Economic Modelling 38 (2014) 581–591

Contents lists available at ScienceDirect

Economic Modelling

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

Urbanization and renewable and non-renewable energy consumption in OECD countries: An empirical analysis

Ruhul A. Salim [a,*], Sahar Shafiei [b]

[a] School of Economics & Finance, Curtin Business School, Curtin University, Perth, WA 6845, Australia
[b] Department of Economics, Azad University, Science and Research Campus, Ahvas, Iran

ARTICLE INFO

Article history:
Accepted 13 February 2014
Available online 11 March 2014

JEL classification:
C23
C33
Q21
Q43
Q48

Keywords:
Renewable energy consumption
Non-renewable energy consumption
CO_2 emissions
Urbanization
STIRPAT model

ABSTRACT

This article aims to analyse the impact of urbanization on renewable and non-renewable energy consumption in OECD countries by using the STIRPAT model and data for the period of 1980 to 2011. Demographic factors including total population, urbanization and population density are found to be significant factors, particularly with respect to non-renewable energy consumption. The results also reveal that while total population and urbanization positively influence non-renewable energy consumption, population density has a negative impact on non-renewable energy consumption. From the demographic factors only total population has a significant impact on renewable energy consumption. Granger causality results indicate that there is unidirectional causality from non-renewable energy use to population density in the short run. However, no causal linkage is found between urbanization and non-renewable energy use. Likewise, no causal direction is seen between renewable energy use and any of the demographic factors.

1. Introduction

Urbanization leads to relative concentration of population as well as economic activities in urban areas. As a result of migration from rural to urban areas, in fact the labour force is transferred from the agricultural sector in the rural areas to the industrial and service sectors in the urban areas. This structural transformation of the economy causes many fundamental changes in natural resources and energy use as well. Although the transformation of production from the low-energy intensive agricultural sector to the high-energy intensive industrial sectors yet this sector is affected by the introduction of new technologies and industrialisation. Due to growing rates of urbanization the volume of production and the market range increase over the past decades. Moreover, urban living as compared to rural life is expected to require more energy as a result of travelling to work by fuel-using vehicles, and also constructing, operating, and maintaining urban infrastructure and services including housing, water supply, roads and bridges (Jones, 2004; Madlener and Sunak, 2011; Parikh and Shukla, 1995). Growing dependency on fossil fuels as a result of concentration of people in cities has led to efforts by policy makers to substitute clean energy resources for fossil fuels. For example, some major cities, particularly in developed countries, have begun to link homes and offices to renewable energy in order to create a fossil-fuel free district in the near future.

The urbanization–energy use relationship has been studied extensively in recent years, and while some researchers show that urbanization increases energy consumption, some others argue that urbanization can improve the efficient use of public infrastructure, resulting in less energy use. However, it is still less clear what sort of energy is more likely to be affected by urbanization. Recently, with the new approach to using more renewable energy, particularly for generating electricity in large cities, the question arises as to whether urbanization can expand the use of renewable energy. Therefore, it is important to study the impact of urbanization on disaggregated energy consumption in terms of renewable and non-renewable in order to gauge as to how urbanization affects disaggregated energy use and where policy makers should focus their attention in this regard.

There are a number of studies that have investigated the urbanization–energy relationship, but none of these studies analyse the impact of urbanization on renewable and non-renewable energy consumption. This article aims to investigate the effects of urbanization on disaggregated energy consumption controlling for other demographic and economic factors such as population size, population density, economic

* Corresponding author at: School of Economics & Finance, Curtin Business School, Curtin University, Perth, WA 6102, Australia. Tel.: +61 8 9266 4577; fax: +61 8 9266 3026.
E-mail addresses: Ruhul.Salim@cbs.curtin.edu.au (R.A. Salim), shafiei.sahar@yahoo.com (S. Shafiei).

http://dx.doi.org/10.1016/j.econmod.2014.02.008
0264-9993/

growth, industrialization and tertiarisation etc. using data from the OECD countries over the period from 1980 to 2011.

The present study differs from the existing empirical studies in a number of ways. First, it estimates the impact of urbanization on non-renewable and renewable energy consumption employing a STIRPAT (STochastic Impacts by Regression on Population, Affluence, and Technology) model. Second, it controls for population density which is a key factor that influences energy consumption, and has been rarely considered in previous studies. Third, it takes into account statistical concerns over the presence of heterogeneity and cross-section dependence that can result in misleading inference and inconsistent estimates, and has been ignored by previous researchers.

The structure of the rest of the article proceeds as follows. Section 2 provides a critical review of empirical studies and develops research hypotheses. Section 3 describes the analytical models and data. The analysis of empirical results is presented in Section 4. Finally, Section 5 concludes the article and provides policy implications.

2. Review of the empirical literature and research hypotheses

2.1. Review of the empirical literature

While there has been useful modelling exercises on the relationship between energy consumption and economic growth, energy consumption and urbanization, but there is hardly any application between renewable and non-renewable energy consumption and urbanization. A good number of studies have been conducted over the last decades on the urbanization–energy consumption linkages either by using cross-section or by time series data or by pooling both time series and cross section data.[1] These studies have been conducted on divergent lines; some have focused on developing countries, some on developed and some on both developed and developing countries. In addition, some studies have focused on a single country and other on multiple countries. Using cross-section data for 59 developing countries in 1980, Jones (1991) concludes that a 10% increase in the proportion of the population living in cities increases per capita energy consumption by 4.5% to 4.8%, holding constant per capita income and industrialization. However, Jones' findings may be subject to some limitations. For instance, the coefficients are estimated only based on a single year (1980) which might yield unreliable results due to using a very small sample size of data.

Parikh and Shukla (1995) also provide an early analysis of the relationship between urbanization and energy use over the period from 1965 to 1987 for a sample of developing countries. Their results, obtained from a panel data fixed-effects model, indicate that a 10% increase in a country's urban population leads to a 4.7% rise in its per capita total energy consumption. In a similar study, Imai (1997) employs a weighted least square method using data from 1980 to 1993 and finds a positive relationship between energy consumption and urbanization in Thailand, China, India, Iran, Japan, Turkey, USA and Germany. However, using a bivariate model in this study can increase the likelihood of reaching incorrect conclusions due to the omitted variables.

There are a number of studies dealing with the relationship between urbanization and aggregate energy consumption in China (Liu, 2009; O'Neill et al., 2012; Shen et al., 2005; Wei et al., 2003; Zhang and Lin, 2012; Zhang and Zhao, 2001), of which Liu (2009) finds the presence of a unidirectional causality running from urbanization to total energy consumption both in the long run and in the short run. Using a similar approach for a single country Turkey, Halicioglu (2007) finds a unidirectional causality running from urbanization and GDP to energy consumption. Mishra et al. (2009) also reveal a unidirectional causal relationship between urbanization and energy consumption in the short run for a panel of nine Pacific Island countries. In a very recent study in Tunisia, Shahbaz and Lean (2012) find bidirectional causality between industrialization and energy consumption in the long run and unidirectional causality from urbanization to energy consumption in the short run.

York et al. (2003a) are the first to develop and use the STIRPAT model to study the impact of urbanization on aggregate energy use. Their results indicate that population is a major driver of the energy consumption; and urbanization, as an indicator of modernization, monotonically increases energy use. In contrast, Liddle (2004) finds that urbanization and population density negatively affect energy use in OECD countries from 1960 to 2000. However, it is noteworthy to mention that Liddle considers road transport energy use in this study and implies that more densely populated and urbanized societies have less demand for personal transport. In a similar study on road transport energy use in high income countries Poumanyvong et al. (2012) obtain evidence opposite to that of Liddle (2004). Focusing on fourteen European Union Nations over the period from 1960 to 2000, York (2007) proves that demographic factors including population size, age structure and urbanization along with economic development affect energy consumption positively. However, predicting energy consumption for the year 2025, based on demographic and economic factors, the author shows that low fertility and thereby decline in population size in Europe can help restrict expansion in energy consumption.

It appears that Liddle and Lung (2010), after Liddle (2004) and York (2007), is the only recent study that investigates the effect of urbanization on energy consumption exclusively for a panel of developed countries. Employing a STIRPAT method for 17 developed countries covering the period from 1960 to 2005, the authors reveal that urbanization has a positive and fairly large effect on both residential energy consumption and residential electricity consumption. Considering different development stages in 99 countries from 1975 to 2005, Poumanyvong and Kaneko (2010) investigate the relationship between urbanization and energy use, controlling for population size, GDP per capita, share of industry and service sectors in GDP. These authors demonstrate that while urbanization increases energy use in the middle- and high-income countries, it decreases energy use in the low-income countries.

Thus, a considerable number of studies have assessed the urbanization and energy consumption nexus. However, there is no consensus as yet as to how urbanization affects energy consumption. Furthermore, there are only a few studies on OECD countries on this issue. In addition, there are only a few studies that focus on population/urban density in the empirical literature although the population density in urban areas is closely related to urbanization and pollutant emissions.

Newman and Kenworthy (1989) measure per capita transport energy consumption and population densities in a range of large cities in high-income countries and find that high population density decreases per capita transport energy use. However, Newman and Kenworthy's study is criticised for not using a multivariate analysis that can affect the research result. Their results are also said to be limited due to using 1980s data, which is suspected as not being accurate and consistent (Mindali et al., 2004).

Larivière and Lafrance (1999) find that in Canada, more urbanized areas have lower energy consumption per capita. Using data for 45 Chinese cities, Chen et al. (2008) reveal that urban density has a negative effect on household energy consumption. The authors argue that this effect is caused by compactness of residential structure. Thus, population density plays a critical role in energy use reduction and should be considered as a policy variable in empirical analysis. Given the limited number of studies on the relationship between population density and energy consumption further study gathering more empirical evidence on this issue is imperative.

[1] With the development of time series econometric modelling the number of studies on the causal linkages among economic variables such as energy consumption and income growth (e.g. Shahbaz et al., 2012) energy consumption and urbanization (e.g. O'Neill et al., 2012), financial development and energy consumption (e.g. Islam et al., 2013), financial development and economic growth (e.g. Hsues et al., 2013), stock prices and exchange rates (e.g. Liang et al., 2013) is far too voluminous to review, we only focus on urbanization and energy consumption in this article.