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**INDUSTRIAL PRODUCTION AS A LEADING INDICATOR FOR CONTAINER PORT THROUGHPUT IN TURKEY**

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***ABSTRACT***

*The purpose of this study is to determine the causal relationship between container traffic in Turkish ports and industrial production of Turkey considering the possible nonlinear structures and lagged impacts in order to generate results which are likely to be useful for the future planning of the ports. In accordance with this purpose, the non-linear test proposed by* *Diks and Panchenko (2006) has been used. The dataset consists of 172 monthly observations and covers the period between January 2005 and April 2019. According to the results obtained by considering the nonlinear structures, there is a significant unidirectional causality relationship from industrial production index to port throughputs and the impact continues during 3 periods (months).* *This situation can be thought to be caused by the intensive use of imported intermediate goods by Turkish producers. According to the demand level, it may take several periods for the changes in the future production planning to be reflected in the ports. These results are hoped to provide significant contributions both to ports, port users and policy makers in terms of strategy development and planning.*

***Keywords:*** *Lagged causality, Turkish Ports, Industrial Production Index.*

**TÜRKİYE’DEKİ KONTEYNER LİMANLARININ ÇIKTISINA ÖNCÜ BİR GÖSTERGE OLARAK ENDÜSTRİYEL ÜRETİM**

***ÖZET***

*Bu çalışmanın amacı, limanların gelecek planlamaları için faydalı sonuçlar elde etmek için Türk limanlarındaki konteyner trafiği ile Türkiye’nin endüstriyel üretimi arasındaki nedensellik ilişkisini doğrusal olmayan yapıları ve muhtemel gecikmeli etkileri göz önünde bulundurarak tespit etmektir. Bu amaç doğrultusunda Diks ve Panchenko (2006) tarafından önerilen doğrusal olmayan nedensellik testi kullanılmaktadır. Veri seti Ocak 2005 ve Nisan 2019 dönemleri arasını kapsayan aylık bazda 172 gözlemden oluşmaktadır. Araştırmaya konu olan değişkenlerdeki doğrusal olmayan yapı göz önünde bulundurularak yapılan analizler sonucunda elde edilen bulgulara göre, endüstriyel üretim endeksinden liman çıktı hacimlerine tek yönlü anlamlı nedensellik ilişkisi olduğu ve 3 dönem (ay) boyunca etkisini sürdürdüğü tespit edilmiştir. Talep seviyesine göre gelecek üretim planlamalarındaki değişimlerin limanlara yansıması birkaç dönem sürebildiği için, bu durumun Türk üreticilerinin ithal ara mallarını üretim faaliyetlerinde yoğun olarak kullanmaları nedeniyle oluştuğu düşünülebilir. Bu sonuçların hem limanlara, hem de liman kullanıcıları ve politika belirleyicilere strateji geliştirme ve planlama konularında önemli katkılar sunacağı umulmaktadır.*

***Anahtar Kelimeler:*** *Gecikmeli nedensellik, Türk limanları, Endüstriyel Üretim Endeksi.*

1. **INTRODUCTION**

Ports are significant transfer nodes of the global supply chains which are directly affected by the fluctuations in production activities within country. These fluctuations may have both positive or negative impacts on ports. One of the most important indicators of production activities for countries is the industrial production index. Various inferences are made by almost all people of the countries, including politicians, economists, researchers, investors and students in order to develop strategies based on several interests.

There are several studies in the port literature that use industrial production as a variable to estimate port throughputs. However, this study differs from the literature in two ways; (i) addressing the issue from a nonlinear perspective; (ii) considering that the causal relationship between variables may be delayed. Since there are various alternative means of transport to foreign markets, it is difficult to establish a linear relationship between industrial production and cargo traffic at ports. Moreover, when political strategies of country with its neighbors are considered, it can be stated that the freight traffic at the ports is subject to many unexpected shocks and developments. In this respect, it is natural that the freight traffic data at ports show non-linear characteristics. Likewise, the industrial production is also subject to many unexpected shocks, which may cause the lack of linearity as well. The non-linear analysis of the relationship between container traffic at ports and industrial production is more justifiable. On the other hand, the interaction between variables may not be formed instantaneously and may occur after a certain time. In fact, the impact of changes in one variable on the other variable may continue for many periods. Neglecting these factors may actually ignore an existing relationship. Despite these important points, in the literature, no study examining the relationship in these perspectives has been found. Thus, this study is hoped to present an original contribution to the literature by approaching the subject from a non-linear point of view which is more suitable for the characteristics of these variables.

After the nonlinear structures of the industrial production index and port throughputs have been verified, the results of the method proposed by Diks and Panchenko (2006) has revealed that the changes in industrial production have an immediate impact on the amount of container throughputs in ports and the impact is continued for further two periods (months). Since the cargo throughputs are not separated as import and export ones, this situation may be due to the high import volume of imported intermediate goods of Turkish exporters. They may plan their future production levels based on current industrial production level and therefore their order of intermediate good levels may be reflected to the port traffics in the further periods. The results provide an original contribution to the literature as well as important proposal for port managers and operators. The results indicate that the industrial production index is an important indicator for port throughput levels and it is hoped that adjustment of capacity planning according to this indicator may help them to achieve more efficient port operations.

After the introduction presented in the first section, the related literature has been reviewed and how this study contributes to the existing knowledge has been explained in the second section of the study. In the third section, the method used in the study has been introduced and why it has been selected has been discussed. The dataset used has been examined and the analyzes have been applied in the fourth section. Finally, in the last section, the results have been presented and conclusions have been drawn for the policymakers and related business entities.

1. **LITERATURE REVIEW**

Within the maritime literature, the studies examining the relationship between macro-economic indicators and their effect on certain outcomes related with the magnitude of maritime transportation (e.g. port throughput, fleet size) occupy a significant place. This is due to the fact that the demand for maritime transportation is derived by its nature and the impact of economic variables determines the sustainability of the businesses carried out by industry actors such as ports, liner shipping companies and intermediaries. Therefore, understanding the link between the economic variables and maritime transportation indicators enables decision makers of the industry to carry out feasible investments, to avoid financial and managerial risks and basically to foresee where the conditions of global and national economy are leading them to. In more detail, Chou et al. (2008) list the major decision activities of a port organization influenced by macro-economic conditions as infrastructure investments, optimization of operation plans, marketing strategies, finance and accounting, and the authors emphasize that all this decision making requires a certain level of information on future impact of macro-economic indicators. From the perspective of government bodies, the authors underline that regional and national transportation plans should be carefully executed with the aid of the information gained from the researches on forecasting transportation demand that use the said indicators as variables.

Given the significance of the macro-economic variables in terms of their role in the management of ports and other maritime businesses, this section will provide the literature review with a focus on the researches which particularly take “industrial production” as a variable linked to port throughput (or similar variables that are capable of representing the volume of maritime transportation). Within this framework, the stream of literature that this paper is interested in is narrow in scope (Vitsounis et al., 2014), and it majorly covers forecasting studies, which operationalize industrial production in their models as one of the independent variables together with several other macro-economic indicators. Although narrow in scope, the mentioned studies reveal significant findings regarding the impact of the indicator on maritime transportation in various country and/or cross-country settings.

For instance, focusing on the Finnish ports, Lättilä and Hilmola (2012) investigate the driving macro-economic factors behind the seaport demand. The authors use regression and ARIMA models together with Monte Carlo simulation to evaluate the impacts of industrial production, GDP, inflation, exchange rates and age distribution. Selection of these independent variables representing the macro-economic conditions which may have an impact on the seaport demand is stated to be carried out based on several interviews with the experts. The results obtained from the model reveal that industrial production is the major driving force behind the demand, although the general assumption considers GDP to be the leading indicator in the Finnish setting. Gosasang et al. (2018) use industrial production together with consumer price index, population, fuel prices, the trade value of imports and exports and growth rate as independent variables in order to forecast the throughput of Bangkok Port. The study aims to integrate this forecasting with equipment planning which in turn enables port managers to enhance port capacity that meet the rising demand. Their data covers 192 months of observation and these are utilized in cause-and-effect forecasting model. The results of the study provide several expansion plans for Bangkok Port which are based on operational and financial evaluations. The study of Chou et al. (2008) aims to forecast Taiwan’s import container volumes by employing industrial production, GDP, whole sale price, GNP per capita and population in its model as driving factors. The authors argue that traditional regression models fail in terms of accuracy when they are used in the settings of developing countries due to the fact that unit price of trade goods produced in these countries has been increasing in value and decreasing in size. Using the data between 1981 and 2001, the study makes a methodological contribution by developing a modified model that fits better for making forecasts for cargo flows of Taiwan. The authors conclude that the same model can be utilized for other developing countries which show similar economic characteristics. The work of Tsai and Huang (2017) is another study that uses industrial production in their forecasting model. The authors aim to predict container flows between major Asian ports. Besides the industrial production, the data consists of exchange rate and GDP covering the period between 1995 and 2010. The authors argue that their forecasting results show relatively small prediction errors, thus can lead ports and shipping companies to make strategic decisions regarding their resource and operations planning.

When the related studies that are focused on Turkey are examined, the study of Korkmaz (2012) comes into prominence as the initial attempt in terms of investigating the relationship between industrial production and maritime transportation related indicators. However, unlike the above-mentioned studies, this study employs industrial production as a dependent variable rather than an independent and evaluates whether number of ships calling Turkish ports has an impact on it. Korkmaz (2012) uses the data covering the period of 2004-2010 and the regression model of the study reveals a positively significant relation between the said variables. The author then concludes that a unit of increase in the ship calls results in 0.65 increase in the industrial production of Turkey. Tunalı and Akarçay (2018), on the other hand, employ industrial production of Turkey as an independent variable in their regression model. The authors aim to reveal the impact of the variable on Turkish maritime trade by using the related data covering the period of 2010-2014. Their results show that the change in industrial production explains 56% of the change in maritime transportation. In aggregate, the studies that are focused on Turkey provide insights on the relationship between industrial production and maritime trade. Our study aims to contribute to this existing knowledge through an investigation on the relationship by employing “port throughput” as the dependent variable. When the broader literature of Turkish port studies is examined, it is seen that port throughput is used as a variable mostly in the studies that evaluate relative operational efficiencies of Turkish ports (e.g. Ateş and Esmer, 2014; Güner, 2015; Açık and Sağlam, 2018). However, these studies are focused on micro level analysis and the use of the variable within a macro level framework still lacks, despite its utility. Considering that ports are crucial elements of maritime transportation together with seaborne transport companies, forming the model as stated is believed to provide richer insights on the relationship from the point of ports.

1. **METHODOLOGY**

There are several methods that are used to determine the relationships between variables in order to define their mechanisms. Selection of these methods differs according to the purpose of the study, the data used and the theory taken as basis. The causality relations between the variables are one of the most popular issues that are found by many researchers to be worth investigating.

The linear standard causality analysis developed by Granger (1969) is the basis of the methods that examine causality relations from several perspectives. This analysis considers whether the past values of a variable predicts current and future values of the other variable while examining the causal relationship between the two (Yu et al., 2015). In other words, the test confirms a correlation between the current value of the first one and the past values of the second when the causality is the case (Chiou-Wei et al., 2008). Four different conditions may occur in this case; (i) both variables may be the cause of each other; (ii) the first variable may be the cause of the second one; (iii) the second variable may be the cause of the first one; (iv) neither of the variables may be the cause of the other. As an illustration, suppose that the causal relationship between a dependent and an independent variable is examined. If the dependent one is better explained by the independent variable and the past values of the independent one compared to its own values, the independent one is stated as Granger cause of the dependent one (Dura et al., 2017).

The Granger causality test is a very successful method for detecting linear relationships, but it is inadequate to detect nonlinear relationships since it assumes relationships to be linear (Brock, 1991; Baek and Brock, 1992; Hiemstra and Jones, 1994; Balcilar et al., 2011; Adıgüzel et al., 2013; Bal and Rath, 2015; Kumar, 2017). Unfortunately, this method loses its functionality, considering that the relations between the variables are far from linear way in the globalized world conditions. Factors such as high volatility, crisis (Bildirici and Turkmen, 2015), reform policies, sudden changes in economic structure and industrial production, and investor heterogeneity (Ajmi et al. 2013) pave the way for the formation of non-linear relationships. With regard to these deficiencies, several non-parametric methods for analyzing non-linear Granger causality have been developed by researchers (Baek and Brock, 1992; Hiemstra and Jones, 1994; Diks and Panchenko, 2006). There is also a large number of nonlinear methods proposed in several other researches, but previously mentioned studies better constitute the basis of the method to determine the lagged relationships in accordance with the objectives of this study.

Firstly, the method developed by Baek and Brock (1992) assumes the series to be mutually and individually independent and identically distributed. However, this assumption has limited the researchers as the macro-economic data generally don’t have these assumed characteristics. In order to overcome this restriction, Hiemstra and Jones (1994) have developed a new method (HJ method) allowing the series to exhibit short-term temporary dependencies. However, in further studies, it has been found that there is an over-rejection problem in HJ method when the size of the sample increases (Diks and Ponchenko, 2005). The most up-to-date method within this causality approach is proposed by Diks and Panchenko (2006), which eliminates the over-rejection problem of HJ method. Another advantage of this method is that it can detect the lagged causality relationships between the considered variables. The method proposed by Diks and Panchenko (2006) is one of the most used non-parametric causality analysis in the related literature. This study follows this methodology based on two major reasons; (i) it identifies non-linear causality relationships, and (ii) it presents the relationship as lagged periods. Based on these advantages that the method has, this study has adopted this methodology for the aim of evaluating the relationship between industrial production and port throughput.

Since the method is a non-linear method, it is important to detect non-linear structures in the related series. Also, nowadays most data are disrupted by their linear structures as they are exposed to too many unexpected events and shocks. Accordingly, ARCH LM test has initially been used to test the linearity of the series. After this verification, non-linear causality test has been applied. On the other hand, it is important to determine the lagged causality relationship between the variables. It is natural to have a lagged interaction since production activities take time and documentation operations in foreign trade transactions are high. The analysis has been performed by considering these factors.

In order to evaluate the relationship, monthly data of industrial production and port throughput have been collected respectively from the databases of Turkish Statistical Institute (TurkStat) and Ministry of Transport and Infrastructure. Industrial Production Index is an indicator that reflects the changes in industrial production levels of the industrial entities in Turkey. The index assumes the production level in 2005 as 100. It is calculated by TurkStat and updated monthly according to the data generated by Monthly Industrial Production Survey conducted with the industry stakeholders. Any increase or decrease in industrial production is observed through this index (Eğilmez, 2012). The index data obtained from the website of the official statistics portal of the Turkey (TurkStat, 2019). Port throughput data, on the other hand, represents the sum of TEU (Twenty-foot Equivalent Unit) handled on a monthly basis and published by Ministry of Transport and Infrastructure in the official website (UDHB, 2019). Industrial production index is obtained seasonally adjusted in the data source, while the port throughput is seasonally adjusted by the authors and used for analysis. The dataset used are presented in Appendix 1 in tabular form.

1. **FINDINGS**

In Figure 1, the relationship between Industrial Production Index and port throughput can be visually monitored. It can be stated that the variables mostly follow a parallel course in general. This is an expected situation since the increase in industrial production of the country is generally caused by external demand, and this external demand is met via handling the goods at ports for their seaborne transportation. However, in order to determine the econometrically healthy relationships, it is necessary to analyze the structure of the variables. For this purpose, descriptive statistics of variables should be examined.

**Figure 1.** Graphical Display of the Industrial Production Index and Tonnage Handled

Source: TurkStat, 2019; UDHB, 2019

Descriptive statistics of the variables used in the study are presented in Table 3. The dataset consists of 172 monthly observations, and covers the period between January 2005 and April 2018. To be able to perform a non-linear causality analysis with the presented data, the series should have non-linear structures in order to provide more robust results. The ARCH LM test has also been applied in the further process in order to determine of the non-linearity. In addition to this test, the distribution of the data which are converted to the return series through *Return Xi = ln(Xi) – ln(Xi-1)* also provides information about non-linearity. The exposures of the variables to many unexpected events and shocks distort their distribution structures and cause non-normal distributions, which is also an indication of the non-linearity. The Jarque-Bera test is a method used to determine the normal distribution, and its null hypothesis indicates that the series is normally distributed. According to the JB test results presented in Table 1, the normal distribution is rejected at 90% confidence interval for Industrial Production, and at 95% confidence interval for Tonnage Handled.

**Table 1.** Descriptive Statistics of the Variables

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Industry** | **Ton** | **Ln Ind.** | **Ln Ton** | **∆ Ln Ind.** | **∆ Ln Ton** |
| Mean | 84.32 | 572222 | 4.40 | 13.19 | 0.003 | 0.007 |
| Median | 83.18 | 584888 | 4.42 | 13.27 | 0.003 | 0.008 |
| Maximum | 120.3 | 1026859 | 4.79 | 13.81 | 0.071 | 0.137 |
| Minimum | 57.00 | 225391 | 4.04 | 12.47 | -0.070 | -0.262 |
| Std. Dev. | 18.76 | 198879 | 0.22 | 0.36 | 0.02 | 0.04 |
| Skewness | 0.25 | 0.17 | 0.03 | -0.31 | -0.28 | -1.00 |
| Kurtosis | 1.73 | 2.01 | 1.65 | 1.95 | 4.34 | 8.80 |
| Jarque-Bera | 13.32 | 7.74 | 12.97 | 10.62 | 15.22 | 268.9 |
| Probability | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 172 | 172 | 172 | 172 | 171 | 171 |

Source: TurkStat, 2019; UDHB, 2019.

ARCH LM test has been applied to determine whether the variables are nonlinear. For this test, the series are first converted to return series by implementing the *Return Xi = ln(Xi)– ln(Xi-1)* formula. Then, after the stationary controls are made, deterministic elements in the series needs to be determined and separated. For this purpose, the most appropriate ARMA model is determined according to Akaike information criteria (AIC), and the model is estimated by least squares method. If the predicted model is significant according to F statistics and all of the roots of the model are smaller than 1, it can be concluded that the model is usable. Finally, the ARCH LM test is applied to the residuals of the model and the linearity test is completed. If the ARCH effect is detected in the stochastic part of the model (in the residuals), it is concluded that the structure of the variable is non-linear. The null hypothesis of this test is that there is no ARCH effect. In other words, the rejection of the null hypothesis means that it is not linear.

Firstly, the Industrial Production Index is converted to a series of returns and the most suitable model is determined by the automatic ARIMA forecasting function. ARMA (12, 7) model with AIC value of -4.92 is determined as the most suitable model. Then it is determined that the model estimated by the least squares method is significant according to the F statistic and all roots are smaller than 1. In the ARCH LM test performed on the stochastic part of the model, the null hypothesis is rejected and an ARCH effect is found. This shows that Industrial Production Index has a non-linear structure. Secondly, the same process is also applied for the tonnage of containers handled. The model ARMA (3, 3), which has a lowest AIC value of -3.42, is determined as the most suitable model for the return variable. Then it is observed that the model predicted by the least squares method is significant according to the F statistic and all the roots are smaller than 1. According to the ARCH LM test performed to the residuals of the model, the null hypothesis is rejected, which shows that the structure of the tonnage variable is non-linear. According to the results of these analyses, it is approved that both variables are suitable for nonlinear causality analysis.

In order to apply the causality analysis developed by Diks and Panchenko (2006), the series must be stationary. For this reason, the Augmented Dickey-Fuller (1979) unit root test is applied to both series and the results are shown in Table 2. According to the results, both of the variables contain unit roots at the level and they become stationary when the first differences are taken. Therefore, it is found that both variables are I (1). As a result, the first differences of both variables are taken and causality analysis is applied.

**Table 2.** Unit Root Analysis of the Series

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Level** | | **First Difference** | |
| **Variable** | **Intercept** | **Trend and Intercept** | **Intercept** | **Trend and Intercept** |
| Ln Teu | -0.961 | -2.860 | -16.788\*\*\* | -16.746\*\*\* |
| Ln Industry | -0.742 | -2.310 | -15.776\* | -15.730 |

Critical values: -2.57\* for 10%, -2.87\*\* for 5%, -3.47\*\*\* for 1% at Intercept; -3.14\* for 10%, -3.43\*\* for 5%, -4.01\*\*\* for 1% at Trend and Intercept.

The results of HJ and DP causality analysis applied with stationary series are presented in Table 3. Since the results are more consistent than the HJ test, the results of the DP test are taken into consideration. The analyses have been carried out with a delay of 4 periods. Since the frequency of the data is monthly, each lag is interpreted to correspond to one month. According to the results of the study, unidirectional causality relationship from Turkish industrial production index and the amount of containers handled at Turkish ports has been determined in first three lags, while reverse causality relationship has not been spotted. The causality from industrial production to total port throughput is probably due to the changes in production resulting from foreign demand for Turkish products, and change in industrial production is felt immediately at the ports and continues its effect during the second and third lags (months). On the other hand, the causality from the port throughput to industrial production is also expected due to the use of imported intermediate goods by the Turkish companies in their production activities, however no significant causality from port throughputs to industrial production can be obtained. In addition to making important contributions to the literature, it is thought that these results also provide significant practical contributions to policy makers and ports. In other words, since this study has spotted the lagged causalities, the container traffic in Turkish ports can be estimated for 3 periods by following the industrial production index.

**Table 3.** Causality Test Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **∆ Ln industry does not granger cause ∆ Ln throughput** | | | | |
| Lags | HJ (1994) Probability | HJ (1994)  T statistics | DP (2006)  Probability | DP (2006)  T Statistics |
| 1 | 0.0455\*\* | 0.6895 | 0.0745\* | 1.4427 |
| 2 | 0.0102\*\* | 2.3170 | 0.0443\*\* | 1.7023 |
| 3 | 0.0228\*\* | 1.9975 | 0.0836\*\* | 1.3807 |
| 4 | 0.1185 | 1.1820 | 0.2729 | 0.6039 |
| **∆ Ln throughput does not granger cause ∆ Ln industry** | | | | |
| Lags | HJ (1994) Probability | HJ (1994)  T statistics | DP (2006)  Probability | DP (2006)  T Statistics |
| 1 | 0.1438 | 1.0632 | 0.2056 | 0.8214 |
| 2 | 0.1414 | 1.0737 | 0.2759 | 0.5948 |
| 3 | 0.1050 | 1.2531 | 0.2111 | 0.8023 |
| 4 | 0.1103 | 1.2246 | 0.2621 | 0.6367 |

\*\*\*Significant at 99%, \*\*Significant at 95%, \*Significant at 90%.

**CONCLUSION**

Theoretically it is certain that there is a relationship between industrial production and port throughput, and practically the relationship is supported by many researches in the literature. However, studies in the literature often have ignored the nonlinearity of the series and used industrial production to make instant forecasts. Performing linear analyzes with nonlinear series may cause erroneous results. Moreover, the fact that the interactions of the variables can be extended over a longer period of time has not been given sufficient attention. In this context, it is hoped that this study gives a new perspective to the literature and presents important findings. Furthermore, the lagged examination of the causal relationship proposed by Diks and Panchenko (2006) makes it possible to develop a strategy by providing information on the timing of the causal impact.

As a result of the analyses conducted, the causality relations between the two variables are determined as unidirectional from industrial production index to port throughputs during 3 periods. The causality from the industrial production to the amount of container cargo at ports can be explained by considering exporting domestically produced products to the international markets. The duration of the causality for 3 periods may be derived from the use of the imported intermediate goods of Turkish industries, and consequently due to the order of intermediate goods for future production activities according to the current industrial production levels. Lags in causalities can be expressed as a delay of impact. Since the frequency of the data used in the study is monthly, the lag periods should be interpreted as month. The impact of changes in industrial production on container amounts handled in ports is realized immediately and continues during further 2 months.

These results suggest that port managers can benefit from tracking industrial production while estimating the possible cargo traffic changes at ports. Thus, they may have the opportunity to pre-set area planning, ship schedule, price tariffs and competitive strategies. In terms of policy makers, container freight traffic at ports can be used as a leading indicator for changes in industrial production levels in the country.

In this study, the total amount of containers handled at Turkish ports has been considered as an aggregation of import, export and transit volumes. Separating these volumes may generate more accurate findings. Nevertheless, since the export products of Turkey are mostly produced with imported intermediate goods, our analyses are carried out without separating the total number of containers handled in Turkish ports. In addition, these analyzes can be conducted on a port basis and more specific results can be obtained. However, the lack of access to port-based container handling data is the biggest obstacle to this research subject. Furthermore, since the relationship between the variables may be asymmetric or significant only in some certain periods over time, further researches may be carried out by using different kind of nonlinear causality methods such as asymmetric or time-varying causality tests in order to examine the subjects from different perspectives and to make significant contributions to the port literature.

**REFERENCES**

Açık, A. and Sağlam, B.B. (2018). Recursive data envelopment analysis in port efficiency: an application on Turkish ports. In: *Proceedings of 17th Internationally Participated Business Congress*. İzmir, Turkey

Adıgüzel, U., Bayat, T., Kayhan, S. and Nazlıoğlu, Ş. (2013). Oil prices and exchange rates in Brazil, India and Turkey: Time and frequency domain causality analysis. *Siyaset, Ekonomi ve Yönetim Araştırmaları Dergisi*, 1(1), 49-73.

Ajmi, A. N., El Montasser, G. and Nguyen, D. K. (2013). Testing the relationships between energy consumption and income in G7 countries with nonlinear causality tests. *Economic Modelling*, 35(2013), 126-133.

Ateş, A. and Esmer, S. (2014). Farklı yöntemler ile Türk konteyner limanlarının verimliliği. *Verimlilik Dergisi*, (1), 61-76.

Baek, E. and Brock, W. (1992). A general test for nonlinear Granger causality: bivariate Model. Working Paper. Iowa State University and University of Wisconsin-Madison.

Bal, D. P. and Rath, B. N. (2015). Nonlinear causality between crude oil price and exchange rate: A comparative study of China and India. *Energy Economics*, 51(2015), 149-156.

Balcilar, M., Ozdemir, Z. A. and Cakan, E. (2011). On the nonlinear causality between inflation and inflation uncertainty in the G3 countries. *Journal of Applied Economics*, 14(2), 269-296.

Bildirici, M. E. and Turkmen, C. (2015). Nonlinear causality between oil and precious metals. *Resources Policy*, 46(2), 202-211.

Brock, W. (1991). Causality, Chaos, Explanation and Prediction in Economics and Finance. Casti, J., Karlqvist, A. (Eds.), . In: *Beyond Belief: Randomness, Prediction and Explanation in Science*. Boca Raton, Fla: CRC Press

Chiou-Wei, S. Z., Chen, C. F. and Zhu, Z. (2008). Economic growth and energy consumption revisited—Evidence from linear and nonlinear Granger causality. *Energy Economics*, 30(6), 3063-3076.

Chou, C. C., Chu, C. W. and Liang, G. S. (2008). A modified regression model for forecasting the volumes of Taiwan’s import containers. *Mathematical and Computer Modelling*, 47(9-10), 797-807.

Dickey, D. A. and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366a), 427-431.

Diks, C. and Panchenko, V. (2006). A new statistic and practical guidelines for nonparametric Granger causality testing. *Journal of Economic Dynamics and Control*, 30(9-10), 1647-1669.

Diks, C. and Panchenko, V., (2005). A note on the Hiemstra-Jones test for Granger non-causality, *Studies in Nonlinear Dynamics and Econometrics*. 9(2),1-7.

Dura, Y. C., Beser, M. K. and Acaroglu, H. (2017). Econometric analysis of Turkey's export-led growth. *Ege Akademik Bakış*, 17(2), 295-310.

Gosasang, V., Yip, T. L. and Chandraprakaikul, W. (2018). Long-term container throughput forecast and equipment planning: The case of Bangkok Port. *Maritime Business Review*, 3(1), 53-69.

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society*,37(3), 424-438.

Güner, S. (2015). Investigating infrastructure, superstructure, operating and financial efficiency in the management of Turkish seaports using data envelopment analysis. *Transport Policy*, 40(2015), 36-48.

Hiemstra, C. and Jones, J. D. (1994). Testing for linear and nonlinear Granger causality in the stock price‐volume relation. *The Journal of Finance*, 49(5), 1639-1664.

Korkmaz, O. (2012). Türkiye'de gemi taşımacılığının bazı ekonomik göstergelere etkisi. *Business and Economics Research Journal*, 3(2), 97-109.

Kumar, S. (2017). On the nonlinear relation between crude oil and gold. *Resources Policy*, 51(2017), 219-224.

Lättilä, L. and Hilmola, O. P. (2012). Forecasting long-term demand of largest Finnish sea ports. *International Journal of Applied Management Science*, 4(1), 52-79.

Tsai, F. M. and Huang, L. J. (2017). Using artificial neural networks to predict container flows between the major ports of Asia. *International Journal of Production Research*, 55(17), 5001-5010.

Tunalı, H. and Akarçay, N. (2018). Deniz taşımacılığı ile sanayi üretimi ilişkisinin analizi: Türkiye örneği. *İktisadi İdari ve Siyasal Araştırmalar Dergisi*, 3(6), 111-122.

Vitsounis, T., Paflioti, P. and Tsamourgelis, I. (2014). Determinants of container ports throughput convergence. A business cycle synchronicity analysis. *International Journal of Transport Economics*, 41(2),201-230

Yu, L., Li, J., Tang, L. and Wang, S. (2015). Linear and nonlinear Granger causality investigation between carbon market and crude oil market: A multi-scale approach. *Energy Economics*, 51(2015), 300-311.

**Internet References:**

Eğilmez, M. (2012). Sanayi Üretimi ve Kapasite Kullanımı Nasıl Ölçülür. Kendime Yazılar, http://www.mahfiegilmez.com/2012/03/sanayi-uretimi-ve-kapasite-kullanm-nasl.html, Access Date: 20.03.2019.

TurkStat (2019). *Industrial Production Index,* https://biruni.tuik.gov.tr/medas/?kn=67&locale=tr, Access Date: 20.03.2019.

UDHB (2019). *Container Statistics*, https://atlantis.udhb.gov.tr/istatistik/istatistik\_yuk.aspx, Access Date: 20.03.2019.

**Appendix 1.** Dataset Used in the Study

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Date** | **IP** | **TEU** | **Date** | **IP** | **TEU** | **Date** | **IP** | **TEU** | **Date** | **IP** | **TEU** | **Date** | **IP** | **TEU** | **Date** | **IP** | **TEU** |
| Jan-05 | 60,2 | 257.067 | Jul-07 | 68,6 | 397.932 | Jan-10 | 63,6 | 387.918 | Jul-12 | 84,2 | 599.733 | Jan-15 | 95,2 | 618.926 | Jul-17 | 111,7 | 851.978 |
| Feb-05 | 57,7 | 225.391 | Aug-07 | 69,7 | 407.262 | Feb-10 | 65,1 | 402.019 | Aug-12 | 83 | 606.656 | Feb-15 | 95,2 | 596.597 | Aug-17 | 114,6 | 869.124 |
| Mar-05 | 57,1 | 279.839 | Sep-07 | 70,2 | 392.272 | Mar-10 | 66,3 | 455.854 | Sep-12 | 84,9 | 594.829 | Mar-15 | 99,1 | 730.719 | Sep-17 | 116,2 | 836.632 |
| Apr-05 | 57,7 | 277.823 | Oct-07 | 69,7 | 391.163 | Apr-10 | 67 | 480.284 | Oct-12 | 85 | 590.125 | Apr-15 | 99,4 | 664.487 | Oct-17 | 116,6 | 919.523 |
| May-05 | 58,2 | 279.764 | Nov-07 | 69,9 | 384.885 | May-10 | 68,9 | 514.046 | Nov-12 | 83,8 | 583.475 | May-15 | 99,5 | 690.320 | Nov-17 | 117 | 879.084 |
| Jun-05 | 58 | 281.125 | Dec-07 | 71,8 | 413.506 | Jun-10 | 69,3 | 511.847 | Dec-12 | 85 | 619.965 | Jun-15 | 100,4 | 713.813 | Dec-17 | 120,4 | 907.232 |
| Jul-05 | 59,3 | 287.452 | Jan-08 | 70,8 | 373.808 | Jul-10 | 69,8 | 529.081 | Jan-13 | 85,4 | 604.107 | Jul-15 | 99,8 | 650.802 | Jan-18 | 118 | 867.346 |
| Aug-05 | 60,3 | 292.152 | Feb-08 | 72,2 | 383.840 | Aug-10 | 71,5 | 512.466 | Feb-13 | 87,3 | 574.889 | Aug-15 | 102,6 | 694.121 | Feb-18 | 116,9 | 838.860 |
| Sep-05 | 61 | 284.863 | Mar-08 | 72,2 | 435.486 | Sep-10 | 71,6 | 474.175 | Mar-13 | 87 | 651.197 | Sep-15 | 102,7 | 662.829 | Mar-18 | 116,5 | 904.270 |
| Oct-05 | 62 | 287.437 | Apr-08 | 71,3 | 422.257 | Oct-10 | 72,3 | 515.553 | Apr-13 | 87,7 | 645.661 | Oct-15 | 100,3 | 698.542 | Apr-18 | 117,3 | 911.527 |
| Nov-05 | 62,2 | 269.036 | May-08 | 71,1 | 470.635 | Nov-10 | 74,6 | 442.032 | May-13 | 87,9 | 697.371 | Nov-15 | 102,5 | 677.256 | May-18 | 115,8 | 984.679 |
| Dec-05 | 61,6 | 290.261 | Jun-08 | 71,4 | 443.389 | Dec-10 | 75,8 | 518.182 | Jun-13 | 90,6 | 700.194 | Dec-15 | 103,3 | 747.986 | Jun-18 | 113,1 | 939.914 |
| Jan-06 | 62,1 | 257.321 | Jul-08 | 69,9 | 449.892 | Jan-11 | 79 | 496.317 | Jul-13 | 90,1 | 715.010 | Jan-16 | 102,5 | 675.210 | Jul-18 | 117,3 | 926.172 |
| Feb-06 | 62,5 | 259.577 | Aug-08 | 69 | 468.123 | Feb-11 | 77,8 | 459.396 | Aug-13 | 87,6 | 650.307 | Feb-16 | 103,9 | 694.529 | Aug-18 | 115,2 | 859259 |
| Mar-06 | 64,1 | 306.801 | Sep-08 | 68,8 | 420.234 | Mar-11 | 77,5 | 531.758 | Sep-13 | 92,7 | 683.213 | Mar-16 | 102,7 | 743.773 | Sep-18 | 112,9 | 840702 |
| Apr-06 | 63,6 | 315.862 | Oct-08 | 65,4 | 464.355 | Apr-11 | 77,4 | 573.517 | Oct-13 | 91,7 | 623.061 | Apr-16 | 102,9 | 740.492 | Oct-18 | 110,3 | 957290 |
| May-06 | 64,1 | 329.560 | Nov-08 | 62,9 | 415.605 | May-11 | 78,2 | 586.301 | Nov-13 | 92,3 | 670.458 | May-16 | 104,6 | 769.310 | Nov-18 | 110 | 870011 |
| Jun-06 | 64,5 | 331.024 | Dec-08 | 61,1 | 343.998 | Jun-11 | 79,7 | 538.920 | Dec-13 | 91,8 | 684.465 | Jun-16 | 103,7 | 749.803 | Dec-18 | 108,7 | 943.968 |
| Jul-06 | 64,4 | 335.446 | Jan-09 | 57 | 300.427 | Jul-11 | 81,2 | 592.088 | Jan-14 | 95,2 | 685.157 | Jul-16 | 97,5 | 704.487 | Jan-19 | 109,7 | 870.732 |
| Aug-06 | 64,2 | 342.392 | Feb-09 | 58,2 | 281.062 | Aug-11 | 83,6 | 579.713 | Feb-14 | 94,3 | 634.199 | Aug-16 | 104,8 | 760.857 | Feb-19 | 111,3 | 847.100 |
| Sep-06 | 64,2 | 351.227 | Mar-09 | 57,6 | 315.889 | Sep-11 | 79,2 | 519.579 | Mar-14 | 94,5 | 712.217 | Sep-16 | 102 | 680.954 | Mar-19 | 113,8 | 955.603 |
| Oct-06 | 64,6 | 339.161 | Apr-09 | 58,5 | 306.763 | Oct-11 | 83,7 | 574.345 | Apr-14 | 93,6 | 716.680 | Oct-16 | 106,4 | 777.768 | Apr-19 | 112,6 | 1.026.859 |
| Nov-06 | 64,3 | 343.865 | May-09 | 60,4 | 340.868 | Nov-11 | 82,9 | 531.332 | May-14 | 92,4 | 748.157 | Nov-16 | 105,8 | 734.729 |  |  |  |
| Dec-06 | 66,7 | 345.818 | Jun-09 | 62,1 | 364.445 | Dec-11 | 82,9 | 540.240 | Jun-14 | 94,2 | 738.107 | Dec-16 | 105,3 | 730.064 |  |  |  |
| Jan-07 | 69,4 | 343.673 | Jul-09 | 63,2 | 409.785 | Jan-12 | 82 | 557.473 | Jul-14 | 96,5 | 716.584 | Jan-17 | 106,2 | 765.981 |  |  |  |
| Feb-07 | 67,8 | 326.901 | Aug-09 | 62,4 | 437.465 | Feb-12 | 80,9 | 557.180 | Aug-14 | 91,8 | 680.243 | Feb-17 | 107,5 | 699.814 |  |  |  |
| Mar-07 | 68,9 | 353.914 | Sep-09 | 63,1 | 402.683 | Mar-12 | 82,7 | 601.712 | Sep-14 | 96,1 | 686.096 | Mar-17 | 108,7 | 762.675 |  |  |  |
| Apr-07 | 69,3 | 388.906 | Oct-09 | 64,3 | 425.481 | Apr-12 | 83,7 | 593.408 | Oct-14 | 94,9 | 650.443 | Apr-17 | 111,6 | 818.622 |  |  |  |
| May-07 | 70,4 | 387.758 | Nov-09 | 67 | 394.035 | May-12 | 84 | 647.444 | Nov-14 | 95,7 | 682.808 | May-17 | 110 | 854.808 |  |  |  |
| Jun-07 | 68,9 | 394.096 | Dec-09 | 64,2 | 425.539 | Jun-12 | 83,4 | 640.398 | Dec-14 | 95,6 | 700.431 | Jun-17 | 110,5 | 845.063 |  |  |  |

Source: TurkStat, 2019; UDHB, 2019.

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