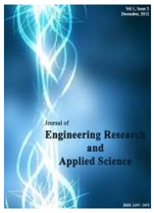
Journal of Engineering Research and Applied Science
Available at www.journaleras.com
Volume 9 (2), 2020, pp 1612-1617
ISSN 2147-3471 © 2020



The role of economic growth and energy prices for renewable energy development in Turkey

K. Kaygusuz

Karadeniz Technical University, Department of Chemistry, Trabzon, Turkey

Accepted 22 November 2020

Abstract

Turkey has abundant reserves of renewable energy sources. The most important renewable sources of Turkey’s energy sector are electrical, solar in its various forms, wind, biomass and geothermal; and the benefits of exploiting these sources would be enormous. This paper presents an alternative perspective on the renewable energy-economic growth nexus from installed capacity. Turkey assessed using panel data methodologies with the data period spanning from 1990-2019. Electricity generation share-weighted price indexes of coal and natural gas are included in explaining differences in fossil fuel reliance in Turkey. Our findings confirm the crucial role of economic growth in the growth of renewable energy capacity and long-term causality is apparent. In comparison to the results obtained from unweighted price indexes, our simple weighted energy price indexes appear to be vital in obtaining a more plausible description of the relationship between energy prices and renewable capacity growth. Our results indicate that climate policies that raise the costs of fossil fuels could potentially help stimulate the addition of renewable capacity and expedite the transition to renewable energy through the price effect.

Keywords: renewable energy capacity, economic growt,. panel data, fossil fuel prices

1. Introduction

In the pursuit to reduce carbon emissions and find sustainable energy systems to combat global climate change, the world economic development narratives increasingly focus on renewable energy initiatives. Renewable sources such as solar and wind will play an increasingly critical role in future energy systems with rapid cost reductions. Whilst renewable energy has attracted much attention in the areas of climate change, sustainability and policy-making, the extensive literature surrounding the renewable energy-economic growth nexus pivots around energy consumption. Scholars have devoted their efforts on assessing the drivers and barriers of renewable energy consumption, adoption and deployment in the move for energy transition. So, it is apparent that relatively less attention paid to renewable production capacity [1-5].

Fossil fuel prices and related policies serve as a major possible influence on the adoption of renewable energy and energy transition implementation. Theoretically, when non-renewable energy is less costly, investments into renewable energy projects become less attractive as fossil fuel energy is more accessible and readily available. With the current climate of research efforts surrounding renewable energies, and in particular consumption of renewable energy and energy transition to increase substitution of non-renewables with more sustainable renewable energy sources, many studies aim to identify the specific favourable factors to enable adoption and diffusion of renewable energy. Existing studies have considered a number of factors including policies, fossil fuel prices, financial systems, trade, innovation and natural endowments, and their impact on the adoption and consumption of renewables [6, 7].

This paper examines the development of renewable energy through the lens of renewable energy production capacity. The production capacity of renewables greatly affects the ability to transition towards a larger share of renewable energy in the output of total electricity generated for each country. A novel feature of this paper lies in our inclusion of fossil fuel prices in the analysis of renewable energy capacity expansion. Our use of influence-weighted price indexes postulates that the impact of a change in fossil fuel prices on the incentive to transition to renewable energy is stronger for those countries that rely more heavily on fossil fuels in electricity generation.

Corresponding author:kamilk@ktu.edu.tr

2. Renewable power in Turkey

2.1. Introduction

Turkey has abundant reserves of renewable energy sources. The most important renewable sources of Turkey's energy sector are electrical, solar in its various forms, wind, biomass and geothermal; and the benefits of exploiting these sources would be enormous.

Turkey, both geographically and geopolitically, situated in a region that makes it a natural "energy bridge" between the major proven oil and natural gas producing areas in the Middle East, Caspian Sea regions and Central Asia on the one hand and consumer markets in Europe on the other. Moreover, Turkey, itself, is a rapidly growing energy consumer. Due to its demographic and economic growth, Turkey constitutes a major energy market, as well as playing an active role within the projects to ensure the diversification of both energy resources and transport routes [8-11].

It is envisaged that the world energy consumption, of which is expected to increase by approximately 40 % within the next 20 years, will be fulfilled by the region where Turkey is located. Turkey's total installed power of the Power Plants commissioned within 2019 is 90 720 MW, out of which 43 900 MW portion of it is the Power Plants producing electricity from Renewable Energy Resources, energy distribution by the Electricity producing Power Plants originating [8-11]:

- 7394 MW of it from wind power
- 28 457 MW of it from hydraulic
- 1402 MW of it from geothermal
- 1057 MW of it from landfill gas and biogas

2.2. Electrical energy

As of end of 2019, the 48% of the electricity produced in Turkey has been obtained through Renewable Energy Resources. As per revised strategy document for Electricity Sector, this ratio is aimed to reach 60% by the year 2030. Figure 1 shows the electricity energy demand and increase rate over the years. As seen in the figure, the demand for electricity has decreased by 0,26% in 2019 for the second time in the last 19 years after 2009 [12].

The distribution of licensed electricity generation by resources is shown in Figure 2. While the share of natural gas-fired power plants in licensed electricity generation in 2018 was 30,88%, it decreased to 19,21% in 2019, while the share of imported coal plants decreased from 21,31% to 20,52%. On the other hand, the share of hydroelectric power plants increased from 20,28% in 2018 to 30,20%, the share of wind power plants from 6,73% to 7,35%, the share of geothermal plants from 2,58% to 3,03%, The share of domestic coal (lignite, hard coal and asphaltite) power plants increased from 17,06% to 17,92% [12].

The development of licensed electricity generation on the basis of resources since 1990 is shown in Figure 3. As can be seen from the figure, the share of renewable energy sources such as geothermal, wind, solar and biomass in electricity generation has increased every year. Turkey's total installed electricity capacity is around 90,000MW while about 16,000MW of this figure constitutes renewable energy capacity. Further, 44,000MW also includes large Hydro Electricity power plants that fall out of the scope of "renewable energy resources" under the Renewable Energy Law. After the application of this law, 800 MW Renewable Power has been installed in 2019 by private sector and 48% of Turkey's electricity has been produced from Renewable Energy Resources [8-12].

With the Amendment Law No. 6094 of 29 December, 2010, Turkish Parliament amended the Law on Utilization of RES for Generating Electrical Energy of 10/05/2005 no 5346. The Amendment Law introduces amendments to improve the incentive mechanism of the electrical energy generated by the license holders and encourage renewable energy investment opportunities in Turkey. Renewables are non-fossil resources such as hydropower, wind, solar, geothermal and bioenergy, wave, current and tidal energy.

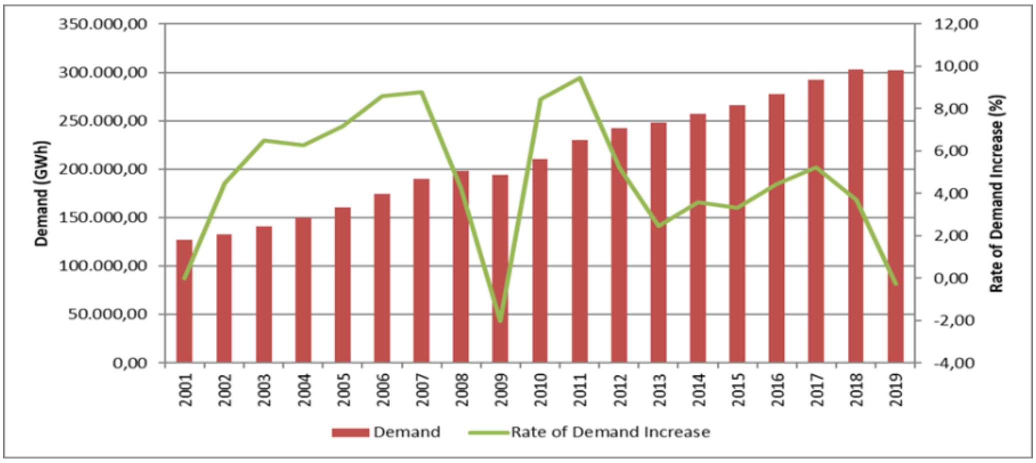


Figure 1. Turkey's electric energy demand and Rate of Increase by Years (GWh-%).

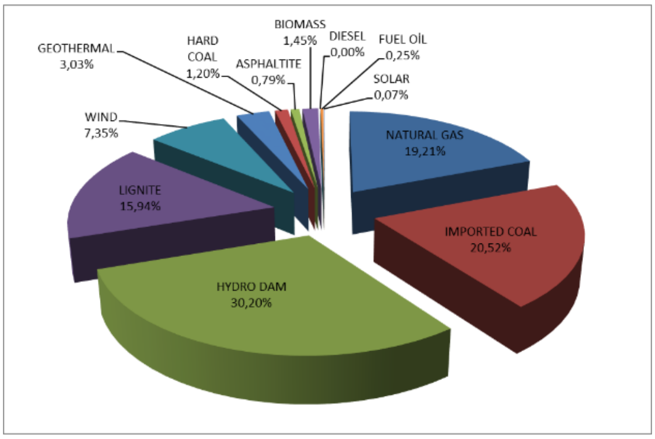


Figure 2. Turkey's distribution of licensed electricity generation by sources in 2019 (%).

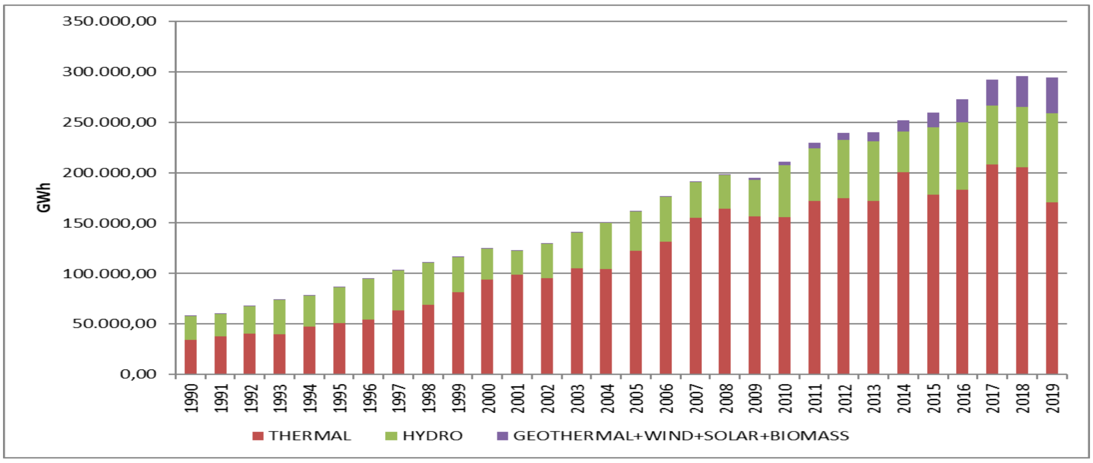


Figure 3. Source-Based Development of Licensed Electricity Generation by Years (GWh).

3.Data and economic analysis

In contrast to the vast literature on the renewable energy-economic growth, which is overtly focused on renewable energy demand, our empirical analysis addresses the supply side of the story by considering renewable energy capacity. Our economic analysis entails the use of panel data techniques to understand the nature of the underlying data and estimate the impact of fossil fuel prices and national income on the expansion of renewable energy capacity. There are several benefits of using panel data as opposed to time-series data [13]. As the time dimension (*T*) of renewable energy data tends to be limited, the inclusion of a cross-section dimension (*N*) can provide more informative data (and degrees of freedom), more variability in the data and higher efficiency in the econometric estimation [1].

3.1 Data

Our data file consists of four variables for Turkey spanning the period of 1990-2019. In this study, we measure renewable energy capacity (*REC*) by the total renewable electricity installed capacity data from the Ministry of Energy and Natural Resources [8]. Rising fossil fuel prices can encourage substitution from fossil fuel-based electricity to renewable electricity through its impact on the total cost of electricity generation. The strength of this total cost effect depends on the share of fossil fuels in total electricity generation. In the empirical analysis, we interact the fossil fuel price indexes with the shares of fossil fuels in electricity generation to capture their joint effect on renewable capacity accumulation. Data for total electricity generation and electricity generated by coal and natural gas are obtained from the. The shares of coal and natural gas in total electricity generation for Turkey calculated basing on this data [8].

3.2 Econometric Methods

Our empirical methodology involves the following main two steps:

[1] Test for panel unit-root in the data series
[2] Test for panel cointegration and the existence of long-run relationships

3.2.1 Panel unit-root tests

In light of the relatively small sample size of our data, we employ two panel unit root tests that are shown to have comparatively better power and size properties in small samples [14]: the IPS [15] and Breitung [16, 17] tests. These two tests differ in the way they deal with serial correlation and the autoregressive parameters in the panel unit root regressions. The IPS test considers an augmented Dickey-Fuller regression for each cross-section member *i* in the panel:

$$\Delta y_{it} = \rho_i y_{it-1} + \sum_{p=1}^{P_i} \gamma_{ip} \Delta y_{it-p} + D'_{it}\omega + \varepsilon_{it} \qquad (1)$$

where subscript t denotes the time period, y_{it} is the series being tested, D'_{it} represents the exogenous variables and □$_{it}$ is the error term. As the IPS test allows for heterogeneous autoregressive parameters, the null hypothesis that each series in the panel contains a unit root (i.e. H_0: □$_i$ = 0 for all *i*) is tested against the alternative hypothesis that some of the series are stationary.

Unlike the IPS test that uses lags of □y_i in equation (1) to control for serial correlation of the error, the Breitung test uses a pre-whitening procedure to adjust the data for short-run serial correlation, so that the test statistic has a standard normal limiting distribution. Another major difference between the Breitung and IPS tests is that the BD test assumes a common unit root process, i.e. □$_i$ = □ for all *i*, so the alternative hypothesis is that the whole panel is stationary.

3.2.2 Long-run equilibrium estimation

Cointegration confirms the existence of a long-run equilibrium relationship between the *REC* and the regressors *X*. In our single-equation setting, the finding of cointegration implies that the *REC* will adjust to disequilibrium caused by movements in *X* in the system. To infer long-run impact (or Granger causality) from a specific element in *X* to *REC*, we also need to examine the statistical significance of each of the coefficients in the long-run equation. Therefore, on the detection of cointegration, we will estimate an error-correction model with the pooled mean group (PMG) estimator proposed by Pesaran et al. [18]:

$$\Delta REC_{it} = \delta_i' d_t + \alpha_i(REC_{it-1} - \beta_i' X_{it-1}) + \sum_{h=1}^{H} \eta_{ij} \Delta REC_{it-h} + \sum_{h=0}^{H} \Psi_{ij}' \Delta X_{it-h} + \mu_i + \upsilon_{it} \qquad (2)$$

4.Empirical results

The test statistics of the IPS and Breitung tests as well as their corresponding *p*-values are given in Table 1. The panel average lag length (as determined by the AIC) in the IPS tests ranges from 0.00 to 0.71, and in light of this, one lag is included in the pre-whitening procedure of the Breitung tests [16]. For all variables in levels, the null hypothesis of non-stationarity is not rejected at conventional significance levels in both tests. The same null hypothesis is strongly rejected at 1% significance for all first-differenced variables in both tests, with *PG* being the only exception where the null is rejected at 10% significance in the Breitung test. Our results unambiguously suggest that all the series in our data are stationary in first difference, or $I(1)$. Apparently, the assumption of homogenous autoregressive parameters did not lead to any major differences in our stationarity analysis.

Table 1. Panel unit root results

	IPS Level		**IPS 1^{st} Difference**		**Breitung Level**		**Breitung 1^{st} Difference**	
Variable	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
REC	0.611	0.729	-5.538	0.000	0.009	0.504	-3.368	0.000
GDP	-1.252	0.108	-6.259	0.000	-0.811	0.209	-4.268	0.000
PC	-0.018	0.474	-9.855	0.000	-0.096	0.462	-5.288	0.000
PG	2.278	0.986	-5.985	0.000	2.186	0.986	-1.394	0.068

Note: the standardized $W_{t\text{-}bar}$ statistic is reported for the IPS test

We estimated equation (2) with the PMG method and the long-run coefficients are reported in panel (a) of Table 2. The Hausman (1978) specification test yields a *p*-value of 0.738, hence our PMG estimates are deemed both efficient and consistent. The speed of adjustment coefficient, □, is highly statistically significant (*p*-value < 0.01). This echoes our finding of cointegration and suggests that *REC* will adjust to the long-run equilibrium following shocks to the system. But with a small point-estimate value at -0.081, the adjustment process is slow and it takes a long time for renewable energy capacity to reach the long-run equilibrium level. This could be due to the considerable time lag between investment decisions and the actual change in renewable capacity as mentioned above. As all variables in the model are in natural logarithm, the estimated coefficient for *GDP* can be interpreted as the income elasticity. The estimate of β_{GDP} is 1.618 and highly significant. This implies that economic growth is an important factor that contributes to the renewable energy transition, as a 1% increase in national income can lead to on average a 1.618% increase in renewable energy capacity in the long-run.

Table 2. PMG estimates of the long-run equation

	(a) Weighted Price Indexes			**(b) Unweighted Price Indexes**		
Coefficient	Estimate	Std. Error	p-value	Estimate	Std. Error	p-value
□	0.091	0.019	0.000	0.100	0.029	0.001
□$_{GDP}$	1.638	0.605	0.008	1.247	0.421	0.003
□$_{PC}$	0.468	0.142	0.002	0.234	0.272	0.381
□$_{PG}$	0.146	0.082	0.056	1.671	0.394	0.002

In order to evaluate the influence of weighted price indexes on the empirical results, we re-estimate Equation (2) with unweighted price indexes and the results are presented in panel (b) of Table 2. The Hausman specification test results in a *p*-value of 0.128, so these PMG estimates are also consistent and efficient. With unweighted price indexes, the GDP and speed of adjustment coefficients are still in comparable magnitudes to those obtained with weighted price indexes. However, the coal price coefficient becomes statistically insignificant while the size of the gas price coefficient becomes more than ten times larger and highly significant (*p*-value < 0.01). These results appear to be less plausible considering the different role of coal and natural gas in electricity generation, as well as their relation to renewable electricity generation.

5.Conclusions

Turkey has abundant reserves of renewable energy sources. The most important renewable sources of Turkey's energy sector are electrical, solar in its various forms, wind, biomass and geothermal; and the benefits of exploiting these sources would be enormous. Moreover, Turkey, itself, is a rapidly growing energy consumer. Turkey's total installed power of the Power Plants commissioned within 2019 is 90 720 MW, out of which 43 900 MW portion of it is the Power Plants producing electricity from Renewable Energy Resources, energy distribution by the Electricity producing Power

Plants originating.

This paper examines the impact of economic growth and fossil fuel prices on the development of renewable energy capacity. We considered data from Turkey spans from 1990 to 2019 with panel time-series econometric techniques. In estimating the fossil fuel price effects, we explicitly took into consideration the varied role of fossil fuels in the electricity generation structure of the countries by weighting the fossil fuel price indexes by the electricity generation share of the fossil fuels. Our results confirm the crucial role of economic growth in renewable energy transition in the long-term, and this will continue to be relevant as long as renewable energy is still relatively dearer than fossil fuel energy when negative externalities not fully internalized. Presented against the backdrop of the extant literature on the renewable energy consumption-economic growth nexus, this paper brought a new perspective into this strand of research by considering the installed capacity of renewable electricity is not subject to the intermittency problem surrounding renewable energy production and consumption.

Acknowledgement

The author acknowledged to the Turkish Academy of Science (TUBA) for financial support of this study.

References

[1] Lia, R., Leeb, H. Renewable energy capacity – The role of economic growth and energy prices. The Energy Journal 2020 (in press).
[2] Best, R., Burke, P. J. Adoption of solar and wind energy: The roles of carbon pricing and aggregate policy support. Energy Policy 2018; 118: 404–417.
[3] Carley, S., Baldwin, E., MacLean, L.M., Brass, J.N. Global expansion of renewable energy generation: An analysis of policy instruments. Environmental and Resource Economics 2017; 68: 397–440.
[4] Eleftheriadis, I.M., Anagnostopoulou, E.G. Identifying barriers in the diffusion of renewable energy sources." Energy Policy 2015; 80: 153–164.
[5] Friebe, C.A., von Flotow, P., Täube, F.A. Exploring technology diffusion in emerging markets – the role of public policy for wind energy. Energy Policy 2014; 70: 217–226.
[6] Pfeiffer, B., Mulder, P. Explaining the diffusion of renewable energy technology in developing countries. Energy Economics 2013; 40: 285–296.
[7] Kaygusuz, K., Yüksek, Ö., Sari, A. Renewable energy sources in the European Union: markets and capacity. Energy Sources, Part B 2007; 2: 19–29.
[8] MENR, Ministry of Energy and Natural Resources. Energy statistics in 2019.MENR, Ankara, Turkey. Available from www.enerji.gov.tr/(accessed 20 May 2020)
[9] IEA, International Energy Agency. Turkey Energy Report 2026. IEA, Paris, 2016.
[10] IICEC, Sabancı University Istanbul International Center for Energy and Climate. Turkey Energy Outlook 2020. İstanbul, Turkey, 2020. https://iicec.sabanciuniv.edu/
[11] CME, Chamber of Mechanical Engineers. Turkey Energy Outlook 2020, May 2020, Ankara, Turkey. https://enerji.mmo.org.tr/accessed 20 December, 2020).
[12] EPDK, Elektrik Piyasası Denetleme Kurumu. Türkiye elektrik Üretim raporu 2020. EPDK. Ankara, Türkiye, 2020. www.epdk.gov.tr/(accessed December 2020).
[13] Hsiao, C. Panel data analysis: advantages and challenges. Test 2007; 16: 1–22.
[14] Hlouskova, J., Wagner, M. The performance of panel unit root and stationarity tests: Results from a large-scale simulation study. Econometric Reviews 2006; 25: 85–116.
[15] Im, K., Pesaran, H., Shin, Y. Testing for unit roots in heterogeneous panels. Journal of Econometrics 2003; 115: 53–74.
[16] Breitung, J. The local power of some unit root tests for panel data. In Advances in Econometrics, Volume 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels, ed. B. H. Baltagi, 161–178. Amsterdam: JAI Press, 2000.
[17] Breitung, J., Das, S. Panel unit root tests under cross-sectional dependence. Statistica Neerlandica 2005; 59: 414–433.
[18] Pesaran, M.H., Shin, Y., Smith, R.P. Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association 1999; 94: 621–634.