CLIMATIC IMPACT ON CHINA'S RESIDENTIAL ELECTRICITY CONSUMPTION: DOES THE LEVEL OF INCOME MATTER?

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Overview

It is widely accepted that energy use contributes to climate change, but in turn, climate change can also affect energy demand. Plenty of literature proves the existence of this feedback mechanism, but there is still no consensus on its exact operation. This needs to be studied in detail in China, which is the largest electricity consumer in the world. One particularly interesting question is how the increasing income of China's residents affects the climate sensitivity of electricity demand. By using a panel dataset including 278 cities in China over the period 2005-2015, this paper attempts to fill some gaps in this context. To this end, a newly developed model, partially linear functional-coefficient panel data model, is employed to analyze the response of residential electricity consumption to climate change and the impact of income.

We add to the existing literature in the following aspects. First, we employ a new empirical strategy to explore the heterogeneous effects of climate change on residential electricity demand at different income levels. Unlike previous studies imposing a specific functional form on the link between marginal effect of climatic variations and income (Gupta 2016; Li et al., 2018) or separately estimating temperature-electricity curve for subgroups with different income levels (Li et al., 2019), we regard the marginal effect of temperature variations as an unknown function of income. This strategy not only helps us to reduce risks of model misspecification but also enables us to identify how income shapes the relationship between temperature variations and residential electricity consumption in details. Second, we provide new evidence on the link between climatic variation and residential electricity consumption at China's city level. The aforementioned study (Li et al., 2019) only focuses on a typical area (Shanghai) rather than all the regions across China. To examine the effect of climatic variations on residential electricity consumption under a more detailed and comprehensive perspective, we compile a city-level panel dataset including 278 cities in China over an 11-year period. Using city-level panel data can take into account not only the dynamic change in temperature but also different geographic locations of China, including various terrains and climate zones.

The rest of this paper is as follows: Section 2 reviews the previous literature to understand the background of climate impacts on electricity consumption. Section 3 introduces the detailed methodology we applied. In section 4, we report and discuss the empirical results. Section 5 concludes the paper.

Methods

Partially linear functional-coefficient panel data model.

Results

First, the results show that residential electricity consumption responds positively to hot days rather than cold days.

Second, income levels have heterogenous impacts on climate sensitivity. An increase in income initially increases the marginal effect of cooling degree days on electricity consumption, while the curve of the marginal increment becomes flatter as income grows.

Conclusions

Our empirical evidence attests our assumptions and draws the following conclusions: (1) Using temperature deviation as a measure of climate change might lead to misleading conclusions since there is remarkable asymmetry of residents' response to hot weather and cold weather; (2) Residential electricity consumption is positively responsive to hot days rather than cold days. Our results are similar to Davis and Gertler (2015), which takes Mexico as research object and find that the response of residential electricity is very sensitive to hot weather but not significantly related to cold weather; (3) Different income levels have different impacts on the process of climate change stimulates electricity consumption. Specifically, the higher the income, the greater the climate sensitivity, but when incomes exceed certain values, the stimulation effect of income basically remains unchanged. This can be testified through the slope variations of marginal effect of CDD, the curve initially rises sharply, then gradually becomes gentle with only slight fluctuations when income increases, which indicates that climate change contributes less to residential electricity consumption for wealthy residents. Although high income groups are able to purchase more cooling facilities, electricity consumption has already peaked due to the saturated number of cooling devices in their houses, therefore, the demand will not be highly responsive to climate change again.

References

Ahmed, T., Muttaqi, K.M., Agalgaonkar, A.P., (2012). Climate change impacts on electricity demand in the State of New South Wales, Australia. Applied Energy 98, 376-383.

Allen, M.R., Fernandez, S.J., Fu, J.S., Olama, M.M., (2016). Impacts of climate change on sub-regional electricity demand and distribution in the southern United States. Nature Energy, 1(8), 16103.

Amato, A.D., Ruth, M., Kirshen, P., Horwitz, J., (2005). Regional energy demand responses to climate change: Methodology and application to the Commonwealth of Massachusetts. Climatic Change 71, 175-201.

Auffhammer, M., Mansur, E.T., (2014). Measuring climatic impacts on energy consumption: A review of the empirical literature. Energy Economics 46, 522-530.

An, Y., H. Cheng, D. Li. (2016). Semiparametric estimation of partially linear varying coefficient panel data models. Advances in Econometrics 36, 47-65.

Bessec, M., Fouquau, J., (2008). The non-linear link between electricity consumption and temperature in Europe: A threshold panel approach. Energy Economics 30, 2705-2721.

Cho, S.H., Kim, H.J., Zaheeruddin, M., (2011). Revised heating degree days due to global warming for 15 major cities of South Korea. Build Serv Eng Res T 32, 377-383.

De Cian, E., Lanzi, E., Roson, R., (2007). The Impact of Temperature Change on Energy Demand: A Dynamic Panel Analysis. FEEM Working Paper No. 46.2007; University Ca' Foscari of Venice, Dept. of Economics Research Paper Series No. 04-2007. Available at SSRN: https://ssrn.com/abstract=984237

Cho, W.G., Nam, K., Pagán, J.A., (2004). Economic growth and interfactor/interfuel substitution in Korea. Energy Economics 26, 31-50.

Davis LW, Gertler PJ, (2015). Contribution of air conditioning adoption to future energy use under global warming. Proc Natl Acad Sci USA 112, 5962–5967.

Eskeland, G.S., Mideksa, T.K., (2009). Climate Change Adaptation and Residential Electricity Demand in Europe. SSRN Electronic Journal, 10(2), 145-156.

Eskeland, G.S., Mideksa, T.K., (2010). Electricity demand in a changing climate. Mitigation and Adaptation Strategies for Global Change 15, 877-897.

Fikru, M.G., Gautier, L., (2015). The impact of weather variation on energy consumption in residential houses. Applied Energy 144, 19-30.

Gupta, E., (2016). The Effect of Development on the Climate Sensitivity of Electricity Demand in India. Climate Change Economics 07, 1650003.

Hsiang S, et al., (2017). Estimating economic damage from climate change in the United States. Science 356, 1362–1369.

IPCC, (2018), Summary for Policymakers. In: Global Warming of 1.5°C. World Meteorological Organization, Geneva, Switzerland.

Isaac, M., van Vuuren, D.P., (2009). Modeling global residential sector energy demand for heating and air conditioning in the context of climate change. Energy Policy 37, 507-521.

Li, J., Yang, L., Long, H., (2018). Climatic impacts on energy consumption: Intensive and extensive margins. Energy Economics 71, 332-343.

Li, M., Cao, J., Guo, J., Niu, J., Xiong, M., (2016). Response of energy consumption for building heating to climatic change and variability in Tianjin City, China. Meteorological Applications 23, 123-131.

Li, Y., Pizer, W.A., Wu, L., (2019). Climate change and residential electricity consumption in the Yangtze River Delta, China. Proc Natl Acad Sci U S A 116, 472-477.

Lin, B., Du, K., (2015). Energy and CO2 emissions performance in China's regional economies: Do market-oriented reforms matter? Energy Policy 78, 113-124.

Mansur, E.T., Mendelsohn, R., Morrison, W., (2008). Climate change adaptation: A study of fuel choice and consumption in the US energy sector. Journal of Environmental Economics and Management 55, 175-193.

Moral-Carcedo, J., Vicéns-Otero, J., (2005). Modelling the non-linear response of Spanish electricity demand to temperature variations. Energy Economics 27, 477-494.

Shen, X., (2014). Influencing factors on rural residential electricity demand in china. Statistical Research. 31 (1), 84-90.

Wu, Y., (2012). Energy intensity and its determinants in China's regional economies. Energy Policy 41, 703–711.

Wenz, L., Levermann, A., Auffhammer, M., 2017. North-south polarization of European electricity consumption under future warming. Proceedings of the National Academy of Sciences of the United States of America 114, E7910-E7918.

Wilbanks, T., Bhatt, V., Bilello, D., Bull, S., Ekmann, J., (2008). Effects of Climate Change on Energy Production and Use in the United States. Washington, DC: United States Climate Change Science Program. Available at: https://digital.library.unt.edu/ark:/67531/metadc12032/

Zhang, Y., and Q. Zhou. (2018). Partially Linear Functional-Coefficient Dynamic Panel Data Models: Sieve Estimation and Specification Testing. Working Paper.

Zachariadis, T., (2010). Forecast of electricity consumption in Cyprus up to the year 2030: The potential impact of climate change. Energy Policy 38, 744-750.