

Doctoral Dissertation

Essays on Carbon Dioxide Emissions

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(Summary of Dissertation)

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Global economic activities mainly rely on primary energy resources such as fossil fuels leading to global warming and environmental degradation. CO₂ emissions from fossil fuel sources comprise nearly 58.8% of greenhouse gas emissions (Bacon and Bhattacharya, 2007). Many countries have been participating in international cooperation agreements such as the 2016 Paris Agreement to control emissions and the United Nations Sustainable Development Goals to transition toward a sustainable economy. The global community strives to substitute cleaner and greener sustainable renewable energy sources, such as hydropower, wind, solar and geothermal, to improve environmental quality and address the energy insecurity issue. Acknowledging that climate change has threatened humankind, many governments, academicians, and business people explore the associated factors and the remedies for reducing CO₂ emissions. The main objective of this study is to investigate the beneficial roles of renewable energy and environmental innovation in reducing the aggregate level and sectoral level CO₂ emissions and specify the sectoral EKC phenomenon in multiple economic sectors in developed and developing countries.

Emerging countries generally strive for economic growth with massive use of non-renewable energy sources. Therefore, they need urgent attention to address pollution by transforming it into a more sustainable economy and promoting renewable energy sources. While the literature investigates the association between energy consumption and CO₂ emissions (Wang et al., 2016; Magazzino, 2016), some studies focus on the role of renewable

energy in mitigating CO₂ emissions (Omri, 2020; Bekun et al., 2019). However, there have been no extensive works on how the prevalence of renewable energy usage alters the responses of CO₂ emissions to an energy consumption shock in emerging countries. To fill this gap in the literature, our first study investigates how the dynamic responses of CO₂ emissions to an energy consumption shock rely on the prevalence of renewable energy use in the short and medium term in emerging countries. Our findings of the first study revealed that the responses of CO₂ emissions to an energy consumption shock are significant in countries with a low prevalence of renewable energy. In contrast, the responses of CO₂ emissions are insignificant in countries with a high prevalence of renewable energy. Our first study suggests that renewable energy consumption offers emerging countries a “double dividend” by ensuring sustainable economic development while fulfilling energy demand and mitigating environmental degradation.

Multiple economic sectors have different features depending on the energy requirement, availability of energy sources, resource endowment, and technological advancement representing diversified income-emissions linkages. Thus, this fact calls for a thorough study of sectoral Environmental Kuznets Curve (EKC) analysis to implement sectoral environmental policies and regulations for addressing sectoral emission issues effectively. Although some empirical studies examine the income-emissions relationship at the sectoral level, these studies focus on specific sectors (Hashmi et al., 2020, for the service sector; Answer et al., for the

residential sector) for specific countries (Wang et al., 2017, for China; Aslan et al., 2018, for the United States), and a specific group of countries (Pablo-Romero and Sanchez-Braza, 2017, for the European Union; Raza et al., 2020, for 16 emerging countries). To contribute to the existing environment and development literature studies, we examine the long-run equilibrium sectoral income-emissions nexuses in seven economic sectors incorporating both developed and developing countries. Our findings of the second study show that the EKC exists for three sectors: the other energies industry own use, the electricity and heat production, and the commercial and public services sectors. Additionally, sectoral emissions are negatively linked with per capita incomes in the agriculture, forestry, and fishing, the manufacturing industries and construction, and residential sectors. In contrast, sectoral emissions have a positive association with the income level of the transport sector. Our second study reveals that different economic sectors have diverged income-emission patterns, which require policy interventions at the sectoral level to cope with pollution issues effectively.

Today, “technological innovation” is an important agenda for enhancing energy efficiency, reducing pollution, and achieving sustainable development (Amri et al., 2019). Remarkably, the development of environment-related technologies through environmental innovation tools, often captured by patents, are crucial for combating the climate change issue (Mongo et al., 2021; Zhang et al., 2017). Environmental innovation is mainly associated with manufactured products and processing activities. More importantly, the manufacturing sector

plays a crucial role in global economic activities by applying enormous use of primary energy sources leading to causing adverse effects of environmental degradation. It is noted that countries with diverged income levels signify different capabilities to utilize the benefits of environmental innovation to improve environmental quality due to technology and resource gaps. A handful of studies examine the association between environmental innovation and sectoral level CO₂ emissions in individual countries or groups of countries. For example, Zhang et al. (2016) find a negative association between industrial sector CO₂ emissions and environmental technology in China. In contrast, Cakar et al. (2021) prove the positive relationships between environmental innovation (patents and trademarks) and transport sector CO₂ emissions in developed and developing Mediterranean countries, respectively. Distinct from the existing studies, our third study explores the role of environmental innovation in mitigating CO₂ emissions in the manufacturing sector in two diverged income-group countries, advanced and emerging countries, which makes this study a novel one in contributing to the existing literature on the context of innovation and environmental studies. Our findings of the third study highlight that the long-run relationship between environmental innovation and CO₂ emissions in the manufacturing sector is significant for advanced countries. In contrast, the long-run innovation-emissions nexus is insignificant for emerging countries. Our third study presents that environmental innovation plays a crucial role in reducing emissions in countries. Therefore, it is vital to maintain the harmonized

development of green technologies among countries with different income levels through technology transfer.

In conclusion, policymakers should focus on transitioning towards sustainable renewable energy use to deal with energy security issues and mitigate CO₂ emissions in emerging countries. In addition, the regulators should consider adopting sector-specific environmental policies based on each sector's unique income-emission relationship to combat climate change issues and build a resilient and green economy. More importantly, the policymakers in both advanced and emerging countries should encourage the development of environment-related technologies via green technology transfer. Last but not least, they should strengthen regional and international cooperation activities to transfer green technology from developed economies to emerging and developing economies through international carbon-mitigation programs, including the Clean Development Mechanism (CDM) under the Kyoto Protocol. The dissertation is organized as follows. Chapter 2 presents a comprehensive view of the crucial role of renewable energy in causing diverse responses of CO₂ emission to energy consumption shock, i.e., "Responses of CO₂ emission to energy consumption shock in emerging economies: the role of the prevalence of renewable energy". Chapter 3 reports the profound insights on sectoral EKC analysis, i.e., "Investigating whether the environmental Kuznets curve hypothesis holds for sectoral CO₂ emissions: Evidence from developed and developing countries". Chapter 4 discusses the study on environmental

innovation as a contributing factor to improving environmental quality titled “Environmental innovation and environmental degradation: Evidence from the manufacturing industries and construction sector in advanced and emerging economies.” The last Chapter provides some conclusions.