Energy Economics 61 (2016) 121–134

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

Energy-growth long-term relationship under structural breaks. Evidence from Canada, 17 Latin American economies and the USA ☆

Carlos Vladimir Rodríguez-Caballero[a], Daniel Ventosa-Santaulària[b,*]

[a] Center for Research in Econometric Analysis of Time Series (CREATES) and Department of Economics and Business, Aarhus University, Fuglesangs Allé 4, Building 2622 (203), 8210 Aarhus V, Denmark

[b] Centro de Investigación y Docencia Económicas (CIDE), División de Economía, Carretera México-Toluca 3655 Col. Lomas de Santa Fe, Delegación Álvaro Obregón, México 01210, Mexico

ARTICLE INFO

Article history:
Received 20 August 2015
Received in revised form 27 October 2016
Accepted 29 October 2016
Available online 12 November 2016

JEL classification:
C32
C51
Q43

Keywords:
Energy consumption
Economic growth
VECM
Causal links
Structural breaks

ABSTRACT

We study the relationship and the causal link between Electric Power Consumption, EPC, and Gross Domestic Product, GDP (both per capita) for 17 countries in Latin America, Canada and the USA. Considering that many of these economies underwent important economic crises in the last three decades, we therefore model the EPC-GDP relationship through a VEC specification that allows for structural breaks, along with a robust testing methodology of causal links based on the concepts of weak and super exogeneity, rather than Granger causality. Evidence favorable to the growth hypothesis (EPC→GDP) is found for eight countries, while data of three countries support the conservation hypothesis (GDP→EPC). For three countries evidence is favorable to the neutrality hypothesis, but should be considered with caution. As for the remaining five countries the evidence is not conclusive.

1. Introduction

The energy sector is a cornerstone in the making of national strategies for sustainable development because of its fundamental role in any modern economy. Sustainable development is now part of the agenda in most countries because it posits a desirable state for future generations: a successful energy policy may contribute to reduce environmental damage.

The relationship between electricity consumption (EPC) and production (GDP) has been widely studied in the literature. Following Ozturk (2010), the causality in such a relationship entails relevant consequences: (i) when there is evidence of causality from EPC to GDP (*growth hypothesis*), electricity policies could therefore have positive (or negative) effects in GDP. Policies aiming to preserve EPC, for example, could lead to a fall in economic growth. (ii) When we have an unidirectional causality running from GDP to EPC (*conservation hypothesis*), a policy that promotes energy consumption conservation may be implemented with little or no adverse effect on economic growth. (iii) When there is no causality (neither positive nor unidirectional) from EPC to GDP (*neutrality hypothesis*), then electricity conservation policies should be encouraged. (iv) The *feedback hypothesis* is supported when energy consumption and economic growth are jointly determined and affect each other, i.e., when there is evidence of bi-directional causality.

The results in the literature are twofold: shocks in energy consumption (such as the common conservation policies implemented in several countries), whether positive or negative (i) do not impact GDP growth, or (ii) have a negative impact on GDP growth (Narayan et al., 2008; Narayan and Smyth, 2005; Belloumi, 2009; Chang and Soruco Carballo, 2011). In other words, there are two opposing point of views in the ongoing debate. On the one hand, energy consumption is seen as a limiting factor for economic growth, and, on the other hand, energy is neutral to growth. The well known neutral hypothesis has been defended by Solow (1978) and Denison (1985),

☆ Carlos Vladimir Rodríguez-Caballero acknowledges support from CREATES - Center for Research in Econometric Analysis of Time Series (DNRF78), funded by the Danish National Research Foundation.

* Corresponding author.
E-mail address: vrodriguez@creates.au.dk (C. Rodríguez-Caballero).

http://dx.doi.org/10.1016/j.eneco.2016.10.026

to mention but a few. In words of Apergis and Payne (2009) [p. 211], the lack of consensus on the direction of the causal link between these two variables is due to "*[1] the heterogeneity in climate conditions, [2] varying energy consumption patterns, [3] the structure and stages of economic development within a country, [4] the alternative econometric methodologies employed, [5] the presence of omitted variable bias along with varying time horizons of the studies conducted.*" (emphasis added). We focus on the fourth argument, notwithstanding the obvious importance of the other ones. We (aim to) provide arguments that could help create a consensus about which time-series econometric methodology should prove the most adequate to deal with causal inference.

This work studies the relationship between EPC and GDP for 17 Latin American economies, Canada and the USA. We re-examine the impact of energy policies on economic growth. Our empirical strategy takes into account possible structural shifts in the time series. Many of the countries considered in our dataset suffered from severe economic crises in the last decades. Such events can be conveniently modeled in time series as structural breaks. Not controlling for such breaks would expose any empirical analysis to many bias sources that would make statistical inference unreliable. To the best of our knowledge, few studies of the EPC–GDP relationship consider structural breaks in the series,[1] specially in emerging economies, such as the ones prevailing in our dataset. This work provides a consistently-estimated EPC–GDP relationship for such economies, and searches for evidence of weak and super exogeneity in the variables. The later properties (and not Granger causality) provides the most important piece of evidence on causal links between the variables: it allows us to draw inference regarding one of the four hypothesis mentioned earlier (growth, conservation, neutrality, and feedback). Super exogeneity is also a vehicle to assess whether the estimated model can be used to guide economic policy. Collaterally, we also study whether the variables are strongly exogenous, which would allow for valid forecasts using single-equation specifications. These results, taken as a whole, should prove relevant in the debate regarding energy policies that foster or inhibit growth.

This work is organized as follows. Section 2 presents a brief overview of the literature; Section 3 provides a detailed explanation of the econometric methodology; empirical results are in Section 4, whereas Section 5 provides the concluding remarks and the policy implications of the results.

2. Brief overview of the literature

The energy-growth causal relationship was first studied in Kraft and Kraft (1978) who found evidence in favor of unidirectional causality from income to energy consumption (conservation hypothesis). Subsequently, Kraft and Kraft's inference was discussed by Akarca and Long (1980) who noted a possible inconsistency in the estimates due to the presence of some instabilities in the relationship. Thenceforth, a vast literature has been developed to examine the nature and the direction of causality of the relationship between electricity consumption and economic growth.

Most of the studies in the field have reported a strong correlation between EPC and GDP. However, in terms of causality, the wide array of empirical methodologies applied has generated an equally wide array of contradicting causality results, even for the same country as Soytas and Sari (2003) point out. There is therefore no real consensus on neither the direction of causality nor the impact on the long (and short) run impact on GDP due to changes in EPC.

Ozturk (2010) and Payne (2010) provide extensive surveys of the literature. Both authors conclude that the literature is not conclusive to provide policy recommendations universally suitable for all countries. One can find out different causal relationships across countries due to specific characteristics of: (i) the energy sector, (ii) the energy policies, and, (iii) the institutional arrangement, see Chen et al. (2007).

Many studies have thoroughly examined the evidence in favor of neutrality and growth hypotheses using a wide range of econometric strategies. Along the last two decades, VAR, VEC, and Panel models have been primordially used. Distinct specifications of VAR models can be found in Fatai et al. (2002), Wolde-Rufael (2004), and Francis et al. (2007), to mention a few. Moreover, many studies have reported the presence of unit roots in the EPC and GDP series. Consequently, VEC models has been extensively used in the literature (e.g. Stern, 2000; Soytas and Sari, 2003; Ghali and El-Sakka, 2004; Galindo, 2005; Karanfil, 2008; Chang and Soruco Carballo, 2011; Ozturk and Acaravci, 2013; Karanfil and Li, 2015;Esso and Keho, 2016). Furthermore, many studies have also focused on the treatment of unit roots by Panel data methodologies, see Chen et al. (2007), Huang et al. (2008), Lee and Chang (2008), Narayan and Smyth (2008), Ozturk et al. (2010), Acaravci and Ozturk (2010), Yildirim et al. (2014), Osman et al. (2016) among others. Some further methods have studied directly the Granger causality between EPC and GDP through different methods, such as bootstrap panel (Chu and Chang, 2012; Wesseh and Zoumara, 2012), Markov switching (Kandemir Kocaaslan, 2013), frequency domain (Bozoklu and Yilanci, 2013), and ARDL models (Ozturk and Acaravci, 2011).

3. Methodology

The causal relationship between EPC and GDP has been frequently studied via Granger Causality (GC, hereafter) (see Ozturk, 2010). Notwithstanding this, drawing inference on causality remains an extremely difficult and controversial task.[2] GC cannot be considered neither a necessary nor a sufficient condition for causality (see Hendry, 2004 [pp. 33–34]). GC basically states that a variable "Granger-causes" another variable if it contains 'special information' about effects not contained elsewhere in the information set. It also assumes that causes must precede effects. Both assertions entail conceptual difficulties and drive Hendry (2004) [p. 33] to consider that GC does not seem to completely characterize the notion of 'cause'. "Causal links are not sensibly tested by forecast evaluation, since neither success nor failure entails correct or incorrect attribution of causality." Moreover, Hendry and Mizon (2000) showed that a model capable of performing adequate forecasts is not necessarily a convenient vehicle to assess economic policy. In words of Hendry (2004) [p. 42] "causality cannot be proved to be a necessary property of variables in dominating forecasting models."

The complexity of causal analysis described above made us define an alternative process to draw inference on the EPC-GDP causality. We follow Hendry (2004, p. 28) by considering that "a cause is a quantitative process that induces changes over time, mediated within a structure that remains invariant to intervention." According to Hendry, this definition of cause is in line with Simon (1957) and Hoover (1990, 2001). Inference on causality is better drawn through a cointegration analysis, and, more precisely, through the Error-Correction Model (ECM) and the weak and super exogeneity properties that the variables may exhibit.

Originally developed by Granger (1981) and Engle and Granger (1987), cointegration implies that there may exist linear combination(s) of two or more nonstationary series that is (are) stationary: the cointegrated variables therefore share a common trend, and exhibit a tendency to move together in the long run. This is usually referred to as the long-run equilibrium relationship (Juselius, 2006),

[1] See Galindo and Sánchez (2005) and Apergis and Payne (2014).

[2] This section heavily draws on Hendry (2004).