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Energy efficiency convergence across countries in the context of China's Belt and Road initiative

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HIGHLIGHTS

- Examine whether BR initiative will worsen other countries' environment or not.
- Trade integration and regional cooperation are two channels between EE convergence and BRI.
- Trade integration and regional cooperation can promote EE convergence.
- BR may have a positive effect on energy efficiency convergence.
- BRI unlikely deteriorates environmental performance in other countries.

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ABSTRACT

After China launched its "Belt and Road" (BR) initiative, the international community became concerned that it may worsen the environmental performance of the BR countries. Due to a lack of data for empirical testing, this paper addresses this concern through an indirect method and draws the implications of the potential impacts of China's BR initiative. This method empirically examines the effects of trade integration and regional cooperation, two major functions of the BR initiative, on energy efficiency (EE) convergence, a concept that describes the catching up process of EE across countries. A sample of 89 countries was selected to analyse the process of EE convergence from 2000 to 2014. The results indicate that although the gaps in EE among countries around the world become larger after 2010, regional cooperation may lead to a convergence process. It also finds that trade integration has a positive influence on convergence across the countries, especially among middle- and low-income countries. The results suggest that the BR initiative, through its roles in trade integration and regional cooperation, may promote EE convergence among countries. This is a desirable environmental outcome. This research also provides policy implications for both China and the other BR countries.

1. Introduction

Facing increasing tension between economic growth and climate change mitigation, energy efficiency (EE) is regarded as a key measure for reconciling the conflict. EE can decouple economic growth from energy demand and is considered the "most available, secure and affordable energy resource" to achieve sustainable development. It has, for some time, been a priority for energy and economic policy makers around the world [1]. For example, from 1971 to 2015, the world economy grew 22.9 times, while the total final energy consumption and total CO_2 emissions in 2015 were only about 2.2 and 2.3 times their 1971 levels, respectively [2].

Apart from EE itself, against the background of equitable growth and achieving the targets of "Sustainable Energy for All (SE4ALL)[1]" by 2030, EE convergence has renewed its status as a key academic and policy topic in the EE literature and deserves continuous study. EE convergence, which means that lagging countries or regions grow faster in EE than advanced ones [3], has an additional implication for inclusive growth and narrowing the gaps in EE across countries [4,5]. A serious issue relating to large gaps is that the economic development

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and living standards of less developed countries will be affected by a lack of access to energy. More broadly, unbalanced and unequal energy use may undermine the new drivers of the world's economy in the long run and may worsen inequality around the world.

The debate over the EE convergence has a new relevant policy contribution that will help clarify the controversy surrounding the Belt and Road (BR) initiative proposed by China in 2013. The intention of the BR initiative, which comprises the Silk Road Economic Belt and the 21st Century Maritime Silk Road, is to build a trade and infrastructure network connecting Asia with Europe and Africa along the ancient Silk Road routes. Strengthening energy cooperation with countries along the BR route is a priority and significant pillar of the BR activities [6]. The BR initiative in the energy sector is not without controversy. On one hand, it is expected to have many positive impacts, such as finance, infrastructure. The BR initiative is also expected to improve energy security for China and its partners through its enhancing of EE and its production of an increased and cleaner energy supply. On the other hand, the international community is concerned that the BR initiative may precipitate a relocation of China's outdated industries to other countries, resulting in a deterioration of their environment and energy performance [7–9]. Such controversy will discourage many BR countries from participating in the initiative and prevent them from benefitting from the technology, finance and expertise that are likely to be made available through the initiative.

Examining the controversy will help both China and the BR countries understand the potential adverse impacts of the initiative, clarify whether the initiative will narrow the gaps in EE among the member economies or not, and also provide practical information for policy makers in China and the other BR countries. Despite its significance, no data are available for empirical tests because the BR initiative was only proposed recently and its implementation will take further time.

This paper tries to measure the impact of the BR initiative on EE convergence through an indirect method: a comparison of the general trend in the world and some typical regional blocks. It then draws implications about the future impact of the BR on EE convergence. The BR can affect EE convergence through its cooperation priorities in trade and regional cooperation. Achieving unimpeded trade is one of the five cooperation priorities in the BR initiative. The trade improvement could also be supported by other cooperation priorities such as facilities connectivity and financial integration [6]. Strengthening regional cooperation is another priority of the BR initiative. According to the BR Vision and Action, the policy coordination priority, one of the five priorities, aims to "promote intergovernmental cooperation…, work out plans and measures for regional cooperation, negotiate to solve cooperation-related issues…" [6].

Applying various convergence assessment techniques with consideration given to spatial effects, this research projects how the BR initiative may affect cross-country EE convergence by examining the impact of trade and regional cooperation on EE convergence. Past studies find that trade is important in explaining the process of EE convergence [10,11]. In Europe, for example, trade—especially the knowledge spillover that it facilitates—advances the EE convergence among European Union (EU) countries [12]. To emphasise the interdependence among countries, trade could also be described as trade integration [13–17]. Regional cooperation could also promote EE convergence across countries. Regional cooperation mechanisms (RCMs), such as the Asia-Pacific Economic Cooperation (APEC), the Association of Southeast Asian Nations (ASEAN), the Organization for Economic Co-operation and Development (OECD) and the EU, affect EE convergence across countries through non-trade measures, such as investment, information sharing, international technology and expertise transfer [18–20].

The contributions of this paper are: (a) it assesses a major international policy concern that the BR may cause deterioration of the environment in other countries. The results provide opportunistic justification that may facilitate its development and inform policy makers in China and other countries in terms of policy development; (b) it demonstrates that the BR initiative can impact the environment through two channels: trade integration and regional cooperation. This framework will be useful in assessing the impact of the BR initiative in the future; and (c) it proposes a specific definition and measurement of trade integration emphasizing the relationship with China.

The structure of the paper is as follows. Section 2 summarises the relevant literature, Section 3 presents the methodology and data, Section 4 reports and interprets the empirical analytical results of the spatial convergence models, Section 5 discusses the implications of this study concerning the BR initiative, and the conclusion is presented in Section 6.

2. Literature review

In the research on EE convergence, the terms σ-convergence and β-convergence are often employed to describe the process. σ-convergence means a decrease in the cross-country differences typically measured by the standard deviation [3]. β-convergence refers to the rate of growth being high in the initial stage but falling as EE increases, approaching the steady state [3].

International trade has been explored as an influential factor in the EE convergence. New technology embodied in capital equipment can spill over to other countries through foreign direct investment and international trade [21] and, thus, lead to convergence of energy productivity. In addition, sector specialisation resulting from international trade may lead to the adjustment of the industrial structure. The proportion of energy-intensive industry in an economy can affect the performance of EE directly and may make a difference in EE convergence across countries [11,22–24]. Moreover, international trade has been explored as an influential factor leading to changes in the industrial structure through the change of production patterns [11,12,25]. At the same time, in the view of trade and measuring the interdependence among specific countries in the literature, trade integration is a positive driver of EE convergence [11].

In addition to international trade, various channels of regional cooperation mechanisms, such as energy integration, can promote more equitable energy access. It may also help low efficiency countries catch up with high efficiency countries [4]. Since different regional cooperation groups have their own characteristics in their use of energy, they usually perform differently in EE convergence. The existing literature finds that regional groups have specific focuses in terms of EE convergence. For the OECD countries, the trend in EE predominantly has an impact on the pattern of the convergence, while structural effects may undermine this process [11,23]. The reduction in gaps in EE comes mainly from consumption efficiency convergence at the sector level [26]. In the scope of the EU, trade intensity is a significant influential factor, while the effect from sector specialisation is not clear [12]. To catch up with the level of the EU average, reforms in governance and in the market have been recommended for the transition countries of Eastern Europe [27]. In the ASEAN, energy integration is considered an important driver of EE convergence [4].

Considering the methods used in the previous studies to explore the process of convergence, a standard β-convergence model, based on the neoclassical growth model is often used [3,28]. With this method, the evolution and influential factors of convergence have been revealed [3,10,12,17,21,27–36]. Due to some misspecification from unaccounted-for spatial effects [37,38], the basic model has also been improved with the spatial econometric method to deal with the spatial externalities of geographical distance, contiguity and economical distance, such as bilateral trade [12,29,30,36]. The weight matrixes in spatial econometric models are further constructed in various forms [12,29,30,36]. Decomposition analysis is another main method used in research on EE convergence. Index decomposition analysis (IDA) and its improved models are used frequently in existing research [11,23,24,26]. Compared with an econometric model, IDA can explore