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Does industrialisation and urbanisation affect energy consumption: A relative study of India and Iran?

Salman Haider
University of Hyderabad

Masudul Hasan Adil
Univeristy of Mumbai

Aadil Ahmad Ganaie
University of Hyderabad

Abstract

This study investigates the dynamic impact of industrialisation and urbanisation on energy consumption including economic growth in a multivariate framework. For this purpose, autoregressive distributed lag model (ARDL) is employed. ARDL bounds testing approach shows that there exists long-run relationship among the variables. Using data for the Indian and Iranian economy from 1971 to 2013, the study found a differential impact of urbanisation and industrialisation on energy consumption in both countries, also they are the key driver for increasing energy demand. Long-run coefficients of urbanisation and industrialisation being statistically significant suggest that these variables have implications in framing the energy policy.

I at this moment acknowledge that this empirical research work is carried out by me and all the suggestions and policy implications belong to the personal viewpoint. Usual disclaimer applies.

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Contact: Salman Haider - s.haideramu786@gmail.com, Masudul Hasan Adil - adilmasood.alig@gmail.com, Aadil Ahmad Ganaie - aadilganaie77@gmail.com.

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"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to fit facts."

Sherlock Holmes

1. Introduction

Energy uses and pollution levels are continuously rising globally, especially in emerging economies such as India—which has become the fifth-largest country regarding energy consumption and third largest carbon emitter in the world. Urbanisation and industrialisation seem to be a key driver for increasing energy demand. Urbanisation intensifies economic activity through a higher level of consumption and production. Nevertheless, it leads to economies of scale and provides the opportunity to achieve energy efficiency. Hence, it is difficult to predict the impact of urbanisation on energy consumption. Economic reforms of 1991 in India emphasises on industrial development through delicensing and privatisation. During the process of industrialisation the introduction of new equipment and techniques, which lead to new and quality products, increases industrial activity that uses more energy as compare to traditional agriculture or manufacturing. Industrial growth also increases the demand for labour and other inputs and thus improves their income which in turn increases demand for consumer durable items such as cars, TVs, refrigerators,computers etc. that also becomes the cause for higher energy consumption. In empirical studies, industrial value added as a percentage of GDP is usually used as a proxy for industrialisation. According to Blanchard (1992), this indicator represents internal manufacturing specialisation and a measure of structural change.

There is a need to address the issue of growing energy demand and supply-side uncertainty. Where energy security remains a challenging issue for emerging economies like India, as 240 million Indians do not have access to household electricity consumption (IEA, 2015). It is evident that India is currently experiencing an electricity deficit of around 10% at its peak hours. India's electricity demand is expected to be doubled by 2035 which raises serious concern about the additional supply sources of energy (Bhat et al., 2018; Haider and Bhat, 2018). Renewable energy is one of the source which government is targeting to fulfill increasing demand of energy. Apart from that policy-makers at national and state levels are making their own efforts to remove obstacles to invest in energy supply while focusing on energy efficiency and pricing reform (Nain et al., 2017a).

Iran is one of the leading energy producer as well as consumer and net exporter of 75.32 million tonne of oil equivalent *(mtoe).* There is also increasing trend in urbanisation (30% increase in Iran while that of India is 11% which is relatively low). There are several channels, such as transportation and population density, by which urbanisation can affect energy use (Jones, 1989, 1991; Madlener, 2011). It is important to have a better understanding of how income, urbanisation and industrialisation impact energy consumption because making pragmatic policy for energy consumption is one way to mitigate concerns regarding climate change, peak oil, and energy security issues.

There are large number of papers examining the empirical relationship between energy use and economic growth due to significant policy implications. However, the results based on causal relation remain mixed due to the different econometric methods employed, the various time periods and countries heterogeneity. The relationship between urbanisation and energy has been studied by a number of authors (for instance, Jones, 1989, 1991; Parikh and Shukla, 1995; Poumanyvong and Kaneko, 2010; York, 2007). However, most of them have not taken into account the industrialisation and structural changes, which may lead to specification bias. Urbanisation is accompanied by industrial development through large-scale movements of the

labour force. Moreover, increased population density puts further pressure on the urban economy. Pacione (2013) estimates that cities account for 75% of the world's consumption of natural resources yet cities cover only 2% of the world's surface. This study is an attempt to examine the impact of increasing urbanisation and industrialisation on energy consumption in emerging countries like India and Iran. Recognising the fact that India has gone through structural changes over time, which is characterised by increasing energy consumption, higher economic growth, and increased urbanisation. Hence, key variables like industrial development and urbanisation are also included in the analysis. This study differs from previous studies by treating industrialisation separately from the effect of GDP on the energy demand. To this end, autoregressive distributed lag (ARDL) method is applied which provides a consistent estimate in small sample size and correcting endogenous bias.

The rest of the paper is organized as follows: Section 2 contains the review of related studies. Section 3 describes the data and methodological strategy followed for the study. Section 4 display empirical results and discussion on that, while Section 5 concludes.

2. Literature review

Number of studies have examined the relationship between energy consumption and economic growth since last decade. Most of the early studies focussed solely on bivariate relationships between economic growth and energy consumption, while latter studies employed multivariate framework by including additional variables to overcome the potential omitted variable bias or to investigate the impact of other economic factors. Ozturk (2010) offered a comprehensive survey of recent contributions to the literature concerning the issue and ultimately conclude that no consensus could be reached regarding the direction of causality between energy consumption and economic growth. More recently, some studies have extended the relationship by including financial development and urbanisation (Shahbaz and Lean, 2012; Islam et al., 2013; Menegaki and Ozturk, 2013). Parikh and Shukla (1995) use a pooled data set of developed and developing countries over the years 1965–87 to investigate the impact of urbanisation on energy consumption and found a positive impact of urbanisation. Liddle (2004) documented that urbanisation and population density have a negative impact on per capita energy use in road transportation, suggesting economies of transport through less transportation need. Mishra et al. (2009) find that urbanisation has a negative impact on energy use in New Caledonia, but a positive impact in Fiji, French Polynesia, Samoa and Tonga in a sample of Pacific Island economies. Poumanyvong and Kaneko (2010) estimated the impact of income, urbanisation, industrialisation, and population on energy use in a sample of 99 countries covering the period 1975 – 2005 in a panel data framework. They find that the impact of urbanisation on energy use varies by income class. Urbanisation tends to decreases energy use in the low-income group, while that of increasing impact in the middle- and high-income groups. Zamani (2007) investigated the causal link among economic growth, industrial and agricultural sectors growth, and consumption of different kinds of energy for the Iranian economy. They found long-run bi-directional causality between GDP and gas consumption, GDP and petroleum consumption and unidirectional causal link running from industrial value added to industrial total energy, petroleum products, and electricity consumption. Moreover, also found bi-directional causality between industrial values added and gas consumption.

Krey et al. (2012) investigate the impact of urbanisation on residential energy use in China and India by using integrated assessment models. They find that residential energy consumption is not directly related with urbanisation. However, the relationship between urbanisation and energy use is linked through labour productivity. Mallick and Mahalik (2014) done a comparative analysis of India and China to explore the relationship between energy use, economic growth, and urbanisation. They found a positive impact of urbanisation and negative

effect of financial development and economic growth on energy consumption for both India and China. There is a small but growing literature looking at the impact of Urbanisation on energy consumption. Urbanisation, like industrialisation, is a key component of modernization of an economy. Urbanization can affect energy use through different channels such as production, mobility, transportation and infrastructure channels (Sadorsky, 2013). Concentration of production in urban areas enhance economic activities. Similary mobility and transportation channels provide opportunities for better transportation facilities. While better urban infrastructure reinforces efficient energy utilisation. However, each of these effects have positive and negative impacts on energy use. Therefore, the empirical evidence on the impact of urbanisation on energy consumption are mixed. Shahbaz et al. (2016) examine the effect of globalisation, urbanisation on energy consumption, found positive effect of urbanisation and negative impact of globalisation for Indian economy, but they have failed to take into account industrial development.

Apart from the above, it is also important to note that major portion of literature in recent years tested environmental Kuznets curve (EKC) hypothesis by using co_2 emission data as a proxy for environmental determinant variable with energy consumption and income variable data as explaining variables. But the "conceptual dependence" between energy consumption and co_2 data leads to serious econometric consequences of using such model[1]. Itkonen(2012) and Jaforullah and King (2017) documented some important problems in detail. Hence, in order to provide consistent results and lucid policy implication one must take caution in model selection. This study only consider data of energy consumption, which will also provide policy insight for carbon emission related issue as reduction in energy consumption also leads to reduction in greenhouse gas emission.

Most of the studies pertain to India, have used either aggregate or disaggregate data on energy consumption (Nain et al., 2017b; Ahmad et al., 2016). While some studies uses total factor productivity as a measure of economic growth and examine the energy-output nexus (Tugcu and Tiwari, 2016; Haider and Ganaie, 2017). In the backdrop of above literature and their shortcomings, this study tries to overcome specific policy issues, using appropriate dataset by analysing the impact of industrialisation and urbanisation on energy demand in case of India and Iran for their relative comparison.

3. Data and methodology

Following Jones (1991), the relationship between energy consumption (EC), income (Y), urbanisation (U), and industrialisation (I) is specified as:

$$lnEC_t = \beta_1 + \beta_2 lnY_t + \beta_3 lnU_t + \beta_4 lnI_t + \varepsilon_t \quad (1)$$

All variables are expressed in natural logarithms so that results of the estimated coefficients can be interpreted as elasticities. Above model is estimated for both countries in time series framework. The sign of the coefficient of urbanisation and industrialisation depends upon different channels such as production, mobility, transportation and so on. However, a positive sign is presumed. Ignoring short-run dynamics from the long-run model may lead to instability problem (Laidler, 1993, p. 175). To avoid such problem, we specify equation by incorporating short-run dynamics as an error-correction model. Hence, study employ ARDL bounds testing approach for simultaneously testing cointegrating property; efficiency and reliability of coefficient estimates. Since generally macroeconomic time-series data are either I(1) or I (0),

[1] Published data on co_2 emissions is equal to average co_2 emission per unit of energy use multiplied by total energy consumption plus emission from gas flaring and cement production.

there is no need for pre unit root testing in this method, but for preliminary examination it has been done(Adil et al., 2017).

$$\Delta\, lnEC_t = \alpha + \sum_{i=1}^{n1} \delta_0 \Delta lnEC_{t-i} + \sum_{i=0}^{n2} \delta_1 \Delta lnY_{t-i} + \sum_{i=0}^{n3} \delta_2\, \Delta lnU_{t-i} + \sum_{i=0}^{n4} \delta_3 \Delta lnI_{t-i} + \sigma_0\, lnEC_{t-1} + \sigma_1\, lnY_{t-1} + \sigma_2\, lnU_{t-1} + \sigma_3\, lnI_{t-1} + v_t \quad (2)$$

This equation includes both short-run (first-differenced) and long-run (one-period-lagged level) variables. For the short-run coefficients, each lag length *n* is chosen by minimising the Akaike Information Criterion (AIC), and each model is estimated at these optimum lags. Equation (2) follows Pesaran *et al.*'s (2001) for bounds testing using unrestricted error correction specification to estimate short-run as well as long-run coefficients. It also tests for cointegration by applying an F test on the joint significance of lagged level variables in (2). The asymptotic distribution is non-standard so Pesaran *et al.*'s (2001) provides two sets of critical values one assumed all variables are to be I(0), other assumed all variables to be I(1). If the computed *F* statistic is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected. As noted by Bahmani-Oskooee and Gelan (2009), the ARDL "bounds testing" methodology has some attractive features for time-series research. Not only it allowed for the inclusion of stationary variables but also I (1) variables. It also provides short-run estimates, long-run estimates, and the basis for a cointegration test in a single estimation (Haider et al., 2017). Also, the test is robust to small samples. Equation (2) is estimated for both India and Iran using time series data for the period of 1971-2013.

Table 1. Descriptive Statistics of Variables under Study

Variables	Observation	Mean	Std. Dev.	Min	Max
		India			
Industrialisation	43	26.41	3.37	20.16	34.67
Urbanization	43	25.96	3.34	19.99	31.99
GDP per capita	43	688.50	343.27	355.33	1555.02
Energy use per capita	43	380.44	96.78	268.49	606.05
		Iran			
Industrialisation	43	41.53	8.59	25.39	63.04
Urbanization	43	58.03	9.00	42.11	72.32
GDP per capita	43	5125.83	1356.70	3214.14	8372.61
Energy use per capita	43	1601.76	730.20	541.75	2960.39

Source: Calculated by Authors

All data points are collected from World Development Indicator (WDI), *World Bank*. Urbanisation is taken as urban population as a percentage of total population. While industrialisation is proxied by industrial value added as a percentage of GDP. Energy consumption is considered as kg. of oil equivalent per capita. Lastly, GDP is taken as GDP per capita in constant US dollar 2010. The descriptive statistics of all variables are given in Table 1. It can be shown from Table 1 that average level of industrialisation of India and Iran is 26.41 and 41.53 percent respectively. While urbanisation is higher in Iran as compare to India, that is 58.03 and 25.96 percent respectively. Likewise, energy use per capita in Iran is higher than the India, that is 380.44 and 1601.76 per capita Kg. of oil equivalent. The data of Iranian economy has more variation than Indian economy, as evident by the standard deviation.

4. Results and discussion

Testing of long-run equilibrium relationship through bounds testing approach is presented in Table 2. The F statistic follows an asymptotic distribution and null of no cointegration is only rejected if calculated F statistic exceeds upper bound value. Long-run estimates are only meaningful if a cointegrating relationship exists among variables. Since the ARDL bounds testing is too sensitive to lag length selection in the model, so the AIC criteria have been used to select the optimal lag order. It is reported by Lütkepohl (2006) that the dynamic relation between the variables can be well captured if one select appropriate lag length. We have used the critical bounds statistics value calculated by Narayan (2005) to determine the the existence of cointegration, which gives exact critical values for a small sample.

Table 2: Cointegration Statistics with Energy Consumption as Dependent Variable

Country	F-statistic	
India	10.326	
Iran	8.566	
Critical values (T = 42)	K=3	
Lower bounds I(0)	Upper bounds I(1)	Sig. Level
5.258	6.526	1%
3.85	4.782	5%
3.264	4.094	10%

Source: Calculated by Authors
Note: Critical lower and upper bounds values are collected from Narayan (2005) including unrestricted intercept and restricted time trend.

Results of bounds test in Table 2 rejects null hypothesis of no cointegration as F-statistic exceed upper bounds critical values at 1% level of significance for both countries. It means there is long-run equilibrium relationship among the variables. The long-run coefficients and short-run dynamics can be estimated as specified in equation (2).

The results of long-run coefficients are shown in Table 3, which shows a positive impact of economic activity that means higher economic growth leads to more energy consumption in both countries. The results of impact for urbanisation are different in both countries. Results show that urbanisation has enabled India to decrease energy use as increasing urbanisation leads to lower energy consumption through economies of scale and adoption of modern technology. While it intensifies energy consumption in Iran, as the positive and statistically significant coefficient of urbanisation implies that the net effect of these *two impacts* is to increase energy consumption. So the results suggest that Iran has to frame an urban policy in such a manner that create positive externalities.

Table 3: Long-and Short-Run Estimates

		Lag Order					
India	0	1	2	Iran	0	1	2
Δlnec	-	-0.199 (-1.51)	-0.315 (-2.28)	Δlnec	-		

ΔLnY	0.00420 (0.815)			ΔLnY	-	0.298 (3.10)	-0.342 (-3.44)
Δlnu	-	-3.651 (-4.15)		Δlnu	-0.058 (-1.11)		
ΔLnd	-	0.097 (2.24)	-0.205 (-3.95)	ΔLnd	0.016 (0.422)		
ECM	-0.30 (-6.06)			ECM	-0.833 (-6.46)		

Long Run Coefficients

	LnY	LnU	LnI	Trend	Constant
India	0.404 (2.83)	-3.253 (-2.30)	1.044 (2.74)	0.030 (2.00)	3.001 (5.91)
Iran	0.149 (1.37)	3.152 (2.22)	0.222 (2.23)	-0.002 (-0.143)	-6.053 (-6.13)

Source: Calculated by Authors
Note: t-values are in parenthesis, ECM is error correction mechanism.

Table 4: Diagnostic Tests

Countries	LM-Test	Adj R-square	RESET	CUSUM (CUSUM Sq)
India	1.397	0.998	0.2807	Stable
Iran	2.858	0.988	0.1446	Stable

Source: Calculated by Authors
Note: (1) LM is the Lagrange multiplier test for serial correlation, it has a $\chi 2$ distribution the critical value at the 5% level of significance is 9.48 (2) RESET is Ramsey's specification test. It has a $\chi 2$ distribution with only one degree of freedom. The critical value at the 5% level of significance is 3.84.

Energy is an important input in the production system. Energy policy should be designed very carefully to ensure optimal energy conservation and higher economic growth. There is a positive relationship between industrialisation and energy use for both countries, but the degree of elasticities for change in the level of industrialisation differ between countries. That might be due to the level and structure of industrial production. Though the share of industrial value added in GDP in case of Iran is greater than India, as dominated by chemical and petroleum industries, however, it seems to be more efficient than India as the long-run elasticity is lower for Iran. The results also suggest that India might have more potential to bring down energy consumption in industrial sector through adopting frontier technology and hence move towards an environmental friendly production system. Promoting green energy may provide a way to enhance productivity through positive spill over and hence results into lower energy consumption (Tugcu and Tiwari, 2016). The cointegration results are further supported by statistically significant and negative coefficient of error correction term (ECT) reported in Table 3. It shows the speed of convergence to long-run equilibrium. For India, the convergence rate is moderate, but for Iran, the error is getting corrected very quickly. Lastly, in order to know whether model adequately fits, it is checked through various diagnostic test reported in Table 4, which shows model is correctly specified, free from autocorrelation and stable as well.

5. Conclusion

It is conceived that urbanisation and industrialisation are one of the driving factors behind increasing energy use in developing countries. The literature associated with the relationship between energy consumption, urbanisation, and industrialisation is not as substantial as the literature of energy consumption and economic growth nexus. Thus, this study aims at investigating the impact of urbanisation and industrialisation on energy consumption in case of India and Iran; two larger energy consuming developing countries for the period of 19971–2013. To this end, study employs ARDL bounds testing approach to check for the long-run relationship among variables. The results of bounds test confirm the cointegrating relationship for both countries. An unrestricted error correction specification of ARDL model is used for estimating the impact of urbanisation and industrialisation on energy consumption. The results show the positive impact of GDP and industrialisation on energy consumption. Urbanisation has lead to less energy consumption in India while it enhances energy consumption in Iran. Though different channels connect relation between urbanisation and energy use, it seems that India has achieved some level of energy conservation through increasing urbanisation, which provides means for achieving energy efficiency. While that for Iran the finding is different, which shows urbanisation demands more energy may be due to inefficiency in energy uses. Therefore promoting clean energy can increase energy efficiency and hence reduce energy consumption in general.

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