

ENERGY CONSUMPTION AND GDP IN TURKEY: IS THERE A CO-INTEGRATION RELATIONSHIP?

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Abstract

Energy consumption and GDP are expected to grow by 5.9% and 7% annually until 2025 in Turkey. This paper tries to unfold the linkage between energy consumption and GDP by undertaking a co-integration analysis for Turkey with annual data over the period 1970–2003. The analysis shows that energy consumption and GDP are co-integrated. This means that there is (possibly bi-directional) causality relationship between the two. We establish that there is a unidirectional causality running from GDP to energy consumption indicating that energy saving would not harm economic growth in Turkey. In addition, we find that energy consumption keeps on growing as long as the economy grows in Turkey.

Key words: Cointegration; error correction; Turkey; energy consumption; economic growth; Environmental Kuznets Curve.

JEL classification: C32, Q43, Q54

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1. INTRODUCTION

There is a multi-dimensional need for studying the energy situation in Turkey. First, Turkey is a candidate for becoming an EU member in the near future and preparation for membership can work as a stabilizer for the Turkish economy. Second, Turkey has a strategic position as a gas and oil transit country (see also Van der Linde, 2004). Finally, the Turkish economy has had a boom-bust structure in the recent past and it is interesting to study her development performance. A recent survey of the OECD shows that Turkey has a long-term yearly growth potential of above 7% (OECD, 2004).

UNDP and WB (2003) provide a broad policy overview of Turkey's energy situation and energy related environmental issues until 2025. They project an annual growth of final energy consumption of 5.9% in the period 2000–2025 (ibid. page 25). In the baseline there is already accounted for an unrestricted increase of gas imports into the energy mix, namely from 14 million tonnes of oil equivalent (mtoe) in 2000 to 73 mtoe in 2015 and 155 mtoe in 2025, serving almost 50% of the total energy demand (ibid.).

Yeldan (2002, 2004) and Voyvoda and Yeldan (2003) discuss the typical boom-bust structure of the Turkish economy. In contrary to the popular believe that bad governance caused the Turkish economic crisis in 2001, they argue that the crisis emerged due to too tight control of the IMF, which disempowered the Turkish central bank. This made an already fragile economy even more fragile to a point that short-term foreign capital fled the country with a first shock in November 2000 and a second shock in February 2001. The presence of short-term capital in the Turkish economy is sometimes ironically referred to as 'casino' capitalism (Yeldan 2002), which, once it is withdrawn overnight, can quickly destabilize the economy, with disastrous effects, as the 2001 crisis has shown.

Furthermore, Yeldan (2002, 2004) argues that due to unsustainable so-called Ponzi-schemes (a process where extra money has to be borrowed for paying the national debt service) important indicators of the Turkish economy have weakened. Moreover, the wave of growth in 2003/2004 is generated by an inflow of foreign capital to keep the Turkish lira strong. This short-term foreign capital is very volatile and this can change overnight, as the two crises in 2000 and 2001 have shown. In addition, unemployment is still high (10.6% in 2004 according to OECD data) and there has been no growth in wages. There is also room for optimism, because the hyperinflation in the 80s and 90s converged to a single digit rate since 2004.

Understanding long-term 'energy transitions' and 'development trajectories' is a great challenge in the move towards sustainable development in a globalising world. Energy transitions are defined as investments in possibly cleaner technologies to replace and expand the depreciating capital stock to meet growing energy demand. When considered over a longer time horizon, but also across countries, significant changes in energy technologies and consumption can be observed. Development trajectories can be characterized by sectoral changes in the economy, which transform the society from traditional (agricultural/industrial sector) to modern (service/ITC sector).

Thereupon, we study the following question in this paper, using a co-integration analysis: Is there a (Granger) causal link between energy consumption (EC) and GDP? What is the direction of this causality? Is there a decoupling of energy consumption from economic growth?

The application of a full-fledged cointegration analysis to Turkey has not been undertaken before (maybe except for Sari and Soytaş 2004, Altınay and Karagöl 2004 but both articles had a different focus and did not do the analysis as outlined in this paper). So the renewing part is to

do a more comprehensive analysis with more recent data. Also the analysis on its own is more comprehensive than is generally the case in the literature, where the focus is mainly on establishing the causality between GDP en EC, rather than building an ECM model as well. Furthermore, the application to Environmental Kuznets Curve (EKC) is also refreshing, as the cointegration analysis, which is hardly used, is the only correct way to test the EKC hypothesis.

The paper is relevant for Turkey, as Turkey is preparing to become a member of the EU, and can play a strategic role a gas (bleu stream through the Black Sea) and oil (Baku-Tblisi-Ceyhan pipeline to the Caspian Sea) transit country. Having a better view on link between energy consumption and GDP can help untangle the question to which extent economic growth can be sustained under various energy availability scenarios.

The relevancy of this article is also related to a more general question, namely how to meet the energy consumption challenges without interrupting economic growth within a country. Conclusions for Turkey may be relevant for a number of countries, which have to go through a similar development path, increasing the pressure of the already scarce energy resources. This paper is also timely, as demonstrated by the current historic high oil/energy prices.

The remainder of this paper is organised as follows. Section 2 presents the method used in this paper and reviews important work on co-integration analyses. Section 3 presents the data and discusses the results of the co-integration analysis. The final section concludes.

2. COINTEGRATION ANALYSIS

2.1 Method

The paper by Engle and Granger (1987) has led them to receive the Nobel price in 2003. Engle and Granger (1987) provided a totally new method for analyzing time series. It is well known that a time-series model can only be built once the included series in the model are stationary. This is, however, not the case for most series of practical interest. Moreover, working with transformed series makes it difficult to interpret the results or impossible to use the model for forecasting. To overcome this dilemma, Engle and Granger (1987) show that if independent series are integrated of the same order d , denoted by $I(d)$, and if the residuals of the linear regression among these series are integrated of the order $d-b$, $I(d-b)$, then the series are said to be co-integrated of the order d, b , denoted as $CI(d,b)$. There is a great advantage in finding (long-term) co-integration relationships, as the series need no longer be transformed and, hence, the forecasting power increases substantially.

Several steps can be distinguished in undertaking a co-integration analysis on time series (e.g. Hondroyiannis et al, 2002, Beki et al, 1999). For ease of exposition, but without loss of generality, we consider two time series only, namely x_t and y_t .

First, the order of integration of x_t and y_t has to be established. Non-stationary series are particularly problematic when they have a unit root, which is equal to being integrated of the order one, $I(1)$. This series is a random walk (possibly with drift), where the future value is equal to the past value (possibly with drift) with an error. The difficulty in using a random walk series is that it is typically heteroscedastic and cannot be used for forecasts. It is possible to test for a unit root using the Augmented Dickey-Fuller (ADF) test (Said and Dickey 1984) or the Phillips-Perron (PP) test (Phillips and Perron 1988). For instance, the ADF produces a t-statistic, which needs to cross a critical value above which the series can be confirmed to be stationary. This test needs to be run for different orders of integration, with trend and/or intercept and a number of lags. In this manner the order of integration can be determined.

Second, let us assume that x_t and y_t are integrated of the order one: I(1). By running a simple OLS, it can be verified whether these series are co-integrated. This is the case once the residuals are stationary. This can be verified by undertaking either the Johansen maximum likelihood co-integration test or by determining the order of integration of the residuals by using the same ADF as before again.

$$y_t = \phi x_t + \varepsilon_t \quad (1)$$

Once the residuals ε_t of Equation (1) are white noise, then there is one co-integrating factor (as established by the OLS), which is a good predictor of the long-term relationship among the variables (Harvey 1990). In general, when more variables are considered, it is possible to find multiple cointegrating vectors.

Third, a so-called vector error-correction modeling approach is needed to test for the exogeneity of the variables. The short-term variation can be predicted by using an error correction model (ECM). For instance, by using the following model:

$$\Delta y_t = \alpha + \sum_{i=1}^k \beta_i \Delta y_{t-i} + \sum_{j=1}^m \gamma_j \Delta x_{t-j+1} + \delta ECT_{t-1} + \varepsilon_t. \quad (2)$$

Where the α , β , γ , δ 's are coefficients which need to be derived through a VAR regression, Δ is the difference, and ϕ is the co-integrating factor, which can be derived through OLS in a first stage. ECT stands for error correction term, which can be established by Equation (1).

Fourth, the causality between variables can be established. It is then possible to verify whether, say, energy *Granger*-causes economic growth, the other way around, or both. Moreover, once a co-integration relation is established between x_t and y_t , then either x_t has to (Granger) cause y_t , the other way around, or both. Masih and Masih (1997), for instance, propose the ECM in equation (3):

$$\begin{aligned} \Delta y_t &= \alpha_1 + \sum_{i=1}^m \beta_{1i} \Delta x_{t-i+1} + \sum_{i=1}^m \gamma_{1i} \Delta y_{t-i} + \delta_1 ECT_{t-1} + \varepsilon_{1t} \\ \Delta x_t &= \alpha_2 + \sum_{i=1}^m \beta_{2i} \Delta x_{t-i} + \sum_{i=1}^m \gamma_{2i} \Delta y_{t-i+1} + \delta_2 ECT_{t-1} + \varepsilon_{2t} \\ ECT_t &= y_t - \phi x_t \end{aligned} \quad (3)$$

Where, as before, the α , β , γ , δ 's are coefficients which need to be derived through a VAR regression, Δ is the difference, and ϕ is the co-integrating factor, which can be derived through OLS in a first stage. ECT stands for error correction term.

2.2 Literature

In the recent literature, we can find cointegration analyses of Japan (Gupta-Kapoor and Ramakrishnan, 1999), US (Stern, 2000), Taiwan (Yang, 2000), Korea (Glasure, 2002; Oh and Lee, forthcoming), Greece (Hondroyannis et al, 2002) and a research note on causality between energy use and GDP in G-7 countries and emerging markets (Soytas and Sari, 2001, 2003, 2004). More details about these and related studies follow below and a summary is given in Table 2.1.

Table 2.1 *Overview of studies on the link between energy consumption and GDP*

Authors	Period	Country	Log	Causality	Remarks	Extra variables
Sari, Soytas (2004)	1969-1999	Turkey	yes	not verified	Variance decomposition, various energy sources	employment
Soytas, et al (2001)	1960-1995	Turkey	yes	EC to GDP		
Altınay, Karagöl (2004)	1950-2000	Turkey	yes	no causality	Test for structural break of the used time series	
Hondroyannis et al (2002)	1960-1996	Greece	yes	bi-directional	Various types of energy consumption	CPI
Yang (2000)	1954-1997	Taiwan	no	bi-directional	Various types of energy consumption	
Glasure (2002)	1961-1990	Korea	no	bi-directional	Oil price turns out to be the main determinant	Government expenditure, money supply, oil prices
Oh, Lee (2004)	1970-1999	Korea	no	EC to GDP		Labour, capital
Yu, Jin (1992)	1974:1-1990:4	US	no	no causality	Monthly data	Employment
Stern (2000)	1948-1994	US	yes	EC to GDP		Labour, capital

Yang (2000) uses different types of energy consumption (oil, gas, coal, power) to test for the causal relation with GDP in Taiwan. He uses yearly data for the period 1954–1997 to conclude that different directions of (Granger) causality exist between GDP and various kinds of energy consumption.

Glasure (2002) employs a five-variable vector ECM to study the (Granger) causality between GDP and energy consumption in Korea. Government expenditure is used as a proxy for government activity, money supply is used as a proxy for monetary policy and oil prices are also included as an important factor in explaining the causality. The period 1961–1990 is considered. Structural breaks of two oil price pikes are further included as dummies in the model. He derives a bi-directional causation, and the oil price is found to have the biggest impact on economic growth and energy consumption.

Oh and Lee (2004) also study data on Korea, but shift the data set one decade ahead to consider the period 1970–1999. They follow an approach that is more based in the classic production function literature (which is also propagated by Stern (1993)). Besides energy, labour and capital are also considered to be important production factors for generating GDP. They correct for quality improvements in energy by using a mean price weighted log Divisia index to establish the level of energy use in the economy. Following Glasure (2002), they also use a vector ECM and confirm the conclusion of bi-directional causation between energy and GDP.

Yu and Jin (1992) use employment as a third variable in explaining the link between energy consumption and GNP. They use monthly data over the period 1974:1–1990:4 for the US and they do not find any evidence for co-integration. With this analysis they find support for earlier conclusions that energy restrictions do not harm economic growth in the US and that energy conservation has no clear impact on employment.

Moroney (1992) argues that energy is a very important production factor. The oil crises in the 70s and 80s revealed this. The influence is more than just a minor expenditure of GDP. Stern (1993) in his extensive review of the literature stresses that economic growth is not only a product of input factor energy use, but input factors labour and capital also play an important role. He argues that the aggregation of labour and energy is problematic. It does not account for quality differences in labour, which can range from unskilled to specialists jobs. Also, an mtoe (million tonne of oil equivalent) of coal may not be as efficient as an mtoe of electricity. Ideally variables need to be developed to account for these quality differences in labour and energy, for instance, by using salaries and energy prices. Stern (1993) shows that the classic measure of energy consumption does not give evidence for causality, while his corrected measure does. He uses annual data over the period 1947–1990 for the US to establish this result. In a similar framework Stern (2000) undertakes a co-integration analysis to conclude that energy is a limiting factor for growth, as shocks to energy tend to reduce output.

Hondroyannis et al (2002) study the link between energy consumption, GDP and the Consumer Price Index (CPI) for Greece. They consider annual data over the period 1960-1996. They find evidence for long-term bi-directional causality between energy consumption (total and industry) and GDP, while there is no causality between residential use of energy and GDP. This means that demand for residential energy is exogenous and merely unrelated to the level of GDP growth.

Sari and Soytas (2004) apply a so-called generalized forecast error variance decomposition technique, which they use to shed light on the link between energy consumption and economic growth. They conclude that energy consumption is almost as important as employment in explaining the variance in the growth of national income in Turkey.

Soytas et al (2001) also study the causality between energy consumption and GDP for Turkey, using a cointegration analysis. They use annual data over the period 1960-1995 from the International Energy Agency and transform these data with logarithms. They, in contrary to the conclusion we derive in this paper, draw the conclusion that energy consumption unidirectionally Ganger-causes GDP. The reasons for this opposite are manifold. The period of the used data differs, the data source differs (the difference between data from the Turkish Ministry of Energy and Natural Resources and IEA is considerable), and they use a log-transformation, while we do not. Finally, data prior to 1970 are problematic as there is a structural break in the data.

Altınay and Karagöl (2004) apply a series of so-called unit root and causality tests to verify whether there is a causality between GDP and energy consumption for the period 1950–2000. Establishing that energy consumption causes GDP has important policy implications, because then a reduction in energy consumption will translate into a break on economic growth. While they show that energy consumption and GDP in Turkey do have a unit root, they also find a structural break in the data. They conclude that there is no causality between energy and GDP.

3. RESULTS

3.1 Data

For Turkey, data have been collected from various sources. These data comprise yearly observations over the years 1970–2003, namely:

- Total population in millions,
- Gross domestic product in trillion TL in constant 1987 prices (available quarterly from 1987 onwards), and

- Total primary energy consumption in btoe.

Energy data are collected from the Ministry of Energy as published by Altaş et al (2003), completed with the updated table for 2002 and 2003 (Altaş 2004, personal communication). The GDP data are taken from the National Accounts, which are available from <http://www.tcmb.gov.tr>. These data have been crosschecked with data from official sources (WDI cd-rom and IEA database).

3.2 Analyses and discussion

GDP = f(EC) or EC = g(GDP)? This is exactly the question we would like to address in this paper. Once we have firmly established a cointegration relationship between EC and GDP, then we know that there is (Granger) causality at least in one direction and possibly both. Continuation of the cointegration analysis can establish the direction of causality. Hence, we leave the decision of causality to the analysis.

Since OLS-estimates of relationships between non-stationary variables are inefficient and biased, we have first tested whether the variables EC and GDP are stationary, using the augmented Dickey-Fuller (ADF) test. The results show the two variables to be non-stationary, while the first order differences of the variables are stationary.

As a second preliminary step we have tested whether the two variables are co-integrated. This is important, since if they are co-integrated, a long-run relationship between the variables would exist even if they are individually non-stationary and we could then estimate an error-correction model (Engle and Granger, 1987). Testing for co-integration proceeds as follows. First we estimate the long-term relationship between the GDP variables and the EC variables:

$$EC_t = \phi GDP_t + \varepsilon_t \Leftrightarrow ECT_t = EC_t - \phi GDP_t \quad (4)$$

Next we test whether the error correction term (ECT_t) in the above equation is stationary or not. We do this also by means of the ADF-test. The ADF-test statistics show that GDP and EC are co-integrated.

Now we can use the error-correction-model and use the estimation results to obtain estimates of the coefficients in the following long run regression equation

$$EC_t = \alpha + \sum_{i=1}^k \beta_i EC_{t-i} + \sum_{j=1}^m \gamma_j GDP_{t-j+1} + \delta ECT_{t-1} + \varepsilon_t. \quad (5)$$

The results presented below are those for the final regression equations obtained by a stepwise regression procedure of variables with a t-value larger than 1, selected from all independent variables x_{t-m}, \dots, x_t . Afterwards we have tested for mis-specification. Assuming $k=2$ and $m=2$ the final estimated regression relation appears to be well specified and passes several tests on mis-specification:

- Durbin-Watson test and Godfrey test (serial correlation in the residuals);
- Ramsey's reset test (functional form of the final regression equation);
- Langrange multiplier test (normality of the residuals);
- Breusch-Pagan test (heteroskedasticity in the residuals);
- Chow test for stability of the coefficients;
- Recursive Chow test for significant structural break in the sample period.

The error correction model (ECM) yields the following result (standard deviations between brackets):

$$\begin{aligned} \Delta EC_t = & \underbrace{-15.583}_{(5.842)} + \underbrace{1.415 \Delta GDP_t}_{(0.226)} - \underbrace{0.243 \Delta GDP_{t-1}}_{(0.377)} - \underbrace{0.005 \Delta EC_{t-1}}_{(0.189)} \\ & - \underbrace{0.610}_{(0.201)} \left(\underbrace{EC_{t-1}}_{(0.389)} - \underbrace{1.966 GDP_{t-1}}_{(0.389)} \right) + \varepsilon_t. \end{aligned} \quad (6)$$

where the residuals ε_t are $I(0)$ and $R^2_{adj} = 0.630$.

Using the estimation results of the above error correction model, we get the following result for the long run relation (standard deviations between brackets):

$$\begin{aligned} EC_t = & \underbrace{-15.583}_{(5.842)} + \underbrace{1.415 GDP_t}_{(0.226)} - \underbrace{0.459 GDP_{t-1}}_{(0.389)} + \underbrace{0.243 GDP_{t-2}}_{(0.377)} \\ & + \underbrace{0.385 EC_{t-1}}_{(0.201)} + \underbrace{0.005 EC_{t-2}}_{(0.189)} + \varepsilon_t. \end{aligned} \quad (7)$$

From the above equation it follows that the Energy Consumption in a specific year is strongly influenced by the GDP in that year (i.e. positive sign), and the Energy Consumption and the GDP of the previous year (i.e. respectively positive and negative sign). The influence of two years ago is statistically insignificant and thus negligible.

We can also test the Granger causality using the above error correction methodology (see Greene, 2000). Therefore we apply an error correction model for the time series EC_t and GDP_{t-1} with $k=1$ and $m=1$. The results of this error-correction model are used to estimate the coefficients of the following long-run relation with $R^2_{adj} = 0.138$ (standard deviations between brackets):

$$EC_t = \underbrace{-9.483}_{(1.822)} + \underbrace{0.322 GDP_{t-1}}_{(0.493)} + \underbrace{0.682 GDP_{t-2}}_{(0.330)} + \underbrace{0.490 EC_{t-1}}_{(0.264)} + \varepsilon_t \quad (8)$$

This long run relation gives a significant indication for Granger causality. While the regression coefficient of GDP_{t-1} is not significant, the regression coefficient of GDP_{t-2} differs significantly from zero (with probability level 0.05). Using the log likelihood ratio statistic with probability 0.01 it turns out that the time series GDP_{t-1} and GDP_{t-2} together are correlated significantly with the time series EC_t . So, we may confirm Granger causality from GDP to EC.

The Granger causality from EC to GDP can also be tested. Once again, we apply an error correction model for the time series GDP_t and EC_{t-1} with $k=1$ and $m=1$. The results of this error-correction model are used to estimate the coefficients of the following long run relation:

$$GDP_t = \underbrace{6.188}_{(1.020)} + \underbrace{0.042 EC_{t-1}}_{(0.142)} + \underbrace{0.115 EC_{t-2}}_{(0.266)} + \underbrace{0.715 GDP_{t-1}}_{(0.264)} + \varepsilon_t \quad (9)$$

This long run relation gives not a significant indication for Granger causality. Using the log likelihood ratio statistic (probability 0.26) it turns out that the time series EC_{t-1} and EC_{t-2} together are not correlated significantly with the time series GDP_t . So, we may not confirm Granger causality from EC to GDP. This has important policy consequences, as it suggests that energy restrictions do not seem to harm economic growth in Turkey.

3.3 The Environmental Kuznets Curve

There is a large body of literature related to the so-called Environmental Kuznets Curve (EKC). If the EKC hypothesis is true than environmental problems will be solved ultimately in time as long as the economy keeps on growing. Stern (2004) gives an excellent survey of this body of

literature and basically concludes that most of the existing studies on EKC suffer from serious weaknesses and the evidence for EKC is very weak. Moreover, even if an EKC relationship could be found, the models used generally are not suitable for forecasting and generalization of the results are not possible. Still then, it would be reaffirming to establish such a relationship for Turkey.

We try to test the EKC hypothesis for Turkey by using energy consumption as an indicator of the environment. Stern (2004) claims that energy use is a good indicator of the overall impact on the environment. So actually we are testing an energy Kuznets curve hypothesis to establish a link between energy consumption per capita (ECPC) and GDP per capita (GDPPC).

In order to test the EKC hypothesis several studies (eg. see Stern (2004) for a review) estimate the coefficients of the quadratic relationship between the dependent variable $\ln(ECPC_t)$ and the independent variables $\ln(GDPPC_t)$ and $\ln(GDPPC_t)^2$. However, in this case this is not allowed because $\ln(ECPC_t)$ (probability 0.458), $\ln(GDPPC_t)$ (probability 0.678) and $(\ln(GDPPC_t))^2$ (probability 0.957) do have unit roots.

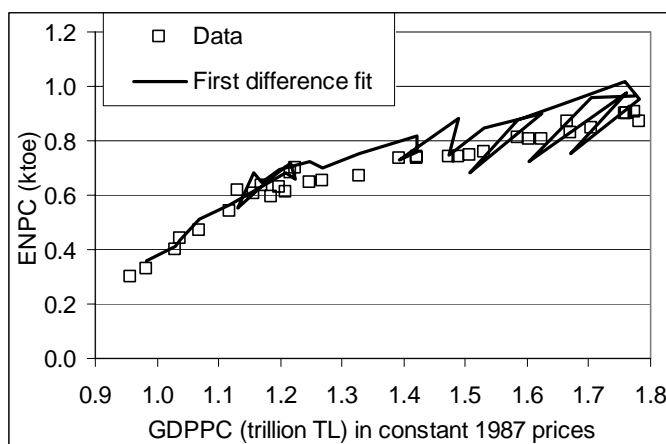
According to the augmented Dickey-Fuller test with two lags, there is no unit root for $\Delta ECPC_t$ (probability 0.002) and $\Delta(GDPPC_t)$ (probability 0.001). Therefore, instead of the mentioned quadratic regression relation we estimate the following simple linear regression relation between $\Delta ECPC_t$ and $\Delta GDPPC_t$ (with the corresponding standard deviations between brackets):

$$\Delta ECPC_t = \underset{(0.018)}{0.027} + \underset{(0.256)}{1.270} \Delta GDPPC_t + \varepsilon_t \quad (10)$$

The regression coefficients in equation (10) have probability levels 0.131 and 0.000, and the R^2_{adj} is equal to 0.424. If the EKC hypothesis is true, the regression coefficient of $\Delta GDPPC_t$ has to be smaller than 0. Nevertheless, this coefficient turns out to have a significantly positive sign.

Figure 3.1 presents a graphical plot of the data and the fitted quadratic curve corresponding to Equation (10).

Figure 3.1 *The link between per capita GDP and per capita Energy Consumption in Turkey.*



From Figure 3.1 it follows that the growth path of Energy Consumption per capita follows the growth path GDP per capita. This result contradicts the EKC hypothesis. During the considered period, energy consumption per capita as an indicator of environment problem keeps on growing in time as long as the economy keeps on growing.

4. CONCLUSIONS

This paper undertook a quantitative analysis of development trajectories and energy transitions for the energy situation in Turkey. A cointegration analysis was undertaken to answer the following question: What is the link between energy consumption and GDP in Turkey?

The analysis shows that energy consumption and GDP are co-integrated. This means that there is (possibly bi-directional) causality relationship between the two. We establish that causality runs unidirectionally from GDP to energy consumption, as we find that the amount of GDP in the previous two years is a good predictor for the amount of energy consumption in the current year. This does not mean that energy consumption does not matter for the Turkish economy, however, the analysis shows that the role of energy consumption is relatively small. This has important policy consequences, as it suggests that energy restrictions do not seem to harm economic growth in Turkey.

Also, the growth in GDP per capita leads to a similar growth in energy consumption per capita. We find evidence that energy consumption and economic growth move in tandem in Turkey. This means that the Turkish economy is still on an unrestrained growth path.

Areas for future research are to undertake a sectoral cointegration analysis to verify in which sectors the results of this paper takes over. This could lead to a more precise policy recommendation as to where energy conservation policies would not harm the economy.

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