in the long-run. Therefore, different views on the real value of the exchange rate and the high volatility may increase the uncertainty and affect exports negatively in the short-run. Official exchange rate intervention operations or oral interventions may also lead to asymmetries since they create uncertainty in the market regarding the long-run value of the exchange rate (Arize et al., 2017). The aim of the intervention is to solve a coordination problem between informed traders and monetary authorities. For example, when the value of a national currency falls, central banks may sell their holdings of foreign reserves to reduce the effects of depreciation. On the contrary, when the value of a national currency rises, the central bank may attempt to rebuild its foreign exchange reserves or do nothing. This is because monetary authorities might be more willing to tolerate currency appreciations than depreciations. Therefore, shocks to the market may result in different outcomes depending on how monetary authorities decide to intervene. Similarly, the central bank's interventions on the exchange rate may change whether the exchange rate is low or high volatile. They are more inclined to intervene in the market when there is high volatility. In the high exchange rate volatility, firms may expect that there will be an intervention to the exchange rate to stabilize the market and there will be no change in prices and sales volumes in the long-term. On the other hand, firms generally expect no intervention by the central bank in case of low volatility.[6] In summary, the theoretical and empirical literature could not reveal a consensus on the effect of exchange rate volatility on foreign trade. In this context, we will try to evaluate the impact of exchange rate volatility on commodity-specific exports of Turkey to its top exporting partners by taking into account the possible asymmetries in the relationship.

The remainder of the paper is structured as follows. In Section 2, data, model, and methodology will be discussed. The empirical analysis will be reported in Section 3 and that will be followed by our summary and policy implications in Section 4.

2. Data and methodology

Following the existing literature (e.g. Bahmani-Oskooee and Arize, 2020; Bahmani-Oskooee and Durmaz, 2021) the export model to be estimated is specified as follows:

$$lnEX_t = a + lnY_t + lnREX_t + lnVol_t + \varepsilon_t \quad (1)$$

where EX_t represents the Turkish exports volume of consumption,

[6] Related to official exchange rate interventions, Bahmani-Oskooee and Aftab (2017) argue that traders' expectations and new information also lead to asymmetric effects. If increased volatility hurts trade by 2% and if traders become more confident in the ability of a central bank to stabilize the exchange rate and reduce the volatility, they may increase trade by much more than 2%.

capital, or intermediate goods to partner countries which are expected to depend positively on the income of partner countries which is denoted by Y_t. Since GDP data is not available in monthly frequency, we use industrial production indices (IPI) of related countries to proxy income, which is pretty common in the literature (e.g. Huchet-Bourdon and Bahmani-Oskooee, 2013; Bahmani-Oskooee and Halicioglu, 2017; Bahmani-Oskooee and Aftab, 2017; Bahmani-Oskooee and Durmaz, 2021; Chien et al., 2020). REX_t represents the real exchange rate and it is the nominal exchange rate multiplied by the ratio of consumer price index (CPI, 2010 = 100) of Turkey over CPI (2010 = 100) of the foreign country. Here, we use the real exchange rate since it captures the variance of the nominal exchange rate and incorporates the relative prices which possibly create an alternate risk for traders. The sign of REX_t is expected to be positive since an increase in REX_t means depreciation of the Turkish Lira. Finally, Vol_t represents the volatility of the exchange rate, and it is calculated with the GARCH methodology.

In the literature, different proxies are used to measure volatility. The standard deviation of the first difference of the log exchange rate and the moving average standard deviation of the log real exchange rate is mostly preferred before the 2010s. Following more recent studies (see, Nazlioglu, 2013; Wong, 2017; Sharma and Pal, 2018; Bahmani Oskooee and Durmaz, 2020), we utilize GARCH models to calculate the exchange rate volatility. GARCH based models more accurately capture risk as they incorporate time-varying conditional variance, which allows larger variances corresponding to the previous periods to yield large variances in the future periods. Therefore, GARCH-type models can forecast volatility based on past values more effectively than other techniques (Sharma and Pal, 2018). We first investigate the non-linearity properties of our volatility variables by employing the BDS test developed by Brock et al. (1987). Our findings indicate that the null hypothesis of linearity is strongly rejected in all cases.[7] Accordingly, we apply alternative GARCH-type models, namely Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Exponential GARCH (EGARCH), and Threshold GARCH (TGARCH) models to capture the best model specification of the volatility of real exchange rates.[8] The optimal model is chosen according to Akaike (AIC) and Schwarz (SIC) information criteria with the minimum. In our cases, TGARCH is found to be the most suitable model specification for measuring the volatility of the dollar and ruble, while EGARCH is chosen as the best fit model for the volatility of the pound and euro.[9]

Our sample consists of time series data for Belgium, France, Germany, Italy, the Netherlands, Russia, Spain, the UK, and the USA for the period 2002:01–2019:12.[10] We obtained data from TURKSTAT, International Financial Statistics of IMF, and OECD. All the variables are expressed in natural logarithms.

To estimate Eq. (1), we use Pesaran et al. (2001) ARDL methodology. One advantage of the ARDL method is that explanatory variables could be the combination of stationary and non-stationary variables. Another advantage is that short and long-run effects are provided in one estimation step. The estimated unrestricted error correction model is shown below in Eq. (2):

$$\Delta lnEX_t = a' + \sum_{k=1}^{n1} b'_k \Delta lnEX_{t-k} + \sum_{k=0}^{n2} c'_k \Delta lnY_{t-k} + \sum_{k=0}^{n3} d'_k \Delta lnREX_{t-k} + \sum_{k=0}^{n4} e'_k \Delta lnVol_{t-k} + \theta_0 lnEX_{t-1} + \theta_1 lnY_{t-1} + \theta_2 lnREX_{t-1} + \theta_3 lnVol_{t-1} + \mu_t \tag{2}$$

Here, the short-run effects of exogenous variables on exports are shown by the coefficients of c'_k, d'_k and e'_k, while the long-run effects are denoted by the estimates of θ_1, θ_2 and θ_3 normalized on θ_1. Lastly, μ_t is the error term.

The impact of the exchange rate volatility on export is assumed to be symmetric in Eq. (2). However, if the effect of the increase in volatility does not equal the effect of the decrease in volatility, it means the volatility shows an asymmetric effect. To capture the possible asymmetric impact of exchange rate volatility on exports, the non-linear autoregressive distributed lag (NARDL) model proposed by Shin et al. (2014) is adopted to our theoretical model. Thanks to the NARDL approach, we reveal the nature of the impact of volatility on export and avoid misspecified model estimation. Before estimation, it is necessary to generate the positive and negative components of the volatility. The negative and positive components of volatility are established by using the partial-sum approach as in equations (3) and (4):

$$Vol\_N_t = \Delta lnVol\_N_k^- = \sum_{k=1}^{n} \Delta lnVol\_N_k^- = \sum_{k=1}^{n} \min(\Delta lnVol\_N_k,\ 0) \tag{3}$$

$$Vol\_P_t = \Delta LnVol\_P_k^+ = \sum_{k=1}^{n} \Delta lnVol\_P_k^+ = \sum_{k=1}^{n} \max(\Delta lnVol\_P_k,\ 0) \tag{4}$$

where Vol_N_t is the partial-sum of negative changes and shows decreases in volatility. On the other hand, Vol_P_t consists of the partial-sum of positive changes and indicates the increases in volatility. When linear ARDL model is augmented with positive and negative components of the volatility, non-linear ARDL model can be written as follows:

$$\Delta lnEX_t = a + \sum_{k=1}^{n} b_k \Delta lnEX_{t-k} + \sum_{k=0}^{n} c_k \Delta lnY_{t-k} + \sum_{k=0}^{n} d_k \Delta lnREX_{t-k} + \sum_{k=0}^{n} e_k^+ \Delta lnVol\_P_{t-k} + \sum_{k=0}^{n} f_k^- \Delta lnVol\_N_{t-k} + \theta_0 lnEX_{t-1} + \theta_1 lnY_{t-1} + \theta_2 lnREX_{t-1} + \theta_3^+ lnVol\_P_{t-1} + \theta_4^- lnVol\_N_{t-1} + \mu_t \tag{5}$$

In the specified model, we used the bounds test to confirm whether there is a cointegration relationship between the variables. In addition, to determine whether volatility has symmetric or asymmetric effects on the export, the null hypothesis of there is no asymmetry is tested by using the Wald-F test. If the null hypothesis, $H_0 : \sum \widehat{e}_k^+ \neq \sum \widehat{f}_k^-$ is not rejected, volatility does not have an asymmetric effect on export in the short-run. On the other hand, if the null of $H_0 : \sum \widehat{\theta}_3^+ \neq \sum \widehat{\theta}_4^-$ is not rejected, there is no asymmetric effect in the long-run.

[7] See the results for the BDS test for exchange rate volatility in Appendix Table A1.

[8] We would like to thank the anonymous referee for his/her valuable comments on GARCH models.

[9] We present the estimation results of GARCH-type models for exchange rate volatility in Appendix Table B2-Table B6.

[10] We excluded the available data for 2020 in order to avoid the drastic changes caused by the Covid-19 pandemic on international trade. However, in future researches, expanding the data set to include the Covid-19 pandemic period or making comparisons between before-and-after pandemic may also provide important implications.

Table 2
Asymmetry test results.

Country	Exports Type	Short-Run	Long-Run
Belgium	Capital	**Non-Linear**	**Non-Linear**
	Intermediate	**Non-Linear**	Linear
	Consumption	**Non-Linear**	**Non-Linear**
France	Capital	Linear	**Non-Linear**
	Intermediate	Linear	**Non-Linear**
	Consumption	Linear	Linear
Germany	Capital	Linear	Linear
	Intermediate	Linear	**Non-Linear**
	Consumption	Linear	Linear
Italy	Capital	**Non-Linear**	Linear
	Intermediate	Linear	Linear
	Consumption	Linear	Linear
Netherlands	Capital	**Non-Linear**	Linear
	Intermediate	**Non-Linear**	Linear
	Consumption	Linear	Linear
Russia	Capital	**Non-Linear**	**Non-Linear**
	Consumption	**Non-Linear**	Linear
Spain	Capital	**Non-Linear**	**Non-Linear**
	Intermediate	**Non-Linear**	Linear
	Consumption	**Non-Linear**	**Non-Linear**
UK	Intermediate	**Non-Linear**	**Non-Linear**
	Consumption	**Non-Linear**	**Non-Linear**
USA	Capital	**Non-Linear**	**Non-Linear**
	Intermediate	Linear	**Non-Linear**
	Consumption	**Non-Linear**	**Non-Linear**

Note: This table is prepared according to the Wald statistics reported in Tables 3–5

3. Empirical results

To investigate the impact of the exchange rate volatility on export from Turkey to its major trading partners, we utilize the NARDL methodology for each of the consumption, intermediate, and capital goods models. We start our empirical analysis by testing unit root properties of variables and employ ADF test developed by Dickey and Fuller (1979) and the ADF test with an endogenous structural break developed by Zivot and Andrews (1992) in which the null hypothesis of unit root is tested against the alternative hypothesis of stationarity. Our results indicate that almost all the series are integrated at order of I(1), specifically for the Zivot and Andrews unit root tests.[11] Then, we test the existence of asymmetric impact of exchange rate volatility on export for each model and country sample. In this point, there are four different scenarios as follows: (i) Both short and long-run are symmetric, (ii) short-run is symmetric, but long-run is asymmetric, (iii) short-run is asymmetric, but long-run is symmetric and (iv) both short and long-run are asymmetric. Therefore, we separate our findings into two categories which are the results from ARDL (in Table 3) and NARDL model estimations (in Tables 4 and 5) with at least one term having an asymmetric effect. According to asymmetry test results in Table 2, exchange rate volatility has symmetric effects on consumption goods export to Germany, France, Italy, and the Netherlands, intermediate export to only Italy, and capital export to only Germany from Turkey in both short and long-run. For other export models, there is at least one significant term for the asymmetric impact of the exchange rate volatility.

Once the correct model specification is determined, we estimate the export models with the appropriate methodological approach.[12] We report our findings in Tables 3–5. For easy comparison of the results for the different types of goods and countries, the estimated short-run and long-run coefficients are given in Panel A and Panel B, respectively. The results of the diagnostic statistics are also shown in Panel C. According to the bounds test, F-statistic is greater than upper-level critical values that means long-run equilibrium relationship is detected. On the other hand, Pesaran et al. (2001) stated that the cointegration relationship between dependent and independent variables can also be detected by using the t-statistic of the error correction mechanism. The negative and statistically significant ECM_{t-1} term for all models indicates that there is a cointegration relationship between the variables. Therefore, our results show that there is a cointegration relationship in all models, except Russia for the export of intermediate goods, and the UK for the export of capital goods.

In diagnostic statistics, LM refers to the Lagrange Multiplier statistic which indicates whether the residuals are autocorrelation free or not. $Wald_{short}$ and $Wald_{long}$ statistics show whether exchange rate volatility has an asymmetric effect in the short-run and long-run, respectively. CUSUM test indicates whether the stability of short-run and long-run forecasts in %5 significance level. While "S" shows that estimated coefficients are stable, "US" specifies that they are not.

The empirical part of this study includes a large number of model estimations. In order to make it easier for the reader, we prefer to present our findings in items according to the explanatory variables. The empirical results can be summarized as follows:

Foreign Income.

- In general, foreign income affects mostly and positively the capital goods export of Turkey both in the short and long-run. The statistically significant coefficients in the long-run are as follows: Belgium (3.9), Germany (5.4) Italy (2.3), Netherlands (5.8), Russia (10.9), and Spain (4.5).
- For consumption goods export, Spain and the UK are also income elastic while Germany is income inelastic in the long-run.
- For intermediate goods export, the coefficient of income is statistically significant and positive for Belgium, Italy, the Netherlands, Spain, and the UK in the long-run.

Exchange Rate.

- The effect of the exchange rate on Turkey's exports varies considerably according to the different types of goods and countries.
- In the short run, even though the effect of the exchange rate on exports is positive in some cases, most of them are either statistically insignificant or negative.
- An increase in the exchange rate reduces only Turkey's capital goods exports to Belgium. A 1% increase in exchange rate decreases −0.81% exports of capital goods in the long-run.
- An increase in the exchange rate increases mostly Turkey's exports to Germany (0.13%), Italy (0.87%), and Russia (1.59%) for consumption goods, Italy (0.81%), the Netherlands (0.47%), and Spain (0.96%) for intermediate goods, and Italy (1.03%) and Russia (1.82%) for capital goods in the long-run.

Exchange rate volatility in the short run.

- For consumption goods export, the effect of exchange rate volatility is statistically significant in 6 out of 9 cases. It is symmetric only for France and asymmetric for others, namely Belgium, Russia, Spain, the UK, and the USA.
  - Increased volatility (ΔPOS) positively affects Turkey's exports of consumption goods to the USA (0.06%).

[11] See the unit root test results in Appendix Table C1.

[12] ARDL approach is highly sensitive to lag selection. In order to avoid this problem, we estimate a simple VAR model and select the six lags length for each model.

Table 3
Short-run and long-run estimation results of linear ARDL for export of consumption, intermediate, and capital goods.

Consumption					Intermediate		Capital	
Variable	France	Germany	Italy	Netherlands	Variable	Italy	Variable	Germany
Panel A: Short-run results								
$\Delta\ln\_CON_{t-1}$	−0.47***	−0.19***	−0.34***	−0.41***	$\Delta\ln\_INT_{t-1}$	−0.19***	$\Delta\ln\_CAP_{t-1}$	−0.46***
$\Delta\ln\_CON_{t-2}$	−0.24***		−0.19***	−0.25***	$\Delta\ln\_INT_{t-2}$		$\Delta\ln\_CAP_{t-2}$	−0.27***
$\Delta\ln\_CON_{t-3}$					$\Delta\ln\_INT_{t-3}$		$\Delta\ln\_CAP_{t-3}$	−0.34***
$\Delta\ln\_CON_{t-4}$	−0.17***				$\Delta\ln\_INT_{t-4}$		$\Delta\ln\_CAP_{t-4}$	−0.24***
$\Delta\ln\_CON_{t-5}$	−0.15**				$\Delta\ln\_INT_{t-5}$		$\Delta\ln\_CAP_{t-5}$	
$\Delta\ln\_CON_{t-6}$		0.14***		0.18***	$\Delta\ln\_INT_{t-6}$	0.16***	$\Delta\ln\_CAP_{t-6}$	−0.10***
$\Delta\ln Y^*_t$	1.74**	1.26***			$\Delta\ln Y^*_t$		$\Delta\ln Y^*_t$	3.95***
$\Delta\ln Y^*_{t-5}$		0.96**		1.18***	$\Delta\ln Y^*_{t-5}$		$\Delta\ln Y^*_{t-5}$	
$\Delta\ln Y^*_{t-6}$	−1.41*				$\Delta\ln Y^*_{t-6}$		$\Delta\ln Y^*_{t-6}$	
$\Delta\ln REX_t$					$\Delta\ln REX_t$		$\Delta\ln REX_t$	
$\Delta\ln VOL_{t-5}$	0.08***				$\Delta\ln VOL_{t-5}$		$\Delta\ln VOL_{t-5}$	
$\Delta\ln VOL_{t-6}$					$\Delta\ln VOL_{t-6}$		$\Delta\ln VOL_{t-6}$	−0.10**
Panel B: Long-run results								
Constant	3.72**	11.17***	4.60***	3.24**	Constant	4.18***	Constant	−1.63
lnY*	−0.08	0.69***	0.51	1.12	lnY*	0.97*	lnY*	5.41***
lnREX	0.36	0.13**	0.87***	0.04	lnREX	0.81***	lnREX	−0.27
lnVOL	−0.12	−0.04*	−0.29**	0.12	lnVOL	−0.25***	lnVOL	0.15
Panel C: Diagnostic Statistics								
F test	3.46	15.06***	6.30***	4.08*	F test	8.59***	F test	6.07***
ECM_{t-1}	−0.20***	−0.67***	−0.31***	−0.23***	ECM_{t-1}	−0.33	ECM_{t-1}	−0.28***
$Wald_{short}$	0.24	-	-	-	$Wald_{short}$	-	$Wald_{short}$	0.61
$Wald_{long}$	0.09	0.27	0.06	0.41	$Wald_{long}$	2.31	$Wald_{long}$	0.83
LM	8.83	12.96**	7.85	7.74	LM	22.11***	LM	11.62
CUSUM	S	S	S	S	CUSUM	S	CUSUM	S

Note: The expressions *, **, and *** in the table indicate that the significance levels of the test statistics are 10%, 5%, and 1%, respectively. The model with constant F-statistics for the cointegration relationship is 5.61(1%), 4.35(5%), and 3.77(10%) upper bound critical values (Pesaran et al., 2001: 300). The autocorrelation relationship between the series is analyzed with Lagrange Multiplier (LM). CUSUM statistics show the short-run and long-run stability of the coefficients.
See the footnotes of Table B2.

- Decreased volatility (ΔNEG) positively effects Turkey's exports of consumption goods to Belgium (0.17%), Russia (0.24%), Spain (0.30%), the UK (0.22%), and the USA (0.10%).

- For capital goods export, the significant effects of exchange rate volatility on Turkey's exports are quite substantial. The exchange rate volatility has statistically significant effect in 7 out of 9 cases. It is symmetric and negative for only Germany (0.10%).
  - An increase in volatility (ΔPOS) positively affects Turkey's exports of capital goods to the Netherlands (1.17%), Spain (0.42%), and the USA (0.11%).
  - A 1% negative shock to the exchange rate volatility also increases Turkey exports to Belgium (0.36%), Italy (0.38%), Russia (0.31%), Spain by (0.78%), and the USA (0.11%).
- For intermediate goods export, volatility is statistically significant in 5 out of 9 cases, namely for Belgium, Germany, the Netherlands, Spain, and the UK.
  - The volatility symmetrically and positively (0.06%) affects the exports to Germany.
  - An increase in the exchange rate volatility increases the exports of Turkey to Belgium, the Netherlands, and Spain. On the other hand, a decrease in the exchange rate volatility positively affects the exports of Turkey to Spain and the UK.

Exchange rate volatility in the long run.

- Effects of exchange rate volatility are found to be statistically significant in 15 out of 27 cases in the long-run. It is asymmetric in 60 percent of the total cases.
- The asymmetric impact of exchange rate volatility is mostly detected for Belgium, France, Spain, the UK, and the USA in models in the long-run.
- For consumption goods export, the impact of exchange rate volatility is symmetric and negative for Germany, Italy, and Russia, while it is asymmetric for Spain, the UK, and the USA.
  - Both the increase and decrease in volatility negatively affect Turkey's exports to the UK and the USA.
  - Increased volatility (ΔPOS) positively affects Turkey's exports of consumption goods to Spain.
- For capital goods export, the impact of exchange rate volatility is asymmetric for Russia, Spain, and the USA in the long-run. For Spain and the USA, the negative shocks to the exchange rate volatility reduce the exports of Turkey to these countries. On the other hand, the positive shock to the exchange rate volatility negatively affects the exports of Turkey to Russia and the USA.
- For intermediate goods exports, exchange rate volatility has negative and asymmetric effects for France, the UK, and the USA.
  - Decreased volatility reduces Turkey's exports to France, the UK, and the USA by 0.15%, 0.46%, and 0.12%, respectively.
  - Lastly, Turkey's exports of intermediate goods to Italy and Spain symmetrically decrease by 0.25% and 0.21%.

4. Concluding remarks and policy implications

In this study, we examine the effects of exchange rate volatility on Turkish exports of consumption, intermediate, and capital goods for the period 2002:01–2019:12. Turkey has experienced a rapid increase in exports since the 2000s. In addition, there has been a significant increase in the exchange rate and its volatility in recent years. Hence, we aim to make a comprehensive analysis of the effects of these movements in the exchange rate on Turkey's exports. Unlike many other papers, we use the economic classification for the traded commodities and implement both linear and non-linear techniques to take into account the asymmetric effects of exchange rate volatility on Turkey's exports.

Our detailed empirical analysis provides some important common findings and policy recommendations regarding the effects of exchange rate volatility on exports in Turkey. First, exchange rate

Table 4
Short-run and long-run estimation results of non-linear ARDL models for export of consumption and intermediate goods.

Consumption						Intermediate							
Variable	Belgium	Russia	Spain	UK	USA	Variable	Belgium	France	Germany	Netherlands	Spain	UK	USA
Panel A: Short-run results													
Δln_CON_{t-1}	−0.28***	−0.21***	−0.54***	−0.19***	−0.44***	Δln_INT_{t-1}		−0.30***	−0.51***	−0.41***	−0.21***		−0.38***
Δln_CON_{t-2}	−0.17**		−0.41***		−0.44***	Δln_INT_{t-2}			−0.22**				
Δln_CON_{t-3}		−0.18***	−0.30***		−0.31***	Δln_INT_{t-3}			−0.20**				
Δln_CON_{t-4}			−0.23***		−0.31***	Δln_INT_{t-4}			−0.17**			−0.13**	
Δln_CON_{t-5}			−0.19***		−0.21***	Δln_INT_{t-6}	0.19***	0.17***	0.25***				
ΔlnY^*_{t-4}	−1.02**					ΔlnY^*_{t}			1.47***	1.23**			
ΔlnY^*_{t-5}			2.12**	−1.89**		ΔlnY^*_{t-1}			1.11**				
$\Delta lnREX_{t}$					−0.69***	ΔlnY^*_{t-2}			1.76***		3.13***		
$\Delta lnREX_{t-1}$					−0.81***	ΔlnY^*_{t-3}		1.16**					
$\Delta lnREX_{t-2}$	0.76**					ΔlnY^*_{t-5}							2.84***
$\Delta lnREX_{t-3}$			−0.83***			ΔlnY^*_{t-6}						4.20***	
$\Delta lnREX_{t-4}$			−1.12***			$\Delta lnREX_{t}$							−0.47***
$\Delta lnREX_{t-5}$		0.70**				$\Delta lnREX_{t-1}$							−0.34**
$\Delta lnVOL_{t-4}$						$\Delta lnREX_{t-2}$			0.39**				
$\Delta lnVOL_{t-6}$						$\Delta lnREX_{t-3}$	0.76**						
$\Delta lnVOL\_P_{t-1}$					0.06**	$\Delta lnREX_{t-4}$					−2.98**		
$\Delta lnVOL\_P_{t-3}$						$\Delta lnREX_{t-5}$					1.42**		
$\Delta lnVOL\_P_{t-4}$						$\Delta lnVOL_{t-4}$			0.06***				
$\Delta lnVOL\_P_{t-5}$						$\Delta lnVOL_{t-6}$			0.04*				
$\Delta lnVOL\_N_{t-1}$		0.24***			0.10***	$\Delta lnVOL\_P_{t-3}$					0.27**		
$\Delta lnVOL\_N_{t-2}$					0.06**	$\Delta lnVOL\_P_{t-4}$				0.17**			
$\Delta lnVOL\_N_{t-3}$			0.30***			$\Delta lnVOL\_P_{t-5}$	0.09**						
$\Delta lnVOL\_N_{t-5}$	0.15**			0.22***		$\Delta lnVOL\_N_{t-3}$					0.49***		
$\Delta lnVOL\_N_{t-6}$	0.17**					$\Delta lnVOL\_N_{t-5}$						0.42***	
Panel B: Long-run results													
Constant	6.16	1.54**	2.70**	0.93	5.49***	Constant	1.61*	3.36**	2.14***	−2.88*	3.29***	−5.45	2.08***
lnY*	0.90	0.62	1.69**	3.55**	−0.58	lnY*	3.31***	1.21	1.62	5.84***	1.72***	7.22***	0.97
lnREX	−0.07	1.59**	−0.80	0.40	0.34	lnREX	0.15	−0.12	−0.15	0.47**	0.96***	0.06	−0.23
lnVOL	-	−0.44*	-	-	-	lnVOL	−0.02	-	-	−0.02	−0.21***	-	-
lnVOL_P	−0.03	-	0.26**	−0.19*	−0.33***	lnVOL_P	-	−0.08	−0.09	-	-	−0.23	−0.06
lnVOL_N	−0.07	-	0.15	−0.26**	−0.38***	lnVOL_N	-	−0.15*	−0.15	-	-	−0.46**	−0.12***
Panel C: Diagnostic Statistics													
F test	6.53***	3.59	7.23***	6.66***	10.08***	F test	24.92***	5.04**	2.83	7.43***	8.85***	9.49***	4.70**
ECM_{t-1}	−0.45***	−0.10***	−0.26***	−0.35***	−0.34***	ECM_{t-1}	−0.61***	−0.27***	−0.18***	−0.31***	−0.37***	−0.35***	−0.19***
$Wald_{short}$	9.04***	6.14**	10.40***	6.95***	10.12***	$Wald_{short}$	4.01**	-	0.08	4.36**	2.89*	8.91***	-
$Wald_{long}$	3.20*	1.75	7.53***	3.17*	33.26***	$Wald_{long}$	0.00	3.93**	5.02**	0.41	0.32	11.80***	68.58***
LM	5.34	8.03	13.03**	2.67	24.46***	LM	6.59	10.20	11.11	10.17	16.15**	6.59	8.36
CUSUM	S	S	US	US	S	CUSUM	S	S	S	S	S	S	S

Note: The expressions in Table 3 are valid for the results in long-term symmetric model predictions. However, the critical values of 5.06 (1%), 4.01 (5%), and 3.52 (10%) are taken into account in the long-term asymmetric model estimations. The autocorrelation relationship between the series is analyzed with Lagrange Multiplier (LM). CUSUM statistic shows the short-run and long-run stability of the coefficients.

volatility plays quite an important role in Turkey's export. The coefficient of volatility is statistically significant in 23 out of 27 cases. Second, the null hypothesis of symmetry in 13 out of 27 cases in the long-run and 15 out of 27 cases in the short-run are rejected. In other words, the behavior of exchange rate volatility is asymmetric in half of the cases, implying that avoiding the true nature of the asymmetry in the relation between exchange rate volatility and export may be misleading. Third, the impact of volatility is commodity-specific. The exchange rate volatility affects Turkish exports of capital and consumption goods at most, which accounts for more than 50% of Turkey's exports each year. Fourth, the impact of volatility is county-specific. For example, while all the coefficients of volatility are insignificant for the Netherlands in the long-run, we find negative and significant effects of exchange rate volatility for the USA in all commodities. Fifth, exchange rate volatility affects exports in opposite directions in the short and long-run.

Surprisingly, both the low and high volatility boosts generally (in 16/27 cases) Turkey's exports in the short-run, in line with Kasman and Kasman (2005), Altintas et al. (2011), Erdal et al. (2012), Tatliyer and Yigit (2016), Bilgili et al. (2019). This finding may be explained by the following argument of De Grauwe (1988): "… exporters are universally made unhappy by the volatility of exchange rates; some may decide that they will be better off exporting more". In this sense, the dominance of income effect over substitution effect results in a positive relationship between exchange rate volatility and export. Therefore, Turkish exporters may be exporting more to compensate for the expected decline in income as a result of exchange rate volatility. For the rest of the cases, we find that the effect of exchange rate volatility is statistically insignificant in the short-run. Sunk costs are an important determinant of entry and exit decisions as well as it makes firms less responsive to short-run volatility. In these cases, Turkish exporting firms might be adopting a "hold-your-breath" (Arize et al., 2017) approach and waiting for volatility to fade away to recoup their sunk costs. These findings are consistent with Yüksel et al. (2012), Demez and Ustaoğlu (2012), Denaux and Falks (2013), and Asteriou et al. (2016).

Opposing to short-run results, we find that both the low and high exchange rate volatility negatively affects Turkey's exports in 12 (27) cases in the long-run, supporting the findings of Caballero and Corbo (1989), Özbay (1999), Doganlar (2002), Saatcioğlu and Karaca (2004), Ozturk and Acaravci (2002) and Dincer and Kandil (2011). There may be several reasons behind this result. First, the risk aversion degree of the Turkish exporting firms might be increasing in the long-run. In this case, the substitution effect

Table 5
Short-run and long-run estimation results of non-linear ARDL for export of capital goods.

Variable	Belgium	France	Italy	Netherlands	Russia	Spain	USA
				Panel A: Short-run results			
$\Delta \ln\_CAP_{t-1}$		−0.54***	−0.24***		−0.43***	−0.22**	−0.44***
$\Delta \ln\_CAP_{t-2}$		−0.29***	−0.15**		−0.31***	−0.16**	−0.51***
$\Delta \ln\_CAP_{t-3}$	0.11				−0.17**		−0.42***
$\Delta \ln\_CAP_{t-4}$					−0.17**	−0.15***	−0.45***
$\Delta \ln\_CAP_{t-5}$					−0.19***	−0.11*	−0.22***
$\Delta \ln\_CAP_{t-6}$							−0.16**
$\Delta \ln Y^*_t$		2.44*	2.94**			6.01***	
$\Delta \ln Y^*_{t-1}$	−2.44**						
$\Delta \ln Y^*_{t-2}$	−2.69***						
$\Delta \ln Y^*_{t-3}$						4.83**	
$\Delta \ln Y^*_{t-4}$						5.97***	
$\Delta \ln Y^*_{t-5}$						4.46*	3.46**
$\Delta \ln Y^*_{t-6}$						4.60**	
$\Delta \ln REX_t$							−0.87***
$\Delta \ln REX_{t-1}$							−0.73**
$\Delta \ln REX_{t-2}$				−3.95***			
$\Delta \ln REX_{t-4}$						−4.66***	
$\Delta \ln REX_{t-6}$	1.54**						
$\Delta \ln VOL\_P_{t-1}$				1.17***			0.11***
$\Delta \ln VOL\_P_{t-3}$						0.42**	
$\Delta \ln VOL\_P_{t-5}$						0.26**	
$\Delta \ln VOL\_N_{t-1}$			0.38**				0.08***
$\Delta \ln VOL\_N_{t-2}$							0.11***
$\Delta \ln VOL\_N_{t-3}$	0.36**					0.78***	
$\Delta \ln VOL\_N_{t-4}$						0.33*	
$\Delta \ln VOL\_N_{t-5}$						0.33**	
$\Delta \ln VOL\_N_{t-6}$					0.31**		
				Panel B: Long-run results			
Constant	−0.76	−2.27	2.45	−5.06	−4.62**	−3.29	4.94***
lnY*	3.74***	6.80	2.28***	5.83***	10.94***	4.47***	0.78
lnREX	−0.81*	−2.32	1.03***	0.40	1.82**	0.01	0.12
lnVOL	-	-	−0.30***	0.11	-	-	-
lnVOL_P	0.03	0.36	-	-	−0.53**	−0.06	−0.24***
lnVOL_N	−0.11	0.12	-	-	−0.38	−0.16**	−0.28***
				Panel C: Diagnostic Statistics			
F test	18.46***	2.01	8.48***	19.91***	4.86**	12.05***	10.03***
ECM_{t-1}	−0.59***	−0.15***	−0.47***	−0.52***	−0.18***	−0.75***	−0.8***
$Wald_{short}$	5.11**	-	4.77**	9.34***	4.33**	3.95**	5.49**
$Wald_{long}$	18.81***	2.99*	2.22	0.01	9.40***	8.29***	48.49***
LM	5.07	10.85	6.33	5.64	7.60	8.15	5.22
CUSUM	S	S	S	S	S	S	US

Notes: See the notes for Table 4.

dominates the income effect, and risk-averse firms reduce their exports and focus on sales in domestic markets. This is also consistent with the "wait and see" approach, as some of the exporting firms might exit the market in the long-run. Our findings show that 6 of the positive coefficients in the short-run turned into negative in the long-run and 10 of the positive coefficients in the short-run are statistically insignificant in the long-run. The second possible explanation is that Turkish exporting firms may not be utilizing proper hedging strategies. Caporale and Doroodian (1994) indicate that hedging may generate difficulties related to the firms' lack of foresight as to the timing and volume of foreign exchange transactions. Also, Obstfeld and Rogoff (1998) confirm that even though risk-averse firms properly hedge against exchange rate fluctuations, hedging costs can translate into higher export prices, thus lowering exports. In this context, increasing financial literacy trainings for exporting companies will help them to determine the right hedging strategies and protect themselves from risk. This is particularly important because risk-averse exporters will most likely reduce their activities and may prefer to sell their goods in domestic markets when the volatility is high.

Lastly, we find that in 21 (27) cases, increased volatility has no impact on Turkey's export in the long-run that might be related to official exchange rate interventions. In high exchange rate volatility, firms may expect that the central bank will intervene in the exchange rate to stabilize the market and there will be no change in prices and sales volumes in the long-run, unlike in the short-run. This finding also implies that the credibility and transparency of the central bank's policies may be other important factors for the nexus between exchange rate and export.

The finding that exchange rate volatility does not affect exports positively in 26 (27) models in the long-run, both positive and negative changes, indicate that policies that aim to prevent excess volatility in exchange rates such as keeping debt in foreign currency under control, limiting both fiscal and current account deficits and accumulating sufficient reserves would benefit Turkish exporters.

Appendix A. BDS tests

Table A1
Results for the BDS nonlinearity test

Variables	M = 2	M = 3	M = 4	M = 5	M = 6
VOL_{BEL}	0.174 (0.000)	0.288 (0.000)	0.362 (0.000)	0.408 (0.000)	0.436 (0.000)
VOL_{FRA}	0.167 (0.000)	0.277 (0.000)	0.351 (0.000)	0.396 (0.000)	0.424 (0.000)
VOL_{GER}	0.171 (0.000)	0.285 (0.000)	0.357 (0.000)	0.401 (0.000)	0.429 (0.000)
VOL_{ITA}	0.178 (0.000)	0.296 (0.000)	0.372 (0.000)	0.421 (0.000)	0.452 (0.000)
VOL_{NED}	0.172 (0.000)	0.287 (0.000)	0.361 (0.000)	0.408 (0.000)	0.436 (0.000)
VOL_{RUS}	0.111 (0.000)	0.184 (0.000)	0.224 (0.000)	0.245 (0.000)	0.244 (0.000)
VOL_{SPA}	0.163 (0.000)	0.269 (0.000)	0.338 (0.000)	0.383 (0.000)	0.411 (0.000)
VOL_{UK}	0.175 (0.000)	0.290 (0.000)	0.368 (0.000)	0.424 (0.000)	0.462 (0.000)
VOL_{US}	0.178 (0.000)	0.295 (0.000)	0.370 (0.000)	0.424 (0.000)	0.462 (0.000)

Notes*:* Numbers in parenthesis are p-values. M represents the dimensions.

Appendix B. Modelling the exchange rate volatility

We apply Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Exponential GARCH (EGARCH), and Threshold GARCH (TGARCH) models to capture the best model specification of the volatility of real exchange rates. To this end, three steps are followed. First, since GARCH modelling requires the variables to be stationary, the augmented Dickey-Fuller (ADF) and Zivot-Andrews unit root tests are carried out and reported in Table B1.

Table B1
Unit root test results of real exchange rates

	ADF		Zivot and Andrews	
Variables	Level	First difference	Level	First difference
REX_{USA}	−0.590	−10.792***	−2.888	−14.728***
REX_{GER}	−1.213	−10.571***	−3.720	−13.561***
REX_{RUS}	−0.724	−8.633***	−4.714	−10.745***
REX_{UK}	−0.621	−10.951***	−2.880	−10.864***
REX_{BEL}	−1.112	−10.761***	−3.729	−10.381***
REX_{FRA}	−1.095	−10.724***	−3.699	−10.348***
REX_{SPA}	−0.933	−10.575***	−3.568	−13.661***
REX_{NED}	−1.199	−10.832***	−3.815	−10.472***
REX_{ITA}	−0.957	−10.760***	−3.698	−10.317***

Notes: ADF critical values are −3.440, −2.856, −2.560 and Zivot and Andrews (1992) critical values are −5.340, −4.800 and −4.580 for %1, %5 and %10, respectively. Maximum lags were chosen as 12 and optimal lags were selected by t-stat significance. ***, **, * indicates the rejection of null hypothesis at %1, %5, and %10 level.

As can be seen in Table B1, since all series are stationary in first differences, the first-differenced variables are included in the analysis. Following Hucket-Bourdon and Bahmani-Oskooee (2013), Bahmani-Oskooee and Aftab (2017), Chien et al. (2020), it is assumed that the variables of concern, REX follows a first-order auto-regressive process, $REX_t = \theta_0 + \theta_1 REX_{t-1} + u_t$. Second, in order to generate the predicted value of the conditional variance, the GARCH-type models are estimated as follows:

$$GARCH \quad h_t^2 = \omega + \alpha u_{t-1}^2 + \beta h_{t-1}^2$$

$$\text{EGARCH} \quad \log\left(h_t^2\right) = \omega + \alpha\left[\left|\frac{u_{t-1}}{h_{t-1}}\right| - \sqrt{2/\pi}\right] + \beta \log\left(h_{t-1}^2\right) + \delta\frac{u_{t-1}}{h_{t-1}}$$

$$\text{TGARCH} \quad h_t^2 = \omega + \alpha u_{t-1}^2 + \beta h_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1}$$

where $u_t \sim N(0,\, h_t^2)$ and h_t^2 is the conditional variance.

Thirdly, after obtaining the volatility proxies for different modelling specifications, the one is chosen which gives minimum Akaike (AIC) and Schwarz (SIC) information criteria. In our cases, TGARCH is the most suitable model specification for measuring the volatility of the dollar and ruble, while EGARCH is chosen as the best specification for pound and euro.

Table B2
GARCH-type models estimations for Belgium and France

	REX_{BEL}			**REX_{FRA}**		
	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH
Mean Equation						
Constant (**c**)	0.016*** (0.006)	0.017*** (0.005)	0.215*** (0.005)	0.015*** (0.005)	0.015*** (0.005)	0.020*** (0.005)
AR(1) (φ_1)	0.149** (0.065)	0.351*** (0.074)	0.233*** (0.078)	0.172*** (0.065)	0.383*** (0.072)	0.261*** (0.074)
Variance Equation						
Constant (ω)	0.001** (0.001)	−0.251*** (0.095)	0.001** (0.001)	0.001** (0.001)	−0.245*** (0.084)	0.001*** (0.001)
ARCH (α)	0.435*** (0.101)	0.034 (0.040)	0.499*** (0.153)	0.449*** (0.107)	0.025 (0.045)	0.542*** (0.159)
GARCH (β)	0.658*** (0.061)	0.953*** (0.022)	0.733*** (0.077)	0.663*** (0.062)	0.954*** (0.020)	0.711*** (0.078)
EGARCH (δ)	-	0.326*** (0.089)	-	-	0.344*** (0.087)	-
TGARCH (γ)	-	-	−0.521*** (0.144)	-	-	−0.558*** (0.157)
LL	180.596	**195.173**	190.422	180.463	**195.327**	189.726
AIC	−1.641	**−1.767**	−1.723	−1.639	**−1.769**	−1.717
SIC	−1.562	**−1.673**	−1.629	−1.561	**−1.675**	−1.622
RMSE	0.2856	0.2846	0.2844	0.3001	0.2990	0.2988

Notes: ***,** and * denote statistically significance at the 1%, 5% and 10% levels, respectively. LL: Log Likelihood. AIC: Akaike Information Criteria. SIC: Schwarz Information Criteria. RMSE: Root Mean Squared Error. Bold represents the chosen model according to LL, AIC and SIC.

Table B3
GARCH-type models estimation results for Germany and Italy

	REX_{GER}			REX_{ITA}		
	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH
Mean Equation						
Constant (**c**)	0.016*** (0.006)	0.016*** (0.005)	0.021*** (0.005)	0.015** (0.006)	0.016*** (0.005)	0.020*** (0.005)
AR(1) (φ_1)	0.153** (0.064)	0.359*** (0.074)	0.235*** (0.077)	0.180*** (0.063)	0.378*** (0.070)	0.285*** (0.077)
Variance Equation						
Constant (ω)	0.001** (0.001)	−0.237*** (0.084)	0.001*** (0.001)	0.001** (0.001)	−0.232*** (0.085)	0.001** (0.001)
ARCH (α)	0.421*** (0.091)	0.021 (0.044)	0.507*** (0.146)	“0.395*** (0.093)	0.033 (0.045)	0.453*** (0.133)
GARCH (β)	0.686*** (0.052)	0.955*** (0.020)	0.738*** (0.069)	0.700*** (0.056)	0.957*** (0.020)	0.777*** (0.066)
EGARCH (δ)	-	0.335*** (0.090)	-	-	0.326*** (0.089)	-
TGARCH (γ)	-	-	−0.539*** (0.140)	-	-	−0.492*** (0.136)
LL	177.147	**193.348**	186.737	180.188	**195.717**	190.372
AIC	−1.608	**−1.750**	−1.689	−1.637	**−1.773**	−1.723
SIC	−1.530	**−1.656**	−1.594	−1.558	**−1.678**	−1.628
RMSE	0.2910	0.2900	0.2898	0.2989	0.2979	0.2977

See the footnotes of Table B2.

Table B4
GARCH-type models estimation results for the Netherlands and Russia

	REX_{NED}			REX_{RUS}		
	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH
Mean Equation						
Constant (**c**)	0.014** (0.005)	0.019*** (0.003)	0.020*** (0.005)	0.001 (0.001)	0.001* (0.001)	0.001* (0.001)
AR(1) (φ_1)	0.164** (0.068)	0.369*** (0.058)	0.236*** (0.080)	0.283*** (0.089)	0.456*** (0.076)	0.436*** (0.082)
Variance Equation						
Constant (ω)	0.001** (0.001)	0.014 (0.019)	0.001*** (0.001)	0.001*** (0.001)	−3.484*** (0.804)	0.001*** (0.001)
ARCH (α)	0.449*** (0.095)	−0.136*** (0.022)	0.579*** (0.157)	0.425*** (0.153)	0.516*** (0.115)	0.745** (0.291)
GARCH (β)	0.662*** (0.049)	0.979*** (0.001)	0.689*** (0.063)	0.448*** (0.101)	0.739*** (0.065)	0.455*** (0.103)
EGARCH (δ)	-	0.281*** (0.045)	-	-	0.292*** (0.076)	-
TGARCH (γ)	-	-	−0.553*** (0.150)	-	-	−0.693** (0.287)
LL	181.109	**202.344**	189.552	943.689	949.397	**949.806**
AIC	−1.645	**−1.834**	−1.715	−9.025	−9.071	**−9.075**
SIC	−1.567	**−1.740**	−1.621	−8.945	−8.974	**−8.978**
RMSE	0.2923	0.2906	0.2911	0.0032	0.0032	0.0032

See the footnotes of Table B2.

Table B5
GARCH-type models estimations for Spain and the United Kingdom

	REX_{SPA}			REX_{UK}		
	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH
Mean Equation						
Constant (**c**)	0.014** (0.006)	0.015*** (0.005)	0.019*** (0.005)	0.019** (0.007)	0.027*** (0.005)	0.025*** (0.007)
AR(1) (φ_1)	0.139** (0.063)	0.363*** (0.071)	0.227*** (0.074)	0.198*** (0.001)	0.342*** (0.063)	0.247*** (0.074)
Variance Equation						
Constant (ω)	0.001*** (0.001)	−0.254*** (0.090)	0.001*** (0.001)	0.001 (0.001)	0.045*** (0.015)	0.001** (0.001)
ARCH (α)	0.552*** (0.117)	0.012 (0.045)	0.745*** (0.182)	0.295*** (0.091)	−0.098*** (0.020)	0.364*** (0.107)
GARCH (β)	0.577*** (0.068)	0.952*** (0.022)	0.596*** (0.078)	0.767*** (0.078)	0.987*** (0.001)	0.779*** (0.062)
EGARCH (δ)	-	0.0338*** (0.090)	-	-	0.207*** (0.037)	-
TGARCH (γ)	-	-	−0.768*** (0.193)	-	-	−0.274*** (0.093)
LL	177.319	**191.106**	187.437	126.610	**146.300**	129.889
AIC	−1.610	**−1.729**	−1.695	−1.136	**−1.311**	−1.157
SIC	−1.531	**−1.635**	−1.601	−1.057	**−1.216**	−1.063
RMSE	0.2968	0.2956	0.2955	0.3243	0.3223	0.3231

See the footnotes of Table B2.

Table B6
GARCH-type models estimations for the USA

	REX_{USA}		
	GARCH	EGARCH	TGARCH
Mean Equation			
Constant (**c**)	0.008** (0.003)	0.012*** (0.004)	0.008*** (0.002)
AR(1) (φ_1)	0.284*** (0.050)	0.393*** (0.064)	0.392*** (0.041)
Variance Equation			
Constant (ω)	0.001** (0.001)	−0.434*** (0.066)	0.001*** (0.001)
ARCH (α)	0.458*** (0.078)	0.221*** (0.069)	0.380*** (0.064)
GARCH (β)	0.692*** (0.040)	0.948*** (0.011)	0.879*** (0.025)
EGARCH (δ)	-	0.345*** (0.059)	-
TGARCH (γ)	-	-	−0.776*** (0.099)
LL	228.275	237.628	**247.673**
AIC	−2.0866	−2.164	**−2.258**
SIC	−2.0080	−2.070	**−2.164**
RMSE	0.2470	0.2457	0.2466

See the footnotes of Table B2. Appendix C: Unit root tests.

Table C1
Unit root test results

	lnCON				lnINT			
	ADF		Zivot & Andrews		ADF		Zivot & Andrews	
	Level	First Dif.	Level	First Dif.	Level	First Dif.	Level	First Dif.
BEL	−2.434	−11.641***	−2.869	−5.733***	−2.539	−9.837***	−2.805	−9.993***
FRA	−3.093**	-	−3.766	−8.967***	−2.208	−14.687***	−2.499	−6.284***
GER	−3.719***	-	−4.015	−13.14***	−2.306	−24.680***	−3.021	−5.73***
ITA	−3.369**	-	−3.140	−12.437***	−2.181	−14.627***	−5.178	−8.974***
NED	−2.830*	-	−2.532	−6.014***	−2.332	−14.958***	−2.743	−6.275***
RUS	−2.999**	-	−2.798	−11.544***	−2.133	−9.972***	−2.995	−19.866***
SPA	−3.460***	-	−2.183	−6.248***	−2.391	−11.374***	−2.471	−7.465***
UK	−2.919**	-	−3.048	−8.548***	−2.620*	-	−2.539	−8.195***
USA	−2.891**	-	−3.232	−10.233***	−2.802*	-	−2.977	−5.278***
lnCAP					lnY*			
	ADF		*Zivot & Andrews*		*ADF*		*Zivot & Andrews*	
	Level	First Dif.	Level	First Dif.	Level	First Dif.	Level	First Dif.
BEL	−2.257	−15.305***	−3.000	−6.24***	−1.214	−15.908***	−2.409	−16.622***
FRA	−2.269	−12.622***	−4.279	−7.288***	−1.761	−19.827***	−5.458	−19.873***
GER	−2.987**	-	−3.048	−4.92**	−2.221	−5.655***	−3.634	−8.588***
ITA	−3.444***	-	−3.244	−11.946***	−1.413	−5.039**	−4.564	−7.71***
NED	−3.347**	-	−3.552	−8.313***	−3.313***	-	−4.924	-
RUS	−2.412	−14.961***	−3.217	−10.931***	−1.868	−16.323***	−2.807	−16.674***
SPA	−3.141**	-	−2.858	−6.738***	−1.027	−5.178**	−3.826	−6.507***
UK	−4.950***	-	−5.418***	-	−1.588	−18.009***	−4.690	-
USA	−2.959**	-	−3.685	−5.615***	−1.560	−3.823***	−3.311	−6.221***
lnREX					lnVOL			
	ADF		*Zivot & Andrews*		*ADF*		*Zivot & Andrews*	
	Level	First Dif.	Level	First Dif.	Level	First Dif.	Level	First Dif.
BEL	0.589	−10.833***	−0.638	−11.098***	−1.214	−12.482***	−3.148	−13.231***
FRA	0.630	−10.787***	−0.909	−11.066***	−1.174	−12.747***	−3.109	−5.791***
GER	0.524	−10.643***	−0.638	−10.91***	−1.212	−12.407***	−3.218	−13.135***
ITA	0.736	−10.821***	−0.615	−11.237***	−1.055	−12.608***	−3.099	−13.358***
NED	0.520	−10.894***	−0.700	−11.285***	−0.399	−13.634***	−2.979	−14.007***
RUS	−0.399	−8.716***	−3.506	−10.646***	−5.475***	-	−6.331	−8.698***
SPA	0.752	−10.600***	−1.200	−10.944***	−1.230	−12.526***	−3.177	−13.249***
UK	0.951	−10.910***	−0.466	−7.256***	0.970	−13.262***	−1.949	−5.906***
USA	1.645	−7.612***	−0.704	−11.317***	−2.149	−10.157***	−3.043	−9.966***

Notes*:* Maximum lags were chosen as 12 and optimal lags were selected by t-stat significance. ***, **, * indicates the rejection of null hypothesis at %1, %5 and %10 level, respectively.

ADF Model is: $\Delta Y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \varepsilon_t$

The critical values are −3.440 (1%), −2.856 (5%) and −2.560 (10%).

Zivot and Andrews (1992) Model is: $\Delta Y_t = \mu + \beta t + \mu_1 DU_t + \alpha y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \varepsilon_t$

The critical values are −5.340 (1%), −4.800 (5%) and −4.580 (10%).

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