Energy Economics 37 (2013) 52–59

Contents lists available at SciVerse ScienceDirect

Energy Economics

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

Do urbanization and industrialization affect energy intensity in developing countries?

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ARTICLE INFO

Article history:
Received 17 May 2012
Received in revised form 17 January 2013
Accepted 20 January 2013
Available online 31 January 2013

JEL classification:
Q43
R11
O14

Keywords:
Energy intensity
Developing countries
Industrialization
Urbanization

ABSTRACT

Against a backdrop of concerns about climate change, peak oil, and energy security issues, reducing energy intensity is often advocated as a way to at least partially mitigate these impacts. This study uses recently developed heterogeneous panel regression techniques like mean group estimators and common correlated effects estimators to model the impact that income, urbanization and industrialization has on energy intensity for a panel of 76 developing countries. In the long-run, a 1% increase in income reduces energy intensity by −0.45% to −0.35%. Long-run industrialization elasticities are in the range 0.07 to 0.12. The impact of urbanization on energy intensity is mixed. In specifications where the estimated coefficient on urbanization is statistically significant, it is slightly larger than unity. The implications of these results for energy policy are discussed.

1. Introduction

Against a backdrop of concerns about climate change, peak oil, and energy security issues, reducing energy intensity is often advocated as a way to at least partially mitigate these impacts. Energy intensity tends to correlate highly with income and higher income countries have lower energy intensity than poorer countries. In addition to income, other factors like urbanization and industrialization may affect energy intensity. The impact that urbanization has on energy intensity is difficult to predict because urbanization increases economic activity through a higher concentration of consumption and production but urbanization also leads to economies of scale and provides the opportunity for increases in energy efficiency.[1] Industrialization, the introduction of new equipment and techniques to make existing and new products, increases industrial activity which uses more energy than does traditional agriculture or manufacturing implying that industrialization has a positive impact on energy intensity.

Energy intensity for high income countries (HIC) has been falling over the past 30 years and for major country income aggregates energy intensity today is lower than what it was in 1980 (Fig. 1). In general, high income countries (HIC) are the most efficient at using energy while low and middle income countries (LMY) tend to be the less efficient. In 2010, for example, energy use (kg of oil equivalent) per $1000 GDP (constant 2005 PPP) in high income countries was 40% lower than in 1980. For the world as a whole, energy intensity in 2010 was 27% lower than in 1980, while for the low and middle income countries energy intensity in 2010 was 23% lower than in 1980.[2]

This paper makes several important contributions to the literature. First, the relationship between urbanization and energy has been studied by a number of authors (eg. Jones, 1989, 1991; Parikh and Shukla, 1995; Poumanyvong and Kaneko, 2010; York, 2007) but most of this research focuses on energy use rather than energy intensity. Jones (1991) appears to be the first to specifically investigate the relationship between energy intensity, urbanization and industrialization for developing economies but on the whole, there is very little known about how urbanization and industrialization affect energy intensity. It is important to have a better understanding of how income, urbanization and industrialization impact energy intensity because increases in energy efficiency are one way to mitigate concerns regarding climate change, peak oil, and energy security issues.

Second, while panel data techniques are becoming more common, most existing models linking urbanization, industrialization and energy use a static model applied to a panel data set. A panel data set offers advantages over a cross-section data set by including a time dimension.

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[1] In this paper, urbanization refers to The World Bank's definition of the percentage of the population living in urban areas as defined by national statistical offices (http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS). However, urban areas can be defined differently by different national statistical offices and in general there is no universally accepted definition of urbanization (eg. Vlahov and Galea, 2002). Moreover, a country's definition of an urban area can change across time. I thank a well informed reviewer for pointing this out.

[2] Notice how energy intensity in the low and middle income country group spiked following the 1991 breakup of the Soviet Union into 15 independent republics.

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http://dx.doi.org/10.1016/j.eneco.2013.01.009

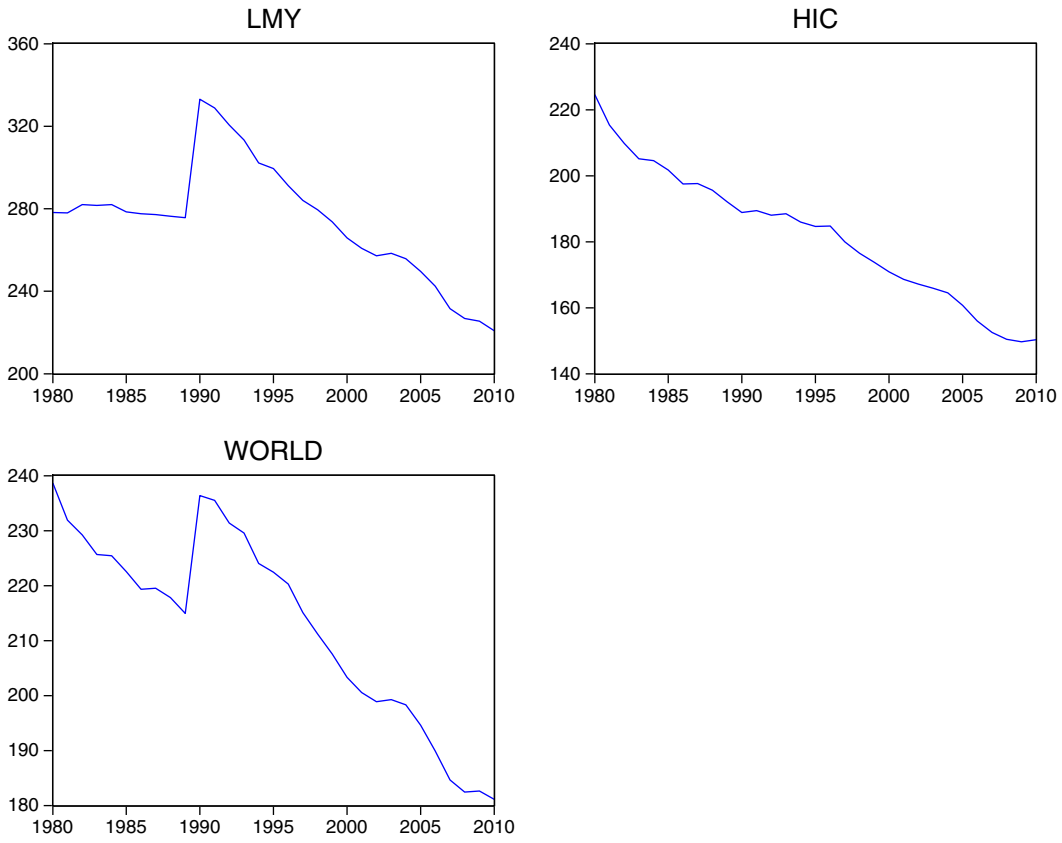

Fig. 1. Energy use (kg of oil equivalent) per $1000 GDP (constant 2005 PPP).
(Data sourced from http://www.worldbank.org/data/onlinedatabases/onlinedatabases.html).

This increases the number of observations and allows for variation in both the cross-section and time dimension. Static models cannot, however, capture dynamic relationships. This present paper uses a dynamic framework to model the impact of income, urbanization and industrialization on energy intensity. Dynamic models are advantageous because both long-run and short-run impacts (elasticities) are modeled.

Third, previous studies have assumed that the impact of urbanization and industrialization on energy use is homogeneous across countries. This is a very strong assumption to make and one that is unlikely to hold across a large grouping of countries. In this present paper panel regression models are estimated using recently developed techniques like mean group estimators that allow for heterogeneity in the estimation of the slope coefficients. If panel data exhibits cross-section dependence, estimating models with homogeneous slope coefficients (as in the case of pooled OLS, fixed effects, or GMM) may yield misleading results. In order to account for cross-section dependence, models are estimated using the mean group (MG) estimator of Pesaran and Smith (1995), Pesaran's (2006) Common Correlated Effects Mean Group (CCEMG) estimator, and the Augmented Mean Group (AMG) estimator of Eberhardt and Teal (2010) and Bond and Eberhardt (2009).

The purpose of this paper is to investigate the relationship between energy intensity, income, urbanization and industrialization for a panel of 76 developing economies. Empirical models are estimated using heterogeneous panel regression techniques. The following sections of the paper set out the contextual material, the empirical model, data, empirical results, implications, and conclusions.

2. The impact of urbanization, industrialization and income on energy use

According to data sourced from the United Nations Population Division (2007), while the most developed regions (MDR) of the world have higher urbanization (% of population living in urban areas) than the less developed regions (LDR) of the world, urbanization for both groups is expected to continue rising (Fig. 2) with urbanization in the LDRs rising the fastest. The year 2010 marks a milestone because this was the year when the world urbanization passed 50%. It is expected that in the year 2020, urbanization in the less developed regions of the world will pass 50%. Notice that for the 100 year time period shown in Fig. 2, urbanization in the less

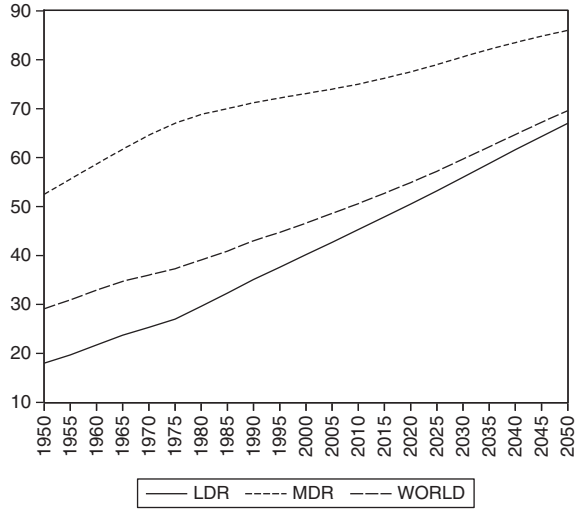

Fig. 2. Percent urban in less developed regions (LDR), most developed regions (MDR) and the World.
(Data sourced from http://esa.un.org/unup/.)