

150 Years of Italian CO₂ Emissions and Economic Growth

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1 Overview

Recently, after a period of prolonged low growth, Italy has found itself at the center of an acute economic crisis. After having turned the corner, from managing the crisis to adopting an intensive reform agenda to boost competitiveness and promote growth, at present the Italian economy is still facing several economic challenges and is urged to take further action to strengthen its growth prospects ([Annicchiarico et al., 2012](#); [European Council, 2012](#)). In this economic scene the environmental policy debate has been put aside and Italy has not yet clearly articulated energy strategy, despite the fact that anthropogenic green-house gases emissions are largely derived from energy-related activities ([OECD, 2012](#)). In many respects, recent economic events represent an opportunity for Italy to restructure its economy in sustainable ways. This paper aims to contribute in this sense.

Italy is a country with limited domestic energy resources and high dependence on external energy supply. Since 1990, final energy consumption has been increasing steadily, with transport and industry being the most energy-consuming sectors. Although Italian per capita carbon dioxide (CO₂) emissions are well below the EU average, carbon dioxide emissions intensity is above the EU level. Oil and gas shares in primary energy supply of Italy, are both above the EU average, while hydroelectricity and other renewables play a very minor role.

To the best of our knowledge, most research has elaborated Italy’s data only in panel analysis, see [Dijkgraaf and Vollebergh \(2005\)](#); [Galeotti et al. \(2006\)](#); [Richmond and Kaufmann \(2006\)](#) *inter alia*. However, according to [de Bruyn et al. \(1998\)](#); [Dijkgraaf and Vollebergh \(2005\)](#); [Stern \(1998\)](#), a correct analysis of the relationship between growth and environment should be developed with regard to individual countries, underlying the importance of the specific historical experience.

This paper examines the relationship between economic growth and carbon dioxide emissions in Italy from unification (1861) until the present day (2011). To this end we make use of the most newly-available statistical reconstruction of the GDP series issued on occasion of the recent celebrations marking the 150 the anniversary of the unification of Italy, see ([Baffigi, 2011](#); [Vecchi, 2011](#)).

2 Methods

We study the link between CO₂ emissions and GDP using different, but complementary, approaches by estimating various time series models. In particular, we first use a linear Cointegrated Vector Autoregressive (CVAR) model following the methodology described in [Juselius \(2006\)](#). The graphical analysis of the series first, and secondly the findings in the Cointegration analysis makes a more careful investigation about a possibly nonlinear behavior of the series a primary interest for a

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policy maker. To this end we performed a battery of tests for the null hypothesis of linearity against the alternative hypothesis of nonlinearity, each of one differs from the others for the type of nonlinear model assumed and from the statistical way to convert it in a testable hypothesis.

The statistical literature provides a plethora of different nonlinear models: in particular the Threshold Autoregressive (TAR) model (Tong, 1978, 1983) is used when an observed threshold is used to divide the estimated parameters in two or more regimes, while the Smooth Transition Autoregressive (STAR) model (Chan and Tong, 1986; Teräsvirta, 1994) allows to estimate a smooth change in the transition between two states, as often happens in macroeconomic variables. A recent development of this family of models, introduced by McAleer and Medeiros (2008) for financial applications, allows the econometrician to test and model for multiple regimes. To the best of our knowledge, this paper is the first to apply this advancement in this field.

An alternative methodology for modelling nonlinear time series assumes that the change in regime is not observed, so that the change in regime is driven by Markov Chain. We explore also this scenario via Markov Switching Vector Autoregressive model (Hamilton, 1989), in order to identify the phases of recession (expansion) for GDP and lower (higher) growing rate of emission for CO_2 .

Finally, we test the Environmental Kuznets Curve (EKC) hypothesis according to which environmental degradation tends to increase as the economy develops, but begins to decline at higher levels of income, see Grossman and Krueger (1993, 1995); Selden and Song (1994), *inter alia*.

3 Results

The Cointegration analysis shows there is empirical evidence of a common trend between real GDP and CO_2 , which changes direction (globally increasing before 1975, decreasing after that date). This could be probably due to the energy efficiency policies implemented in the aftermath of the oil crises of the 1970s. The impulse-response analysis on the estimated CVAR model shows that shocks are persistent and in some cases are on an explosive path.

Not surprisingly, all the tests reveals that real GDP, carbon dioxide emissions and the emission intensity are strongly nonlinear, a fact which seems consistent with the strong persistent of the shocks driven by the CO_2 series. The estimated TAR and STAR models are significant and suitable of having at least three regimes. In the 19th Century, a long, smooth transition is detected between 1880 and 1915, while the 20th Century is characterized by a shorter, more abrupt transition in 1975-90. These dates corresponds to the "accumulation period" of the first step of the industrialization and to the "restructuring period" after the oil shocks, coherently with economic history literature (Zamagni, 1993). Similar results are given by bivariate Markov-Switching VAR for GDP and CO_2 . The years after 2008 seem to correspond to another change in regime.

Finally, an EKC-type regression for the post-war period provides evidence of an inverted U-shape at a reasonable level of per capita GDP.

4 Conclusions

With regard to the motivations previously described, the lack of a serious debate in green energies development for implementing an agenda for environmentally sustainable economic growth is associated with a lack of a structural break in the CO_2 series in the decade after the Kyoto agreement. On the other hand, the decline in the CO_2 emissions and emission intensity rates seems to be part of a long-term trend, driven by exogenous events.

In light of these results and given the high dependence on fossil fuels of the Italian economy, reaching the Europe 2020 national targets for sustainable growth represents a serious environmental challenge for policy makers, requiring a significant break from past policies and a radical change in the attitude towards environmental issues.

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