ECONOMIC GROWTH AND ENERGY CONSUMPTION IN TURKEY AND ITALY: A FREQUENCY DOMAIN CAUSALITY ANALYSIS

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Abstract

This paper tests the causality relationship existing between electrical power consumption and economic growth in Turkey and Italy by employing a Frequency Domain Causality approach over the period of 1961-2012. The two countries represent a very interesting case-study, since Turkey is an important bridge and outlet for transporting oil and natural gas from Central-Asia to world markets. Italy, however, is one of the least energy intensive countries in the world, mainly due to the high level of taxation in the domestic energy market, which is employed to promote energy efficiency and to reduce energy imports. Previous works, which have analysed the income-energy demand nexus in the two countries separately, have achieved mixed and inconsistent results about the direction of the causality. Our findings show a lack of any causality relationship in short term from electricity consumption to economic growth in Turkey, despite the existence of a significant causality relationship from economic growth to electricity consumption in the long run. While in Italy, electricity consumption seems to cause economic growth in the short, medium and long terms.

Keywords: *Economic Growth, Electricity Consumption, Frequency Domain Causality, Turkey, Italy.*

JEL Classification: *F43, L94, Q41, Q43.*

Özet

Bu çalışmada, Türkiye ve İtalya'da elektrik tüketimi ve ekonomik büyüme arasındaki ilişki frekans alanı nedensellik yaklaşımı ile 1961-2012 dönemi için test edilmiştir. Bu iki ülke çok ilginç bir örnek çalışmayı temsil etmektedir. Çünkü, Türkiye Merkez-Asya ve dünya piyasalarına petrol ve doğal gaz taşımacılığında önemli bir köprü görevi görmektedir. Buna karşın İtalya ise, enerji verimliliğini teşvik etmek ve enerji yoğunluğunu azaltmak için iç enerji piyasasında oldukça yüksek düzeyde vergilendirmeye sahip olan dünyanın enerji yoğunluğu en düşük olan ülkelerinden birisidir. İki ülkede hasıla ile enerji talebi bağlantısı önceki çalışmalarda ayrı ayrı incelenmiş ve nedenselliğin yönü hakkında karışık ve tutarsız sonuçlar elde edilmiştir. Çalışmadan elde edilen bulgular, Türkiye'de uzun dönemde çok önemli bir nedensellik ilişkisi sözkonusu olmasına rağmen, kısa dönemde elektrik tüketiminden ekonomik büyümeye doğru bir nedenselliğin olmadığına işaret etmektedir. İtalya'da ise, elektrik tüketimi, kısa, orta ve uzun vadede ekonomik büyümeye neden olmaktadır.

Anahtar Kelimeler: *Ekonomik Büyüme, Elektrik Tüketimi, Frekans Alanı Nedenselliği, Türkiye, İtalya.*

JEL Sınıflandırması: *F43, L94, Q41, Q43.*

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INTRODUCTION

Despite the existence of a positive correlation between energy use and economic growth, which is well recognised in the economic literature, the issue of "causality", i.e. whether economic growth determines more energy consumption or *vice-versa*, still remains to be conclusively answered (Lee and Chien, 2010). Recently, the question has roused renewed interest, given the growing debate about the world climate changes as a consequence of greenhouse gases emissions. Indeed, the direction of causality can help policy makers to take the most appropriate decisions to preserve the natural environment without compromising economic growth of a country. For instance, evidence of unidirectional causality running from income to energy consumption (so called "conservation hypothesis") may suggest a less energy-dependent economy where policies for energy conservation should have few effects on income (Jumbe, 2004). Similarly, the lack of any causality between income and energy ("neutrality hypothesis") implies that energy consumption does not affect income, and consequently policies for energy conservation and policies to foster economic growth can be compatible, the former being pursued without limiting the latter (Yu and Choi, 1985). In contrast, the existence of unidirectional causality running from energy consumption to income ("growth hypothesis") may be indicative of an energy-dependent economy where a reduction in the amount of energy available can negatively affect income (Lee, 2006). Finally, the existence of a bi-directional causality between energy and growth ("feedback hypothesis") suggests that when the economy grows, energy demand increases, although the opposite is also true (Fuinhas and Marques, 2012).

However, starting from the pioneering work of Kraft and Kraft (1978), the empirical literature has failed to provide a definitive conclusion about such a causal nexus. Indeed, different evidences of causality have emerged according to the country investigated and the period analysed (Payne, 2009; Jobert and Karanfil, 2007). Additionally, the income-energy demand nexus has been tested by employing different econometric techniques, all of which have produced very different findings. In particular, the use of the standard Granger's test (1969) and the Sims' methodology (1972) have produced inconsistent results, since both approaches assume that data series are stationary and thus do not provide any long-run information between the variables (Granger, 1986). Later, the use of the cointegration approach (Engle and Granger, 1987) overcame the inconsistency problems by suggesting that, if two or more variables are cointegrated and have common trends, then at least one long-run relationship exists between them and the direction of Granger causality can be tested through the vector-error correction model (VECM). Additional econometric techniques used to test the income-energy causal relationship are the multivariate and the bivariate approaches, where the former employs a production function model including GDP, energy, labour, and capital (see, for instance, Narayan and Smyth, 2005; Oh and Lee, 2004), while the latter focuses essentially on the directionality of causality (see, for instance, Yoo, 2005; Shiu and Lam, 2004). Another very recent way to investigate the income-energy demand causal nexus is founded upon the use of the Frequency Domain Causality (FDC), which consists of short, medium and long-term causality analyses.

In this framework, the present study contributes to the existing literature on the income-energy demand nexus by making a comparative analysis of Turkish and Italian electric power consumptions by means of a FDC approach. The remainder of the study is organized as follows; Section 2 reports the literature review for the two countries, section 3 the empirical application, and section 4 ends with some concluding remarks.

I. LITERATURE REVIEW

In the framework of the causal nexus between income and energy demand, the comparative analysis between Turkey and Italy represents a very interesting case study. Indeed, despite the two countries exhibiting a number of different characteristics, both have experienced several economic and political turbulences in the last decades (e.g. the oil shocks of 1973 and 1979, the shift from a dictatorial regime to a democratic political environment in the case of Turkey, the deregulation of the energy sector and the inclusion in the Economic and Monetary Union in the case of Italy, etc.), which have heavily affected the energy demand and the economic growth in both countries. Nowadays, Turkey represents an important bridge and an outlet for transporting oil and natural gas from central-Asia to world markets, although it has to import part of its energy needs from abroad, incurring the consequent increase in energy costs for the domestic population. Nonetheless, Italy is currently one of the least energy intensive countries in the world, mainly because of the high level of taxation in the domestic energy market, which is employed to promote energy efficiency and to reduce energy imports and energy related pollution.

To the best of our knowledge there are no previous studies that specifically compare the income-energy demand nexus in Turkey and Italy. Despite a number of works having analysed the two countries separately, the empirical results achieved are largely inconsistent concerning the direction of the relationship (Tables 1 and 2).

Table I. Summary of the Empirical Literature for Energy Consumption and Economic Growth for Turkey

Author(s)	Metodology	Period Analysed	Resulst Achieved
Bakirtas et. al. (2000)	ECM	1962-1996	GDP → EC
Soytas¸ et. al. (2001)	Cointegration Analysis	1960–1995	EC → GDP
Soytas and Sari (2003)	VECM	1950-1992	EC → GDP
Altinay and Karagol (2004)	Unit root, Causality test (Hsiao's version of Granger causality)	1950–2000	no causality
Sari and Soytas (2004)	Generalized Forecast Error Variance Decomposition	1969-1999	EC → GDP
Altinay and Karagol (2005)	Dolado–Lutkepohl, Granger Causality	1950–2000	EC → GDP
Karagol et. al. (2006)	VECM	1971–2003	GDP → EC
Halicioglu, F. (2007)	Bounds Testing Procedure To Cointegration	1968–2005	GDP → EC
Jobert and Karanfil (2007)	Granger Causality, VAR	1960–2003	no causality
Soytas and Sari (2007)	VECM		EC → GDP
Lise and Van Montfort (2007)	ECM	1970–2003	GDP → EC
Erdal et. al. (2008)	ADF, Philips–Perron (PP), Johansen Cointegration Test, Pair-Wise Granger Causality Test	1970–2006	EC ↔ GDP
Karanfil (2008)	ECM	1970-2005	GDP → EC
Aktas and Yilmaz (2008)	Granger Causality Test	1970-2004	EC ↔ GDP
Narayan and Prasad (2008)	Bootstrapped Causality Test	1960–2002	no causality
Fuinhas and Marques (2012)	ARDL Bounds Test Approach	1965–2009	EC ↔ GDP
Aslan (2014)	ARDL Bounds Testing Approach	1968–2008	EC ↔ GDP
Nazlioglu et. al. (2014)	ECM	1967–2007	EC ↔ GDP (from linear Granger causality) no causality (from non linear Granger causality)

Notes:
EC → GDP means that the causality runs from energy consumption to growth;
GDP → EC means that the causality runs from growth to energy consumption;
EC ↔ GDP means that bidirectional causality exists between energy consumption and growth.

Table II. Summary of the Empirical Literature for Energy Consumption and Economic Growth for Italy

Author(s)	Metodology	Period Analysed	Resulst Achieved
Erol and Yu (1987)	Granger Causality	1952-1982	GDP → EC
Soytas and Sari (2003)	VECM	1950-1992	GDP → EC

Sica (2005)	ECM	1960-2001	no causality
Zachariadis (2007)	VECM ARDL Toda–Yamamoto model	1960–2004	EC ↔ GDP (from VECM) EC ↔ GDP (from ARDL) no causality (from Toda–Yamamoto model)
Narayan and Prasad (2008)	Bootstrapped Causality Test	1960–2002	EC → GDP
Lee-Chien (2010)	Toda–Yamamoto model Generalized impulse response approach Variance decompositions in a multivariate setting	1960-2001	EC → GDP
Vecchione (2011)	VECM	1963–2007	GDP → EC
Fuinhas and Marques (2012)	ARDL Bounds Test	1965–2009	EC ↔ GDP
Yildirim and Aslan (2012)	Todaro-Yamamoto Procedure Bootstrap-Corrected Causality Test	1971–2009	EC ↔ GDP
Bozoklu and Yilanci (2013)	Granger Causality	1970–2011	GDP → EC

Notes:
EC → GDP means that the causality runs from energy consumption to growth;
GDP → EC means that the causality runs from growth to energy consumption;
EC ↔ GDP means that bidirectional causality exists between energy consumption and growth.

Table 1 shows that, within the 18 works so far that have investigated the Turkish case, 5 have found evidence of a causality relationship running from the energy consumption to growth; 5 of a causality relationship running from growth to energy consumption, 5 of a bidirectional causality between energy consumption and growth, and 3 of the lack of any causality relationship. Table 2 suggests that, within the 10 works so far that have analysed the Italian case, 2 have found evidence of a causality relationship running from the energy consumption to growth; 4 of a causality relationship running from growth to energy consumption, 3 of a bidirectional causality between energy consumption and growth; and 1 has indicated a lack of any causality relationship. Although these works have taken into account different time spans and dissimilar econometric techniques, the existence of such mixed results suggests the need for further empirical investigations.

II. EMPIRICAL APPLICATION

II.I. Data

In order to investigate the income-energy demand nexus in Turkey and Italy, we consider the electricity demand in the two countries. Data about electrical consumption were obtained from the Turkish and the Italian Electricity Transmission Companies (TEIAS and TERNA, respectively), while data about GDP were obtained from the World Bank. In both cases, data cover the period from 1961 to 2012. More precisely, the dataset includes annual measures of GDP per capita in 1995 in $US million (GDP), as well as electric power consumption in kWh per capita (EPC) over the sample period. Looking at Figures 1 and 2, from 1980 to 2012, the electric power consumption has increased in both countries, moving from less than 25 billion KWh to approximately 200 billion KWh in Turkey and from about 175 billion KWh to approximately 330 billion KWh in Italy. In 2011, 74.8% of the Turkish production of electricity came from thermal sources, while the remaining 25.2% from hydro, geothermal, and wind sources (Table 3). In the same year, 62.8% of the Italian production of electricity came from traditional sources, 24.0% from renewables, and the remaining 13.2% from net imports from other countries (Table 4). Looking at the GDP growth rates in the two countries (Figures 1 and 2) it seems that from 1980 to 2012 the Italian growth rate has been more stable compared to the Turkish one, although both countries have noticeably suffered from the recent economic and financial crisis.

Table III. Turkey's Gross Electricity Generation by Primary Energy Sources in 2011

Electricity Sources	Absolute Value (GwH)	Percentage Value
Hard Coal+Imported Coal+Asphaltite	27,347.5	11.9%
Lignite	38,870.4	16.9%
Coal Total	**66,217.9**	**28.9%**
Fuel Oil	900.5	0.4%
Diesel Oil	3.1	0.0%
LPG	0.0	0.0%
Naphtha	0.0	0.0%
Liquid Total	903.6	0.4%
Natural Gas	104,047.6	45.4%
Renewables and Wastes	469.2	0.2%
Thermal Total	**171,638.3**	**74.8%**
Hydro+Geothermal+Wind Total	**57,756.8**	**25.2%**
Turkey Total	**229,395.1**	**100.0%**

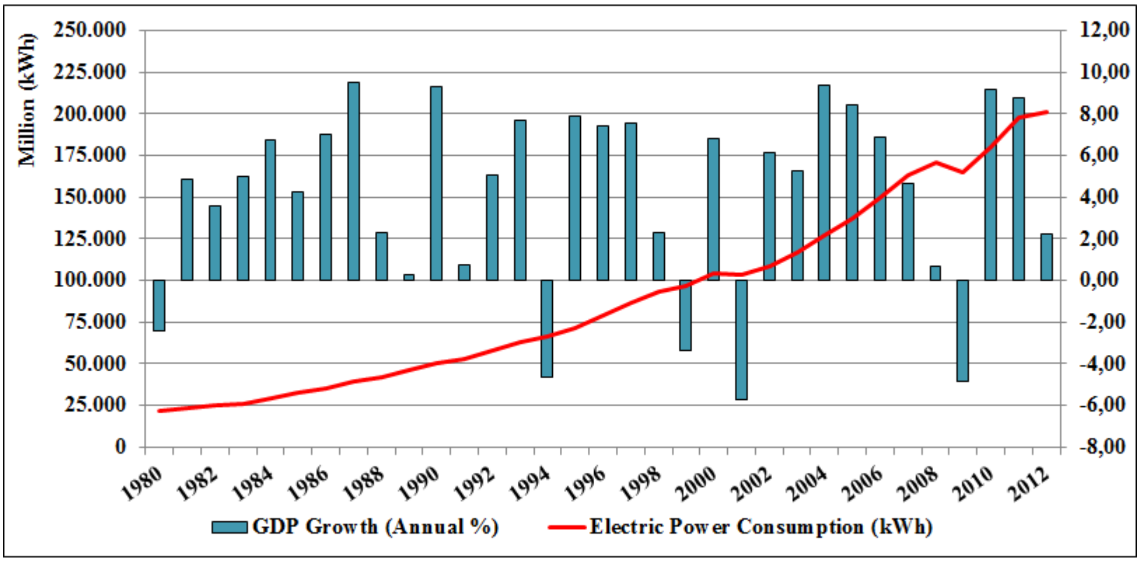
Source: Own elaboration based upon data from the Turkish Electricity Transmission Company (TEIAS).

Table IV. Italy's Gross Electricity Generation by Primary Energy Sources in 2011

Electricity Sources	Absolute Value (Gwh)	Percentage Value
Traditional Sources	**217,674**	**62.8%**
Solid fuels	44,726	12.9%
Natural Gas	144,539	41.7%
Petroleum products	8,474	2.4%
Other fuels	19,935	5.8%
Renewables	**82,961**	**24.0%**
Hydro from natural inflows	45,823	13.2%
Geothermal	5,654	1.6%
Wind	9,856	2.8%
Photovoltaic	10,796	3.1%
Bioenergy	10,832	3.1%
Net Imports	**45,732**	**13.2%**
Italy Total	**346,368**	**100.0%**

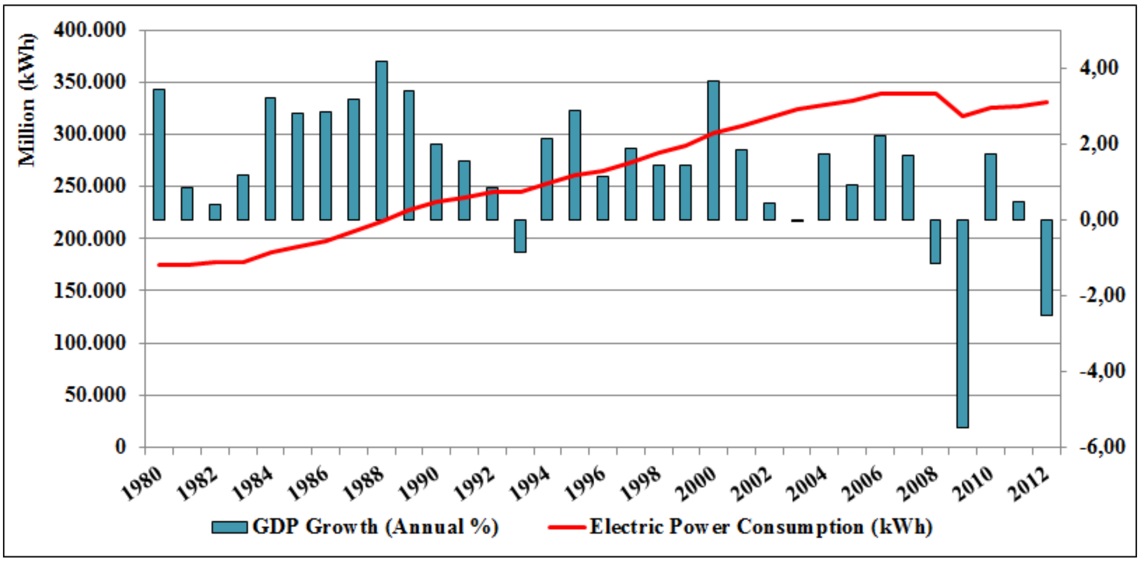
Source: Own elaboration based upon data from the Italian Electricity Transmission Company (TERNA).

Figure I. Electric Power Consumption and GDP Growth in Turkey 1980-2002



Source: Own elaboration based upon World Bank data.

Figure II. Electric Power Consumption and GDP Growth in Italy 1980-2002



Source: Own elaboration based upon World Bank data.

II.II. Methodology

In order to examine the relationship between energy consumption and economic growth, we first verify the presence of a unit root in the series by implementing the Augmented Dickey-Fuller (ADF) test. Then, we employ the FDC approach in order to test for short, medium and long-term causal relations between series.

II.II.I. Augmented Dickey-Fuller Unit Root Test

Given a simple AR (1) process:

$$y_t = \rho y_{t-1} + x_t'\delta + e_t \qquad [1]$$

where y_t is a series, x_t an optional exogenous regressor (e.g. a constant or a constant and a trend), ρ and δ two parameters to be estimated, and e_t a white noise error component, subtracting y_{t-1} from both sides of the equation [1] we obtain:

$$\Delta y_t = \alpha y_{t-1} + x'\delta + e_t \qquad [2]$$

where Δ is the first difference operator, $\alpha = \rho - 1$, and e_t is the error term with zero mean and constant variance. In this framework, the ADF test allows correcting for possible higher order correlations by adding p lagged difference terms of the dependent variable to the right hand side of regression [2]:

$$\Delta y_t = \alpha y_{t-1} + x'\delta + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \upsilon_t \qquad [3]$$

In the present study, the ADF test was performed on the natural logarithm of Turkish and Italian per capita electric power consumption (i.e. $\ln(EPC_{TUR})$ and $\ln(EPC_{ITA})$, respectively), and to the natural logarithm of Turkish and Italian per capita GDP (i.e. $\ln(GDP_{TUR})$ and $\ln(GDP_{ITA})$, respectively) by including a constant and a linear trend.

II.II.II. Frequency Domain Causality Test

Frequency domain causality analysis explains the causal relations between the variables over the short, medium and long-terms. In this respect, it is separated from the traditional causality analysis. In particular, in this paper we employ a methodology founded upon the study of Breitung and Candelon (2006; 2001), which starts from the measures of causality in the frequency-domain proposed by Geweke (1982) and Hosaka (1991) to test for causality in predetermined frequency.

We assume that $z_t = [x_t, y_t]'$ is a two-dimensional vector of the time series observed at $t = 1, \dots, T$ and that z_t represents a finite delay VAR fermentation of the following type (Breitung and Candelon, 2006: 364):

$$\Theta(L)z_t = \varepsilon_t \qquad [4]$$

where:

$$\Theta(L) = I - \Theta_1 L - \cdots - \Theta_p L^p \qquad [5]$$

is a 2×2 lag $L_{Zt}^k = z_{t-k}$ polynomial.

Let the error vector ε_t be white noise with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t{}') = \Sigma$ (where Σ is positive) and G the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$. Thus, the moving average representation of the system (assumed to be stationary) is:

$$z_t = \begin{bmatrix} x_t \\ y_t \end{bmatrix} = \Phi(L)\varepsilon_t = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad [6]$$

$$= \Psi(L)\eta_t = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \end{bmatrix} \qquad [7]$$

where $\Phi(L) = \Theta(L)^{-1}$ and $\Psi(L) = \Phi(L)G^{-1}$

Equation 8 reports the spectral density of x_t:

$$f_x(\omega) = \frac{1}{2\pi}\left\{\left|\Psi_{11}(e^{-i\omega})\right|^2 + \Psi_{12}(e^{-i\omega})\right|^2\right\} \qquad 8]$$

while equations 9 and 10 define the causality measurements proposed by Geweke (1982) and Hosaya (1991):

$$M_{y\to x}(\omega) = log\left[\frac{2\pi f_x(\omega)}{|\Psi_{11}(e^{-i\omega})|^2}\right] \qquad [9]$$

$$= log\left[1 + \frac{\left|\Psi_{12}(e^{-i\omega})\right|^2}{|\Psi_{11}(e^{-i\omega})|^2}\right] \qquad [10]$$

If $\left|\Psi_{12}(e^{-i\omega})\right| = 0$ then *y* is not a frequency causality (ω) of x. Therefore, in order to test that *y* does not cause *x* at frequency (ω) our null hypothesis is:

$$H_0 = M_{y\to x}(\omega) = 0 \qquad [11]$$

III. RESULTS ACHIEVED

Table 5 reports the results obtained from the ADF unit-roots tests for stationarity.

Table V. ADF Unit-Roots Tests for Stationarity

Variables	Intercept		Trend and Intercept	
	Level	First-Difference	Level	First-Difference
$\ln(EPC_{ITA})$	-3.961 (0)	-9.080 (0)	-6.562 (0)	-9.024 (1)
$\ln(GDP_{ITA})$	-4.273 (0)	-8.943 (0)	-6.921 (0)	-8.831 (1)
$\ln(EPC_{TUR})$	-4.371 (0)	-8.512(0)	-5.484 (1)	-8.415 (1)
$\ln(GDP_{TUR})$	-7.261 (0)	-8.427 (0)	-7.320 (0)	-8.349 (1)

Note: (1) The datas in the parenthesis indicate the number of lags which are selected based on the SIC.
(2) MacKinnon (1996) critical values were used for determine the level of statistical significance at the 1, 5 and 10 percent respectively.

According to the SIC *(Schwarz Information Criteria)*, the number of lags used is equal to zero, meaning that the standard DF test is, in this case, preferred to the ADF test. Results suggest that the null hypothesis, namely that the two series contain a unit root, cannot be rejected, while the null hypothesis assessing whether the series in the first difference contain a unit root can be rejected. Summarizing, all series are I(0).

Results from the Frequency Domain Causality are reported in Table 6. According to these results, electricity consumption in Italy causes economic growth in the short, medium and long-terms "growth hypothesis". While in Turkey there is no causality relationship apparent between electricity consumption and economic growth ("neutrality hypothesis"). Although, in the long-term, there is a meaningful causality relationship from economic growth to electricity consumption "conservation hypothesis".

Table VI. Results from the Frequency Domain Causality

ω_i	Long Term		Medium Term		Short Term	
	0.01	**0.05**	**1.00**	**1.50**	**2.00**	**2.50**
ITAGDP→ITAELEC	0.702	0.622	2.423	0.453	1.867	1.139
ITAELEC→ITAGDP	8.015*	7.996*	1.514	4.585*	6.199*	1.152
TRGDP→TRELEC	4.089*	3.998*	0.886	0.483	1.192	3.006
TRELEC→TRGDP	1.010	1.016	2.164	3.009	0.502	1.438

Note: F- distribution with (2, T-2p) degrees of freedom equals 3.15. For every ω_i (frequency) between 0 and π, $\omega \in (0,\pi)$

CONCLUDING REMARKS

This paper has tested the causality linkages existing between electrical power consumption and economic growth in Turkey and Italy by employing a Frequency Domain Causality approach. In the last decades, both countries have faced a constant growth in the electrical power consumption, although both of them have noticeably suffered from the recent economic and financial crisis. Results achieved show the lack of any causality relationship from electricity consumption to economic growth in Turkey despite the existence of a significant causality relationship from economic growth to electricity consumption in the long run. While in Italy, electricity consumption seems to cause economic growth in the short, medium and long-terms.

These findings should suggest that electrical consumption in Turkey does not affect economic growth, and that policies for energy conservation and policies to foster economic growth can be perfectly compatible, since the former can be pursued without limiting the latter. In contrast, in Italy the existence of unidirectional causality from electricity consumption to growth may be indicative of an energy-dependent economy where a reduction in the amount of electricity available can negatively affect economic growth.

Further lines of research could investigate the potential channels through which economic growth and energy use interact in the two countries analysed. Moreover the econometric methodology could be extended to include other economic factors that may affect both real income and energy consumption (as, for example, exports, capital stock, etc.), with the aim of achieving a complete understanding of the income-energy demand interaction in both countries.

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