

## ENERGY CONSUMPTION, TRADE OPENNESS AND GROWTH NEXUS IN TURKEY: EVIDENCE FROM VECM

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### Abstract

This research investigates the relationship between energy consumption (ENE), trade openness (TI) and economic growth (GDP) in the case of Turkey in the period 1970-2015. VECM is employed. The results suggest a long-run causality which is inferred from the statistically significant error term with GDP and ENE. However, short-run coefficients are not found to be significant in the case of GDP and TI equation. Moreover, the findings suggest that a percentage change in ENE will result in a 1.35% increase in real GDP per capita. While for TI, a percentage change in this variable will result in 0.13% decrease in GDP in the long-run. Hence, real GDP per capita is elastic to the change in energy consumption but inelastic to the change in TI. This paper summarizes in detail the policy implications and the recommendations for future research. At last, the diagnostic tests advocate the stability of the model.

**Key words:** economic growth, energy consumption, trade openness, Turkey, VECM

### Türkiye'de Enerji Tüketimi, Ticari Dışa Açıklık Ve Büyüme İlişkisi: Vektör Hata Düzeltilme Modeli (VECM)

### Özet

Bu araştırma, Türkiye'de enerji tüketimi (ENE), ticari dışa açıklık (TI) ve ekonomik büyüme (GDP) arasındaki ilişkiyi 1970-2015 dönemi için incelemektedir. VECM uygulaması yapılmıştır. Sonuçlar, istatistiksel olarak anlamlı bir hata döneminden çıkarılan GDP ve ENE ile uzun süreli bir nedensellik göstermektedir. Ancak, kısa dönemli katsayılar GDP ve TI denklemi açısından anlamlı bulunmamıştır. Ayrıca, bulgular ENE'deki yüzde değişimin kişi başına düşen GDP'de % 1.35'lik bir artışa yol açacağını göstermektedir. TI için, bu değişimdeki yüzde değişim, uzun vadede GDP'de % 0.13 düşüşe neden olacaktır. Dolayısıyla, kişi başına düşen GDP, enerji tüketimindeki değişime karşı esnek olmakla birlikte, TI'daki değişime karşı esnek değildir. Bu çalışma gelecekteki araştırmalar için politika sonuçlarını ve önerileri detaylı olarak özetlemektedir. Sonuç olarak teşhis testleri modelin istikrarını desteklemektedir.

**Anahtar kelimeler:** ekonomik büyüme, enerji tüketimi, ticari dışa açıklık, Türkiye, VECM

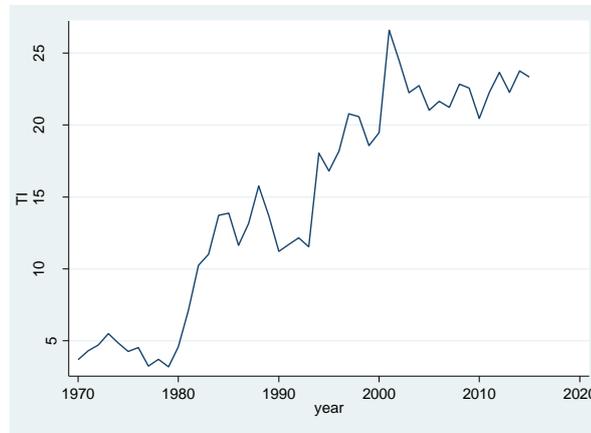
### INTRODUCTION

The trade liberalization process has been started in Turkey in the 1980s. Since that period, trade openness has increased significantly leading into progressing macroeconomic performance. The macroeconomic performance has recorded a tremendous increase after the 2002. As a result, the urbanization has been increased, the poverty rate has been diminished and the extreme poverty almost eliminated. In addition, the income has recorded a significant increase. With regard to

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economic growth, Turkey has recorded a significant increase leading into the rise of real GDP per capita what is used as a proxy of economic growth in this paper.

In order to explain the link between the variables of interest, we start first by presenting the trade statistics of Turkey (<https://atlas.media.mit.edu/en/profile/country/tur/>). Turkey is ranked in the top 30 largest export economies at the global level in the year 2016. However, it has recorded a trade balance that is negative. With regard to exports, the highest amount of money is earned by exporting the gold, second best statistics is in terms of cars and the third in terms of delivery trucks. On the other hand, the highest imports share is connected with the cars, second is petroleum and the third is gold. The Turkey imports the highest amounts in USD from China, Germany and Russia while the top destinations in terms of exports are Germany, United Kingdom and Italy. Both exports and imports have increased significantly as of Turkey in the period of interest. The proxy variable of trade openness in this paper is suggested to be the amount of goods and services in USD that is sold, exchanged as of barter or as a gift (% of GDP). Graph 1 suggests a significant increase in this proxy variable in the period of interest.



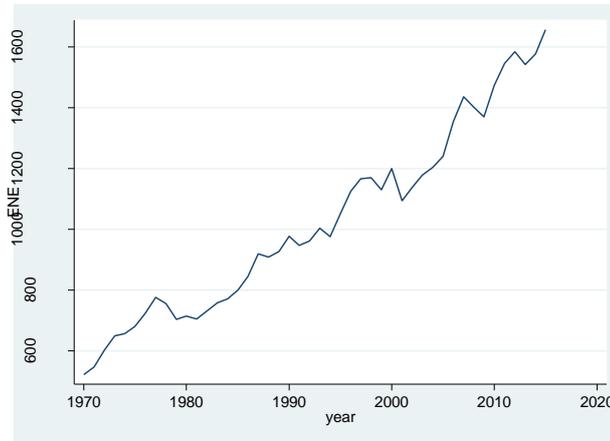
**Graph 1: Trade (Source: Author)**

It is important to emphasize that the relationship between trade liberalization and economic growth has been an interesting issue of debate in the last few decades. Thus, most of the authors suggest a positive link (Grossman and Helpman, 1990:796, Shayanewako, 2018:1, Satrovic, 2018a:97, among others). Apart from these finding, Rodriguez and Rodrik (2001:264) indicate that some of the authors suggest the negative link while some suggest the link that is not significant (Cooke, 2010:94 and Jafari et al., 2012:573) indicating mixed evidence on the link of interest. Besides that, the authors suggest two significant drawbacks in research to follow that arose from the measurement issues as well as the econometrics technique applied. The positive link is connected to the improvement in the productivity. Trade openness does not only increase the availability of the foreign goods and services but also spillovers the foreign human capital which tends to have a significant positive impact on the productivity of the host country. Moreover, the countries specialized in high-tech products can earn much by the inclusion in international trade. With regard to Turkey, it is also important to emphasize a significant increase in the both, export and import, after 1980s as indicated by Meschi et al. (2008).

As of energy consumption-growth nexus, it has been also well-studied in the empirical research to date. However, most of the empirical research provides the conflicting results thus the conclusion on the definite link between these two economic terms of interest can hardly be drawn (Ozturk et al., 2010:4422). Hence, if the results report a unidirectional causal relationship from energy to economic growth, economy is found to be energy dependent and thus policy makers should be aware of this position while making the strategies. In the case when causality runs from

growth to energy, an economy does not need to have that strict energy policy (Ozturk et al., 2010:4422). Chaudry et al. (2012:371) suggest that the globalization has drastically changed the global economy and brought up many issues. Of the most considering is energy, since the demand increases tremendously leading many countries to face a shortage. With regard to Turkey, it is important to emphasize that Turkey has enough resources to produce all energy needed (<https://www.worlddata.info/asia/turkey/energy-consumption.php>).

However, Boluk and Koc (2011) have indicated that only 28% of the total energy demand was met by the energy consumption in Turkey in 2009. Thus, Turkey depends heavily on the imported energy which is in general too expensive. In the light of Turkish economy, it is also important to emphasize that it faces a tremendously increasing energy demand in the period of interest which is summarized by Graph 2.



**Graph 2:** Energy consumption (Source: Author)

The consumption of energy produced from fossil fuels has brought up a serious environmental concern. Due to the fact that Turkey desires to become EU member state, it has to take much care on sustainable development. This is true since the energy consumption is found to be one of the greatest producers of CO<sub>2</sub> globally. Thus, special care should be given to the promotion, consumption and production of energy based on renewable resources. Satrovic (2018b:20) suggests that Turkey has a great potential for it.

The rest of this research article will present the summarized literature review on the link of interest. In addition, we will display the variables used and the methodology that we have conducted to provide the results. Moreover, we will display the results and provide the interpretations. To conclude, some conclusive remarks will be presented together with the policy implications.

## **I. LITERATURE REVIEW**

In the last few decades, the link between the consumption of energy, trade openness and economic growth has been explored quite intensively. To mention a few, Shahbaz et al. (2013:8) suggests long-run link between these variables in the case of China in the period 1971-2011. The authors have used the ARDL bounds testing approach. Moreover, Muhammad and Majeed (2015:658) provide supportive evidence to the long-run relationship between the consumption of energy, trade openness, economic growth and the development of financial sector in the case of India, Nepal, Sri Lanka, Bangladesh and Pakistan. Apart from these findings, Kumar et al. (2015:1300) suggest mixed evidence on the variables of interest implying the unidirectional causality from capital stock and energy consumption to output; bidirectional causality between

trade openness and output and no causality between financial development and output. Despite to the fact that the link between energy, trade openness and economic growth has received significant attention among research community, the evidence to date provides inconclusive findings and do not investigate enough the case of Turkey what was the motivation to conduct this study. Thus, the paragraphs to follow present the recent evidence on the Turkish economy.

Acaravci et al. (2015:1050) have explored the link, if any, between energy consumption, economic growth, trade liberalization and FDI in the case of Turkey. They have collected the time-series data in the period between 1974 and 2013 and have employed the time-series econometrics. The findings of ARDL and Granger causality model suggest a long-run link between the variables of interest. Moreover, the authors have found a unidirectional link running from electricity consumption to growth advocating the “growth hypothesis”. The authors also outline the fact that the empirical findings to date suggest the mixed evidence on the link between the variables of interest. As a possible reason, Ozturk (2010:340) suggests that the difference in reported results arises from the differences in methodology as well as the sample of interest.

Cetin (2016) suggests the consumption of energy, trade liberalization and the development of financial market to be one of the main factors of growth in Turkey in the time span between 1980 and 2014. The empirical results of ARDL bounds test and Johansen-Juselius technique confirm this link in the long-run. The authors also suggest that the decrease in the supply of energy tends to slow down the growth. In this light, Altinay and Karagol (2004:985) also provide the empirical evidence on the positive relationship between these macroeconomic variables employing Hsiao’s version of Granger causality method for the period 1950-2000 in Turkey.

With regard to Turkey, it is also important to emphasize that Sahbudak and Sahin (2018:1648) have explored the link between the consumption of energy, trade liberalization and growth in the period between 1980 and 2013. The empirical results of ARDL-bounds testing approach advocate the positive trade-energy nexus in the long-term. The findings of this paper are also supported by Kaplan et al. (2011:31) in the period between 1971 and 2006 in the case of Turkey by employing VECM.

To summarize, most of the papers investigating the case of Turkey suggest a positive link between energy consumption, economic growth and trade liberalization (Acaravci et al., 2015; Cetin, 2016; Altinay and Karagol, 2004; Sahbudak and Sahin, 2018 and Kaplan et al., 2011). However, it is important to be aware of the fact that these studies use different proxy variables of the macroeconomic terms of interest and the different time-span while making comparison. Despite to the fact that most of the studies agree on the positive link between the variables of interest, Ozturk (2010) outlines the mixed evidence on the links of interest due to the differences in methodology as well as the sample of interest.

In terms of the panel data evidence, it is important to emphasize that Nasreen and Anwar (2014:82) have explored the link of interest for the following Asian economies (Pakistan, India, Indonesia, Iran, Japan, Jordan, Korea Dem., Malaysia, Nepal, Philippines, Sri Lanka, Thailand, Vietnam, China). The period of interest is between 1980 and 2011. The empirical results of panel cointegration and causality approaches provide the supportive evidence on the cointegration link in the trivariate model. Terms of trade has been recognized as one of the most important explanatory variables of the growth in South America in the period between 1980 and 2007 by employing panel cointegration technique (Sadorsky, 2012:476). The supportive evidence to the positive energy-growth nexus is also given by Narayan et al. (2008:2765). Hasson and Masih (2017) have specified that a very few empirical studies treat the link of interest in the case of South African countries. The authors have found a link to be direct in the period 1971-2013 by employing ARDL approach. Trade openness is also found to be the important determinant of growth. Energy is found to be an important determinant of economic growth in Belke et al. (2011) for the sample of OECD countries in the time-span 1981-2007 by employing causality tests.

The empirical studies presented in this paper, in general, agree on the positive energy-growth nexus, this is due to the significant role of the energy in the production sector. Besides that, trade is also accepted to have a positive impact especially in the long-run. Thus the positive link between the variables of interest is expected in this paper taking into account the exponential increase in energy consumption in Turkey as well as the statistics in terms of trade openness. Even though the research to date does not have a final consensus on the link between the variables of interest, the positive link is expected in terms of Turkey.

The contribution of this paper to the literature can be summarized in the following. At first, the study employs the latest available data and longer time-span compared to the studies to date. Moreover, as opposed to the studies presented in the literature review section, we have employed Vector Error Correction Model that provides the opportunity to estimate the variables that do not meet the assumption on covariance stationarity in levels but in the first difference. At last, the findings of this paper serve to propose the significant policy implications for the decision makers.

## II. METHODOLOGY, DATA AND VARIABLES

Vector Error Correction Model (VECM) has been used quite intensively in the recent empirical research based on the time-series data. It can be considered as the restricted Vector Autoregressive (VAR) model. One of the assumptions of VECM is that it enables the manipulation with the integrated variables. Simply said, VECM is actually the cointegrated VAR model. One of the advantages of VECM over VAR model is the fact that it enables the estimation of the variables that do not meet the assumption on covariance stationarity in levels but in the first difference. Thus, Baum (2013) suggests that VECM is appropriate in the case when the first difference of the variables does not contain unit root. Besides that, one of the most important advantages of VECM over VAR is the fact that it estimates the coefficients in the short- as well as the long-run.

With regard to the difference between the regression analysis and VECM, it is important to emphasize that regression analysis answers the question whether or not the outcome variable is influenced by the regressor. Apart from this, the findings of regression analysis do not provide any info on the causation between the variables. Thus, there is a need to extend the regression results by employing VECM and providing the empirical evidence on the causality. The VECM depends upon the uncorrelated error terms and the same order of the integration of the variables. In terms of the model specification, VECM can be formalized as the differenced VAR. This procedure will erase one lag, thus the variables contain k-1 lags. In addition, the outcome variables should be expressed with operator that is differenced. The model to be investigated in this paper can be expressed as following (Baum, 2013):

$$\Delta \ln GDP_t = a + \sum_{i=1}^{k-1} \beta_i \Delta \ln GDP_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta \ln ENE_{t-j} + \sum_{m=1}^{k-1} \varphi_m \Delta \ln TI_{t-m} + \lambda_1 ECT_{t-1} + u_{1t}$$

$$\Delta \ln ENE_t = \sigma + \sum_{i=1}^{k-1} \beta_i \Delta \ln GDP_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta \ln ENE_{t-j} + \sum_{m=1}^{k-1} \varphi_m \Delta \ln TI_{t-m} + \lambda_2 ECT_{t-1} + u_{2t}$$

$$\Delta \ln TI_t = \theta + \sum_{i=1}^{k-1} \beta_i \Delta \ln GDP_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta \ln ENE_{t-j} + \sum_{m=1}^{k-1} \varphi_m \Delta \ln TI_{t-m} + \lambda_3 ECT_{t-1} + u_{3t}.$$

The meaning of the symbols is given below (Baum, 2013):

- $k-1$  = represents the desired number of lags corrected by 1 due to the first differencing.
- $\lambda_i$  = answers the question how fast the equation adjusts. The sign is negative implying the tendency on the long-run equilibrium.
- $ECT_{t-1}$  = provides the info in the long-run and represents the residual obtained by estimating the cointegrating regression.
- $u_{it}$  = is the notation for innovations or better to say it is the stochastic error.
- $\beta_i, \phi_j, \varphi_m$  = are the notations for coefficients in the short-term.
- $GDP$  = is the abbreviation for GDP per capita (constant 2010 US\$) (Satrovic and Muslija, 2019:143).
- $TI$  = Trade in goods and services outlines the change of the ownership between two economies. It includes the sales as well as the barter transactions or gifts of goods and services. It is measured as a share of GDP.
- $ENE$  = energy use (kg of oil equivalent per capita) is used as a proxy of energy consumption.

To provide the empirical evidence on the matter it is first essential to provide the specification of the model. Moreover, due to the requirements of the VECM, it is necessary to check whether or not the first difference meets the stationary properties. The commonly used criteria will be employed to determine the desired number of lags. With regard to the cointegration, we will employ the Johansen cointegration test to check whether or not the variables are cointegrated. Besides VECM, this paper will employ the Granger causality test. The empirical evidence ends by providing the results of the tests on the stability of the model.

### III. RESULTS OF THE RESEARCH

The results of the research will be presented within few steps. At first, we present the main measures of the summary statistics in the Table 1.

**Table 1:** The description of the data

stats	GDP	ENE	TI
mean	7532.11	1026.57	14.72
sd	2593.27	314.38	7.44
max	13898.70	1656.80	26.58
min	4221.16	522.20	3.20
skewness	0.81	0.35	-0.24
kurtosis	2.72	2.06	1.63

Real GDP per capita reaches mean value of 7532.11 constant 2010 USD in the case of Turkey in the period between 1970 and 2015. The last observed year outlines the maximum value of real GDP per capita to be 13898.7 constant 2010 USD while the first observed year displays the lowest recorded value. In terms of energy consumption, the average value of energy use (kg of oil equivalent per capita) is showed to be 1026.57. The maximum value is reported in the last

observed year while the minimum reported value is displayed in the year 1970. With regard to the proxy of trade openness, it equals on average 14.72%. The maximum value is recorded in the year 2001 while the minimum value of 3.20% is found in the year 1979. The year 2001 is the post-crisis year in Turkey what advocates the maximum value in terms of trade openness. To deal with the variation of the variables and to ease the interpretation we have transformed variables in natural logarithmic form and thus interpret the coefficients as elasticity. The research moves forward to the selection of the optimal number of lags. Most of the criteria agree on the one lag, thus the research proceeds further by operating with the one lag. Due to the properties of VECM, we have tested whether or not the log levels and first difference of the variables contain unit root by applying the ADF test. Table 2 displays the results.

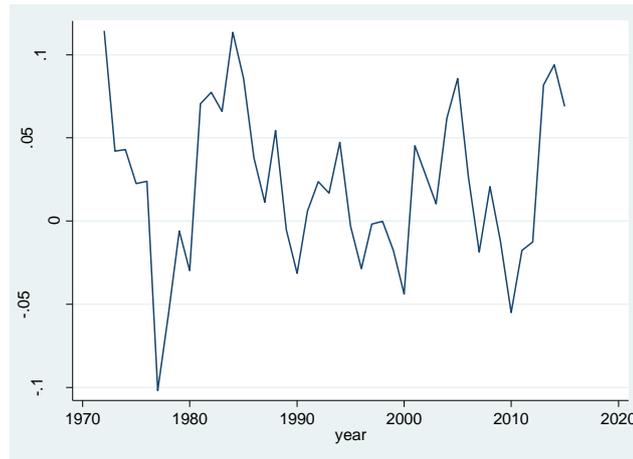
**Table 2: ADF test**

Variable	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	Z(t) - p value
lnGDP	Z(t) 0.579	-3.621	-2.947	-2.607	0.987
<b>D.lnGDP</b>	<b>Z(t) -4.397</b>	<b>-3.628</b>	<b>-2.950</b>	<b>-2.608</b>	<b>0.000</b>
lnENE	Z(t) -1.043	-3.621	-2.947	-2.607	0.737
<b>D.lnENE</b>	<b>Z(t) -5.387</b>	<b>-3.628</b>	<b>-2.950</b>	<b>-2.608</b>	<b>0.000</b>
lnTOT	Z(t) -1.391	-3.621	-2.947	-2.607	0.587
<b>D.lnTOT</b>	<b>Z(t) -4.109</b>	<b>-3.628</b>	<b>-2.950</b>	<b>-2.608</b>	<b>0.001</b>

The findings of Augmented Dickey-Fuller test for unit root suggest that the null on unit root cannot be rejected in the case of all log level values. However, the test suggests the stationary properties of the first difference. Thus, the variables are found to be integrated of the order 1 for a 1% level of significance. Moreover, we have tested for the number of cointegration equations by employing the Johansen cointegration test. In the case when rank equals 0, null assumes no cointegration among variables. Table 3 displays the trace and max statistics to be higher than the 5% critical values suggesting the rejection of null on no cointegrating relationship between the variables. Additionally, null hypothesis in the first rank suggests one cointegration between the variables. The findings suggest that this null cannot be rejected suggesting the long-run link between the three variables of interest. Thus, these variables move together in the long-term. We have also evaluated the cointegrating equation by using the graph below.

**Table 3: Cointegration test**

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	12	189.7414	.	32.3096	29.68
1	17	203.2032	0.45768	5.3859*	15.41
2	20	205.8796	0.11454	0.0332	3.76
3	21	205.8962	0.00075		
maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	12	189.7414	.	26.9237	20.97
1	17	203.2032	0.45768	5.3527	14.07
2	20	205.8796	0.11454	0.0332	3.76
3	21	205.8962	0.00075		



**Graph 3:** Predicted cointegrated equation (Source: Author)

With this step completed, we move forward to the presentation of the VECM results and we provided the detailed interpretation.

**Table 4:** VECM

	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
<b>D_LNGDP</b>						
_CE1 L1.	0.236	0.134	1.77	0.077	-0.026	0.498
lnGDP LD.	-0.212	0.229	-0.93	0.354	-0.662	0.237
lnENE LD.	0.208	0.211	0.98	0.325	-0.206	0.621
lnTI LD.	-0.043	0.044	-0.98	0.328	-0.129	0.043
_CONS	0.023	0.008	2.76	0.006	0.007	0.039
<b>D_LNENE</b>						
_CE1 L1.	0.566	0.111	5.08	0.000	0.347	0.784
lnGDP LD.	-0.339	0.191	-1.77	0.076	-0.714	0.036
lnENE LD.	0.226	0.176	1.28	0.199	-0.119	0.571
lnTI LD.	-0.072	0.037	-1.96	0.050	-0.144	0.000
_CONS	0.018	0.007	2.57	0.010	0.004	0.031
<b>D_LNTI</b>						
_CE1 L1.	-0.535	0.554	-0.97	0.334	-1.620	0.550
lnGDP LD.	0.330	0.950	0.35	0.728	-1.533	2.193
lnENE LD.	0.263	0.875	0.3	0.764	-1.452	1.977
lnTI LD.	0.168	0.182	0.92	0.357	-0.189	0.524
_CONS	0.029	0.034	0.84	0.400	-0.038	0.096

With regard to the Table 4, it is important to distinguish between the adjustment coefficients (coefficients with the error term) and the short-run coefficients (other coefficients in the table). We infer a long-run causality from the statistical significance of error term with GDP and ENE. Hence, the long-run causal effect in these two equations is significant at the 10% level of significance. However, short-run coefficients are not found to be significant for a 10% level of significance in the case of lnGDP and lnTI equation. Short-run coefficients are found to be

significant in the lnENE equation implying that the reaction of the energy consumption on the increase in growth proxy and trade openness is negative in the short-run. However, the long-run links are expected to be positive which is explored in the table below. In terms of lnGDP and lnTI equations, these results suggest that it takes a long for the trade openness and real GDP per capita to use the advantage of the increase in other variables of interest. With regard to the strong causality, it can be concluded only in the lnENE equation. There is no evidence on the strong causality in the case of other equations since short-run coefficients are not found to be significant.

To explore the impacts in the long-term, we present the long-term equation. This equation served a basis to derive the EC. Table 5 presents the obtained results.

**Table 5:** Johansen normalization restriction imposed

	beta	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
_ce1							
lnGDP		1	.	.	.	.	.
lnENE		-1.3484	0.062444	-21.59	0	-1.47078	-1.22601
lnTI		0.126828	0.026998	4.7	0	0.073912	0.179744
CONS		0.124914	.	.	.	.	.

The Table 5 shows the generation of the error term. The outcome variable is GDP, thus the normalization is on this variable. While interpreting the signs are inversed, due to the fact that cointegrating vector can be reformulated as a long-run equation by taking the vector to be zero. The results can be interpreted as following: a percentage change in ENE will result in a 1.35% increase in real GDP per capita in the long-run. While for TI, a percentage change in this variable will result in 0.13% decrease in GDP in the long-term. Hence, proxy of growth is elastic to the change in energy consumption but inelastic to the change in TI. These results imply that energy gluttons tend to record a higher growth rates in the long-run which brings up an environmental concern as well as the CO2 emissions indicating a need to promote the renewable energy. Due to the significant climate change all over the World, Turkey as well as the other countries needs to critically pay attention to the sustainable energy and development. This is especially true in the case of Turkey taking into account the great potential in terms of renewable resources.

To validate the results of VECM model, we have used the Wald test. The findings of this test suggest no significant coefficients in lnGDP and lnTI equations. However, coefficients in lnENE equation are found to be significant in the short-run. To finish this empirical research, we employ some diagnostic tests and present the results in the Tables 6 and 7.

**Table 6:** Autocorrelation test

lag	chi2	df	p
1	5.0254	9	0.83209
2	4.9097	9	0.84211

**Table 7:** Normality test

Equation	chi2	df	p
D.lnGDP	2.843	2	0.24137
D.lnENE	0.079	2	0.96128

D.lnTI	0.341	2	0.84324
All	3.263	6	0.77521

The test for autocorrelations suggests that the null on no serially correlated errors cannot be rejected at both lags. In addition, Jarque-Bera test suggests the errors to be normally distributed in the case of all three equations as well as overall. Lastly, we have tested for the stability of the model. The VECM asks for the two unit model, hence the findings of the stability test advocate the stability of the model.

### CONCLUSION

In the present paper, we have explored the relationship, if any, between energy consumption, trade openness and economic growth at annual level in the case of Turkey. Due to the availability of the data, our time-span ranges from 1970 to 2015. Thus, the results section starts by presenting the measures of descriptive statistics. Moreover, we have tested for the unit root, and the results show the variables to be stationary at the first difference. In addition, the selection criteria propose the one lag. The results of Johansen test for cointegration suggest one cointegrated relationship between the variables, thus we have employed VECM and interpret these findings in paragraphs to follow.

We infer a long-run causality from the statistical significance of error term with GDP and ENE. However, short-run coefficients are not found to be significant for a 10% level of significance in the case of lnGDP and lnTI equation. With regard to the strong causality, it can be concluded only in the lnENE equation. There is no evidence on the strong causality in the case of other equations since short-run coefficients are not found to be significant. Moreover, the findings suggest that a percentage change in ENE will result in a 1.35% increase in real GDP per capita. While for TI, a percentage change in this variable will result in 0.13% decrease in GDP in the long-run. Hence, real GDP per capita is elastic to the change in energy consumption but inelastic to the change in TI.

These results imply that energy gluttons tend to record a higher growth rates in the long-run which brings up an environmental concern as well as the CO<sub>2</sub> emissions indicating a need to promote the renewable energy. Due to the significant climate change all over the World, Turkey as well as the other countries needs to critically pay attention to the sustainable energy and development. This is especially true in the case of Turkey taking into account the great potential in terms of renewable resources what is the main policy implication of this paper. Besides that, developing countries should make necessary steps to promote the development of renewable energy, to fund the establishment of the technology that is crucial for the production and usage of wind, solar and other types of renewable energy. In addition, governments can subsidize those factories that tend to use the renewable sources. Besides that, there are various positive examples on the usage of renewable energy in the World, and policy makers should use these positive examples while creating the growth strategies.

The recommendations for future research can be summarized as following. It is first necessary to explore the link between renewable energy, trade openness and economic growth in the case of Turkey. Moreover, the other proxy variables of trade openness can be employed to test for the sensitivity of the model to the proxy variable selection. Furthermore, it is of crucial importance to include the proxy of environmental degradation due to the fact that energy consumption presents one of the biggest energy gluttons and thus significantly contributes to the CO<sub>2</sub> emissions. As a last recommendation, there is a need to observe the year 2016 and 2017 what was not possible in this research due to the missing data.

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