# Electricity demand, GDP and employment: evidence from Italy

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This paper applies time series methodologies to examine the causal relationship among electricity demand, real per capita GDP and total labor force for Italy from 1970 to 2009. After a brief introduction, a survey of the economic literature on this issue is reported, before discussing the data and introducing the econometric techniques used. The results of estimation indicate that one cointegrating relationship exists among these variables. This equilibrium relation implies that, in the long-run, GDP and labor force are correlated negatively, as well as GDP and electricity. Moreover, there is a bi-directional Granger causality flow between real per capita GDP and electricity demand; while labor force does not Granger-cause neither real per capita GDP nor electricity demand. This implies that electricity demand and economic growth are jointly determined at the same time for the Italian case. The forecast error variance decomposition shows that forecast errors in real per capita GDP are mainly caused by the uncertainty in GDP itself, while forecast errors in labor force are mainly resulted from the labor force itself, although aggregate income and electricity are important, too.

**Keywords** energy policies, electricity demand, GDP, labor force, stationarity, structural breaks, cointegration, causality, Italy

## 1 Introduction

The study of the causal relationship between electricity demand and GDP fosters a better understanding of the role electricity has played in Italy’s economic growth. The results of causality tests can be useful in shaping future electricity policies, such as conservation programs, capacity expansion planning, and construction of nationwide interconnections of power networks. Electricity demand, supply and pricing have an impact on socioeconomic development, living standards and the overall quality of people’s [1]. On the other hand, a higher level of economic development could induce more electricity demand.

If electricity consumption causes economic growth, then policies encouraging a reduction in electricity consumption will have an effect on growth. On the other hand, if electricity consumption does not cause economic growth or economic growth causes consumption, then electricity conservation policies will have no impact on growth [2]. Over the past three decades, many studies, using cointegration and Granger causality, have focused on different countries and time periods. Since Kraft and Kraft’s [3] pioneering study, empirical research has produced mixed and, for some countries, controversial results [4]. These results differ also for the direction of causality and the short-term versus long-term effects on energy policies. Depending upon what kind of causal relationship exists, its policy implications may be significant.

Moreover, multiple causality studies have been performed in many countries in the world; however, very few studies have been devoted to the analysis of the Italian case [2,5–9].

This paper examines the nexus between real per capita GDP and per capita electricity demand in Italy from 1970 to 2009, using time series methodologies. The results could be used to define and implement appropriate energy development policies in Italy. The data used are obtained from total economy database (TED) and organization for economic cooperation and development (OECD) database.  

The cost of energy in Italy, in particular electricity prices, is among the highest within the EU. Rents due to the lack of competition in sheltered sectors imply higher prices for a range of intermediate goods and services [10].

1) For more information: http://www.ggdc.net/databases/ted.htm and http://www.oecd.org/document/0,3746,en_2649_201185_46462759_1_1_1_1,00.html.
After a timid initial recovery during 2010, the drop of electricity markets trading in Europe caused by the economic crisis continued also in 2011. In the second half of 2012, the greatest retail price increase in EU was observed in Italy (20%), while in France prices fell by 13% [11]. Italy remains very dependent on imports because of limited available capacity and a lack of siting approvals for new power plants, having undertaken partial privatization (Table 1).

Table 1 2012 electricity price comparison

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost(US $)/kW·h</th>
<th>1 year change/%</th>
<th>2011 rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>20.23</td>
<td>18.4</td>
<td>1</td>
</tr>
<tr>
<td>Germany</td>
<td>15.15</td>
<td>–5.8</td>
<td>2</td>
</tr>
<tr>
<td>Portugal</td>
<td>13.63</td>
<td>12.1</td>
<td>7</td>
</tr>
<tr>
<td>Spain</td>
<td>13.52</td>
<td>1.4</td>
<td>4</td>
</tr>
<tr>
<td>UK</td>
<td>12.45</td>
<td>–12.3</td>
<td>3</td>
</tr>
<tr>
<td>Belgium</td>
<td>11.92</td>
<td>–9.7</td>
<td>5</td>
</tr>
<tr>
<td>Australia</td>
<td>11.68</td>
<td>27.8</td>
<td>13</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>11.28</td>
<td>–6.9</td>
<td>8</td>
</tr>
<tr>
<td>Austria</td>
<td>11.05</td>
<td>–12.6</td>
<td>6</td>
</tr>
<tr>
<td>Poland</td>
<td>9.30</td>
<td>0.3</td>
<td>12</td>
</tr>
<tr>
<td>South Africa</td>
<td>9.13</td>
<td>23.1</td>
<td>16</td>
</tr>
<tr>
<td>USA</td>
<td>8.89</td>
<td>–6.2</td>
<td>11</td>
</tr>
<tr>
<td>France</td>
<td>8.76</td>
<td>5.1</td>
<td>14</td>
</tr>
<tr>
<td>Finland</td>
<td>8.64</td>
<td>–17.7</td>
<td>9</td>
</tr>
<tr>
<td>Sweden</td>
<td>7.95</td>
<td>–22.6</td>
<td>10</td>
</tr>
<tr>
<td>Canada</td>
<td>7.58</td>
<td>1.4</td>
<td>15</td>
</tr>
</tbody>
</table>

Notes: All prices are in US cents per kilowatt-hour, excluding the value added tax (VAT). The percentage change is calculated using the local currency in order to eliminate currency movement distortion.
Sources: NUS Consulting Group (2012)

More than 80% of Italy’s electricity supplies are purchased in the deregulated market. Electricity demand in Italy increased by 0.56% during 2011. The modest upswing in electricity consumption is still below the 2007–2008 level, indicating that the slump of the previous year has not yet been overcome. Currently 57.9% of all electricity consumption is traded on Italy’s electricity exchange (IPEX) with the remaining amount being consumed through bi-lateral contracts [12].

2 The nexus between electricity demand and GDP

In the last two decades, owing to the strong and constant increase in electricity consumption, which imposed an accurate planning in order to avoid electricity shortage and guarantee adequate infrastructures, a load of study focused on the relationship between economic growth and electricity.

The directions of causality between electricity demand and aggregate income could be based on four different hypotheses, each giving rise to different and important implications for energy policy [13]. As explained in Ref. [14], there are:

1) Neutrality hypothesis: if no causality exists between GDP and electricity demand. This implies that energy consumption is not correlated with GDP. The absence of Granger-causality supports the neutrality hypothesis as documented by Refs. [13,15–20].

2) Conservation hypothesis: the unidirectional causality runs from GDP to electricity demand. If there is unidirectional causality running from economic growth to electricity consumption, electricity conservation policies through changes in the tariff structure, energy efficiency improvements and other demand side managements, aimed at curtailment of wastage of electricity and reduction of electrical consumption without affecting the end-use benefits, can be initiated without deteriorating a country’s economic growth [21]. This hypothesis was empirically supported by Refs [3,15–17,22–30].

3) Growth hypothesis: the unidirectional causality runs from electricity demand to GDP. If causation is found to run from electricity consumption to economic growth with no feedback, planners can justify prioritization of more resources to boost a country’s electrical network. This hypothesis is in line with empirical findings in Refs [13,15,17,20,21,28,31–41].

4) Feedback hypothesis: if there is a bi-directional causality flow between GDP and electricity demand. If results suggest that there is a mutual relationship between electricity and GDP, then any global policy to reduce electricity consumption in order to reduce emissions would have an impact on the GDP of all countries. The feedback hypothesis was documented in Refs. [15,16,20,28,42–53].

Table 2 presents concisely the main findings on causality between aggregate income and electricity demand discussed in several studies on this topic.

3 Econometric methodology, data, and empirical results

According to Ref. [54], a linear combination of two or more non-stationary series (with the same order of integration) may be stationary. If such a stationary linear combination exists, the series are considered to be cointegrated and therefore long-run equilibrium relationships exist. Incorporating these cointegrated properties, an error-correction model (ECM henceforth) could be constructed to test Granger causation of the series in at least one direction. In this study, the ECM is specifically adopted to examine the Granger causality between real GDP and electricity demand.

To investigate the stationarity properties of the series