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Industrial Relocation and CO_2 Emission Intensity: Focus on the Potential Cross-Country Shift from China to India and SE Asia

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Abstract

The potential relocation of various industrial sectors from China to India and countries of the SE Asian region presents low cost opportunities for manufacturers, but also risks rising energy demand and CO_2 emissions. A cross-country shift of industrial output would present challenges for controlling emissions since India and SE Asian countries present higher industrial emissions intensity than China. We find that although there is a convergence in emissions intensity in the Machinery manufacturing and Paper and Pulp industries, there are significant variations in all other industrial sectors. Indian emissions are double that of China in the Iron and Steel and Textile and Leather industries and almost triple in the cement industry; Indonesian emissions are almost double those of China in the Non-Metallic Minerals and Textile and Leather industries and 50% higher in the Chemical and Petrochemical industry. We demonstrate that the expected higher emissions are driven by both a higher fuel mix carbon intensity in the new countries and a higher energy intensity in their industrial activities. While industrial relocation could benefit certain countries financially, it would impose considerable threats to their energy supply security and capacity to comply with their Paris Agreement commitments.

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Keywords: India; China; Indonesia; Philippines; Thailand; Industrial emissions; Emissions intensity; Coal; CO_2 Emissions

1. Introduction

India has presented the highest GDP growth among the major global economies, amounting to 7.2% for 2017 and expected to further develop at a rate of 7.7% for 2018 [1]. With China showing evidence of further slowing down, its

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economic growth rates expected to decline from 6.7% to 6.2% between 2016 and 2018 [2], the ASEAN countries Indonesia, The Philippines and Thailand are experiencing a 5.1%, 6.7% and 3.2% growth rate respectively for 2017 [2–5]. Overseas firms focus on India, among others, for establishing their production lines, with India surpassing China for greenfield FDI in this perspective by \$6.4 billion in 2015 [6,7] aided by initiatives such as the "Make in India" state programme aimed in attracting foreign investors. In contrast to the anaemic growth of crisis hit countries in the EU [8] and other regions, SE Asia provides promising industrial hub destinations. Apart from India [9], Thailand, the Philippines and Indonesia are discussed as potential destinations by industries wanting to relocate from China [10,11].

Furthermore, in comparison to China, India, Indonesia, the Philippines and Thailand present young demographic characteristics which enhance their potential as destination for manufacturers [12,13]. However, they also present different emission characteristics [14]. From a manufacturer's point of view, industrial relocation from China to SE Asian countries can be preferable for a range of factors such as ageing population and the respective increased social security costs [15], increased labour and production costs [16], higher environmental regulation standards [17], higher land value and less attractive tax policies [18,19]. However, the relocation impact on industrial CO_2 emissions is complex to estimate and depends on the specific country shifts, their relative energy intensity and their relative emissions intensity.

While the extent and trajectory of industrial relocation between the aforementioned countries is an issue for debate in the literature [20,21] in this manuscript, we compare the emissions intensity of China, India and SE Asian countries to understand better the CO_2 impacts of a potential industrial relocation. Therefore, our contribution is in improving the understanding of the impact that potential relocations of industries might have in terms of emissions, and more significantly to identify which sectors might be best and worst placed to accommodate relocation activities in the near future.

2. Method and Data

Emissions intensity can be expressed in forms of CO_2 per total economic output [22] or CO_2 per total primary energy supply (TPES) according to IPCC [23]. To calculate CO_2 emissions intensity, the IEA database has been selected as the most appropriate to extract the raw primary energy data of the industrial sectors examined. IEA has a wide variety of flows and respective Net Calorific Values (NCVs) per country, extended time series availability and reporting consistency. The economic total output values have been extracted from UNIDO data, converted to US 2005\$ values and ISIC rev.4 to match the reporting methodology of IEA [24]. Physical quantities of fuels are converted to petajoules, and by using the appropriate IPCC 2006 net carbon content per fuel [25], are summed for each industrial sector total CO_2 emissions.

3. Discussion of the Results

Emissions intensity for total industry is presented in figures 1 and 2 in relation to economic output and consumed energy. India's emissions intensity per economic output is approximately 3 times higher than that of China and the Philippines, and almost 2 times higher when compared to Indonesia and the Philippines. China, Indonesia and India present a declining trend with China experiencing the steepest and most continuous decline as an effect of central organisation and robust policies [26,27].

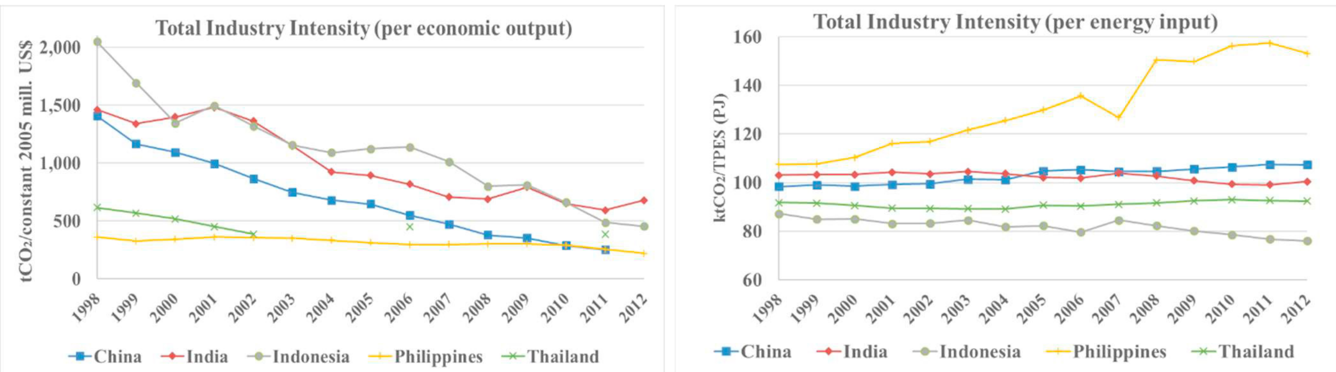

Fig. 1-2. Total industrial emissions intensity CO_2/million US\$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

However, when comparing the emissions intensity per energy, the trends appear to be stable for all countries but the Philippines. China and India produce approximately 30% higher CO_2 emissions per energy input than that of Indonesia. Under that prism, the Philippines shows a vast divergence from the rest of the countries assessed, with 60% higher emission intensity than India and approximately 55% than China. This differentiated Philippines trend is the result of an 8-fold increase in CO_2 emissions originating from coal between 1994-2014, while the total CO_2 emissions have increased by approximately 150% [30], presenting an industrial fuel mix highly influenced by coal in relation to the other countries.

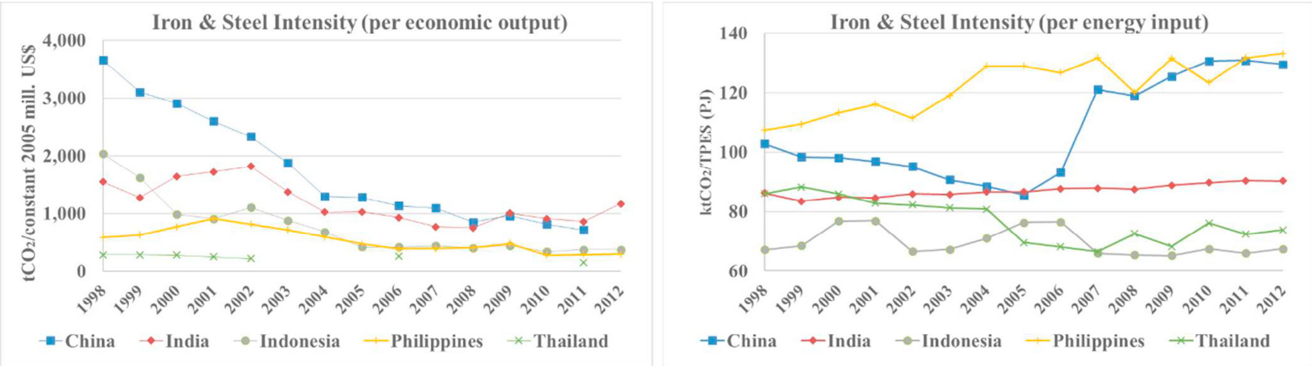

Fig. 3-4. Iron & Steel emissions intensity CO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

While there is a wider electrification trend with innovative technologies in industry [31] and transport [32] it is necessary to look in more detail at the decomposed sectoral analysis. China's Iron and Steel (fig. 3-4) emissions intensity per economic output follows a steep decline between 1998 and 2004 and then continues on the same trend at a slower pace. India surpasses China in 2011 and stands at almost 3 times higher intensity than Indonesia and the Philippines. China and the Philippines present the highest emissions intensity per energy input, at approximately double the level of the other countries as a result of their blast furnance gas technology which is extremely carbon intensive.

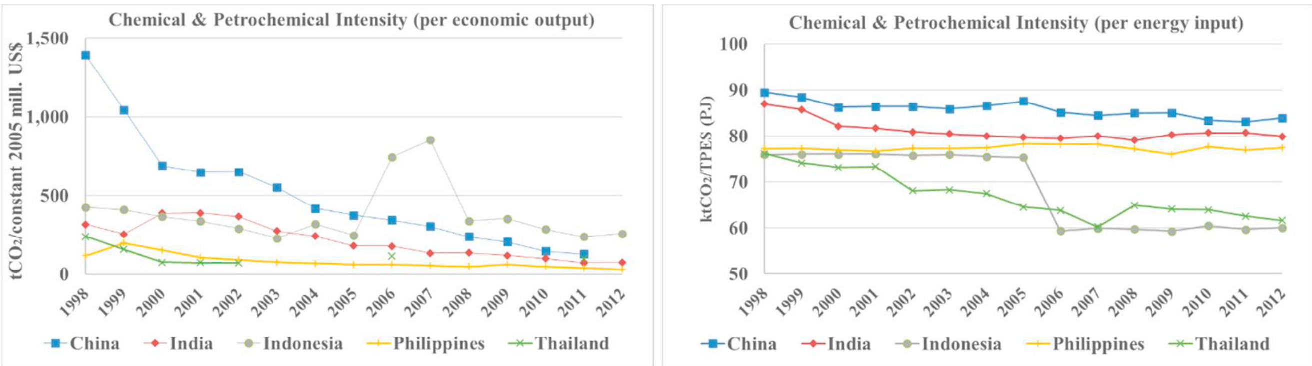

Fig. 5-6. Chemical & Petrochemical emissions intensity tCO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

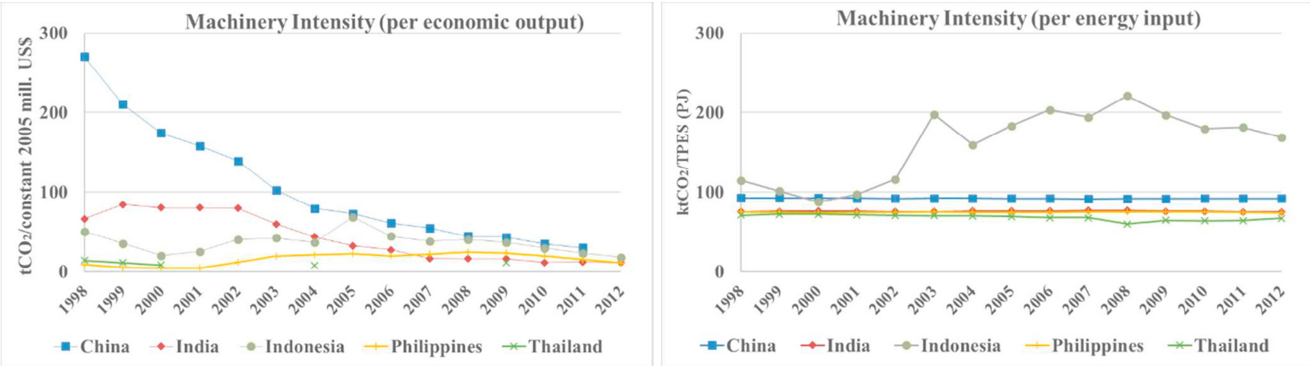

Fig. 7-8. Machinery emissions intensity tCO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

The emissions intensity in the Chemical and Petrochemical industry (fig. 5-6) shows Indonesia being the most emissions intense country per economic output, surpassing China by 2 times and India by 3 times. However, emissions intensity per energy input shows China, India and the Philippines being the most emissions intense countries with Indonesia and Thailand having approximately 35% lower intensity, due to their use of natural gas.

Similarly, the trend of Chinese emissions intensity per economic output for the Machinery industry (fig. 7-8) presents a declining trend, following a stable rate from 1998 to 2011. However it is the most emission intense country per economic output, averaging a 30% higher rate than India for 2008-2011. The rest of the examined countries present a high convergence since 2007. All countries apart from Indonesia present very little changes in their emissions intensity per energy input. Indonesia presents 50-60% higher emissions intensity than China, due to relying on gas/diesel fuel compared to the Chinese more diverse fuel mix.

Figures 9-10 present the emissions intensity of Non-Metallic minerals; mainly cement. Examined on an economic output basis, the most intense countries are Thailand and the Philippines. They have a significantly higher intensity than China by almost 4 and 2 times respectively. India has the highest emissions intensity per energy unit, but its difference to China is quite narrow averaging at 13%. Both countries rely mainly on bituminous coal in their fuel mix.

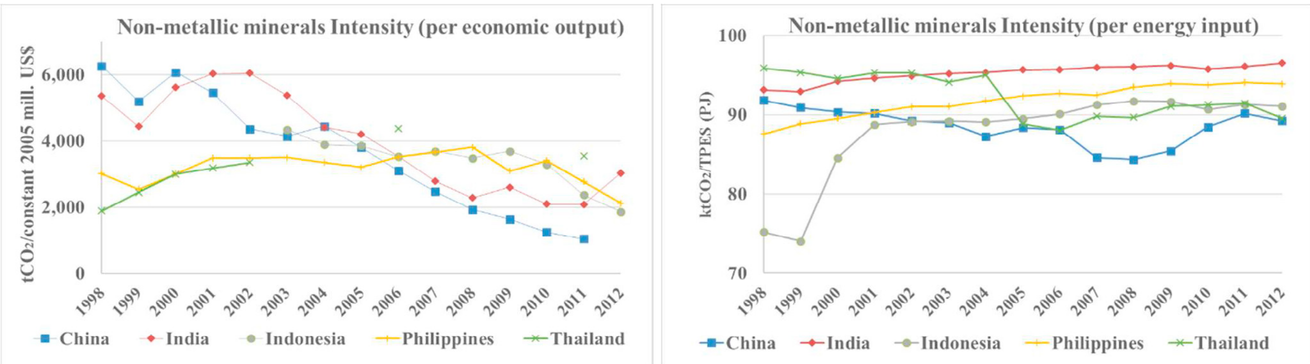

Fig. 9-10. Non-metallic minerals emissions intensity tCO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

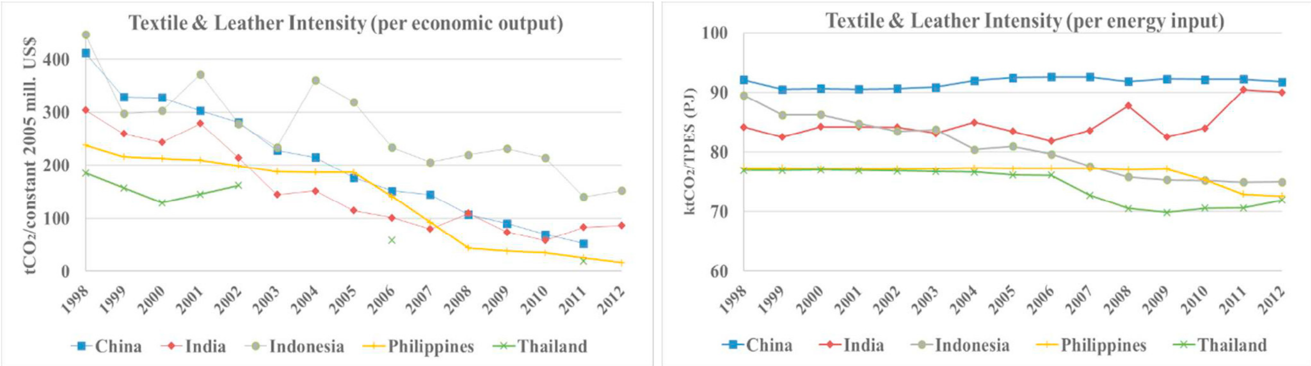

Fig. 11-12. Textile & Leather emissions intensity tCO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and Thailand 1998-2012. Data Source: [25,28,29]

In Textile & Leather industries, Indonesia has the highest emissions intensity per economic output (fig. 11-12), approximately 55% higher than India, 3 times higher than China and 6 times higher than the Philippines. China and India have the highest emissions intensity. Their difference to Indonesia, the Philippines and Thailand is a result of excessive use of coal products (lignite, other bituminous) in their fuel mix which increase their CO_2 emission intensity.

Carbon dioxide per economic output in the paper, pulp and print industrial sector (fig. 13-14) presents mixed emission intensity between the examined countries throughout the period of 1998-2012. However, China's intensity per economic output has been in continuous decline and was surpassed by India in 2009. India retains the highest intensity, almost 3-fold higher, than Indonesia. China, India and Indonesia's intensity per energy input convergence implying technological and fuel mix convergence.

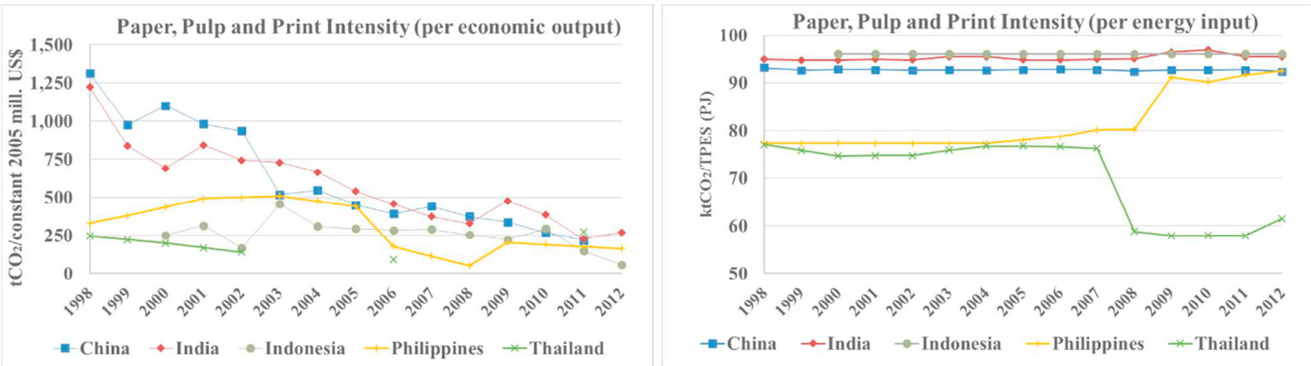

Fig. 13-14. Paper, Pulp and Print emissions intensity tCO_2/million US$ 2005 and $ktCO_2$/PJ timeline of China, India, Indonesia, the Philippines and
Thailand 1998-2012. Data Source: [25,28,29]

4. Conclusions

Potential relocation of industrial activities from China to India and SE Asian countries is likely to alter the emissions output in different ways depending on the industrial sector in focus. In this manuscript, we focused on the impact of this potential relocation on regional emissions and on the identification of suitable and unsuitable industries for relocation. The pace, intensity and extent of actual industrial relocation taking place among the studied countries has not been the focus of this work but might provide a pathway for interesting further research.

This case is especially pronounced for the Philippines for its emissions intensity per energy input and India for its emissions intensity per economic output. China demonstrates a stable trend of reducing emissions intensity per economic output, despite an overall growth in living standards and non-industry consumer consumption, due to factors such as increased energy efficiency [33,34]. However, its high emission intensity per energy input in many of the industrial sectors is a determinant of technological structure being orientated towards high energy consumption [35].

However, assuming equal demand for economic output, industrial relocation from China to India, Indonesia, the Philippines and Thailand could increase total regional emissions significantly. This presents a challenge, especially in light of the regional INDC commitments toward the Paris Agreement [36]. The industrial sectors for iron and steel, chemical and petrochemical, non-metallic minerals, paper pulp and print and textile and leather present lower emissions intensity per economic output in China than in India and the SE Asian countries examined.

Regional policies might be best suited to maintain an optimal balance between economic development and a stronger driver for technological innovation and knowledge transfer. Regional markets with innovative technologies have the capacity to facilitate progress while not compromising emission control commitments [37]. Further research is necessary to explore the potential learning curves for industrial improvements in emissions intensity across different industrial sectors and the role of factors such as indigenous fuel availability, industrial economies of scale and commitment to emissions reduction. Finally, extended research should additionally focus on the role of industrial electrification and subsequently the electrification options and decisions [38] that are required to control and impact on energy and industrial emissions intensity.

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