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Electricity intensity across Chinese provinces: New evidence on convergence and threshold effects

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ABSTRACT

Energy intensity has gone through different stages across Chinese regions. In this paper, we investigate the stochastic electricity-intensity convergence across the Chinese provinces. Unlike previous work, this paper highlights the relevance of the level of technology of each province and takes into account the economic geography through the examination of club convergence. We perform several unit root tests that introduce structural breaks, nonlinearities and time variation, with the aim to capture the economic transformation of the Chinese economy. Results indicate that the majority of the Chinese regions have converged according to the unit-root tests in time-series analysis, indicating that technological differences diminish over time. However, this convergence pattern occurs within groups of regions, according with club convergence test. Indeed, we find a dominant club and others smaller clubs that few regions belong. However, it is observed that there are regions that still diverge. These findings support our argument that special policy attention is required for those regions displaying divergence.

1. Introduction

One of the most active debates in energy economics is an observed decline in energy intensity across developed countries over the last two decades. Works focusing on the causes of the decline have revealed that technological progress, economic structure, sectoral decomposition of energy use, fuel mix, efficiency in the conversion and end-use of energy account for the improvements in the use of energy resources across countries (Liddle, 2010).[1] However, whether differences in energy intensity across countries diminish over time, achieving convergence, has received little attention in the literature, especially compared with related fields like environment and growth (Le Pen and Sévi, 2010). Within this literature, convergence in energy intensity could imply that technological differences across regions diminish over time. By contrasts the finding of divergence may be a motive to promote energy-saving policies. Thus, examining this issue may provide new insights to the energy-economics literature.

Energy intensity in the fast growing economies is of great importance due to the fact that these countries require a large amount of energy resources to fuel that process. Among them, the case of China is probably the most fascinating one since its economy has achieved an impressive performance over the last two decades. The rapid growth has resulted in a huge increase in demand for electricity in recent years.[2] Thus, an interesting question to investigate is the relationship between energy consumption and growth through the examination of energy intensity levels in this economy.

The observed decline in energy intensity has also generated a large amount of empirical research in the Chinese case (Ma and Stern, 2008; Ma et al., 2009; Zhang, 2003). These works conclude that during the 1980s and 1990s the use of energy per unit of output at the national level improved. This trend changed, after that period until recent years, showing a deterioration of efficiency levels of energy (Zhao et al., 2010). However, the existence of these two trends makes necessary that in the empirical analysis either structural breaks or nonlinearities have to be introduced in the model. However, none of previous works takes into account this issue. In addition, these studies investigate the whole country leaving the regional dimension out of such analysis.

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[1] See also Chai et al. (2009), Cornillie and Fankhauser (2004), Fisher-Vanden et al. (2004), Garbaccio et al. (1999), and Sinton and Levine (1994).

[2] See Wang et al. (2010) and Zhang et al. (2011) for a review of China's energy situation.

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We extend the previous works by introducing endogenous structural breaks and nonlinearities for each region, we consider not only the aforementioned two trends, but also the new improvement in the use of electricity in 2009–2010. Ignoring these changes, may cause bias in any estimation especially in the case of China that is continuously and gradually transforming its economy. On the other hand, the regional dimension presents new directions on energy aspects in this country. First, there are some energy exporting regions like Guangxi and Shanxi that display a sharp decrease in electricity intensity in the supply side in the nineties, but for the remaining regions a steady pattern is observed. In the energy importing regions, the behavior is quite irregular e.g. we observe some of these regions with a high level of energy intensity, or others that either has improved it or remains relatively stable over time. These differences in energy-intensity might show differences in economic structure and technologies. The Chinese government, regarding reduction in energy intensity as a desirable way of limiting the incremental environmental damage associated with the rapid economic growth, established in the 11th Five-Year Plan the objective of reducing energy intensity by 20% between 2005 and 2010. This objective is expected to achieve through optimization of the industrial structure and improvement of efficiency and reduction in consumption. However this expectation has not yet been fully realized.[3]

It is well-known that energy intensity is a measure of the direct link between energy consumption and economic activity, which in turn is related to emissions and environmental protection. Thus, analyzing the convergence behavior in energy intensity across Chinese provinces may lead to new insights. This is the goal of this work. To carry out research, we focus on the concept of stochastic convergence, which has relied on unit-root tests in time-series analysis and apply it to the case of electricity-intensity across Chinese regions over the period 2003–2009 with monthly data. We perform several unit root test. First, we use Kwiatkowski–Phillips–Schmidt–Shin (*KPSS*) test and Ng and Perron tests, which are some of the traditional test without breaks used in the literature, and then improve the power of such tests by introduction of endogenous structural breaks and nonlinearities according to Kapetanios et al. (2003) and Lee and Strazicich (2003). This allows us to consider a situation where each region has its own level of technology in China, which is a realistic assumption. This analysis is complemented by investigating the existence of club convergence through the application of the Hansen (2000) and Phillips and Sul (2007) tests, since the uneven distribution of energy resources in the vast territory in the Chinese economy makes us expect the presence of regional clusters.

Analyzing energy-intensity convergence among Chinese regions is important because the decrease in energy intensity is mainly due to changes in economic structure and technological progress and these factors have possible impacts on institutions and flows comprising international trade. If the first influence predominates, namely, structural change- then, trade, may lead to divergence in energy intensity. However if technological progress dominates, then, trade by encouraging or facilitating best-efficiency practice, could lead to energy intensity convergence.[4] Furthermore, the finding that both developed regions and the less developed ones are converging toward a common pattern of energy use could be evidence of a "leapfrogging process" (Liddle, 2010). By contrast, finding divergence in energy intensity may cause damage to the credibility of local and national governments in their attempt to reduce the use of energy. In addition, it could imply a lack of diffusion of energy-related technologies. This is important not only for the ability of China to improve environment, but also for resources saving that is critical for sustainable development. In this case, local and national governments may prioritize energy-saving measures across sectors i.e. providing incentives and technological policies aiming at encouraging knowledge diffusion, particularly in regions with lower energy efficiency.

In existing research, there is little evidence on convergence in energy intensity across Chinese regions.[5] However, we can find it for other, developed and developing, countries in Ezcurra (2007), Le Pen and Sévi (2010), Liddle (2010) and Markandya et al. (2006) among others.[6] Our study distinguishes itself from previous work in many significant ways. First, we explore the novel aspect of stochastic electricity intensity convergence, which is the most important energy resource in the Chinese economy. Second, we perform our study at the provincial level, since one of the characteristics of the Chinese economy is its heterogeneity across regions. Besides, we use a unique and rich monthly data. Third, we use two traditional unit-root tests as well as the most recent developments that allows for structural breaks and nonlinearities in the data to take into account the significant transformation of Chinese regions over our sample period.[7] In addition, given that some of Chinese regions are much larger than many countries, we analyze convergence within a group of regions—in which we group regions or provinces into a 'club' according to their stage of economic development. This test is particularly relevant for economies in transition, since it allows a wide range of transition paths toward the steady state. Finally, we contribute to the literature in providing empirical evidence of notable convergence across regions, when unit-root tests that allow either structural breaks or nonlinearities in the data-generating process are introduced in the model, since the traditional ones (KPSS and Ng and Perron tests) support different conclusions. However, we also find that Chinese regions converge into clubs, namely, to their own steady state, except a few places like Liaoning, Tianjin, and Yunnan. These findings suggest that a common energy policy applied to Chinese provinces may provide unsatisfactory results, implying the need to design specific energy policies according to the clusters found.

The plan of the paper is as follows. Section 2 reviews the notions of convergence and their applications in the energy intensity literature. Data and methodology are presented in Section 3. Results are explained in Section 4, while conclusions are drawn in Section 5.

2. The notion of convergence

The concept of convergence in growth empirics is related to the reduction of inequality between countries or regions. However, convergence is not restricted to the growth literature, and has been applied recently to other fields, including energy economics. One of the most active lines of research in energy economics has focused on the factors of the decline in energy intensity (Chai et al., 2009; Cornillie and Fankhauser, 2004; Goldemberg and Prado, 2011; Ma and Stern, 2008; Sinton and Levine, 1994; Sun, 2003; Zhang, 2003; Zhao et al., 2010) and more recently has examined whether that decline has favored the convergence process across developed and developing countries (Duro et al., 2010; Ezcurra, 2007; Ian, 2008; Le Pen and Sévi, 2010; Liddle, 2010; Markandya et al., 2006).

As stated by Islam (2003), different notions of convergence are linked to different methodological approaches. Among them, we can distinguish on the one hand, *absolute* versus *conditional* β-convergence and on the other hand σ-convergence according to the seminal paper by Barro and Sala-i-Martin (1992). Often these notions have been tested empirically, initially with cross-sectional data and latter with panel

[3] See Chai and Zhang (2010) and Zhang and Wang (2008) for the need to promote energy saving measures in China.

[4] The finding of convergence could also be interpreted as convergence in technological progress across regions.

[5] Ito et al. (2010) investigated the energy demand in China from regional aspects, but these authors do not analyze the hypothesis of energy intensity convergence.

[6] See additional works for other countries in Liddle (2009), Mielnik and Goldemberg (2000), Mulder and De Groot (2007) and Sun (2002).

[7] See Kebede (2011) for the need to test for unit root test in an application of the efficiency of US natural gas market and by using a similar notion of convergence in the case of carbon dioxide emissions in Lee and Chang (2008).