# ROLE OF URBANIZATION AND URBAN INCOME IN CARBON EMISSIONS: REGIONAL ANALYSIS OF CHINA

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**Abstract.** The study aims to analyze the impact of urbanization and urban income on carbon emission, in the case of China. Panel data estimations use the data from 30 Chinese provinces from 1998 to 2016. Empirical result of urbanization confirms significant and positive coefficient, whereas, urban income has a negative coefficient. This illustrates that higher urbanization trend escalates the carbon emission, while this urban-based carbon emission can be controlled by increasing the per capita income of the urban population. Moreover, economic growth, industrialization, coal, and oil consumption are responsible for carbon emission, as reported by the significant and positive coefficients. The findings of the regional analysis are in line with the full sample results. Based on the results, the study provides practical implications for policy makers to curtail the environmental degradation process.
**Keywords:** *economic growth, industrialization, coal consumption, oil consumption, GMM*

## Introduction

There are a number of challenges that are to be faced by the developing countries with the higher pace of economic growth such as, urbanization and greenhouse gas emission. The increase in urbanization leads to a higher demand for fossil fuels which ultimately results in higher carbon emission (Kumar and Madlener, 2016), but the contribution mechanism of urbanization in carbon emission varies due to underlying factors, such as economic condition, dependence on fossil fuels, industrialization, energy consumption etc. However, it is required to analyze the role of urbanization in carbon emissions for China, specifically. Furthermore, it is also important to study the factors that are helpful to control the urban based carbon emission.

A number of studies have been made in order to analyze relationship of urbanization and carbon emission (Parikh and Shukla, 1995; York, 2007; Kasman and Duman, 2015; Sun et al., 2016; Shahbaz et al., 2016; He et al., 2017; Ding and Li, 2017; Khoshnevis et al., 2018; Dai et al., 2018), the results have confirmed the role of urbanization in carbon emission. Several types of research have documented a positive relationship between urbanization and carbon emission (Parshall et al., 2010; Zhang and Lin, 2012; Fang et al., 2015; Hao et al., 2016; He et al., 2017; Ding and Li, 2017). On contrary, a number of researches have put forward the statement that the urbanization can be a reason for the decrease in carbon emission (Liddle, 2004; Mishra et al., 2009). Moreover, Martínez-Zarzoso and Maruotti (2011) confirmed a U-shaped association between urbanization and carbon emission.

Moreover, Xu and Lin (2015) have worked upon the effects of urbanization and industrialization on carbon emissions in China over the period of 1990-2011. The


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regression estimations have reported U-shaped relationship. Likewise, a large number of studies has analyzed the relationship of urbanization and carbon emissions in accordance with Environmental Kuznets Curve (EKC). The study concluded that urbanization is in the favor of environmental development only if the economic development reached at a specific level (Martínez-Zarzoso and Maruotti, 2011; Hao and Peng, 2017; Yao et al., 2018). Recently, Chikaraishi et al. (2015) analyzed different factors that are responsible for urban-based carbon emission. For instance, the country's per capita gross domestic product and the ratio of service industries are one of the most important factors that influence the relationship between the urbanization and carbon emissions. Beside this, there are various factors that affect carbon emissions (such as, technological progress, energy consumption structure, economic development, and industrial structure (Jiang and Lin, 2012; Shahbaz et al., 2016; Waheed et al., 2018; Song and Wang, 2018).

Alkhathlan and Javid (2015) reported a non- linear trend between carbon emission and economic growth of Saudi Arabia, the reason for the positive relationship is the dependence on oil for energy, transportation and industrial activities. Kumar and Madlener (2016) confirmed that higher economic growth is among the major causes of carbon emission in India. Adewuyi and Awodumi (2017) reported that oil consumption and energy consumption have a significant impact on economic growth which further boosts the carbon emission. Previous studies have affirmed that industrialization is also a source of carbon emission (Sadorsky, 2013; Yuan et al., 2014; Lin et al., 2015; Zhu et al., 2017; Ding and Li, 2017; Liu and Bae, 2018).

In addition, the role of coal and oil consumption is considered as the main contributor to carbon emission in China (IPCC, 2014). As China is among the fastest growing economy as well as the biggest carbon emitter of the world (WDI, World Development Indicator, 2017); that is responsible for the around 30% of global carbon emission. According to the Information Energy Administration (2014), China is the second largest oil consumer in the world, the oil consumption of China 11.96 million bpd in 2015. Hence, on one side, the oil is important for economic growth, but, on the other side, the oil consumption has an adverse impact on the environment. The oil consumption, in form of industrial process, transportation, energy generation etc., is one of the main contributors of carbon emission. According to a recent statistics, the demand for oil will increase in the next few decades (Cook and Cherney, 2017). Coal is the main element of energy generation in China which contains around 65% of total energy mix (China Electric Council, 2016).

Previously, the studies have investigated the impact of economic growth, urbanization, industrialization, coal and oil consumption in carbon emission. However, after identifying the role of economic growth, urbanization, industrialization in carbon emission, current paper contributes to the existing literature through analyses the role of urban income to control the carbon emission, which is missed by the previous researches.

The current study has following objectives: the study analyzes the role of urbanization in carbon emission. Furthermore, the role of urban income to control the urban-based carbon emission is another objective. The main contribution of given study is to examine the role of annual average urban income to control the urban based carbon emission. It is known that the higher urbanization tends to boost the carbon emission by different channels: (i) forest need to cut down to extend the urban lands which causes to increase the carbon emission; (ii) higher urbanization triggers the industrialization,


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transportation and energy consumption etc. which are the major carbon emitters (Shahbaz et al., 2016; Ding and Li, 2017)[1]. In concise, higher urbanization directly or indirectly boost the carbon emission. On the other side, the urbanization trend is increasing since few decades and it will be higher in upcoming decades, as mentioned in *Figure 1*. However, it is required to explore the counter measures that support to reduce carbon emission that is caused by urbanization. On this basis, this study assumes that higher urban income enables the urban population to invest in eco-friendly products that require less energy (e.g. advanced energy efficient home appliances, hybrid or electricity vehicles etc.) that assist to control the environmental degradation process. However, it is clear that urbanization increases the rate of carbon emission as well as it can also contribute to the green technology and its innovation (Martínez-Zarzoso and Maruotti, 2011). Finally, the regional based analysis is used to examine the carbon contributors and the role of higher urban income to mitigate the carbon emission. The findings can assist the policy maker to define the environmental policies to control the carbon emission.

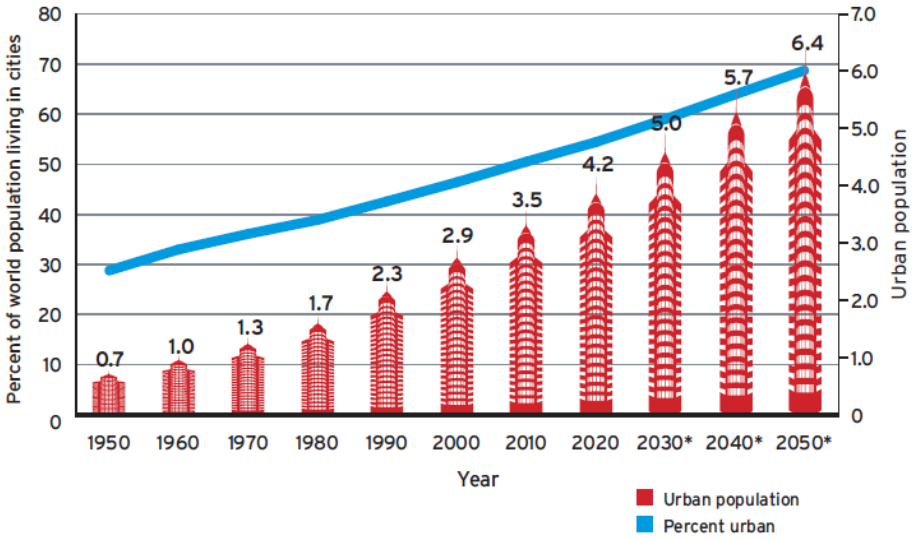


***Figure 1.*** *Urbanization population and percentage of world population living in urban areas. (Source: UN, Department of Economic & Social Affairs, Population Division)*

## Materials and methods

Current study investigates the urbanization, urban income, economic growth, industrialization, coal consumption and oil consumption on carbon emission. For empirical estimations, panel data of 30 Chinese provinces are collected over the period 1998 to 2016. Mainly, the paper concerns the role of urbanization on carbon emission and the corrective measures to reduce the urbanization based carbon emission in China. The bulk literature has confirmed the adverse effect of urbanization on carbon emission;

[1]Industrialization requires higher energy for operational activities that contribute in carbon emission, similarly, the waste of industries is also a source of carbon emission. The higher urbanization trend stimulates the buying of cars and the use of other transportation mean (Zhang, 2014), which use the fossil fuels and in turn increase the carbon level. Similarly, the urbanization increases the electricity consumption by city authorities for street lights, electricity sign boards and households (Shahbaz et al., 2016).


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higher urbanization leads to increase the carbon emission (York, 2007; Wang et al., 2016; Kasman and Duman, 2015; Shahbaz et al., 2016; He et al., 2017; Zhu et al., 2017; Yao et al., 2018). This adverse relationship can be due to multiple reasons: firstly, there is a need to cut down the forests to increase the urban land which reduces the carbon balance. Secondly, higher urbanization requires the higher energy to meet the electricity demands, for transportation etc., however, this higher energy consumption causes to boost the carbon emission. It is necessary to find practicable solutions to control the urban based carbon emission. In light of this, we propose that the government should increase the per capita income of urban people and motivate them to buy energy efficient and environmental friendly products. In such domain, we use two assumptions: firstly, the industries are producing green and energy efficient equipment for industrial and household uses. Secondly, the urban population are motivated to purchase latest green technology household items; meaning that higher per capital income enables them to have environmental friendly items. The general form of studied model is given below:

$$CO_2 = f(U, UI, EG, I, C, O)$$

The log form of model is below:

$$\ln CO_{2\,it} = \beta_0 + \beta_1 CO_{2\,i,t-1} + \beta_2 U_{it} + \beta_3 UI_{it} + \beta_4 EG_{it} + \beta_5 I_{it} + \beta_6 C_{it} + \beta_7 O_{it} + \varepsilon_{it}$$

where $CO_{2\,it}$ and $CO_{2\,i,t-1}$ is current carbon emission and lagged carbon emission in million tons (Mt), respectively, which is calculated by using energy consumption based methodology. Energy consumption based carbon emission follows Intergovernmental Panel on Climate Change (IPCC, 2006). $U_{it}$ is the urbanization (10,000 people) and $UI_{it}$ is the proxy of urban income which measured as per capita income in Yuan. $EG_{it}$ is the economic growth measured as gross regional product for each province (100 million Yuan). $I_{it}$ represents the industrialization measured in 100 million Yuan. $C_{it}$ and $O_{it}$ presents the coal consumption and oil consumption (10,000 tons).

Difference-GMM, system-GMM and dynamic mean group (DMG) are employed for econometric estimations. We emphasize on panel data estimations due to following reasons: firstly, it assists to control the heterogeneity issues; secondly, is deals with the increase in degree of freedom. Thirdly, it is useful to control the multicollinearity issues.

## Results and discussion

*Table 1* reports the empirical estimations of difference-GMM, system-GMM and dynamic mean group (DMG). The findings of difference-GMM confirm the significant and positive coefficients of lagged carbon emission, urbanization, economic growth industrialization, coal, and oil consumption. These findings imply that higher urbanization trend, economic and industrialization activities, coal and oil consumption in different economic sectors are the main culprits of environmental degradation in China. On contrary, the coefficient of urban income has reported statistically significant and negative coefficient, which validates our hypothesis that higher urban income causes to reduce the carbon emission. The reason for this relationship is that the higher


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urbanization leads to the advance and green technology innovation (Mishra et al., 2009; Martínez-Zarzoso and Maruotti, 2011). However, the increase in urban income raises the chances that urban population buys advanced green technologies that are useful to control the carbon emission from urbanization.

***Table 1.*** *Econometric estimations*

| | ***Difference-GMM*** | | ***System-GMM*** | | ***DMG*** | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| $CO_{2\,i,t-1}$ | 0.415 | 0.000 | 0.348 | 0.000 | 0.366 | 0.000 |
| $U_{it}$ | 0.035 | 0.000 | 0.041 | 0.000 | 0.055 | 0.000 |
| $UI_{it}$ | -0.631 | 0.000 | -0.230 | 0.001 | -0.278 | 0.000 |
| $EG_{it}$ | 0.051 | 0.015 | 0.024 | 0.000 | 0.132 | 0.022 |
| $I_{it}$ | 0.136 | 0.001 | 0.097 | 0.038 | 0.110 | 0.061 |
| $C_{it}$ | 0.302 | 0.000 | 0.311 | 0.000 | 0.229 | 0.000 |
| $O_{it}$ | 0.106 | 0.010 | 0.086 | 0.041 | 0.081 | 0.039 |

$CO_2$ is lagged carbon emission, *U* represents the urbanization and *UI* is the urban income. *EG* mentions the economic growth, whereas, *I* is the industrialization. And *C* and *U* are the coal and oil consumption, respectively

System-GMM has reported similar results; the positive relationship of lagged carbon emission, urbanization, economic growth, industrialization, coal consumption and oil consumption (there is a slight difference; the coefficients of industrialization and oil consumption are statistically significant at 5% level). The coefficient of urban income is statistically significant and negative, at 1% level, which illustrates that higher carbon emission can be managed by increasing the urban income. The estimations of the dynamic mean group present the positive coefficient of urbanization, economic growth, coal consumption and oil consumption, whereas, industrialization turns out to be insignificant. The coefficient of urban income is still significant and negative.

### *Regional analysis*

Empirical results of the regional analysis provide more insight that is useful for environmental policymakers, as the factors of carbon emission vary across different economic and geographical basis. The Chinese provinces are divided into six geographical regions to estimate the regional analysis. In *Table 2*, the coefficient of urbanization has reported significant and positive coefficients in five out of six regions, Southwest region reports insignificant coefficient. These significance and positive coefficients of urbanization exhibit that higher urbanization movement induces the carbon emission in most of the Chinese provinces. In case of urban income, the results are statistically significant and negative in five out of six provinces. The results confirm the role of urban income in carbon mitigation in most of the regions, however, it is suggested that urban-based carbon emission can be managed by increasing the per capita income of urban population. Moreover, motivate the urban population to have eco-friendly home appliances and vehicles.

Economic growth is a source of carbon emission in all six regions of China, as mentioned by the positive coefficients. The coefficients of industrialization are significant and positive in four out of six regions (North, Northeast, East and


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Southcentral), whereas, insignificant in two regions (Southwest and Northwest). It is not hard to conclude that industry is also responsible for higher carbon emission in China. Estimated results of coal and oil consumption mentioned statistically significant and positive coefficients in all six regions, which indicate that fossil fuels are among the main sources of carbon emission. As China is a developing economy that requires fossil fuels (coal and oil) for industrial process, transportation, electricity generation etc., however, it is quite difficult for China to suddenly replace the fossil fuels with renewable energy.

***Table 2.*** *Regional analysis*

| | **North** | **Northeast** | **East** | **South Central** | **Southwest** | **Northwest** |
|---|---|---|---|---|---|---|
| $Lag\,CO_2$ | 0.162*** | 0.041*** | 0.167*** | 0.513** | 0.527*** | 0.014*** |
| *U* | 0.061** | 0.042*** | 0.031*** | 0.052*** | 0.033 | 0.142** |
| *UI* | -0.131*** | -0.204*** | -0.092*** | -0.105 | -0.117*** | -0.032*** |
| *EG* | 0.010** | 0.025*** | 0.031*** | 0.064*** | 0.462*** | 0.140*** |
| *I* | 0.016*** | 0.008** | 0.067*** | 0.105** | 0.019 | 0.062 |
| *C* | 0.257*** | 0.634*** | 0.138*** | 0.335*** | 0.614*** | 0.556*** |
| *O* | 0.082*** | 0.034** | 0.415*** | 0.320*** | 0.014** | 0.185*** |

$CO_2$ is lagged carbon emission, *U* represents the urbanization and *UI* is the urban income. *EG* mentions the economic growth, whereas, *I* is the industrialization. And *C* and *U* are the coal and oil consumption, respectively.
***, ** represents the significance level of 1% and 5%, respectively

## Conclusion

There are two main objectives of given study: firstly, investigate the role of urbanization in carbon emission; secondly, examines the role of the urban income in carbon mitigation. The data from 30 Chinese provinces are used for empirical estimations that cover the time period of 1998-2016. Estimated findings have validated that higher urbanization causes the environmental degradation in China. In case of urban income, the coefficients present significant and negative results, which affirm our hypothesis that higher urban income likely to reduce the carbon emission by changing the buying behavior of urban population. The increase in income enables the urban population to have advance and green technology that uses less energy and have lesser emission than conventional technologies. The findings of economic growth, industrialization, coal and oil consumption are responsible for carbon emission in China. Similar findings are confirmed by regional based analysis; the higher per capita urban income assists to control the role of urbanization in carbon emission.

On the basis of above results, the study proposes significant policy implications that are useful to control the environmental degradation process. The study examines, the urban and central authorities should increase the urban income and motivate the urban population to acquire green technologies. The studies proposed that the government should impose the carbon tax on industries that force them to install carbon treatment plants. Lastly, the Chinese government needs to replace the non-renewable source of energy (coal and oil) to renewable energy (e.g. water, solar, wind, biomass etc.).

The authors have faced some limitations during the data collection and assigning the proxies; such as, the data before 1998 is missing in China statistical database which forces to limit the time series. For future studies, the authors can gather the previous


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data by using some other available sources, to examine the robustness of results. Another limitation of current study is the base of two assumptions; firstly, the industries have to produce green and energy efficient equipment for industrial and household uses. Secondly, the urban population are motivated to purchase latest green technology household items; proposing that higher per capital income enables them to have environmental friendly items. However, for future direction, there is a strong need to find some alternate proxies to examine the role of urban income.

## REFERENCES

[1] Achard, F., Eva, H., Mayaux, P., Stibig, H., Belward, A. (2004): Improved estimates of net carbon emissions from land cover change in the Tropics for the 1990's. – Global Biogeochemical Cycles 18(2).

[2] Arellano, M., Bover, O. (1995): Another look at the instrumental variable estimation of error-components models. – Journal of Econometrics 68(1): 29-51.

[3] Bekhet, H. A., Othman, N. S. (2017): Impact of urbanization growth on Malaysia CO2 emissions- Evidence from the dynamic relationship. – Journal of Cleaner Production 154: 374-388.

[4] Blundell, R., Bond, S. (1998): Initial conditions and moment restrictions in dynamic panel data models. – Journal of Econometrics 87(1): 115-143.

[5] Brown, S., Dushku, A., Pearson, T., Shoch, D., Winsten, J., Sweet, S., Kadyszewski, J. (2004): Carbon Supply from Changes in Management of Forest, Range, and Agricultural Lands of California. – Winrock International for California Energy Commission, Arlington, VA.

[6] Ding, Y., Li, F. (2017): Examining the effects of urbanization and industrialization on carbon dioxide emission: evidence from China's provincial regions. – Energy 125: 533-542.

[7] Dong, F., Bian, Z., Yu, B., Wang, Y., Zhang, S., Li, J., ... Long, R. (2018): Can land urbanization help to achieve CO2 intensity reduction target or hinder it? Evidence from China. – Resources, Conservation & Recycling 134: 206-215.

[8] EIA (Energy Information Administration) (2011, February 09): History of energy consumption in the United States 1775-2009. – https://www.eia.gov: https://www.eia.gov/todayinenergy/detail.php?id=10.

[9] Fang, C., Wang, S., Li, G. (2015): Changing urban forms and carbon dioxide emissions in China: A case study of 30 provincial capital cities. – Applied Energy 158: 519-531.

[10] He, Z., Xu, S., Shen, W., Long, R., Chen, H. (2016): Impact of urbanization on energy related CO2 emission at different development levels: regional difference in China based on panel estimation. – Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2016.08.155.

[11] IPCC (2006): Greenhouse Gas Inventory: IPCC Guidelines for National Greenhouse Gas Inventories. – United Kingdom Meteorological Office, Bracknell, UK.

[12] Kasman, Adnan, and Yavuz Selman Duman. 2015. "CO2 Emissions, Economic Growth, Energy Consumption, Trade and Urbanization in New EU Member and Candidate Countries: A Panel Data Analysis." *Economic Modelling* 44 (January). North-Holland: 97–103. doi:10.1016/J.ECONMOD.2014.10.022.

[13] Lai, L., Huang, X., Yang, H., Chuai, X., Zhang, M., Zhong, T., ... Thompson, J. (2016): Carbon emissions from land-use change and management in China between 1990 and 2010. – Science Advances. DOI: 10.1126/sciadv.1601063.

[14] Li, K., Lin, B. (2015): Impacts of urbanization and industrialization on energy consumption/CO2 emissions: does the level of development matter? – Renewable and Sustainable Energy Reviews 52: 1107-1122.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1705_1030310311

[15] Liddle, Brant. 2004. "Demographic Dynamics and Per Capita Environmental Impact: Using Panel Regressions and Household Decompositions to Examine Population and Transport." *Population and Environment* 26 (1). Kluwer Academic Publishers-Plenum Publishers: 23–39. doi:10.1023/B:POEN.0000039951.37276.f3.
[16] Lin, B., Omoju, O., Okonkwo, J. (2015): Impact of industrialisation on CO2 emissions in Nigeria. – Renewable and Sustainable Energy Reviews 52: 1228-1239.
[17] Liu, X., Bae, J. (2018): Urbanization and industrialization impact of CO2 emissions in China. – Journal of Cleaner Production 172: 178-186.
[18] Liu, Y., Gao, C., Lu, Y. (2017): The impact of urbanization on GHG emissions in China: the role of population density. – Journal of Cleaner Production 157: 299-309.
[19] Lund, H., Kempton, W. (2008): Integration of renewable energy into the transport and electricity sectors through V2G. – Energy Policy 3578-3587.
[20] Madlener, R., Sunak, Y. (2011): Impacts of urbanization on urban structures and energy demand: what can we learn for urban energy planning and urbanization management? – Sustainable Cities and Society 1(1): 45-53.
[21] Martínez-Zarzoso, Inmaculada, and Antonello Maruotti. 2011. "The Impact of Urbanization on CO2 Emissions: Evidence from Developing Countries." *Ecological Economics* 70 (7). Elsevier: 1344–53. doi:10.1016/J.ECOLECON.2011.02.009.
[22] Parikh, Jyoti, and Vibhooti Shukla. 1995. "Urbanization, Energy Use and Greenhouse Effects in Economic Development: Results from a Cross-National Study of Developing Countries." *Global Environmental Change* 5 (2): 87–103. doi:https://doi.org/10.1016/0959-3780(95)00015-G.
[23] Pata, U. K. (2018): Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey- Testing EKC hypothesis with structural breaks. – Journal of Cleaner Production 187: 770-779.
[24] Pinghui, Z. (2017, March 03): Thousands tackling huge forest fire in northern China. – South China Morning Post: http://www.scmp.com/news/china/society/article/2092663/thousands-tackling-huge-forest-fire-northern-china.
[25] Routa, J., Kelomaki, S., Kilpelainen, A., Peltola, H., Strandman, H. (2011): Effects of forest management on the carbon dioxide emissions of wood energy in integrated production of timber and energy biomass. – Global Change Biology Bioenergy 3: 483-497.
[26] Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., Jabran, M. A. (2016): How urbanization affects CO2 emissions in Malaysia? The application of STIRPAT model. – Renewable and Sustainable Energy Reviews 57: 83-93.
[27] Schlamadinger, B., Marland, G. (1999): Net effect of forest harvest on CO2 emissions to the atmosphere: a sensitivity analysis on the influence of time. – Tellus B: Chemical and Physical Meteorology 51(2): 314-325.
[28] Shen, A. (2017, November 17). Forest fire burns across mountainside in western China. – South China Morning Post. http://www.scmp.com/news/china/society/article/2120376/forest-fire-burns-across-mountainside-western-china.
[29] Shi, A. (2003): The impact of population pressure on global carbon dioxide emissions 1975-1996: Evidence from pooled cross-country data. – Ecological Economics 44: 29-42.
[30] Shi, X., Li, X. (2018): Research on three-stage dynamic relationship between carbon emission and urbanization rate in different city groups. – Ecological Indicators 91: 195-202.
[31] Stern, N. (2006): Stern Review: The Economics of Climate Change. HM Treasury. – Cambridge University Press, Cambridge, UK.
[32] Sarwar, Suleman. 2019. "Role of Urban Income, Industrial Carbon Treatment Plants and Forests to Control the Carbon Emission in China." *Environmental Science and Pollution Research* 26 (16): 16652–61. doi:10.1007/s11356-019-04854-3.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1705_1030310311

[33] Sun, Chuanwang, Xiang Yuan, and Xin Yao. 2016. "Social Acceptance towards the Air Pollution in China: Evidence from Public's Willingness to Pay for Smog Mitigation." *Energy Policy* 92 (May). Elsevier: 313–24. doi:10.1016/J.ENPOL.2016.02.025.
[34] Thuy, P. T., Moeliono, M., Locatelli, B., Brockhaus, M., Gregorio, M. D., Mardiah, S. (2014): Integration of adaptation and mitigation in climate change and forest policies in Indonesia and Vietnam. – Forests 2016-2036.
[35] Waheed, R., Chang, D., Sarwar, S., Chen, W. (2017): Forest, agriculture, renewable energy, and CO2 emission. – Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2017.10.287.
[36] Wang, S., Fang, C., Wang, Y. (2016): Spatiotemporal variations of energy-related CO2 emissions in China and its influencing factors: an empirical analysis based on provincial panel data. – Renewable and Sustainable Energy Reviews 55: 505-515.
[37] Wang, S., Li, G., Fang, C. (2018): Urbanization, economic growth, energy consumption, and CO2 emissions: Empirical evidence from countries with different income levels. – Renewable and Sustainable Energy Reviews 81: 2144-2159.
[38] Wang, Y., Li, L., Kubota, J., Han, R., Zhu, X., Lu, G. (2016): Does urbanization lead to more carbon emission? Evidence from a panel of BRICS countries. – Applied Energy 168: 375-380.
[39] Wang, Z., Feng, C., Zhang, B. (2014): An empirical analysis of China's energy efficiency From both static and dynamic perspective. – Energy 74: 322-330.
[40] Xu, B., Lin, B. (2015): How industrialization and urbanization process impacts on CO2. Evidence from nonparametric additive. – Energy Economics 48: 188-202.
[41] Yao, X., Kou, D., Shao, S., Li, X., Wang, W., Zhang, C. (2018): Can urbanization process and carbon emission abatement be harmonious. New evidence from China. – Environmental Impact Assessment Review 71: 70-83.
[42] Yeh, J.-C., Liao, C.-H. (2017): Impact of population and economic growth on carbon emissions in Taiwan using an analytic tool STIRPAT. – Sustainable Environment Research 27: 41-48.
[43] York, R. (2007): Demographic Trends and Energy Consumption in European Union Nations, 1960–2025. – Social Science Research 36 (3). Academic Press: 855–72. doi:10.1016/J.SSRESEARCH.2006.06.007.
[44] Yuan, J., Xu, Y., Hu, Z., Zhao, C., Xiong, M., Guo, J. (2014): Peak energy consumption and CO2 emissions in China. – Energy Policy 68: 508-523.
[45] Zhang, C., Lin, Y. (2012): Panel estimation for urbanization, energy consumption and CO2 emissions: a regional analysis in China. – Energy Policy 49: 488-498.
[46] Zhang, N., Yu, K., Chen, Z. (2017): How does urbanization affect carbon dioxide emissions? A cross-country panel data analysis. – Energy Policy 107: 678-687.
[47] Zhu, Z., Liu, Y., Tian, X., Wang, Y., Zhang, Y. (2017): CO2 emissions from the industrialization and urbanization processes in the manufacturing center Tianjin in China. – Journal of Cleaner Production 168: 867-875.
[48] Zi, C., Jie, W., Hong-Bo, C. (2016): CO2 emissions and urbanization correlation in China based on threshold analysis. – Ecological Indicators 61(2): 193-201.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1705_1030310311