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Energy consumption–economic growth nexus for Pakistan: Taming the untamed

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ABSTRACT

A recent survey of energy-growth literature has highlighted the potential trade-off between bivariate models that suffer from omitted variable bias, and the danger of over-parameterization of multivariate models in the individual country setting (Narayan and Smyth [2]). This is a serious limitation when the interest is in drawing policy implications for specific countries with short times series of available data. The maximum entropy bootstrap approach was used to re-examine the nature of causal relationship between energy consumption and economic growth for Pakistan where the available time series data was only from 1971 to 2011. Unlike the techniques used in much of the earlier literature, this approach does not rely on asymptotic methods and, therefore, leads to robust inference even in small samples. Moreover, the approach can be applied in the presence of non-stationarity of any type, and structural breaks, without requiring data transformation for to achieving stationarity, and is not sensitive to specification errors such as those in lag length selection. The empirical findings, based on both the bivariate as well as the multivariate frameworks, supported the conservation hypothesis, implying the existence of a unidirectional causality from economic growth to energy consumption.

Contents

1. Introduction

The seminal work of Kraft and Kraft [1] inspired a large body of literature that looked at the energy growth relationship (see Narayan and Smyth [2] for a survey). This literature focused on empirically testing four mutually exclusive hypotheses with important policy implications. The hypotheses are: (a) the *conservation hypothesis* that postulates unidirectional Granger causality running from GDP to energy; (b) the *growth hypothesis*, that

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suggests the causality runs from energy to GDP; (c) the *feedback hypothesis*, that posits the existence of bidirectional Granger causality between energy and GDP; and (d) the *neutrality hypothesis* that postulates energy and GDP as being independent.

Mehrar [3], and Coers and Sanders [4] identified several generations of studies that tested the above mentioned hypothesis. While the recent studies adopted more sophisticated methods, consensus has eluded researchers in terms of establishing the existence of long run relationship between energy and growth, and the direction of causality between them (see Ozturk [5]; Payne [6]; both cited in Narayan and Smyth [2]).

There are several reasons for this lack of consensus. These include, the omitted variable bias in the bivariate studies leading to wrong conclusions regarding the direction of causality, as cautioned by Lütkepohl [7]; the inclusion in the energy-growth relationship of additional variables selected on an ad hoc basis, the existence of multiple structural breaks that affect the cointegration relationship between energy and other variables of interest (Narayan and Smyth [2]); and the use of asymptotic theory for testing for unit roots and cointegration in small samples, (see Yalta [8] and Yalta [9]).

Some studies tried to address these limitations by using multivariate models where the additional non-energy variables were chosen in a theoretically consistent way. For example, Stern ([10,11]) employed the theoretical framework of a production function, where the output (GDP) depended on energy, and other inputs i.e. capital and labor. Other studies employed normalized production function with output and inputs normalized by labor or population (for example, see Liddle [12] and Narayan and Smyth [13]). According to Narayan and Smyth [2], many recent studies used augmented production function framework where the relationship between GDP and energy was augmented by a third or fourth variables such as urbanization (Liddle [12]; Liu and Xie [14]; Mishra et. al. [15], Sadorsky [16]; Wang [17]), indicators of financial development (Coban and Topcu [18]; Jalil and Feridun [19]; Sadorsky [20], Sadorsky [21], Sadorsky [22] and Shahbaz and Lean [23]), and measures of trade (Aissa [24], Farhani et. al. [25]; Lean and Smyth [26]; Narayan and Smyth [13], Sadorsky [21] and Sadorsky [27]).

While the studies employing the augmented production function framework attempted to deal with the problems due to omitted variables, the approach was no panacea for modeling the relationship between energy and growth. The multivariate framework could be a costly modeling choice, leading to over-parametrization of the model and the loss of degrees of freedom, if the available time series of data were short. Many researchers tried to use panel data techniques to overcome difficulties posed by short time series. In particular, the studies published from 2007 and 2008 onwards – labeled as 'fifth generation' studies (Cooers and Sanders [4]) – employed panel VECM, included other non-energy inputs, and estimated capital-energy complementarities (for example, see Apergis and Payne [28]; Coers and Sanders [4]; Liddle [12], Narayan and Smyth [13], Sadorsky [21], Sadorsky [27]).

The panel data models are not the ideal methodological approach, however, if the interest is in drawing policy implications for the individual countries. The recent survey of literature on the energy-growth relationship by Narayan and Smyth [2] highlighted the trade-off that necessarily arises in these circumstances between using the bivariate model susceptible to omitted variable bias, and employing a multivariate approach with the associated model over-parameterization risk. This is clearly a research gap that needs to be addressed, especially in view of its relevance for formulating energy policy for individual countries.

As mentioned above, another important reason for the lack of consensus about the energy-growth relationship is that the traditional studies used asymptotic methods for testing for possible unit root and cointegration in small samples. However, there is no guarantee that this approach would lead to correct inference in small samples (Yalta [8,9], and Zhou [29]). According to Narayan and Smyth [2], "when using data for single countries, a long time span is preferable. Stern and Enflo [30] and Vaona [31] set the gold standard in this regard, although in most cases 150 years of data will not be available." In fact with the exception of a few countries, the available time series on energy consumption are rather short.

This paper attempted to fill the two research gaps identified above. First, it used an approach suited for studying energy-growth relationship when the interest is in drawing policy conclusions for a specific country with short available time series of

Table 1
Studies on energy consumption (EC) and economic growth (Y) for Pakistan.

No.	Authors	Time span	Direction of Granger causality
1.	Javed et al. [36]	1971–2008	ec $\leftrightarrow Y$
2.	Muhammad et al. [44]	1971–2013	EC $\rightarrow Y$
3.	Akhmat and Zaman [37]	1975–2010	NEC $\leftrightarrow Y$
4.	Abbas and Choudhury [38]	1972–2008	AEC $\leftrightarrow$ AY
5.	Ahmad et al. [49]	1973–2006	$Y \rightarrow$ EC
6.	Chaudhry et al. [43]	1972–2012	EC $\rightarrow Y$
7.	Shahbaz and Lean [23]	1972–2009	ec $\leftrightarrow Y$
8.	Shahbaz et al. [34]	1972–2010	NGC $\leftrightarrow Y$
9.	Shahbaz et al. [35]	1972–2011	EC $\leftrightarrow Y$
10.	Shahbaz and Feridun [48]	1971–2008	$Y \rightarrow$ ec
11.	Bedi-uz-Zaman et al. [47]	1972–2008	$Y \rightarrow$ EC
12.	Kakar and Khilji [42]	1980–2009	EC $\rightarrow Y$
13.	Jamil and Ahmad [46]	1960–2008	$Y \rightarrow$ EC
14.	Khan and Ahmad [41]	1972–2007	ec $\rightarrow Y$, CC $\rightarrow Y$
15.	Asghar [40]	1971–2003	CC $\rightarrow Y$, $Y \rightarrow$ ec
16.	Hye and Riaz [33]	1971–2007	EC $\leftrightarrow Y$
17.	Mushtaq et al. [39]	1972–2005	ec $\rightarrow Y$, $Y \rightarrow$ OC
18.	Aqeel and Butt [45]	1955–1995	$Y \rightarrow$ EC, $Y \rightarrow$ PC, ec $\rightarrow Y$, Y neutral NGC

Note: EC=energy consumption; Y=economic growth (real GDP); ec=electricity consumption; PC=petroleum consumption; NEC=nuclear energy consumption; AEC=agricultural electricity consumption; AY=agricultural growth; NGC=natural gas consumption; OC=oil consumption; CC=coal consumption

a. EC $\leftrightarrow Y$ indicates a bidirectional causality between energy consumption and economic growth
b. $Y \rightarrow$ EC represents a unidirectional causal relationship that runs from economic growth to energy consumption
c. EC $\rightarrow Y$ shows a unidirectional causal link from energy consumption to economic growth

Neutral means no causal relationship.