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Urbanization and Carbon Emission in South Asia

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Abstract

Background: Rapid urbanization in South Asia has led to increased energy consumption, transportation, and construction of new infrastructure, resulting in high carbon emissions. South Asia is the world's fastest urbanizing region, and its carbon emissions are influenced by the building industry, which accounts for more than 30% of the region's energy-related carbon emissions. This issue poses a serious policy concern as South Asia is vulnerable to the impact of carbon emissions and climate change. The relationship between urbanization and carbon emissions in South Asia is the concern of this paper.

Objective: To analyze the relationship between urbanization and carbon emissions in South Asia and to test the validity of urbanization Kuznets' curve for the region.

Methods: Modified version of the Influence, Population, Affluence, and Technology (IPAT) model framework is used to study the relationship between carbon emissions and urbanization in South Asia. The data spans from 1970-2019.

Results: The study finds a significant positive relationship between carbon emissions and urbanization, population, and population structure. The existence of Urbanization in Kuznets' Curve for South Asia is proved.

Implication: The positive relationship between carbon emissions and urbanization poses a major policy challenge in South Asia. With increasing population and economic growth, sustainable urbanization must be a top priority for policymakers in order to mitigate the effects of climate change.

Paper Types: Research Paper

Keywords: Urbanization, Carbon Emission, Urbanization Kuznets' Curve

JEL Classification: R11, Q54

Introduction

The trade-off between urbanization and increasing carbon emissions is an issue of discussion and contention in the 21st century. Due to its considerable influence on economic growth and the environment of any country, urbanization is considered a topic of importance among economists. Urbanization is often directly linked to the degradation of environmental quality via carbon emission. With urbanization, the increase in income and industries contribute to increased carbon emissions, which are detrimental to the environment. Scholars predict that by 2050, more than 70% of the population will live in urban areas, with the most rapid levels of urbanization taking place in South Asia. Traditional urban development plans in South Asia have been more focused on increasing the rate of urbanization, while environmental deterioration has taken a back place.

Urbanization and carbon emissions are closely linked in South Asia. Rapid urbanization has led to increased energy consumption, infrastructure development and increased use of transportation, resulting in higher carbon emissions. According to a report by the World Bank, South Asia is the world's fastest-urbanizing region, with an urban population expected to reach 1.75 billion by 2050. This rapid urbanization has led to increased energy consumption and transportation, as well as the construction of new buildings and infrastructure. The report states that the energy demand in South Asia is projected to triple by 2040, primarily driven by the growth in the residential and transport sectors.

Building new structures and infrastructure also influences South Asia's carbon emissions. The building industry is to blame for more than 30% of the region's energy-related carbon emissions, according to research by the International Energy Agency (IEA). According to the report, South Asia's construction industry is known for its low energy efficiency, and many buildings are built without sufficient insulation or ventilation.

South Asia is particularly vulnerable to the atrocities of carbon emissions and the climate change it entails because of its geographical and socioeconomic landscape, including sea level rise, melting Himalayan glaciers, and increased frequency of typhoons. With urbanization, the carbon emission rates and their effect on the environment have increased, posing a serious policy concern.

Although the discussion of the relationship between these two topics is hot, their relationship is still regarded as an academic puzzle. Various literature like Parikh et al. (1995), Zarzoso et al. (2011), and Al Mulali et al. (2012) say that urbanization has a positive effect on CO2 emissions, other literature like Sharma (2011) and Sadorsky (2014) deduce that there is a negative and insignificant relationship between the two variables. This difference could be due to the use of different methods and the difference in the sample picked by the authors.

Although many papers study the impact of urbanization in South Asia, they barely focus on the existence of environmental Kuznets's curve. Also, the existing studies do not examine the impact of population structure on the carbon emission levels of South Asian countries. This paper examines both the existence of the environmental Kuznets's curve and the effect of population structure on the carbon emission levels of South Asian countries.

In this paper, I use a cross country panel data of 6 South Asian countries for 1970-2019 and use the Panel OLS regression method to investigate the relationship between urbanization and carbon emission from a South Asian perspective and also check the validity of Urbanization Kuznets' Curve in this region.

The rest of the paper is organized as follows: Section 2 reviews the literature, Section 3 describes the methodology, Section 4 presents the empirical results, Section 5 discusses the implications, and Section 6 concludes

Review of literature

The problem of carbon dioxide emissions is serious and grave. Several explanatory elements explaining carbon dioxide emissions have been thoroughly researched in the last few decades.

We are aware of a lot of research on the relationship between urbanization and carbon emissions; however, the majority of it has focused on examining how carbon emissions and carbon intensity have changed over time. The relationship between urbanization and carbon emission effectiveness is not often studied. Liu et al. (2018) studied the shifting urbanization regulations and carbon emission efficiency between 2008 and 2015 using ten typical urban agglomerations in China as the research object. The study's time frame and geographic scope are constrained, and the effects of various urbanization levels have not been covered. The study by Li et al. (2018) defined carbon emission efficiency as the ratio of actual carbon emissions to goal emissions, which did not accurately capture the relationship between the degree of economic development and carbon dioxide emissions. This paper uses the stochastic frontier analysis (SFA) model to analyze 17 years of data from 30 Chinese provinces in order to fill the current research gap. Consider the technological efficiency while evaluating the efficiency of carbon emissions. Additionally, look at the relationship between the degree of urbanization and carbon emission effectiveness as well as any potential effects of urbanization growth.

There are many studies on the connection between economic development and CO2 emissions. The EKC hypothesis, which holds that environmental degradation worsens as per capita income increases initially and subsequently declines with economic growth, is the basic assumption of research on the emissions-growth nexus. Numerous subsequent studies using various nations, periods, econometric techniques, and variables have produced controversial and inconsistent empirical results since Grossman and Krueger (1991) pioneered the empirical research using the EKC hypothesis (Jha, 1997; Azomahou et al., 2006; Coondoo and Dinda, 2008; Ozcan, 2013; Omri et al., 2015).

Most of the literature on carbon emission efficiency falls into one of two categories: that which examines individual differences and that which examines influencing variables. We talk about the industrial and spatial variability of carbon efficiency. According to Yao et al. (2015), the high variation in the spatial distribution of carbon emission efficiency among Chinese provinces may be caused by the varying energy and economic systems in each region. In order to analyze the power sector, Yan et al. (2017) built an inadequate slack-based measuring model, which revealed that the carbon emission efficiency in different parts of China varies substantially and is highest in the eastern coastline region. Data from 280 cities were gathered by Cai et al. (2019), who concluded that China's low-carbon development is uneven and that its coastal regions are the most effective.

Scholars used numerous classical models to examine the impact of population and economic expansion on carbon emissions. For instance, Ehrlich and Ehrlich (1970) present the IPAT equation in which population (P), degree of wealth (A), and technology deterministically characterize environmental pressure (T). To address this issue, Dietz and Rosa (1997) extended IPAT to STIRPAT, a stochastic equation that can maintain other factors constant while one factor is modified. However, IPAT has been critiqued for being overly simplistic in assuming that P, A, and T are independent of one another (Alcott, 2010). Many recent studies on the impact of urbanization on carbon emissions have used this (e.g. Zhang and Lin, 2012; Chikaraishi et al., 2015).

Another significant issue is the impact of demographic changes on carbon dioxide emissions. Studies on this topic typically used the IPAT model, as in the works of Shi (2003), York et al. (2003), Kwon (2005), Martnez-Zarzoso et al. (2007), Kerr and Mellon (2012), Yao et al. (2015), and STIRPAT formulation, as in the works of Dietz and Rosa (1997), York et al. (2003), Li (2013). According to Shi (2003) and several other studies, population density significantly influences carbon dioxide emissions. In addition to population number, additional demographic parameters were considered, such as age distribution (Liddle and Lung, 2010).

The weighted mean carbon emission coefficient for each type of energy is used to represent the energy carbon emission coefficient in the Kaya Identity. This is because, according to the United Nations Intergovernmental Panel on Climate Change, the carbon emission coefficient of a particular type of energy is a fixed value. Contrarily, the agglomeration effects of population and industry brought about by urbanization can have a negative impact on the local economy (Wu et al., 2011). According to Lu and Chen (2004), the GDP per capita of rural and urban areas differ dramatically in developing nations, and as urbanization advances quickly, the variable GDP per capita is highly impacted, which has an impact on carbon emissions (Zhou, 2013).

Urbanization, as defined by Gries and Grundmann (2018), Yasin et al. (2019), and Cruz et al. (2017), is the expansion of towns and cities, frequently at the expense of rural regions, as a result of people moving there in pursuit of employment and a higher quality of life. Urbanization was defined by Liao et al. (2020), Keet et al. (2017), and Ponte et al. (2018) as the population movement from rural to urban regions, the decline in the percentage of people living in rural areas, and the social adaptations to this transition. It mostly refers to the process through which towns and societies develop and enlarge when more people start residing in and working in urban centres (Gries and Grundmann 2018; Yasin et al. 2019; Cruz et al. 2017; Liao et al. 2020; Keet et al. 2017; and Ponte et al. 2018). The impacts of urbanization on the environment are numerous. For instance, one significant impact the urban population has on the environment is the incidence of eutrophication in aquatic bodies. When it rains, contaminants from the air, including CO2 emissions and other greenhouse gases, fall to the ground in big cities. These substances are immediately deposited into rivers, streams, and seas, where they degrade the water quality and harm marine habitats (Jiang et al., 2008; Zhang 2019, 2017).

Recent studies have increasingly focused on samples of many different nations and have demonstrated through empirical data that there are many distinct types of urbanization-emission relationships at various phases of development. According to the amount of GNP per capita, Fan et al. (2006) categorized the world's 207 nations into four categories: high-income economies, upper-middle-income economies, lower-middle-income economies, and low-income economies. They discovered that other factors, like the degree of economic growth, the structure of the energy system, and others, limited the impact of urbanization on the lowering of carbon intensity. According to Li and Lin (2015), the impact of urbanization on energy use and carbon emissions differed depending on the stage of development. Based on yearly income levels, they categorized 73 nations from 1971 to 2010 into four categories. The major findings supported York et al.'s conclusion that increased carbon dioxide emissions directly resulted from urbanization (2003). But in line with Poumanyvong and Kaneko, it slows the rise of emissions in the middle- and high-income groups (2010). Furthermore, Martinez and Maruotti (2011) established an inverted U-shaped association between urbanization and environmental pollution in developing nations from 1975 to 2003 and Salim and Shafiei (2014) in OECD countries from 1980 to 2011.

Research Methodology

Literature dealing with urbanization and carbon emission/climate change generally uses the IPAT (Influence, Population, Affluence, and Technology) model proposed by Ehrlich and Holdren (1971). It is useful in describing the effects of human activities on the environment. This paper also uses a modified version of the IPAT model.

The explanatory variable CO2 emissions (*co2*) is chosen not only because of its wide use in the literature review but also because of data availability. Total population (*pop*) and GDP per capita (*gdp*) measure the demographic and economic factors. At the same time, the *gdgp* and *popstr* that measure GDP growth and population structure are also incorporated into the model, according to Al-Mulali (2014). Since the GDP growth rate might not always be positive, this model does not take its logarithmic form compared to other literature. According to our extensive literature review, trade openness (trade) is also taken into account in this model, significantly affecting emission levels. *Urban,* the variable, shows the share of the urban population in the country's total population. In contrast, $lnurban^2$ is a quadratic term of *lnurban* incorporated in our model in order to study the nonlinear relationship between the two core variables.

Table 1 Description of Variables

	Symbol	Variable	Source	Definition
Dependent	CO_2	Total CO_2 emission	Oak Ridge Laboratory	CO_2 emission from fossil fuel and manufacturing industry
	Pop	Total population	CBS, Simulation	Mid-year population
	Gdp	Gdp per capita	World Bank	Gdp per capita at constant 2015 price
	Popstr	Population structure	ILO, CBS	Percentage of people aged 65 and above
Explanatory	Gdpg	Gdp growth rate	World Bank	Annual gdp growth rate
	Trade	Trade openness	World Bank, Self calculation	Import+export divided by gdp
	Urban	Urbanization	NLSS, Simulation	Share of urban population
	Urban2	The square of urbanization	NLSS, Simulation	Quadratic term for urban

Our core model for this paper is the following:

$$lnco2_{it} = \alpha + \beta_1 lnpop_{it} + \beta_2 lngdp_{it} + \beta_3 lnpopstr_{it} + \beta_4 gdpg_i t + \beta_5 lntrade_{it} + \beta_6 lnurban_{it} + \beta_7 lnurban_{it}^2 + \lambda_t + \gamma_i + e_{it} \quad (1)$$

Where λ_t and γ_i capture the time effects and individual effects, α represents the constant term and e_{it} is the idiosyncratic error term.

Result Analysis and Discussion

The results of running the eqn (1) are given in the table below.

	Coefficients (s.d.)
lnpop	0.786***
	(0.256)
lngdp	0.436***
	(0.128)
lnpopstr	0.118***
	(0.0245)
gdpg	-0.045
	(0.00125)
lntrade	0.034
	(0.732)
lnurban	0.306***
	(0.0835)

	Coefficients (s.d.)
lnurban^2	-0.000053***
	(0.000)
Constant	-8.366
	(2.563)
Time effect	YES
Country effect	YES
Adj. R^2	68%
N	6

According to the table, urbanization positively increases carbon emissions and is significant at a 5% level while controlling other variables. The estimated coefficient is 0.306. This means that when urbanization increases by 1%, the total carbon emission increases by 0.306% and vice-versa. When the population increases by 1%, we can see that the carbon emissions also increase by 0.786%, and this relationship is significant at a 5% level of significance. Also, with an increase in gdp by 1%, the carbon emissions increase by 0.436% with validity at a significance level of 5%. Similarly, with an increasing share of the population over 65 years of age, carbon emission also increases by 0.118% with a per cent increase in the old age population. It is also significant at the 5% level.

Contrary to the existing literature, South Asian trade openness has no significant effect on the CO2 emissions of the region. The significant and negative relationship between the quadratic function of urban population and co2 emission also shows that there might be an Urbanization Kuznets' Curve in the South Asian region. The results are significant at the 5% level, and the Hausmann specification test shows that the panel regression results are valid.

Conclusion and Recommendations

This paper analyzes and finds a positive relationship between carbon emissions and urbanization using the panel data of South Asian countries. The negative relationship between the quadratic log term of urbanization and log carbon emission suggests an inverted Urbanization Kuznet's Curve in the South Asian region. This relationship means that with the onset of urbanization, increased human density, income, and consumption lead to increased carbon emissions. But with the agglomeration of urban economies and economies of scale, carbon emission will decrease with an increase in the efficiency of production and an increase in the rate of technology. So, governments need to focus on making the institutional environment suitable for creating agglomerate economies.

Similarly, we see a positive and significant relationship between population growth and carbon emissions, which means that to reduce carbon emissions, the government should introduce appropriate policies to control the population. Also, the share of the population over 65 years increases, and the carbon emission also increases. The outcomes of these findings carry significant policy implications. As urbanization continues to drive a surge in carbon emissions, it becomes imperative for policymakers to prioritize sustainable urbanization strategies that minimize adverse environmental impacts.

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