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Investigating Environmental Kuznets Curve in China–Aggregation bias and policy implications

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ABSTRACT

Aggregation bias may lead to a wrongly estimated Environmental Kuznets Curve (EKC), and misguide the policy-makers. This paper aims to test the existence of aggregation bias in the Environmental Kuznets Curve with the sulfur dioxide (SO_2) emission. The empirical methods robust to cross-sectional dependence and slope heterogeneity reveals that the estimation of SO_2 EKC in China suffers from aggregation bias. The results with the disaggregate data cannot support the EKC estimated at the aggregate level. The finding of aggregation bias has several policy implications. First, the government should not be misled by the false relationship between the pollutant emission and the real GDP per capita at the aggregate level. Second, the local governments should play more important roles in making environmental protection policies since the more disaggregate data can mitigate the aggregation bias. To provide enough incentives to the local government, the Chinese national government should align the interests of the local governments with those of the national government. On the other hand, the findings indicate that China can stick to the policy of encouraging foreign direct investment, openness and financial development since they have not influenced the SO_2 emission in China.

1. Introduction

In the past decades, China has achieved remarkable economic growth. According to the United Nations data, the GDP per capita in China has increased from USD 227 in 1978 to USD 8109 in 2015. Meanwhile, China has emitted the largest volume of pollutants (such as sulfur dioxide) in the world (World Bank, 2007). With more and more frequent smog problems in China, the nexus between the economic growth and pollutants emission in China has become a heated topic not only in China but also in the world. Will the environmental problem deteriorate in China as the economy continues its trend, or will the environment eventually improve as the real per capita GDP increases as implied by the Environmental Kuznets Curve hypothesis? This question has a very important policy implication. If EKC hypothesis holds in China, there will exist a inverted U-shape relationship between pollutants emission and real per capita GDP, and pollutants emission will decrease as the real per capita GDP reaches the turning point.

There are several studies on the existence of EKC in China. However, the literature has not reached a consensus. Besides the conventional factors affecting the existence of EKC (Dinda, 2004), the aggregation bias may be a key reason for the disagreement on the relationship between pollution and economic growth in China. Aggregation bias can be frequently found in dealing with aggregate data, while understanding aggregates is essential for economic policy (Stoker, 2008). Most literature has used the aggregate data in China (eg. Jalil and Feridun, 2011; Jayanthakumaran et al., 2012; Onafowora and Owoye, 2014), and even the few provincial level analyses have focused on estimating one EKC for the whole country by applying panel data method (Llorca and Meunie, 2009). The effort to find out the national-level EKC may fail simply because the national-level EKC may not exist in such a large country with significant regional differences. Due to the different industrial structures, regions with huge pollutant emission may be hundreds or even thousands of kilometers away from the regions with better economic performance. The national level analysis may be purely a result of arbitrarily relating the pollutant emission of one region to the economic activities of another region. Hence, the analysis at the national level may suffer from aggregation bias. In relevant literature, the results of panel countries and that of individual or subsample vary significantly (Dijkgraaf and Vollebergh, 1998; Stern and Comman, 2001), which has indicated the existence of aggregation bias. With aggregation bias, the EKC estimation will be distorted, and hence cannot depict the relationship between pollution and real per capita GDP. The government may make wrong judgments if it depends on EKC to assess the effect of environmental policies.

To test aggregation bias in estimating EKC in China requires plausible model specification and rigorous estimation method. The result of EKC estimation is sensitive to the choice of specification and estimation technique (Dinda, 2004). The conventional specification of EKC is to

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run a regression with the pollutant emission on income and its square. If the coefficient of the former is positive and that of the latter is negative and significant, the EKC hypothesis is verified. Narayan and Narayan (2010) criticize the conventional method for multi-collinearity. However, Brown and McDonough (2016) suggest that the long-run and the short-run, income elasticity cannot convey any information about the shape of EKC, and argue that the conventional method can work well despite the problem of multi-collinearity. In this paper, I will adopt Brown and McDonough's (2016) method. As far as the estimation method is concerned, to control the problems of cross-sectional dependence and slope heterogeneity in panel data, this paper will adopt the panel cointegration test and Chudik and Pesaran's (2015) VECM, which are robust to both cross-sectional dependence and slope heterogeneity. Besides, ARDL model has been employed for robustness test.

The sulfur dioxide has been used for the pollutant factor for two reasons. First, the choice of sulfur dioxide can provide a more rigorous evidence of aggregation bias in EKC estimation, given that sulfur dioxide emission has been found to follow the EKC hypothesis more significantly in some literature. Second, the sulfur dioxide emission data can be dated back to the 1980s in China, which has provided enough for sample use. Moreover, China has emitted the most sulfur dioxide in the world. Research on SO_2 emission is more important for environmental policy making.

This paper has also investigated the impacts of foreign direct investment, trade openness and financial development. Pollution Haven Hypothesis proposes that heavy polluters may move to countries with weaker regulations if there were higher trade openness (Mani and Wheeler, 1998; Wu, 2003; Cole, 2004). Financial development has been considered following Jalil and Feridun (2011).

This study contributes to the relevant literature in two aspects. First, this paper is among the first efforts to investigate the aggregation bias in EKC estimation within a country. The existent literature has noticed that there may not exist a global EKC, but rarely discussed the problem within a country. The findings can provide better information for the government to make environmental policies. Second, a series of statistical methods which are robust to the cross-sectional dependence and the heterogeneity have been employed to achieve the rigidity in testing the aggregation bias in EKC estimation, such as Pesaran's (2015) CD test for the weak cross sectional dependence, and Chudik and Pesaran's (2015) VECM. The ARDL model has also been estimated as a robustness test.

2. Literature review

Despite much attention paid to the aggregation bias in economic research, there is nearly no literature concerning the aggregation bias in the estimation of EKC. The only exception is Heerink et al. (2001). Based on the aggregation bias literature, they try to overcome the aggregation bias problem by introducing the "income inequality" term to control the impact of income variance. They have found the evidence of aggregation bias in sub-Sahara countries. However, they have not tested another type of aggregation bias caused by different coefficients estimated with the aggregate data and the disaggregate data (so-called "exact aggregation"). Hence, this paper will explore whether the Chinese provinces share the same shape of EKC as implied by the national-level EKC in addition to the Heerink et al. (2001) type test.

There are much literature estimating the Environmental Kuznets Curve in China, but no consensus has been reached. The extant literature varies a lot in the samples, environmental indicators, methodologies and findings.

First, as far as the samples are concerned, most of the relevant researches with China can fall into three strands, i.e. research only on the aggregate data of China, researches on a panel of countries with China as a member, and researches on a panel of the Chinese provinces. The first includes Jalil and Mahmud (2009) and Jalil and Feridun (2011). They focus on the Chinese aggregate data to test the existence of the Environmental Kuznets Curve in China. The second strand includes Jayanthakumaran et al. (2012), Govindaraju and Tang (2013) and Onafowora and Owoye (2014). They have either compared China with India, or investigated China in a panel of countries. Llorca and Meunie (2009), Wang et al. (2011) and Du et al. (2012) have employed panel data with the Chinese provinces, so their researches fall into the third strand. An exception is Yang, Haisheng et al. (2005), who have used a panel of 30 city-level data.

Second, with respect to environmental indicators, most of the researches aim to investigate the relationship between CO_2 emission and output, and Llorca and Meunie (2009) is the only exception. Their study focuses on the sulfur dioxide emission. Thanks to the government report regarding the emission of sulfur dioxide over a long period, Llorca and Meunie (2009)'s data can be dated back as early as 1985, which is also the earliest time ever found in the relevant researches with China. Because there is no successive report of CO_2 emission data, all the provincial level CO_2 emission data are estimated from the energy consumption breakdown by each fuel category, with the assumption that there exist stable CO_2 emission coefficients for each category of fuel consumption.

Third, concerning the methodologies, most of the researches with the aggregate data have employed the autoregressive distribution lagged (ARDL) model (Jalil and Mahmud, 2009). Bound testing technique has also been used in some literature (Jalil and Feridun, 2011; Jayanthakumaran et al., 2012); Onafowora and Owoye (2014) have also combined ARDL, bound testing, the CUSUM and the CUSUMSQ test. The exception with the aggregate sample is Govindaraju and Tang (2013), who have adopted Bayer and Hanck (2010) cointegration method. However, with much shorter time dimension, most of the panel studies at the provincial level have to resort to other methods. Among them, Wang et al. (2011) have employed the cointegration technique, but the results may suffer from the problem of short sample of only thirteen years. Llorca and Meunie (2009) has employed the fixed effect panel data model, while Du et al. (2012) estimate series of static and dynamic panel data models, and then apply out-of-sample criteria to select an optimal forecasting model. However, most of the provincial level panel data analyses haven't given due attention to the cross-sectional dependence and the heterogeneous slope problems.

Finally, with different research aims, samples and methodologies, no consensus has reached on the existence of EKC in China. Some researchers have found the evidence of EKC in China (Haisheng et al., 2005; Jalil and Mahmud, 2009; Jayanthakumaran et al., 2012), others have not (Du et al., 2012; Wang et al., 2005; Govindaraju and Tang, 2013; Onafowora and Owoye, 2014). For example, Onafowora and Owoye (2014)'s recent findings indicate an N-shaped relationship between CO_2 and economic growth, which doesn't support the existence of EKC.

Some literature has also investigated the factors influencing the nexus between pollutant emission and economic growth in China. Jalil and Mahmud (2009) find that trade has a positive but statistically insignificant impact on CO2 emissions. Jalil and Feridun (2011) concluded that financial development can reduce the CO2 emission. Onafowora and Owoye (2014) have included trade openness in their study. Haisheng et al. (2005) have investigated the impacts of trade and FDI inflows on EKC in China, and find trade can reduce pollution while FDI can make pollution worse.

The extant literature has not estimated the provincial level EKC due to data availability problem. As the result, the studies with the aggregate level data are most likely to suffer from the aggregation bias problem. The few panel data analyses haven't ruled out the estimation problems, such as the cross-sectional dependence and the heterogeneous slope and coefficients problems. Hence, the following part will employ the methods free from such problems to test the aggregation bias in China and develop some policy implications.