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TIME VARYING CAUSALITY BETWEEN EXCHANGE RATE AND CONTAINER HANDLING VOLUME IN TURKISH PORTS

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Abstract:
The aim of this study is to determine the causal relationship between the tonnage of containers handled at the Turkish ports and major exchange rates. Especially the recent extreme rise in exchange rates in the country increases the motivation of the study. There have been certain studies in the port literature and the results of which contradict one another. It is thought that this situation stems from the use of methods that generate constant coefficients based on the whole sample. In this respect, it is hoped that this study also makes an important contribution to the literature by its method. Time-varying causality method, which allows to determine the causal relationship in the course of time by dividing whole sample into sub-samples instead of examining the causal relationship based on whole sample, is used in the study. The dataset consists of 178 monthly observations and covers the dates between January 2004 and October 2018. According to the results of the analysis carried out in the study, in some periods of the sample, significant causal relations are determined from exchange rates to the volume of container handled at the Turkish ports. In particular, there is a significant causality to the container tonnage handled from the excessive exchange rate increase in recent periods. Due to the derived demand structure, the demand for the ports also varies with the volume of trade. Exchange rate is one of the most important factors of international trade, however dominance of the factors can change over time. It is seen that the conducted studies about the topic have contradictory results. It is thought that this situation stems from methodological constraints and the result of the time-varying causal relation obtained in this study provides a solution to all these contradictions.

Key words:
Nonlinear causality, Turkish ports, throughput, exchange rate

INTRODUCTION

Ports are critical logistics infrastructures for the international movement of goods. Considering that ports work under the umbrella of international trade system in general and maritime transportation in particular, any change that occurs in overall world economy influences the volume of the demand for ports as well as the competition dynamics in the port industry [1]. In terms of gaining a competitive edge in the industry and sustaining their functions economically, port managers should be well aware of the macro-level determinants that might have an impact on the demand. The literature provides evidence for the impact of macro-level determinants such as domestic real income, world commodity prices and foreign exchange market volatility on port throughput [2]. Thus, future planning for ports in terms of port development projects and economic sustainability should be carefully evaluated by taking these external factors into consideration.

For the case of Turkish container terminals, the increase in demand has been showing significant trend shifts over time. In total, 8.8 million TEUs of containers including import, export, cabotage and transit were handled at Turkish container terminals in 2016 whereas the volume reached 10.01 million TEUs in 2017 [3]. In 2018, the statistics provided so far shows an increase of 9.76%, considering the volume of TEU handled in October 2018 and the volume handled in October 2017 [4]. It is expected for the end of the year that the total volume will again exceed the previous years and a new record will be achieved. Naturally, these dramatic increases in the container terminal throughput volumes is a result of increased economic activities in the region. One of the major factors that might help explaining current positivity in Turkish trade is considered to be the recent excessive rise in foreign currencies against Turkish Lira. However, the literature on exchange rate volatility presents contradictory findings in terms of revealing whether it has a positive or a negative impact on international trade of nations (or port throughputs). Therefore, to figure out the relation between the impact of exchange rates on cargo volume of container terminals, this study aims to statistically test whether the presumptions on this causal relationship really exist in the setting of Turkey.

The theoretical explanation of the relationship between the said variables is simple, but it is quite difficult to reveal this relationship statistically. The major reason behind this is that exchange rates in developing countries such as Turkey are very vulnerable to shocks and do not follow a steady course. The external factors that exchange rates are exposed to make them have a nonlinear structure. Therefore, while examining the relationship between exchange rates and other economic variables, linear methods may be insufficient. Moreover, since there are many factors affecting international trade, it is not reasonable to claim that the factor affecting trade is only or permanently the exchange rates. As the dominant factors during the period are constantly changing, impact of exchange rates may vary in terms of magnitude based on some other effects within the period. In this context, the causal relationship between the exchange rates and the tonnage of containers that has been handled at Turkish container terminals is examined by means of time-varying causality analysis, which makes it possible to examine the causal relations that vary in the course of time. The data employed for this analysis covers container terminal throughput volumes in tonnages and major exchange rates (USD/TL and Euro/TL) between January 2004 and October 2018. The findings show significance of the relationship changes throughout the covered period. However, especially for the recent years the significant relationship between container terminal throughput volumes and exchange rates has become apparent.

The study is structured as follows; the related literature is reviewed in the first section; the method used in the study is introduced in the second section; the results obtained from the

analysis are presented in the third section; and lastly, the findings are evaluated in the final section.

1 LITERATURE REVIEW

The literature investigating the relationship between exchange rate and its trade related consequences is broad, covering contradictory evidences. In general, the literature on exchange rate volatility includes researches which reveal a positive or a negative effect on trade flows. In addition to this, several papers report that exchange rate volatility does not have any effect on trade flows at all [5].

The researches which report that trade flows are negatively influenced by the exchange rate volatility, mainly argue that uncertainty associated with volatility decreases firms' volume of trade. In other words, not knowing how the exchange rates would affect their revenue, firms hesitate to get involved in international trade activities and narrow down said transactions as much as possible, if there is no mechanism to cope with this risk [6, 7].

In contrary, many researches in the literature support that in some circumstances a positive relationship can exist between firms' exports and volatile exchange rates. This is due to the fact that said condition may result in stronger income over substitution effects and enable firms to enjoy profitable trading transactions [8, 9]. The study of Sercu [10] shows that volatility can increase trade considering that such volatility may not affect the costs of production as much as it affects the sale profits that are to be achieved from foreign markets. Similarly, Sercu and Vanhulle [11] argue that volatility would encourage exports as it increases the value of exporting firms.

When the researches on exchange rate volatility particularly focused on Turkey are examined, some country-specific insights can be obtained. In their study, Demirhan and Demirhan [12] use monthly data between 2001 and 2010 and their findings reveal that stability in the exchange rates has positive effects on export volumes both in the short and the long run. Their study also reveals that Turkish real exports are highly sensitive to the economic crises faced by European countries, as these countries are major importers of Turkey. Focusing on the MINT (Mexico, Indonesia, Nigeria and Turkey) countries, Asteriou et al. [13] investigate the impact of exchange rate volatility on these countries' international trades. Their findings underline that international trade of Turkey shows different characteristics, as in the long term the influence of exchange rate volatility on trade is greater. Considering the short term characteristics, the study reveals that no evidence is present regarding the causality between volatility and import/export demand for Turkey whereas it is present for the cases of Mexico and Indonesia. Tunc and Solakoglu [14] investigate the link between exchange rate volatility and exports by using firm-level data collected from Turkish exporters. Their study adds to our understanding on said relationship as it reveals that the impact of volatility (in terms of its magnitude) varies based on the characteristics of firms. In particular, the study concludes that foreign market dependent firms, the firms listed in the stock market and small firms are not influenced by the volatility.

Lastly, there are several studies that evaluate the impact of exchange rate volatility within the maritime transportation context. In their study on Australia's trade relations with major Asian countries, Chi and Cheng [15] investigate the exchange rate volatility impact within said setting by employing quarterly data from 2000 to 2013. The findings present evidence that maritime export volume is influenced by the exchange rate volatility in majority of the cases. In addition, the authors have found that the effect of volatility varies across country-pairs under investigation. Focusing on the impact of exchange rate volatility on seaborne imports of South Korea, Kim [2] employs import and currency exchange data from the period between 2000 and 2015. The findings of this study reveal a significantly negative

impact. In conclusion, Kim [2] argues that revealing of this causal relationship is important considering that it should be taken into account by the decision makers of port policy and infrastructure development. Kim [16] also focuses on South Korea and employs loaded port cargo throughput in his model along with nominal exchange rates, Baltic Dry Index (BDI) and global economic activities in monthly basis. The findings of this study also support that increases in the nominal exchange rate positively impacts ports' cargo throughput. Regarding the volatility in BDI, the author shows that ports' loaded cargo throughput is affected negatively.

In aggregate, the relationship between exchange rate volatility and trade volume is a topic that has been attracting scholarly interest since the collapse of Bretton Woods system of fixed exchange rates in 1973 [17]. Due to the fact that said relationship is revealed to vary based on the characteristics of countries in terms of their trade and firm structures, our study aims to fill the gap in the literature by focusing on the container handling throughput of Turkey and the exchange rate balance between Turkish Lira, US dollars and Euro.

2 METHODOLOGY

There are quite a number of methods that examine the relationship between variables statistically. Econometric studies take their place in the literature by choosing these from economic variables. The methods used differ according to the purpose of the study, the type of data and their theoretical foundations. Since this study aims to test a causal relationship, it is appropriate to make use of causality analysis.

The most fundamental causality analysis is the method developed by Granger [18] and most of the other causality analyses are derived from this method. The logic of this method is quite simple and the causal relation is related to the past values of the variables examined. If the past values of one of the variables can explain the current value of the other variable, it can be concluded that the explanatory variable is the Granger cause of the other one. The analysis relates to the significance of the historical values of the explanatory variable, and, if significant, Granger causality exists [19]. However, some of the shortcomings of this method have been revealed by researchers in the literature. Firstly, this method assumes a linear relationship between the variables. But, particularly economic and financial series are volatile by their natures and often exposed to unexpected shocks and economic crises [20]. Linear methods, such as Granger causality analysis, assume that the parameters are constant over time [21], which makes them inadequate to detect non-linear relationships [22]. Secondly, standard Granger-based causality analyses examine the relationship considering the whole sample, however the causal relationship between the variables may change over time. A variable may "Granger cause" the other in some periods, but not in other periods [23]. One of the methods developed in order to cope with these limitations is time-varying causality analysis as this method partially alleviates the deficiencies of conventional methods. In this method, causality relations are determined according to the time based on sub-sample data by using bootstrap rolling window technique. Besides, the lack of constant causality assumption at every fraction of time is eliminated [24]. In this way, the evolution and move of the causal relationship between sub-periods can also be tracked [21]. There is no clear technique for the choice of window size, but its being too big or too small makes it difficult to achieve healthy results. Therefore, it is necessary to select the optimum window that will balance between accuracy and representativeness [25]. In addition, the maximum degree of integration (dmax) must be determined before the time varying causality analysis. This value corresponds to the maximum difference level that must be taken in order to make all the series used in the analysis stationary.

As time-varying causality analysis is used for nonlinear relationships, it is necessary to determine that the variables used in the analysis are not linear. ARCH LM test is used for this purpose. First, each variable is converted to a series of returns, then the most appropriate ARIMA model is determined. This model is the one that makes the Akaike information criteria the smallest. Then the model is estimated by the least squares method and examined for robustness. Finally, the non-linearity of the model is tested by applying the ARCH LM test. The null hypothesis of this test can be established as the series has linear structure. Then, according to the results obtained, time-varying causality analysis is applied.

3 FINDINGS AND DISCUSSION

Table 1 presents descriptive statistics of the data used in the study. The dataset consists of 178 monthly observations and covers the dates between January 2004 and October 2018. The statistics of raw series, the logarithmic series and log-return series are shown. According to some values in the return series, the relatively high Kurtosis value (greater than 3) and the different from zero skewness value provide information about the shocks faced by the variables. USD and Euro variables have high Kurtosis values and their Skewness values are positive which means that positive shocks have been more effective in their values in the covered period. The concept of positive shock is value-increasing news. The Jarque-Bera value obtained using these values also shows the distribution of the series. The null hypothesis of this test is that the series are normally distributed. When the probability values are examined, the null hypothesis is rejected in all variables. The fact that the series do not exhibit normal distribution characteristics also provides preliminary information about their nonlinear structure. The nonlinear series are better for the implementation of the nonlinear causality analysis. The JB value provides preliminary information, but identifying the nonlinear structure with different and up-to-date tests increases the validity of the method used in the study. Therefore, the structures of variables are examined using the ARCH LM test.

Tab. 1 *Descriptive Statistics of the Variables*

	TON	**USD**	**EUR**	**Ln TON**	**Ln USD**	**Ln EUR**	**Δ Ln TON**	**Δ Ln USD**	**Δ Ln EUR**
Mean	5785509.	2.07	2.57	15.49	0.64	0.88	0.008	0.008	0.007
Med.	5887838.	1.64	2.22	15.58	0.50	0.79	-0.0006	0.001	0.004
Max.	10518507	6.36	7.42	16.16	1.85	2.00	0.29	0.18	0.17
Min.	2285003.	1.17	1.57	14.64	0.15	0.45	-0.22	-0.08	-0.09
Std. D.	2137471.	0.97	1.03	0.39	0.38	0.33	0.08	0.03	0.03
Skew.	0.20	1.79	1.96	-0.25	0.97	1.00	0.29	1.51	0.99
Kurt.	1.88	6.41	7.62	1.85	3.05	3.56	3.90	8.05	6.59
J-B	10.4	181.6	272.4	11.65	28.49	32.23	8.57	256.1	124.7
Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Obs.	178	178	178	178	178	178	177	177	177

Source: [4, 26]

In order to test the nonlinear structures of the variables by ARCH LM test, the most suitable ARIMA models for each variable are determined and then the ARCH test is applied to the residues of each models. Therefore, the applicability of nonlinear causality tests is supported. First of all, each variable is transformed into a return series using the *Return* $X_i = ln(X_i) – ln(X_{i-1})$ formula, because the financial data need to be transformed into return series in order to establish ARIMA models with them. Then, the best model for each variable according to Akaike values are determined by the automatic ARIMA forecasting function in

an econometric software. The model that makes the Akaike value the smallest is positioned as the most suitable model. Maximum AR and MA values are selected as 12 before the estimation. The model is then estimated by the least squares method. At this point, the values that should be considered in the model are F value, AR roots and MA roots. The F value indicating the meaning of the model should be significant, and the AR and MA roots should be less than 1 in order to say that the model is usable in estimations. After the models are estimated and their consistencies are achieved, the ARCH LM tests are applied to the residues of the models. The null hypothesis of this test is that there is no ARCH effect and the rejection of the null hypothesis confirms the existence of nonlinear structure in the variables.

This procedure is applied for each variable used in the study and the results are summarized briefly. Firstly, ARIMA (10, 8) model, which gives the value of -2.41 in the automatic model selection, is determined as the most suitable model for the tone variable. Then, it is seen that the desired robustness values are obtained by the least squares method. Then the nonlinear structure test is applied and the null hypothesis is rejected in some lags in the ARCH LM test. In other words, the tone variable has non-linear structure. When the same procedure is applied for Euro variable, ARIMA (2, 6) model is determined as the most suitable model with -3.97 Akaike value. Then the model predicted by least squares method is significant according to the value of F and the roots of the model is less than 1. According to the results of the ARCH LM test applied to Euro for the determination of the non-linear structure, the null hypothesis is rejected and the series is confirmed to be nonlinear. Finally, ARIMA (5, 2) model with Akaike value of -3.92 is determined as the most suitable model in the process applied for the USD variable. The estimated model is significant according to the F value and the roots of the model are smaller than 1. According to the ARCH LM test applied later, the null hypothesis can not be rejected. In other words, this non-linear structure cannot be determined by this test. In order to apply nonlinear causality analysis, nonlinearity of one of the variables is enough. However, when the USD variable is examined with the BDS test, which is another test for determination of the nonlinear structure, the result reveals the non-linearity of the model. In other words, there is no problem in the application of non-linear analyses.

In the time-varying causality analysis, the series are not required to be stationary, because this test follows the Toda and Yamamoto [27] process. However, the maximum degree of integration (dmax) is required to be used in the analysis. This value is the maximum degree of difference that the series need to become stationary ones. Therefore, dmax value is determined by applying Augmented Dickey Fuller [28] and Philips Perron [29] unit root tests to the series. According to the test results presented in Table 2, Ton variable is I (0), USD variable is I (1) and Euro variable is I (1).

Tab. 2 *Unit Root Analysis of the Series*

Test	Variable	Level		First Difference	
		Intercept	Trend and Intercept	Intercept	Trend and Intercept
Augmented Dickey-Fuller	Ln Ton	-1.7320	-5.6410***	-17.124***	-17.099***
	Ln USD	2.0317	-0.3543	-6.3415***	-10.228***
	Ln Euro	2.2240	0.2738	-10.379***	-10.737***
Philips-Perron	Ln Ton	-1.6093	-5.6995***	-19.160***	-19.143***
	Ln USD	2.0525	-0.0953	-9.1681***	-9.1753***
	Ln Euro	2.2578	-0.2438	-9.8806***	-9.9699***

Critical values: -2.57 for 10%, -2.87** for 5%, -3.46*** for 1% at Intercept; -3.14* for 10%, -3.43** for 5%, -4.01*** for 1% at Trend and Intercept.*

When the first differences are taken, non-stationary series (USD and Euro) become stationary, which reveals that the maximum integration degree value is set to 1.

After the determination of dmax value, the other initial values that should be selected before the analysis are type of the information criterion, maximum number of lags, rolling window size and bootstrap replications. The number of bootstrap replications is selected as 1000, maximum number of lags is selected as 12, and window for rolling regression is selected as 50. Akaike information criteria (AIC) is used as the information criterion in the study. The maximum number of lags is 12 as the observations are on a monthly basis. If the rolling window is too small, it cannot catch the causality. Conversely, if it is selected too large, it causes loss of information. Therefore, the recommended value is usually 50. The critical value for determining the significance of the relationship is selected as 0.1, and GAUSS econometric software is used in the analysis.

For the purpose of the study, firstly, the causal relationship between the USD and Ton variables is examined unidirectional from the exchange rate to the tonnage and the analysis result is presented in Figure 1. Since the first 50 observations are used in initial calculations, they are excluded from the results of the causality analysis. The null hypothesis of the analysis is that there is no significant causal relationship. The red dashed line in the graph shows a measure of significance at the level of 10%. The blue line shows the probability value of the causal relationship at the related time. The null hypothesis is rejected in the periods when the blue line falls below the red line, and these periods appear as periods in which the significant causal relationship is obtained.

When the graph is examined, it is determined that the null hypothesis is rejected in some periods and there are some significant causal relationships in different lengths. Firstly, there is a causal relationship between USD and Ton for June and October 2010. Also it can be said that there is a long-term causality between the dates of December 2009 and July 2011 although the probability value exceeds the critical value in some short periods. After this period, significant causality relationship could not be determined until March 2017. After this date, even if the significance line is exceeded in the form of short periods, it is clear that there is a causality from exchange rate to tons in the related period. Especially determination of the causal relationship in the recent period of excessive exchange rate increase in the country supports the hypothesis set forth in the study.

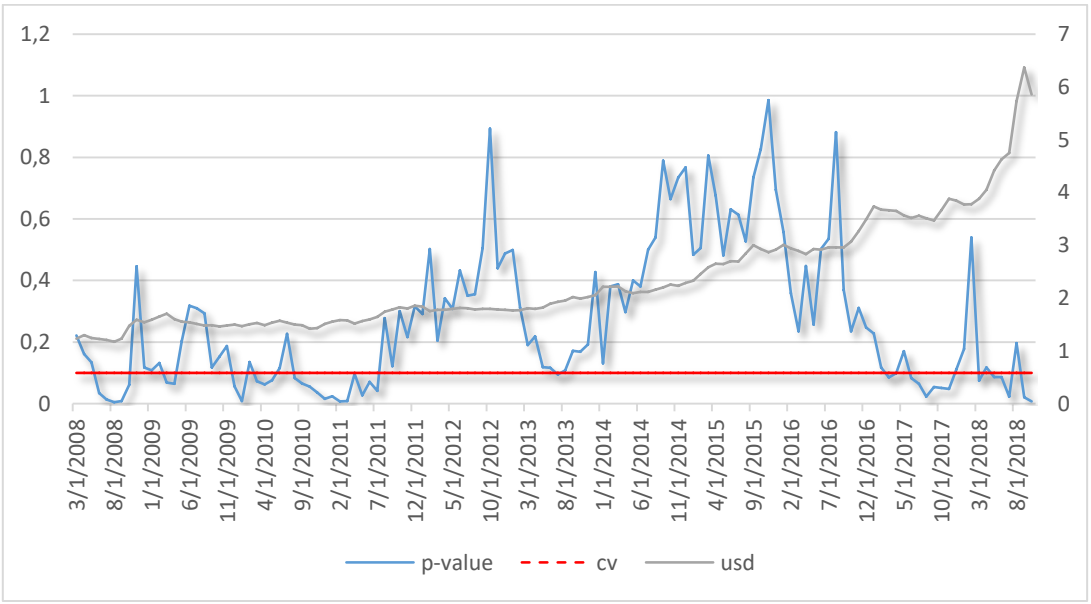

Fig. 1 *Time-Varying Causality between USD and Handling Volume*

The results of the causal relationship from the Euro variable to ton variable is presented in Figure 2. According to the results, several periods of different lengths are determined in which the null hypothesis is rejected. Apart from some minor causal relationships, it can be said that there is a causality relationship between January 2011 and March 2011 for a period of 3 months and between September 2012 and September 2013 for a period of approximately 12 months. Recently, due to the excessive exchange rate increase, there has been a long-term significant causal relationship after August 2017, which also supports the view of the study.

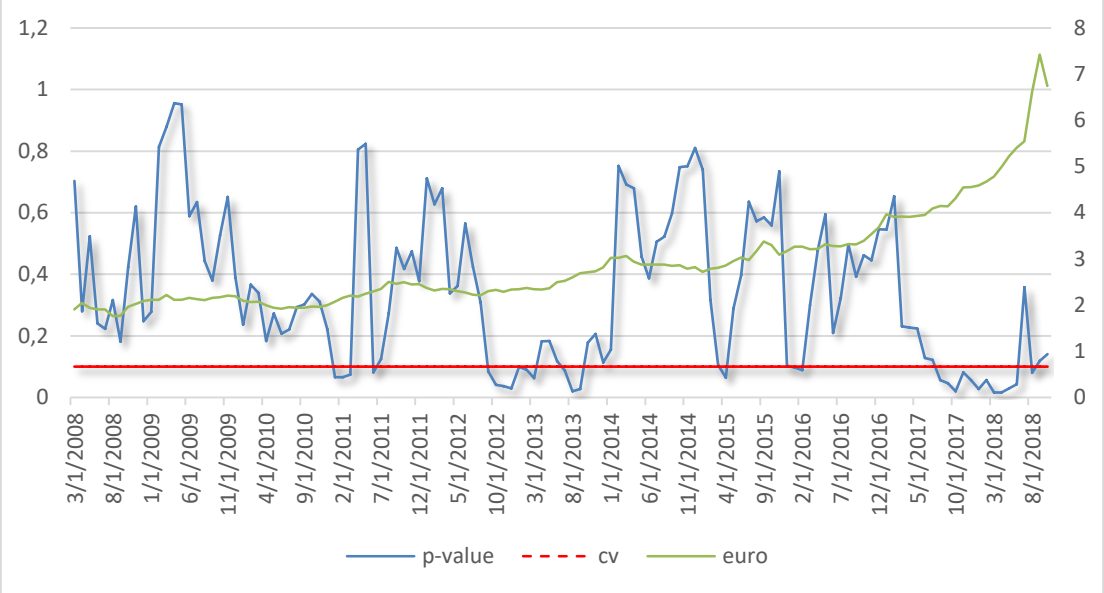

Fig. 2 *Time-Varying Causality between Euro and Handling Volume*

When all the findings are considered in aggregate, it is seen that the measurement based on time-varying causality provides support for both views in the literature. Especially in the time periods characterized by excessive increases in foreign currencies, significant causal relationship between exchange rates and the container terminal throughput volume becomes apparent. This is due to the fact that appreciation of foreign currencies results in increased demand for Turkish products as these products become attractive in terms of their prices when compared their foreign alternatives. This demand not only impacts the export volumes but also causes increases in the import volumes, considering that the firms would need imported intermediate goods for their production [30]. From the ports' perspective, such increase in the economic activities in their hinterland is important considering the derivative nature of demands for port services. In other words, demand increase that the firms located in their hinterland enjoy reflects on the demand for port services. The study of Kim [16] also provides evidence for this causal relationship, as it reveals a positively significant relationship between increase in nominal exchange rate and ports' cargo throughput. On the other hand, findings of this study also reveal that for the larger portion of the time period that is under investigation, evidence for significant relationship is lacking. Stated differently, in many conditions, changes in the exchange rate do not show significant impact on container terminal throughput.

When the impacts of US dollar and Euro are compared based on the above graphs, evidence for the significant relationship exists in longer periods for the case of Euro. This is consistent with the argument of Demirhan and Demirhan [12] as the authors state that Turkish trade is highly influenced by the demand from European countries since these countries are major trading partners of Turkey.

3 CONCLUSION

It can be concluded that impact of exchange rate volatility on container terminal throughput varies based on the time period. The studies reviewed in the literature section differ in terms of their methodological approaches as they carry out their analysis based on the whole sample, presuming the parameters to be constant throughout the time period that is covered. However, the significance of the relationship between the parameters may be changing in time. Therefore, when compared to said findings in the literature, our findings do not jump directly to the conclusion by stating either there is a significant or an insignificant relationship between parameters, rather it provides more detailed investigation results on the characteristics of causality relationship as a result of the methodological nuances. In sum, the causal relationship between efficiency rate volatility and container terminal throughput is rarely stable as there are many other macro and micro level determinants that might influence the impact of volatility on seaborne trade in general.

An important finding that should be highlighted is that exchange rate volatility starting from the end of 2016 has been influencing the container terminal throughput positively. From the terminal managers' perspective, such indicators are important as they may enable forecasting the future demand for their services. Moreover, port development projects regarding the capacity and efficiency issues need to be evaluated by the decision makers in order not to have operational bottlenecks resulted by the increased demand.

However, the investigation that this study provides is in macro-level, and the findings should be evaluated accordingly. Considering that container terminals in Turkey have different characteristics when their competitive position, balance of export/import volumes, hinterland characteristics and roles in the international transportation networks are compared, impact of exchange rate volatility may differ based on these factors. The literature also provides insights on how micro-level analysis may be useful to reveal firms' behaviors under exchange rate volatility. Therefore, we believe that further research on individual container terminals and/or export-import firms in selected hinterlands is necessary to fully understand the volatility impact on container terminal throughput. Moreover, such studies may provide more proper guidelines for respective container terminals in terms of their port development plans.

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