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Long-term equilibrium relationship between urbanization, energy consumption and economic activity: Empirical evidence from India

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ABSTRACT

The study examines cointegrating relationship between energy consumption, urbanization and economic activity for India using threshold cointegration tests complemented by ARDL (Autoregressive Distributed Lag) bounds testing approach and Johansen–Juselius maximum likelihood procedure for cointegration for the period 1971–2008. Considering the rapid urbanization and growing energy demand in India in recent years, this study is highly pertinent and presents some important results which should guide the policy makers to develop long-term energy and urban policies in India. Threshold cointegration tests suggest the existence of long-run relationship among the variables having endogenous structural breaks or regime shifts. Toda–Yamamoto version of the Granger causality tests indicate unidirectional causality running from energy consumption to economic activity and economic activity to urbanization. The article elaborately discusses the possible reasons behind its empirical findings and prescribes ways and means to enhance energy supply. The findings of the study are critical and warn the need of designing and executing long-term energy and economic policies which judiciously address the issues of incessant urban migration in India to achieve a sustainable growth path. The study also advocates that the consequences of rapid urbanization should be an integral part of long-term energy planning in India.

1. Introduction

The objective of this article is to explore relationship between energy consumption, urbanization and economic activity in India. India is one of the fastest-growing economies in the world. According to IMF (International Monetary Fund), Indian economy is the eleventh largest in the world by nominal GDP (Gross Domestic Product) and the third largest by PPP (purchasing power parity). India's service industry accounts for 57.2% of the country's GDP while the industrial and agricultural sectors contribute 28.6% and 14.6% respectively. However, there is widespread income inequality as 42% of Indian population lives less than $1.25 a day (Planning Commission of India). India needs to grow more than 8% for the next couple of decades in order to lift the bottom 40% of the population to an acceptable standard of living and provide economic well being (IEP (Integrated Energy Policy) Document, Planning Commission, Government of India).

Urbanization is an integral part of economic growth. As in most countries, urbanization in India is happening at a faster rate. India's towns and metropolitan cities have expanded rapidly with increasing number of people migrating from rural areas. As per the census reports, the urban population in India has increased to 31% in 2011 as compared to 28% in 2001. The survey report of UN State of World Population, 2007 estimates that the country's urban population is expected to grow up by 41% by 2030. As per 2011 census, Indian cities like Mumbai, Delhi and Kolkata are witnessing the fastest rate of urbanization in the world. Economic opportunities, infrastructure facilities and growth of private sectors post economic deregulation in 1990s are some of the principal reasons of rapid urbanization in India. One-third of 1.2 billion population in India live in urban areas contributing two-third of country's economic growth and 90% of government revenues. The contribution of agricultural sector to country's economic growth has been declining.

Economic growth of India is severely affected by inadequate energy-supply. Though India is the fifth largest consumer of energy after USA, China, Russia and Japan, its per capita energy consumption of 560 KOE (kg of Oil Equivalent) is far below the world average of 1788 KOE in 2009. According to IEP, India needs to

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increase its primary energy supply by at least 3–4 times by 2031 (with respect to the base financial year 2003) to maintain a GDP growth of 8%. Rapid urbanization instigates urban hot spots on energy consumption, which add further pressure to existing energy infrastructure. Rising urban population, industrialization, increased vehicular population and widespread dieselization of the urban centers propel environmental degradation.

India currently uses coal for about half of its energy requirements. 52% of India's energy supply is dependent on coal due to the availability of large coal reserves (An Approach to the Twelfth Five Year Plan (2012–17), Planning Commission of India). Projection by various national and international agencies shows that coal is expected to dominate its share in India's energy supply further due to its affordability. But coal is a dirty fuel, which has the highest CO_2 (carbon dioxide) emission coefficient.[2] CO_2 is a major GHG (Green House Gas) responsible for global warming. Developed world express its concern over India's burgeoning CO_2 emission which is, at present, fourth largest emitter of CO_2 after USA, China and Russia though, in per capita terms, CO_2 emissions are well below than that of world averages.

So, Indian economy faces the challenge of balancing act between economic growth and burgeoning energy consumption due to rapid urbanization and industrialization with environmental responsibility like many other developing economies in the world.

Considering the rapid urbanization and growing energy demand in India, there is an urgent need to investigate the relationship between urbanization and energy consumption for guiding and developing long-term energy policies in India.

The current study investigates cointegrating relationship between energy consumption, urbanization and economic activity deploying threshold cointegration tests of Gregory and Hansen [1] and Hatemi-J [2] complemented by ARDL (Autoregressive Distributed Lag) bounds testing approach and Johansen–Juselius maximum likelihood procedure for cointegration. The study further investigates TY (Toda–Yamamoto) version of Granger non-causality tests [3] among energy consumption, urbanization and economic activity. This article is a unique contribution to the existing literature of urbanization and energy consumption nexus in emerging economies as no studies have looked into the long-run relationship of these variables in a cointegration methodology where the cointegrating model determines and incorporates structural breaks endogenously.

The remaining part of the article is organized as follows: Section 2 gives literature review. Section 3 provides data description, estimation models and econometric methodology. Section 4 analyses the empirical results. Section 5 concludes the study.

2. Literature review

There have been numerous studies which examine the relationship between energy consumption and urbanization for developed and developing economies.

Urbanization is a major demographic trend in the world especially in Asia and Africa [4] having major consequences for development and environment [5]. Hence it should be taken into consideration for energy policy and planning. Urbanization plays an important role in "energy transition" [6]. In the household energy transition analysis for India and China, Pachauri and Jiang [7] have shown that the total energy consumption in rural households is more than urban households as rural households depend more and more on inefficient solid fuels. They have also shown that there is an increasing dependence on modern fuels by urban population. So, urbanization has created shift in energy consumption from inefficient fuels like biomass to more efficient fuels like kerosene, LPG (liquefied petroleum gas) and electricity.

Rapid urbanization and economic development also propel anthropogenic GHG emission. Liu et al. [8] present features, trajectories and driving forces for energy-related GHG emissions in four mega-cities: Beijing, Tianjin, Shanghai and Chongqing from China during 1995–2009. The study reveals that GHG emissions are mainly generated from energy use in industrial sector and coal-burning thermal power plants. Li et al. [9] present the current status, basic concepts, and town practices for the development of 'low carbon towns' in China.

The extensive literature examining the nexus between energy consumption and urbanization suggest that the authors have also considered economic activity, industrialization and financial development as additional determinants in understanding the relationship between urbanization and energy consumption in a most comprehensive manner. To explain the oil demand in developing economies, level of urbanization and industrialization are considered as the primary determinants [10]. Studies like the one by Burney [11], Lenzen et al. [12]. have analyzed and compared the impact of urbanization on energy consumption for cross-section of countries for a single period. The study finds that urbanization has dissimilar effects on energy consumption across countries such as Australia, Brazil, Denmark, India and Japan. This finding is in line with Burney [11] who has studied the impact of urbanization on electricity consumption with additional determinants like per capita income and share of industry in GDP across countries for a particular time period. Studies by Jones [13–15], Parikh and Shukla [16] and Imai [17] establish a positive relationship between urbanization and energy consumption. However, some studies have found a strong negative relationship between energy consumption and urbanization [18–21]. Lariviere and Lafrance [20] show that more urbanized areas have lower per capita energy consumption in Canada. O'Neill et al. [22] assess the implications of a plausible range of urbanization for energy use and carbon emissions in a general equilibrium model for India and China. The main finding of the study is that the urbanization has a somewhat less than proportional effect on energy use and carbon emission for both countries.

Some studies have explored Granger-causality time series approach to explore causal relationship between urbanization and energy consumption in a bivariate or multivariate framework. Holtedahl and Joutz [23] show that urbanization Granger causes energy consumption. Greater and better access to electricity supply is explained as the possible reason of higher energy consumption in urban areas. Mishra et al. [24] studied the causal relationship between energy consumption and urbanization with an additional variable GDP for Pacific Island countries. The study unfolds that there exists a short-run Granger causality running from energy consumption to urbanization and long-run Granger causality running from electricity consumption and urbanization to GDP and from GDP and urbanization to electricity consumption. Studies by Halicioglu [25], Liu [26] and Shahbaz and Lean [27] have investigated the long-run and short-run relationship between energy consumption and urbanization in ARDL bounds tests multivariate framework. Halicioglu [25] has examined the causal relationship between energy consumption, energy prices, GDP and urbanization for Turkey. The study reveals a long-run causality running from GDP, energy prices, urbanization to energy consumption. Liu's [26] study shows a cointegrating relationship amongst total energy consumption, population, GDP and urbanization with unidirectional Granger causality running from urbanization to total energy consumption for China. Shahbaz and Lean [27] confirm the

[2] As per the report on 'CO_2 emission from fuel combustion; highlights' International Energy Agency Report, 2012.