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# Could Nuclear Energy Production and Economic Growth Relationship for Developed Countries Be An Incentive for Developing Ones?: A Panel ARDL Evidence Including Cointegration Analysis

Süleyman DEĞİRMEN*, Ömür SALTIK**

**Abstract**

The purpose of this study is to develop policy recommendations for indebted developing countries which have big balance of payment deficits due to high energy costs. For this reasons, the study initialy explores developed countries' nuclear energy policies and hence, to guide developing countries (especially for Turkey and similar countries) who can adopt alternative energy resources to reach a sustainable and higher GDP per capita and to protect themselves against energy price volatilities. Therefore, in available theoretical studies, developing countries, also named as middle income countires whose GDP per capita is lower than developed countries, have been searching for different strategies to catch up the wealth level of developed countires from the aspect of catch-up effect in the Growth Theory. In the context of cross sectional and time series data, the paper anlaysis all available retroperspective panel data method which uses time interval between 1977-2014 for 14 developed and developing countires. The study employs Panel ARDL approach to serve the aim of the study. According to the emprical results, as expected, vector error correction coefficient was founded negaitvely and accepted numerical interval. Therefore, test results indicate that there has been significant and positive relationship between the increment of nuclear share in electricity production and GDP per capita. Countries, especially dependent on raw materials, can reduce reliance on energy import with nuclear energy sources, then they will have a stabilizer for a reasonable level of current deficits which may be necessary for economic growth. In conclusion, the results also indicates that nuclear energy production in developing countries can stimulate economic growth by lowering energy import related production costs in favor of country-wide producers.

**Keywords:** Nuclear Energy, Panel ARDL, Developed Countries, Developing Countries, Energy Dependency

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## Gelişmiş Ülkeler İçin Nükleer Enerji Üretimi ve Ekonomik Büyüme İlişkisi Gelişmekte Olan Ülkeler İçin Teşvik Edici Olabilir Mi?: Panel ARDL Eşbütünleşme Analizi

**Öz**

Bu çalışmanın amacı yüksek enerji maliyetleri nedeniyle ödemeler dengesi bilançosu büyük açık veren gelişmekte olan ülkeler için politika önerilerinde bulunmaktır. Bu nedenle, çalışmanın ilk hedefi gelişmiş ülkelerin nükleer enerji politikalarının ortaya konulması, böylece sürdürülebilir ve daha yüksek kişi başı gelir ve enerji fiyatlarındaki oynaklıklara karşı kendilerini koruma altına alabilmeleri için (özellikle Türkiye ve benzeri ülkeler) gelişmekte olan ülkelerin alternatif enerji politikalarını adapte etmelerine sevk etmektir. Bu hedefler, gelişmiş ülkelerden daha düşük kişi başına sahip gelişmekte olan ülkeler veya bir diğer adıyla orta gelirli ülkelerin, Büyüme Teorisi'nde yakalama etkisi olarak bilinen gelişmiş ülkelerin refah seviyelerini ulaşmalarına ve bu anlamda aradıkları alternatif stratejilerinin tespitine yardımcı olacaktır. Bu sebeple, kısıtlı yatay kesit ve zaman serileri üzerinden, 14 gelişmiş ve gelişmekte olan ülke ve 1977- 2014 dönemlerine panel veriler kullanılmıştır. Çalışmanın amacına hizmet etmesi adına Panel ARDL yaklaşımı kullanılmıştır. Ampirik bulgular, beklendiği gibi, hata düzeltme katsayısı negatif ve istenen aralıkta tespit edilmiştir. Bulgular elektrik üretiminde nükleer üretimin artması ile kişi başına düşen GSYİH arasında anlamlı ve pozitif bir ilişkiyi gösterirken, bu tür enerji üretim fikrine karşı kişilerin gelişmekte olan ülkelerde nükleer tipi enerji üretiminin alternatif olarak tavsiye edilmesini mümkün kılabilecektir.

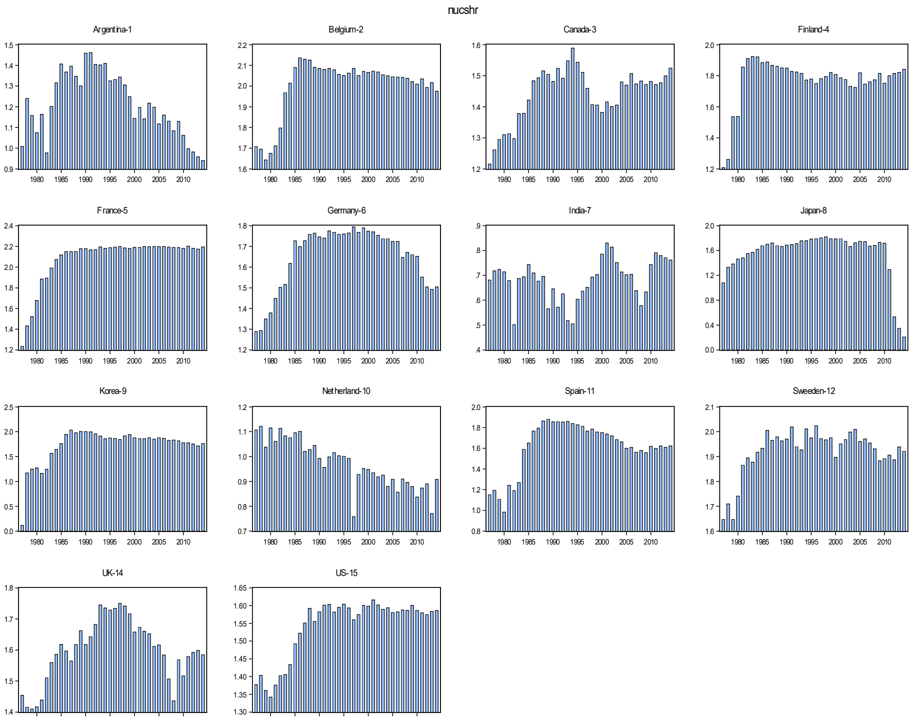
**Anahtar Kelimeler:** Nükleer Enerji, Ekonomik Büyüme, Gelişmiş ve Gelişmekte Olan Ülkeler, Panel ARDL, Eşbütünleşme Analizi

**JEL Kodları:** F43, C33

## 1. Introduction

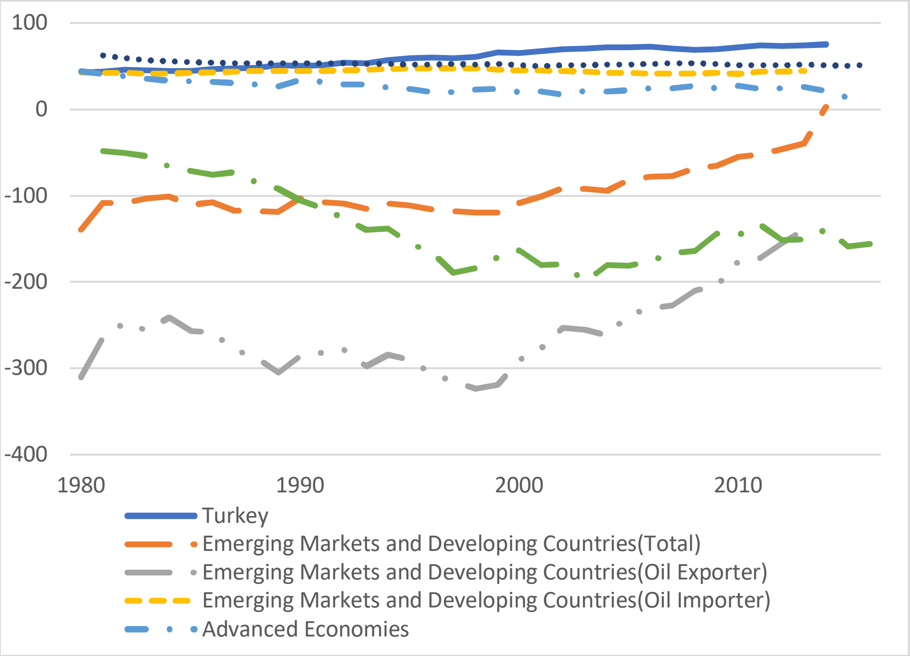
This study, especially, adresses to the countries that struggle with the twin deficits and even triple deficits problems which are the combination of current account defitics, budgets deficits and net private saving gap. But also, in literature, these kind of countries are commonly accepted as to have the middle income trap. This study develops some energy production policies for developing countries (especially for Turkey and similar countries) by analyzing 14 developed and developing countires for 37 years. These countries have a kind of role model in terms of energy policies for countries which has twin and tripple deficit problems (especially, for countries with huge energy deficits) with their effectively distributed electric proudcution sources among five supplement sources (Natural Gas, Oil, Hydroelectric, Coal and Hydroelectric Plants (the countries involved in this study have a nuclear power generation share of over 20% in total). When we scrutinize the foreign trade and energy dependency figures of Turkey, for January- November 2016, current account deficit was $26.5 billion (Ministry of Commerce, 2016 Commerce Reports). While energy imports of Turkey, in the first half of the year, is amounted $ 12.97 billion. The share of fossil fuels in the foreign source dependency is followed; Natural Gas %98, Crude Oil %92, Types of Coal %30. In case of the calculation including both domestic and renewable energy sources, the total dependency ratio will fall at 72% (TUİK, External Trade Data). But these percentages are still warning red for Turkey, a developing country status when the balance deficits and investment saving deficits are taken into consideration. As well as some difficulties of accessing funding sources in the balance of payments accounts due to global uncertainties in monetary policy implicated by BOJ, ECMB, FED Quantitative Easing and Money Supply Policies, such balance deficits are becoming more chronic issues for Turkey and similar developing countries. Bolat, et al. (2015) investigate coentingration and interactions among Triple Deficit Phenomenon for 23 European Countries between 2002-Q1 and 2013-Q3. Their emprical results demonstrate significant cointegration between foreign trade deficit, saving gap and budget deficit (Bolat et al., 2015). Akbaş and et. al. (2014) demonstrate coentingration and interactions among Triple Deficit Phenomenon for Turkey between 1960 and 2012 (Akbaş et al., 2014) Therefore, notably during economic expansion, reducing of the energy costs share in foreign trade deficit, especially for the countries who has large energy deficits deficit and low saving rates, stands for strategic factor.

In addition, when there is an upward trend in oil and natural gas prices, global exchange rate volatilities put more pressure on primarly demand and then, on supply side inflation in economics, which is called *"Pass Thorugh Effect"* in the literature (Alacahan, 2011). Morever, following of some monopolistic interventions, e.g. OPEC's cutting down of oil production, which interrupt on natural market mechanism, these cyclical affects create a breaking point on series, then may cause permanent effects on the economy side (Roubini & Setser, 2004).



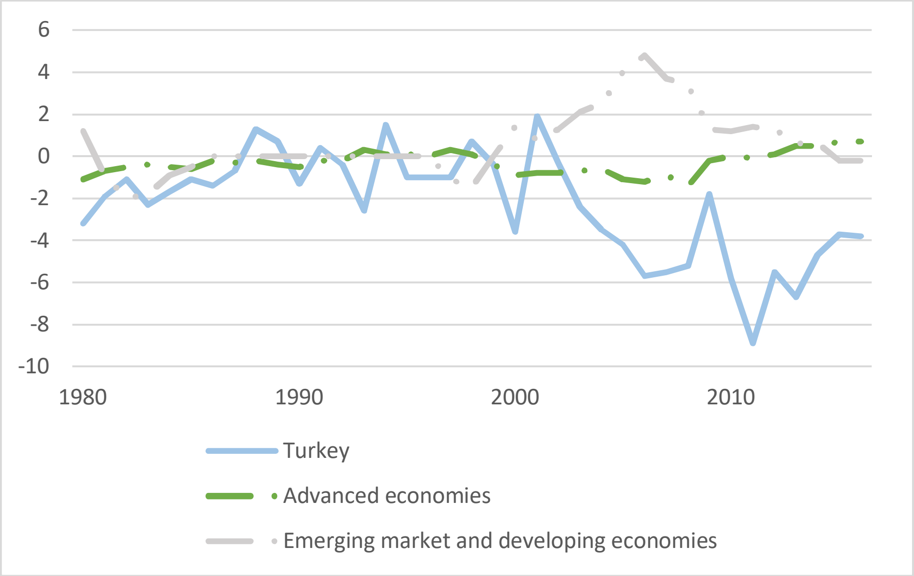

Graph 1: 14 Developed and Developing Countries Nuclear Production Share Between 1977-2014, Index Mundi Country Facts Explorer

In the light of above graphs, in the other countries apart from France, Germany, Netherland and Japan (who experienced devastating nuclear accedent of Fukushima and thus, put quotas in nuclear energy production) analyzed, the share of nuclear energy in electricty production occured on avarage during analysis period.



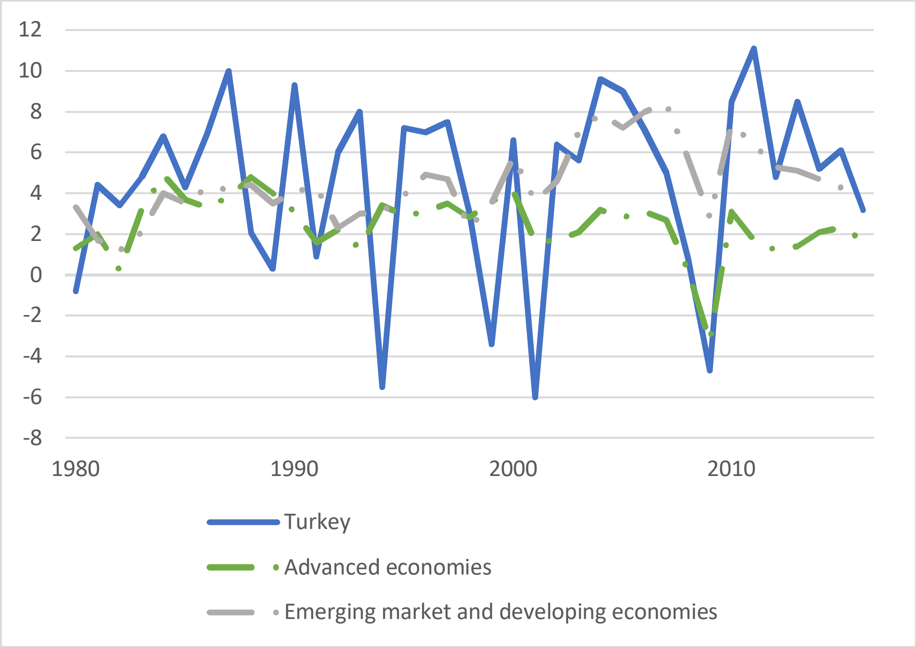

Graph 2: Energy Import (% of energy use) Turkey, Emerging Markets and Developing Countries (Net Exporter and Importer) and Advanced Countries: 1980-2016, World Bank

The classification data for emerging markets in Graph 2, developing countries and advanced countries, the lists which are announced by the United Nations and World Bank's. The negative signed percentages in the data signify that the country is an energy exporter. Since energy import data is represented by percentages in energy use, the graphs are drawn by taking the averages of these percentages by years. Advanced energy exporter countries have increased their exports revenue from 1980 to 2002. It has been observed that the advanced oil importing countries support the stable growth (excluding crisis periods) by expanding their energy portfolios, maintaining their energy import rates and remaining at a certain level of current account deficits. As Ogunniyi et al. (2018) pointed out, advanced countries that have mostly fossil fuels oriented export revenues, as a result of sudden price movements in these resources, they suffered an increase in current account deficits, sudden decrease in foreign trade revenues, and lastly, short and long term instability in growth rates. It was observed that developing oil exporting countries followed policies towards the reduction of the share of these revenues between the years 1980-2016 (Ogunniyi et al., 2018).



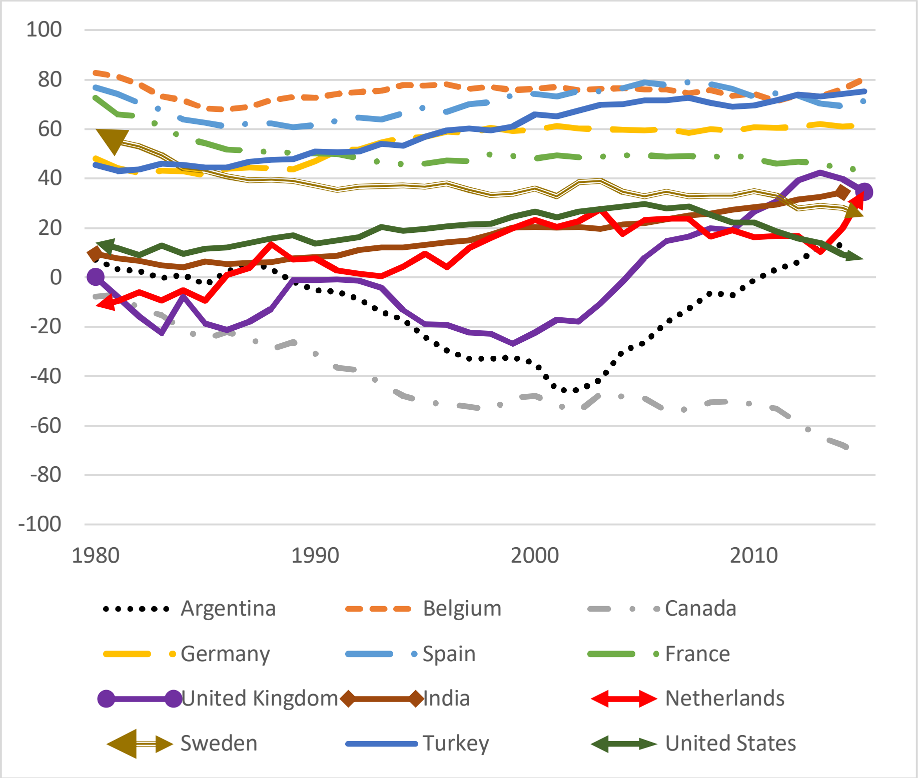

Graph 3: Current Account Balance % of GDP for Turkey, Emerging Countries and Advanced Countries: 1980-2016. IMF Data Mapper

When the graphs of energy imports, current account deficit and active nuclear reactor numbers are togetherly analyzed, it is seen that countries that have expanded their portfolio for energy production have no problems with current deficit figures due to energy inputs and growth figures are stable except for crisis periods.



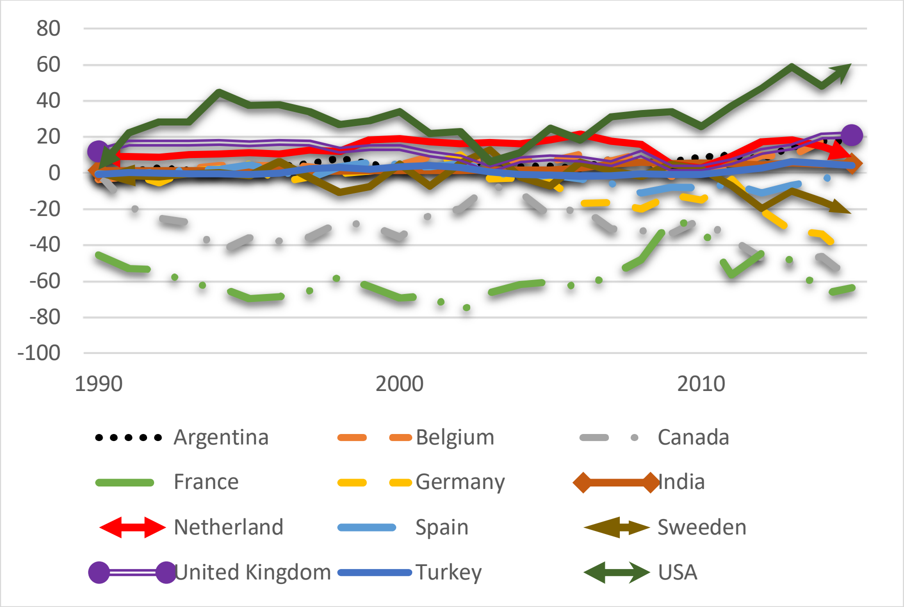

Graph 4: Real GDP Growth Rate for Turkey, Emerging Countries and Advanced Countries: 1980-2016. IMF Data Mapper

When the growth chart for developed and developing countries is examined, it is possible to say that economic growth is distributed around an average. In the light of the current deficit and energy import graphs (Graph 4 and Graph 5), following an uptrend in energy imports, the percentage of current deficit in GDP in emerging economies has led to a contraction in growth. In developing countries which have a wide range of energy generation source portfolio (such as nuclear and renewable energy), this prevents fluctuations in energy imports. Therefore, it is not possible to observe negative outputs in such economies.



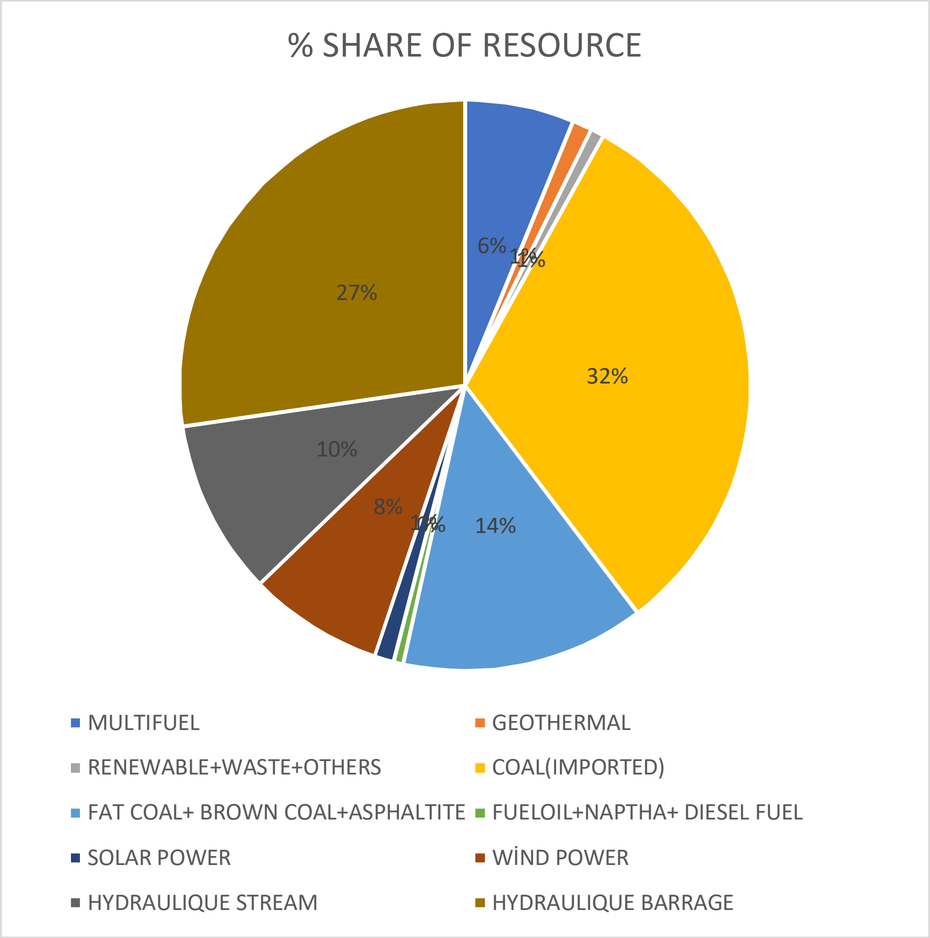

Graph 5: Energy imports, net (% of energy use) of 11 Developed Countries and Turkey: 1980-2015. World Bank

The negative sign of energy import, net (% energy uses) indicates that the country is a net energy exporter (Argentina, Canada, United Kingdom). In the majority of developed countries, although some of these countries are rich in fossil fuel, within a range of 3-20, they have been operating nuclear reactors actively, and these countries have no deal with energy-based current deficit problem which damages sustainable economic growth except in crisis periods.



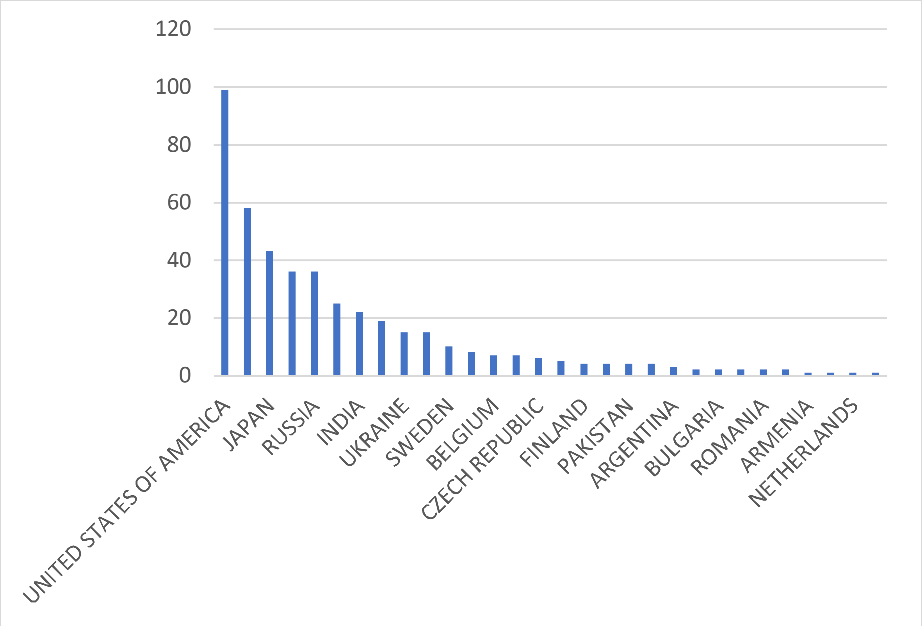

Graph 6: Electricity Balance of Trade for 11 Developed Countries and Turkey (Terawatthours) for 1990-2015. Global Energy Statistical Book, 2018.

Electricty balance of trade data for 11 advanced countries and Turkey are graphed during 1990-2015 periods. In the context of graphical analysis, the countries who radically focused on changing energy policies by converting electricity generating process into renewable energy sources, has been experienced negative balance of trade. Despite of positive externalities of renewable energy production plants, the main reasons of this negative balance of trade can be due to following negative externalities, not having alternative sources in order to supply excess demand, investment periods of renewable energy plants require long periods of time and costs, the operation of plants and the efficiency of electricity generation may not be at expected levels ("Fact check: Does infrasound from wind farms make people sick?" *ABC* (3 March 2016)).




Graph 7: Turkey’s Percentage Share of Electricity Production Distribution By Source for December 2016. Energy Engineering Chambers

In the light of the data on Graph 7, Turkey has encumbered to operate the plants and sources which are environmentally harmful effects at the highest level (e.g. Coal and Hydraulique Barage and Multifuel). So, we can conclude that there seems strong signals to transform energy production policy for Turkey and similar energy production portfolio countries.




Graph 8: Number of Reactors Around The World In November 2016. International Atomic Energy Agency (IAEA)

Since 20 December 1951, the first nuclear power plant which is only able to illuminate 4 lamps (EBR-I in Arco, Idaho, US) ("Nuclear power plants, world-wide", *EuroNuclear* (28 November 2016)), in 2016 there have 450 reactors in operation around the world. The total net installed capacity of these reactors is 392.012 MWe (meets approximately 117.603.600 houses electricty energy needs) and also for coming years 55 nuclear power reactors are under construction ("The Database on Nuclear Power Reactors", *IAEA* (21 March 2019)).

Some basic objectives have been set by the European Union member states (Germany, Belgium, Italy, Luxembourg) in the context of the Messina Declaration published on June 3, 1955. The most important of these is providing of cheap energy for the continuation of the European Union economies and protect their competitiveness (Messina Declaration, 1955). Within the scope of the European Union Energy Policy (2007) published by the European Commission, it emphasized the importance of nuclear energy in its energy production, as well as the importance of this energy type in order to ensure lower carbon emissions, competition in production and stable energy prices (An Energy Policy for Europe, 2007)

The current account balance has a key role for the open economies under free exchange rate system, in order to preserve their external and the internal equilibrium. Current account balance is an important element for open inflation targeting as a component of medium and long term economic policies, helps to keep unemployment rates at the natural level and thus ensure stable economic growth (Özdamar, 2015).

For the first time, the oil crisis in 1973, the negative-supply side shocks of oil, render the policy makers with the coexistent situation of unemployment and inflation, called stagflation. Stagflation phenomenon has led to paradigm shifts toward the monetarist economists criticizing the inadequacy of Keynesian economic policies with activist macroeconomic policies. The fact that the demand-side economy could not be revived by activist macroeconomical policies has brought the necessity to reconsider the factors that shift the total supply curve to the left. In general terms, technological progress, capital accumulation and supply-side shocks (energy costs, geographic disturbances etc.) are the main factors that cause the supply curve to shift. These factors affect the cost of production with the change of cost of production factors and cause shifts in the supply curve.

In the literature, many empirical studies conducted primarily on determining the reasons of current deficits for developing countries and Turkey. In these studies, the main determinants of the current deficit are budget deficits, interest rates, sudden and rapid changes in exchange rates, energy expenditures (oil and natural gas), and lagged value of current deficits. And, most of the emprical studies have been conducted on determining relationship between current deficit and economic growth, indicated that chronic or extreme amount of current deficits causes imbalances in economic growth in studied countries (Calderon et al. , 2000; Chin & Prassad, 2000; Peker & Hotunoğlu, 2009; Mangır, 2012; Göçer, 2013; Çiftçi, 2014; Huntington, 2015; Yüksel, 2016) .

Nuclear power generation can relieve the problems of economic growth by relieving the current deficit-driven pressures in countries that are significantly dependent on external energy and raw material sources. In order to reduce the economic fluctuations caused by the increase in volatility and rising price of fossil fuels (oil and natural gas), especially in the periods of depreciation of local currency, having some flexible protection methods based on portfolio diversification of energy sources. This diversification can only be achived by having territorial, abundant, inexpensive and continuous energy sources (Bordo et al., 2010; Mari, 2014).

Therefore, the aim of this study is to develope an energy policy for countries that have a large share of energy source import in foreign trade deficit. For this purpose, empirical research will attempt to reveal the bi-directional relationship between growth and nuclear energy production, and a policy proposal will be presented on the basis of the decreasing foreign trade deficit and the contribution of current account deficit to econmic growth as a result of the decline in energy imports. In fact, the the territorial, abundant, inexpensive and continuous energy input, which is an important complementary factor of production together with labor and capital inputs, will be able to support production in such countries and thus have sustainable economic growth rates (Rufael & Menyah, 2010).

## 2. Literature Review

In the literature, emprical results with different econometrical methods, countries and time periods indicate a positive and strong relationship between share of nuclear energy in electricity production and growth rates (Yemane and Menyah, 2010; Nazlıoğlu et al., 2011). There has been four different approaches in the growth literature on the direction of relationship between energy consumption and growth. The first one is called "Growth Hypothesis", according to the assumptions of this hypothesis, energy consumption has two different effects: direct and indirect effects on economic growth. The indirect effect induces economic growth through by hiring or purchasing production factors as labor and capital. The second one is called "Conservative Hypothesis": this hypothesis accepts bilateral relationship between energy consumption and growth rate. The third hypothesis is known as "Feedback Hypothesis" that argues cyclical movements. First of all, energy consumption will generate economic growth then the next phase, this growth rate will be the cause of energy consumption. The fourth and the last one is called "Neutrality Hypothesis", according to the assupmtions of this hypothesis, energy consumption has an insignificant affects on economic growth rate (Öztürk, 2010; Narayan, 2016).

Narayan (2016) investigated the existence of "Protective Hypothesis", "Feedback Hypothesis", "Neutral Hypothesis" with panel data estimation models for 135 countries. The "Protective Hypothesis" for the developing 90 countries shows that while growth has a role in predicting energy consumption, 32 per capita low-income panel shows that per capita electricity consumption accurately predicts per capita GDP (Narayan, 2016).

Naser (2015) considered cointegration among the four industrialized countries (USA, Canada, France, Japan) for 1965-2010. The results demonstrate the one-way relationship between nuclear energy and economic growth. Furthermore, the relationship between petroleum consumption and production of nuclear energy in the United States, France and Japan. The upturn demand for nuclear energy is because of hedging against price volatility in the global oil market (Naser, 2015).

Fuinhas and Marques (2012) investigated relationship between energy consumption and growth for PIGST (Portugal, Italy, Greece, Spain and Turkey) countries through the 1965-2009 with ARDL Bound testing approach. Empirical findings support the "Feedback Hypothesis" in the long and short run. Emprical results indicate an interaction from energy consumption to growth, except for Turkey. At the same time, the direction of the interaction has been found to be a spiral movement, primarily from energy consumption and then, from growth to energy consumption (Funhas & Marques, 2012).

Rufael and Menyah (2010), between the years 1971-2005 examined 9 developed countries (the Netherlands, Switzerland, Canada, Sweden, France, Spain, Japan, the United Kingdom and the United States) one-way causality and bi-directional causality economic growth and nuclear energy. An increasing in nuclear energy use in Spain, the United Kingdom and the US tended to an increase in economic growth rate. In addition, another result indicates that the contribution of nuclear energy consumption to growth rate is more than the employment and capital inputs (Rufael & Menyah, 2010).

Göçer (2013), who analyzed the data with VAR and VEC analysis methods between January 1996 and January 2012 for Turkey, the cost of energy imports was found as the most important determinant of the current deficit (Göçer, 2013). Yüksel (2016), for the quarterly data between 1994- 2014, investigated the determinants (incleded oil price) of the current deficit in Turkey. The most important finding of the study is that an increase in oil prices will tend to increase the current deficit and this will reveal some negative effects on the economic growth rates because of high raw material and energy demand (Yüksel, 2016).

Akkaya and Gürkaynak (2011) mentioned that the importance of understanding the effectiveness of the policy tools of central banks and how they are affected by external shocks (the increase in oil prices and the transition mechanism for the effect of inflation on the real economy) that are remedies for economic challanges such as credit growth and current deficit in the short term (Akkaya & Gürkaynak, 2011).

Huntington (2015) examined the relationship between the crude oil trade and the countries' current accounts for 91 countries between 1984 and 2009. In this period, it was observed that an increase in oil prices affected the price of imported inputs through real and financial channels, and caused pressure on the current deficit because of price inelastic demand in the short term and had a negative impact on economic growth for oil imporitng countries. They emphasized that a reduction in oil imports would create a decline in foreign trade deficit under certain conditions and relaxation of the inelastic price demand will induce economic growth in the short term (Huntington, 2015).

Özata (2014), showed that an increases in exchange rates and short-term exchange rate volatilities, especially for raw material and energy source foreign-dependent economies, they suffered a huge pressure in terms of energy costs, which are transmitted via financial channels into the real economy (Özata, 2014).

Agarwal (2014) examined BRICS countries (Brazil, China, India, Russia and South Africa) between 2000 and 2014, the determinants of the current deficit and the relationship between current deficit and economic growth. They have shown that the current deficit requires mechanisms and tools such as exchange rate depressions and trade policies in order to increase competition, have a sustainable growth in the long term (Agarwal, 2014).

Through efficient portfolio analysis, Mari (2014) showed the direct costs of nuclear energy as a result of the fosil fuels’ price volatilities and the indirect effect of carbon emission (Mari, 2014). Aydın and Esen (2016), between the years 1999-2014 in Turkey, they studied the relationship between the current deficit and economic growth through TAR models. They hypothesized on the threshold level of percentage of current deficit for the countries which have high level reliance on raw material, intermediate and energy imports to have a sustainable growth, they determined this level at %3.99 for Turkey. And they have shown that exceeding this level of current deficit will have some negativities on growth rates (Aydın & Esen, 2016).

Ogunniyi et al. (2018) examined the effect of the size of the current account deficit on economic growth in the SANE (South Africa, Algeria, Nigeria and Egypt) countries between 1986 and 2015 with the FMOLS model. They showed that the current account deficit has very serious negative effects on Algeria, Egypt and Nigeria's economy. In this respect, it is an empirical finding that in oil exporting countries, sectoral diversity in exports can reduce the impact of negative shocks of oil prices in the economy. Because South Africa is one of the largest gold exporter countries in the world, it has shown that the current account deficit contributes to its economic growth via inducing effect of depreciation of exchange rates (Ogunniyi, 2018).

## 3. Data and Model

### 3.1 Unit Root Tests Specifications

The reviews on methods and tests methods, the authors were mostly benefited from Eviews User Guide in order not to encountering a problem while comparing and interpreting coefficients.

| **Type of Test** | **Null/Alternative Hypothesis** | **Considered Deterministic Trend** | **Methods for Autocorrelation Correction** |
|---|---|---|---|
| Levin, Lin and Chu (2002) | Unit Root/No Unit Root | No Exogenous Variables, Fixed Effect, Individual Effect and Individual Trend | Lags |
| Breitung | Unit Root/No Unit Root | No Exogenous Variables, Fixed Effect, Individual Effect and Individual Trend | Lags |

| **Type of Test** | **Null/Alternative Hypothesis** | **Considered Deterministic Trend** | **Methods for Autocorrelation Correction** |
|---|---|---|---|
| IPS (Im, Paseran,Shin) | Unit Root/Some Cross-Sections without Unit Root | Fixed Effect, Individual Effect and Individual Trend | Lags |
| Fisher-ADF | Unit Root/Some Cross-Sections without Unit Root | No Exogenous Variables, Fixed Effect, Individual Effect and Individual Trend | Lags |
| Fisher-PP | Unit Root/Some Cross-Sections without Unit Root | No Exogenous Variables, Fixed Effect, Individual Effect and Individual Trend | Kernel |
| Hadri | Unit Root/No Unit Root | Fixed Effect, Individual Effect and Individual Trend | Kernel |
| Paseran CADF | Unit Root/No Unit Root Between Generalised Cross Sections | - | Lags |

Table 1: Robustness of Unit Root Tests Eviews User Guide II, p.564; Tatoğlu; p.223.

While testing for nonstationary series, unlike time series unit root tests, we must take into account cross sectional and time dimensions of asymptotic behaviors of panels. Characteristics can be taken form on three conditions; "*sequential limit theory*", "*diagonal path limits*", "*joint limits*" (Kunst, 2011).

Test are seperated from each other simply by appointed assumptions on AR(1) coefficients $\rho_i$, LLC, Breitung and Hadri Unit Root Tests naturally accepts persistence parameters coefficients $\rho_i$ = $\rho$. The Im, Pesaran, and Shin (IPS), and Fisher-ADF and Fisher-PP persistence parameters coefficients $\rho_i$ varies across cross sections.

### 3.1.1 First Generation Individual Unit Root Tests

#### *3.1.1.1 Levin, Lin, Chu Unit Root Test*

Levin, Lin, Chu(2002) regresses $\Delta\bar{Y}_{it}$ ( the autocorrelation and deterministic effects fixed representor $\Delta y_{it}$ and $\Delta y_{it,s}$ the first difference of $y_{it}$ and $y_{it-1}$ (AR(1) of $y_{it}$ ) on lag terms of $\Delta y_{it-j}$ (here for j=1,2,2,…, $p_i$) .

$$\Delta\bar{Y}_{it} = \alpha\Delta y_{it} - \sum_{j=1}^{pi} \beta'_{ij} \ \Delta y_{it-j} - X'_{it}\delta$$

At this formulatin $\alpha$ = 1- $\rho$ . Now, the second regression model is based on AR(1) coefficient is regressed on the indepent variables and difference parameters.

$$\bar{Y}_{it-1} = y_{it-1} - \sum_{j=1}^{pi} \beta''_{ij} \ \Delta y_{it-j} - X'_{it}\delta$$

So after estimating of $\Delta\bar{Y}_{it}$, $\bar{Y}_{it-1}$ now we need to standardise this statistics by dividing both of them with as the following ADF model's standard errors;

$$\Delta y_{it} = \alpha y_{it-1} - \sum_{j=1}^{pi} \beta_{ij} \ \Delta y_{it-j} - X'_{it}\delta + \epsilon_{it}$$

And then we can figure out standardised statistics of $\Delta\bar{Y}_{it}$ and $\bar{Y}_{it-1}$

$$\Delta\breve{Y}_{it} = (\Delta\bar{Y}_{it} / s_i)$$

$$\breve{y}_{it-1}=(\bar{Y}_{it-1}/s_{i})$$

Finally, we can estimate and get a clue about stationarity of variables with the following regression;

$$\Delta\breve{y}_{it} = \alpha\breve{y}_{it-1}+ \eta_{it}$$

Here, null and alternative hypotheses for LLC unit root test are:

$$H_0: \alpha =0$$
$$H_1: \alpha<0$$

(Levin and et al., 2002)

#### *3.1.1.2 Breitung Unit Root Test*

Bretiung(2000) has also similar logics for estimating parameter α. But, the model can be distinguished from LLC unit root test by eliminating $X'_{it}\delta$ elements while figuring out standardisation of estimation in the model and also only disregarding all deterministic elements except from "trend" variables.

Here the formulation of standardisation of proxies of estimator;

$$\Delta\breve{y}_{it}=( \Delta y_{it} -\sum_{j=1}^{pi}\beta'_{ij}\ \Delta y_{it-j} )/s_i$$
$$\breve{y}_{it-1}=( y_{it-1} -\sum_{j=1}^{pi}\beta''_{ij}\ \Delta y_{it-j} )/s_i$$

So now, we need to calculate our detrended estimator proxies by transforming with the number of subperiods and end of periods;

$$\Delta\ddot{y}_{it}=( \sqrt{\frac{(T-t)}{(T-t+1)}}(\Delta\breve{y}_{it}+\frac{\Delta\breve{y}_{it+1}+\cdots+\Delta\breve{y}_{iT}}{T-t}$$
$$\ddot{y}_{it-1} = \breve{y}_{it-1}- \breve{y}_{i1}- \frac{t-1}{T-1}(\breve{y}_{it}- \breve{y}_{i1})$$

And finally we can estimate α;

$$\Delta\ddot{y}_{it} = \alpha\, \ddot{y}_{it-1}+v_{it}$$

Here, null and alternative hypotheses for Breitung unit root test are:

$$H_0: \alpha =0$$
$$H_1: \alpha<0$$

(Breitung, 2000).

#### *3.1.1.3 Hadri Unit Root Test*

Hadri unit root test calculate Lagrange Multiplier test statistics which runs a regression model is based on OLS with a trend and constant variables which enable null hypothesis as no unit root for critical intervals. The error terms to be used for LM test statistic are obtained by applying the ordinary least squares method to the following model. Since we benefit from the algorithm of the Eviews program to obtain the residuals, the fixed effect and trend added model is tested ;

$$y_{it} = \delta_{it} + \eta_i t + \epsilon_{it}$$

In this model " $\delta_{it}$ "is assumed as a random walk. Likewise, mathematically, this conduction can be formulated as follows;

$$\delta_{it} = \delta_{it-1}+ u_{it} \text{ and } \quad u_{it} \sim (0, \sigma^2{}_u)$$

In this formulation , in order to avoid variance inflation factor effect, the critical assumption is that the individual fixed effects " $\delta_{it}$ "and residuals "$u_{it}$" are diagonal. That means there is no correlation between them. Mathematically;

$$y_{it} = \delta_{it} + \eta_i t + \epsilon_{it}= \delta_{it-1} + \eta_i t + \epsilon_{it} = \ldots = \delta_{it-T} + \eta_i t + \epsilon_{it}$$

Before proceedings on null and alternative hypothesis, it should be better to show cumulative representations as follows:

$$e_{it} = \sum_{t=1}^{T} \epsilon_{it} + u_{it}$$

And integrating this equations on general formula, we can obtain nested model for hypothesis test;

Indivdual fixed effect nested model;

$$y_{it} = \delta_{it} + \sum_{t=1}^{T} \epsilon_{it} + u_{it}$$

$$y_{it} = \delta_{it} + e_{it}$$

And individual fixed effect and trend included model;

$$y_{it} = \delta_{it} + \eta_i t + \sum_{t=1}^{T} \epsilon_{it} + u_{it}$$

$$y_{it} = \delta_{it} + \eta_i t + e_{it}$$

Then null and alternative hypotheses can be written as follows:

$$H_0: \lambda = 0 \; (\frac{\sigma_u^2}{\sigma_e^2} = 0)$$

$$H_1: \lambda = 0 \; (\frac{\sigma_u^2}{\sigma_e^2} > 0)$$

If $\sigma^2{}_u = 0$ then, $e_{it} = \epsilon_{it}$ and we can say $u_{it}$ will be zero and $e_{it}$ is stationary, but otherwise If $\sigma^2{}_u = 0$ then $e_{it} \neq \epsilon_{it}$ and we can conclude that $e_{it}$ is not stationary.

The non-reduced forms of standard deviations which is also called "Cumulative Standard Errors" and individual LM statistics is given below;

$$S_i(t) = \sum_{s=1}^{t} \hat{e}_{it}$$

and LM statistics can be computed as follows;

$$LM = (\frac{1}{N} \sum_{i=1}^{N} \frac{1}{T^2} \sum_{t=1}^{T} S_{it}^2) \,/\, \hat{\sigma}_e{}^2 = \frac{1}{\hat{\sigma}_e^2} + \frac{1}{NT^2} (\sum_{i=1}^{N} \sum_{t=!}^{T} S_{it}^2)$$

In formulation, consistent estimator variance of residuals ($\sigma_e^2$ ) can be computed as follows;

$$\hat{\sigma}_e{}^2 = \frac{1}{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{e}_{it}^2$$

Now we can construct Hadri Z test statistic as following formula;

$$Z = \sqrt{N} \left\{ LM - E\left[\int_0^1 v(r)^2 dr\right]\right\} / \sqrt{\left[\int_0^1 v(r)^2 dr\right]}$$

(Hadri, 2000; Tatoğlu, 2013).

### *3.1.1.4 Im-Paseram-Shin Unit Root Test*

This type of unit root test applies avaraged individual ADF methodology to all cross sectional units, with this type of seperated analysis, it would be possible to evaluate of stationary state of each countries data individually.

$H_0: \rho_i = 0$

$H_1: \rho_i < 1$

We use the formula given below to compute to estimate t value of avaraged ADF value

$$\Delta Y_{it} = \rho_i Y_{it-1} + \sum_{L}^{\rho_i} \emptyset_{iL} \, Y_{it-L} + \mu_i \Upsilon + u_{it}$$

IMP unit root test assumes Linbera-Levy Central Limit Theorem while K -> ∞ and avaraged ADF statistic value is formulated as below:

$$\bar{t} = \frac{1}{K} \sum_{i=1}^{K} t_{\rho_i}$$

(Im et al., 2003; Tatoğlu, 2013)

#### *3.1.1.5 Fisher ADF and Fisher Philips Perron Unit Root Tests*

The logic behind of these kind of unit root tests are based on calculation of probability values (p) of ADF and Philips Perron test value to evaluate stationarity of each units.

Null and alternative hypotheses are formulated as follow:

$$H_0 = \rho_i = 0$$

$$H_1 = \rho_i < 1$$

Fisher ADF and Fisher PP test statistic values:

$$P = -2\sum_{i=1}^{K} \ln(p_i)$$

$$P = -2\frac{1}{\sqrt{N}}\sum_{i=1}^{K} -2\ln(p_i) - 2$$

These test statistic values are accepted as "Chi-Square" and "Gaussian Normal", respectively, distributed (Tatoğlu, 2013).

### 3.2 Second Generetion Individual Unit Root Test

The first generation pooled unit root tests have an assumption as common autocorrelation coefficient for each cross sections ( $\rho = \rho_i$ ), but in the second generation unit root tests allow to predict multiple autocorrelation coefficients for each units ($\rho_3$ , $\rho_2$ .... $\rho_i$ ).

#### *3.2.1 Paseran CADF Unit Root Test*

The superiority of PCADF test is that instead of orthogonalizing the dependence between cross-sections, PCADF use the cross sectional avarages of the first differences and lagged values by employing Augmented Dickey Fuller algorithm. Similar to IPS (2003) PCADF compares obtained t values with t-table values. (Paseran, 2007; Lewandowski 2007) .

$$y_{it} = (1 - \emptyset_i)\mu_i + \emptyset_i y_{i,t-1} + u_{it}$$

i=1,....N ; t=1,...T

$$u_{it} = \gamma_i f_t + \varepsilon_{it}$$

in which $f_t$ is the unobserved common effect, and $\varepsilon_{it}$ is the individual-specific (idiosyncratic) error. So we can compound two formula:

$$\Delta y_{it} = \alpha_i + \beta_i\, y_{i,t-1} + u_{it} = \gamma_i f_t + \varepsilon_{it}$$

where $\alpha_i = (1 - \phi_i)\mu_i$, $\beta i = -(1 - \phi i)$ and $\Delta y_{it} = y_{it} - y_{i,t-1}$.

$$H_0 = \beta_i = 1 - \emptyset_i = 0$$

for all i

$$H_1 = \beta_i = 1 - \emptyset_i\ ,$$

i=1,....$N_1$ , $\beta_i$ =0 , i = $N_1$ +1, $N_1$ +2, .... N

$$t_i(N,T) = \frac{\Delta y_i' \overline{\boldsymbol{M}_w}\ y_{i,-1}}{\sigma_i (y'_{i,-1}\overline{\boldsymbol{M}_w}\ y_{i,-1})^{1/2}}$$

The critical values of the CADF test can be computed by stochastic simulation;

$$\text{CADF} = \frac{\int_0^1 W_i(r)dW_i(r) - \psi'_{if}\lambda_f^{-1}\boldsymbol{\kappa}_{if}}{(\int_0^1 W^2{}_i(r)d(r) - \boldsymbol{\kappa}'_{if}\lambda_f^{-1}\boldsymbol{\kappa}_{if})^{1/2}}$$

| **GDP Per Capita** | **Selection** | **Statistic Value** | **Prob Value** |
|---|---|---|---|
| Levin, Lin, Chu Unit Root Test | 1.Difference -None | -8.85992 | 0.0000 |
| Breitung Unit Root Test | 1. Difference-Invidiual Intercepts and Trend | -5.63342 | 0.0000 |
| Hadri Unit Root Test | 1. Difference-Invidiual Intercepts | 0.65185 | 0.2573 |
| Im-Paseran-Shin Unit Root Test | 1. Difference-Invidiual Intercepts | -7.68035 | 0.0000 |
| Fisher ADF Unit Root Test | 1.Difference -None | 165.079 | 0.0000 |
| Fisher PP Unit Root Test | 1.Difference -None | 154.245 | 0.0000 |
| Paseran CADF | Level-Constant Stationary | -1.228 | 0.984 |

| **Share of Nuclear Production** | **Selection** | **Statistic Value** | **Prob Value** |
|---|---|---|---|
| Levin, Lin, Chu Unit Root Test | 1.Difference -None | -12.3232 | 0.0000 |
| Breitung Unit Root Test | 1. Difference-Invidiual Intercepts and Trend | -4.83456 | 0.0000 |
| Hadri Unit Root Test | 1. Difference-Invidiual Intercepts | 0.31367 | 0.3769 |
| Im-Paseran-Shin Unit Root Test | 1. Difference-Invidiual Intercepts | -8.36915 | 0.0000 |
| Fisher ADF Unit Root Test | Level-None | 120.594 | 0.0000 |
| Fisher PP Unit Root Test | Level-None | 126.437 | 0.0000 |
| Paseran CADF | Level-Constant Stationary | -1.732 | 0.56 |
| **Foreign Direct Investment** | **Selection** | **Statistic Value** | **Prob Value** |
| Levin, Lin, Chu Unit Root Test | Level-Individual Intercept | -3.37 | 0.0004 |
| Breitung Unit Root Test | Level-Individual Intercept | -3.23561 | 0.0006 |
| Hadri Unit Root Test | Level-Individual Intercept | - | - |
| Im-Paseran-Shin Unit Root Test | Level-Individual Intercept | -6.6514 | 0.0000 |
| Fisher ADF Unit Root Test | Level-None | 106.386 | 0.0000 |
| Fisher PP Unit Root Test | Level-None | 44.0681 | 0.0274 |
| Paseran CADF | 1. Difference-Constant Stationary | -2.165 | 0.058 |

| **Consumption Share** | **Selection** | **Statistic Value** | **Prob Value** |
|---|---|---|---|
| Levin, Lin, Chu Unit Root Test | 1.Difference -None | -17.1281 | 0.0000 |
| Breitung Unit Root Test | 1. Difference-Invidiual Intercepts and Trend | -8.66755 | 0.0000 |

| | | | |
|---|---|---|---|
| Hadri Unit Root Test | Level-Individual Intercept | -0.69332 | 0.7559 |
| Im-Paseran-Shin Unit Root Test | 1. Difference-Invidiual Intercepts | -14.7727 | 0.0000 |
| Fisher ADF Unit Root Test | 1. Difference-Invidiual Intercepts | 44.3019 | 0.0259 |
| Fisher PP Unit Root Test | Level-None | 61.0478 | 0.0003 |
| Paseran CADF | | -1.577 | 0.778 |

| **Total Factor Productivity** | **Selection** | **Statistic Value** | **Prob Value** |
|---|---|---|---|
| Levin, Lin, Chu Unit Root Test | 1.Difference -None | -11.3868 | 0.0000 |
| Breitung Unit Root Test | 1. Difference-Invidiual Intercepts and Trend | -7.02266 | 0.0000 |
| Hadri Unit Root Test | 1. Difference-Invidiual Intercepts | 0.78272 | 0.2169 |
| Im-Paseran-Shin Unit Root Test | 1. Difference-Invidiual Intercepts | -7.55621 | 0.0000 |
| Fisher ADF Unit Root Test | 1.Difference -None | 168.274 | 0.0000 |
| Fisher PP Unit Root Test | 1.Difference -None | 288.173 | 0.0000 |
| Paseran CADF | Level-Constant Stationary | -1.493 | 0.865 |

Table 2: Unit Root Test Results of Variables

Note: **t-bar values was considered with %10 Critical Values for Paseran CADF Unit root Test Result. For the lag selection Stata "varsoc" and "lutstats" commands were used.*

### 3. 3 Fixed and Random Effects

Before, we proceed to the next step, we need to apply some techniques because of long run memory of panel data series in order to detect cross sectional dependicies and heterogenity problem. If and only if we determine the real characteristic of panel data series, we can choose the right cointegration and causality methods (Chudika et al., 2015).

### 3.3.1 Individual Fixed and Time Fixed Effects

While working on panel data, Hausmann and Taylor (1981) indicated that data combined with cross sectional and temporal (time, periods) dimensions may generate some unobservable individual fixed effects. The individual effects are originated from the hesitated control variables which causes correlations in the model. Individual fixed and time fixed effect can bring about different Y axis intersect points or slopes of regression line by depending on econometric methods. Individual fixed effect and time fixed effects can be modeled as follows (Hausmann & Taylor, 1981):

$$Y=\beta_0 + \beta_1 X_i + F_i + \epsilon$$
$$Y= \beta_0 + \beta_1 X_i + F_i + T_j + \epsilon$$

### 3.3.2 Two Side and One Side Test

In the literature, it is recommended to apply one sided test to highlight the random or fixed effects of your parameter statistics, in case you desregard unobservable or missing effects, then this model covers all of the remained part we would like to examine. So simply, although our variance constraint doesn't include positivity or negativity priority, It is usually accapted as more powerful than Hausmann Random Effect Test, we also run, in literature mostly used, Moulton and Randolph (1989) “Standardized Honda LM”, Honda UMP One-Sided Test, King and Wu (1997) “King Wu LLMP (Locally Mean Most Powerful)” LM tests for our fixed and random effects model selection cirteria (Moulton & Randolph, 1989; King & Wu, 1997).

*$H_0$: There is no cross sectional dependency among cross sections along time (for one and two sided critical values)*

*$H_1$: There is cross sectional dependency among cross sections along time (for one and two sided critical values)*

| | ***Cross-section*** | ***Time*** | ***Both*** |
|---|---|---|---|
| ***Breusch-Pagan (Statistical Value)*** | 1278.143 | 632.9302 | 1911.074 |
| *Prob Values* | (0.0000) | (0.0000) | (0.0000) |
| ***Honda (Statistical Value)*** | 35.75113 | 25.1581 | 43.06933 |
| *Prob Values* | (0.0000) | (0.0000) | (0.0000) |
| ***King-Wu (Statistical Value)*** | 35.75113 | 25.1581 | 43.58245 |
| *Prob Values* | (0.0000) | (0.0000) | (0.0000) |
| ***Standardized Honda (Statistical Value)*** | 42.02436 | 25.61895 | 42.19106 |
| *Prob Values* | (0.0000) | (0.0000) | (0.0000) |

| **Critical Values** | **1%** | **5%** | **10%** |
|---|---|---|---|
| | 7.289 | 4.321 | 2.952 |

Table 3: Lagrange Multiplier Tests for Random Effects

### 3.3.3 Some More Tests for Random Effects Robustness and Heterogenity of Coefficients

Panel data analyses are required the estimation results of $\alpha_i$ implicitly, it accepts that the characteristics of each of cross sections are constant over time. So, the estimated parameters will be implicitly acknowledged by the practicer as homogenous or unobserved heterogenity. The first term of equation $X_{it}$ indicates the observed part of the heterogenity. In order to use pooled panel regression coefficients, we need to test $H_0$ hypothesis for the implicit (unobserved) heterogenity in the model.

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha$$

| | **Statistic** | **d.f.** | **Prob.** |
|---|---|---|---|
| **Cross-section F** | 27.386234 | (13,514) | 0.0000 |
| **Cross-section Chi-square** | 279.988476 | 13 | 0.0000 |

Table 4: Unobserved Fixed Effect Determination With Redundant Fixed Effects Tests

So the Redundat Fixed Effect Loglikelihood Test result shows that fixed effect default estimated model $\alpha_i$ coeffciients have unobserved heterogenity. Under this condition, we have to avoid estimating robust coefficients with Pooled ARDL Model.

### 3.3.4 Random Effects Models

$$Y_{it} = X'_{it}\beta + c + \epsilon_{it}$$
$$\epsilon_{it} = \alpha_i + v_{it}$$

In random effects model, unobserved heterogenity coeffcient, $\alpha_i$, is embeded into the residual variable and named as random effect coefficient. The second term $v_{it}$ is named as white noise.

In order to strength the results of analysis, we estimate the ARDL parameters with Random Effects Model and analysed the validation of $H_0$. So the Hausman test result is corroborative with the previous "Redundant Fixed Effect Models". That's why, we used random effect ARDL option for the estimation of the long run causality coefficient.

*$H_0$: $Corr(\alpha_i, X_{it})$ Random Effect Model is appropriate*

*$H_1$= Fixed Effect Model is appropriate*

| ***Variable*** | ***Coefficient*** | ***Std. Error*** | ***t-Statistic*** | ***Prob.*** |
|---|---|---|---|---|
| ***CONSMPSHR*** | -0.034143 | 0.070585 | -0.483725 | 0.6288 |
| ***FDI*** | 0.035817 | 0.006965 | 5.142725 | 0.0000 |
| ***NUCSHR*** | 0.35268 | 0.051782 | 6.810913 | 0.0000 |
| ***TFP*** | 3.178868 | 0.396544 | 8.016427 | 0.0000 |
| ***C*** | 2.759806 | 0.142291 | 19.39549 | 0.0000 |

Table 5: Hausman Test for OLS Estimated Model

This result indicate that $H_0$ is true and our model is more appropriate to be estimated with random effects.

### 3.4 Autoregressive Distributed Lag Panel Models

The fact that the Mean Group (MG) estimator doesn't allow the heterogeneity that can arise from the characteristic shocks of the horizontal level in cross sectional series, at the level of certain parameters among the horizontal level in cross sections lead to the improve a pooled mean group estimators. These estimators give the heterogenetiy of short-term parameters, cross-sectional variances, and constant coefficients. The effectiveness of the parameters obtained from the pooled mean group model are shown through simulations. (Güler and Özyurt, 2011; Erdem et al. 2010;

Paseran, et al. 1999; Hausman, 1978). Besides allowing different cointegration levels for variables, another advantage of using ARDL (autoregressive distributed lag) models while searching causality and cointegration among panel data is that the ARDL model are robust to prevent multiple linearity among the lagged values of the panels. (Tatoğlu, 2013)

All of the variables were logarithmically transformed. Theoritically and mathematically our PMG Panel ARDL (p,q) model can be specified as given below:

$$GDPPERCAP_{it} = \beta_0 + \sum_{J=1}^{p} \alpha_{ij} GDPPERCAP_{\text{İ},t-j} + \sum_{J=0}^{q} \theta_{ij} CONSMPSHR_{\text{İ},t-j}$$
$$+ \sum_{J=0}^{q} \theta_{ij} FDI_{\text{İ},t-j} + \sum_{J=0}^{q} \theta_{ij} NUCSHR_{\text{İ},t-J} + \sum_{J=0}^{q} \theta_{ij} TFP_{\text{İ},t-J}$$

Here are the represenation of variable: GDPPERCAP; gross domestic product per capita. CONSMPSHR; share of the consumption in the country's gross domestic product. FDI: foreign direct investment. NUCSHR; nuclear energy share in electricity production. TFP; total factor productivity.

| | ***Long Run Equation*** | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.*** |
| ***FDI*** | 0.052929 | 0.024255 | 2.182166 | 0.0296 |
| ***NUCSHR*** | 0.658516 | 0.178036 | 3.698774 | 0.0002 |
| ***CONSMPSHR*** | -2.262821 | 1.437848 | -1.573756 | 0.1163 |
| ***TFP*** | 6.891545 | 1.167001 | 5.905346 | 0.0000 |
| | ***Short Run Equation*** | | | |
| **COINTEQ01** | -0.05779 | 0.018168 | -3.180797 | 0.0016 |
| **D(GDPPERCAP(-1))** | 0.278627 | 0.05652 | 4.929669 | 0 |
| **D(FDI)** | 0.001506 | 0.003842 | 0.391934 | 0.6953 |
| **D(NUCSHR)** | -0.080204 | 0.047818 | -1.677276 | 0.0942 |
| **D(CONSMPSHR)** | -0.402954 | 0.466602 | -0.863593 | 0.3883 |
| **D(TFP)** | 1.578535 | 0.613325 | 2.573732 | 0.0104 |
| **C** | 0.10986 | 0.03853 | 2.851321 | 0.0046 |

Table 6: Pooled Mean Group Panel ARDL Model Estimation Results

According to the Pooled Mean Group Panel ARDL model, vector error correction parameter (-0.05) indicates the existence of cointegration among variables. In the long run, %1 increase in share of nuclear production increases per capita income at %0.65. Again, in the long run, %1 increase in foreign direct investment increases per capita income at %0.05.

## 4. Conclusion

It is noted that this study puts more attention to the analysis of countries with nuclear energy production over %20 (nuclear energy plants, fuel oils sources, hydraulique streams and barages, steam power plants, and renewable energy plants) by years. In the light of emprical evidenvces and historical experiments in the context of nuclear energy, the know-how gains of these countries and also the implementation of sustainability policies intended for the production of nuclear energy and for the storage of nuclear waste will potentially guide new entrants with a kind of development path. Despite of strong and positive emprical evidences on relationship between growth and nuclear energy production, it doesn't mean to ignore the general concerns of the society about sustainability in nuclear energy production. While the effects of the incidents in Chernobyl and Fukushima Nuclear Power Plants still have deep social effects, in order not to refresh of etched memories, policy makers should lead to reconstruction of trusts in society (Corner et al., 2013).

In the recent years, some of the researches for the determination of the "Rebound Effect", as mostly accepted, the energy policies is just not only enough to find sources or efficient production technique, but also other policies towards consumption efficiency are also hugely discussed. In the sustainable energy literature, the result of these studies can be classified as "energy" and "non-energy" factors, as stated by the non-energy factors, the sustainable growth policies must also be collaboration with some energy saving implementations towards firms and household daily usage, under "*Build Your Energy Efficient Policies and Constructions"* motto (Greening et al. 2000; Zha & Ding, 2015). In order to carry into effect of these kind of mottos, The World Bank project, called "Small and Medium Enterprises Energy Efficiency Project", has been launched since 2013 (a five year project) towards Small and Medium-Sized firms in Turkey, which has a budget of $ 301 million ("Turkey SME Energy Efficiency Project", World Bank, 2018 ).

Our empirical evidence suggests that the "Growth Hypothesis" is valid for developed countries studied. There seems reasonable long run cointegration, direct and indirect effects of energy production on gross domestic product in 14 developed and developing countires for 37 years. For electricity production, an increase of gross domestic per capita and reduction of dependency on energy import will only be result of diversification of energy sources among alternatives. For this reason, countries which has huge energy trade and current deficits and also countires which desire sustainable growth rate, higher sustainable GDP per capita and lower trade deficits, by the way in order to minimize the negative externalities of some risks (e.g. geographical problems, exchange rate volatility, budget deficits, current deficits, interest rate, monopolistic institutions policies and ambargos) must focus on the electric production policies that considers production from a range of energy sources.

In future studies, examining the effects of the energy policies on the growth rates of developing or developed energy exporter and importer countries with the threshold regression and VAR model will make good contributions to the literature.

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***Özet***

*Bu çalışmanın amacı, enerji maliyetleri ve enerji faturaları ödemeler bilançosu dengesinde yüksek düzeyde açığa neden olan borçlu ve gelişmekte olan ülkelere üretimin önemli bir girdisi olarak enerji ithalatının maliyetinin fiyat oynaklıklarından, arz ve talep sorunlarından etkilenmemesi adına gelişmiş ülkelerin yıllar içerisinde gerçekleştirdiği enerji üretim imkânlarındaki dönüşümleri ve büyüme modellerini baz alarak, 14 ülkeye ait 1977-2014 yılları makroekonomik göstergelerinden elde edilen bulgular ile gelişmekte olan ülkelere yönelik nükleer enerji politikalarını da kapsayan enerji politikaları geliştirmektir.*

*Çalışmada ele alınan 15 ülkenin (ABD, Almanya, Arjantin, Belçika, Birleşik Krallık, Finlandiya, Fransa, Hindistan, Hollanda, İspanya, İsviçre, Japonya, Kanada, Kore) son 37 yılına ait (1977-2014) nükleer enerji tesislerinin sayısının yıllara göre değişimi, gelişmiş ve gelişmekte olan ülkelerin ödemeler dengesi bilançosu verileri, reel GSYİH miktarları, enerji ithalatı ve elektrik üretimine yönelik dış ticaret dengelerine ait grafikler üzerinden analizler sunulmuştur. İncelenen dönem itibariyle ülkelerin genel olarak nükleer enerji tesisleri sayısında radikal düşüşler olmadığı, birçok ülkede yıllar itibariyle ihtiyaçlarını karşılayacak düzeyde enerji üretiminin gerçekleştirilmesine bağlı olarak artış trendinin veya enerji imkânları yeterli düzeye ulaşmış ülkelerin ortalama olarak nükleer enerji santrallerinden enerji üretimini arttırdıkları ve yeni santrallerin inşa edildiği gözlenirken, santral sayılarında incelenen ülkelerin çoğunda radikal düzeyde kapanmaların olmadığı gözlenmiştir. Gelişmiş olan ülkelerin enerji ithalatlarına ait zaman içindeki eğilimsel hareketi incelendiğinde bu ülkelerin enerji ihracatı gelirlerinin özellikle 1980 ve 2002 yılları arasında artış gösterdiği, reel GSYİH rakamlarına yönelik eğilimler incelendiğinde sürdürülebilir ve durağan bir büyüme seviyesinin yakalanmış olduğu gözlenmektedir. Enerji ihtiyaçlarına yönelik üretimlerini eşit düzeyde dağılmış bir üretim politikası üzerinden uygulayan bu ülkelerin enerji ithalat ve ihracat oranlarını dış ticaret ve ödemeler dengesi açıklarına oranla sabit bir düzeyde korudukları veya azaltabildikleri anlaşılmaktadır. Bu durum, ilgili ülkelerin kriz dönemlerinde arz ve talep dengesi ile enerji ürünleri fiyatlarından etkilenmedikleri ödemeler dengesi bilançosu rakamlarından anlaşılmaktadır. Elektrik ticaret dengesi grafiği incelendiği zaman, gelişmiş ülkelerden bazılarının birçok pozitif dışsallık barındıran yenilenebilir enerji kaynaklarını enerji portföylerine entegre etmiş olmaları, bu tür yatırımların uzun geri dönüş süreleri ve verimlilik düzeylerinde beklentilerin altında kalması sebebiyle negatif elektrik ticaret dengesi ile sonuçlandığını söylemek mümkündür. Türkiye'nin Elektrik üretiminde enerji kaynakları dağılımına bakıldığında (2016 yılı itibariyle) %32 +%16 ithal ve yerli kömür, %14+%6 fuel-oil benzeri ürünlerden elde ettiğini söylemek mümkündür. Bu durum ülkemizin, enerji politikalarında hızlı bir dönüşüm ihtiyacı içerisinde olduğunu göstermektedir. 2016 yılı itibariyle global çapta, halen aktif olarak çalışan 450 nükleer enerji santrali mevcut iken, 55 adet nükleer enerji tesisinin inşasının devam ettiği tespit edilmiştir. Analizler kapsamımda, 14 ülkeye ait 37 yıllık kişi başına gelir, nükleer üretimin payı, doğrudan yabancı yatırım, tüketimin payı, toplam faktör verimliliği panel data verilerinin durağanlık düzeyleri, Levin, Lin, Chu (2002), Breitung, IPS( Im, Paseran, Shin), Fisher ADF, Fisher-PP, Hadri, Paseran CADF birinci ve ikinci nesi birim kök testleriyle test edilmiştir. Birim kök testleri sonucunda farklı koentegrasyon düzeylerinin tespit edilmesi, Sabit ve Rassal Etkiler modeline yönelik olarak Hasmann, LM ve Robustness testi sonuçlarına göre bu modellerden PMG ARDL testinin eşbütünleşme analizi uygulanmıştır.*

*Ampirik bulgular, 14 gelişmiş ve gelişmekte olan ülke için 37 yıllık zaman serisi verisinde "Büyüme hipotezini" destekler niteliktedir. Enerji üretimi ile kişi başına gelirde*

*büyüme arasında uzun dönemli eşbütünleşik, doğrudan ve dolaylı nedensellik ilişkisi mevcuttur. Bu durum ödemeler bilançosu ve yüksek borçluluk düzeyine sahip ülkelerin ağırlıkları eşit dağılmış veya coğrafik ve finansal anlamda bağımlılıklar yaşayan ülkelerin enerji portföylerinde çeşitlendirmeler yapmalarının ne kadar önemli olduğunu gösterir niteliktedir.*