Article submitted to the Proceedings Book of the VIth. International Symposium–2022, *Theme: "Biosphere & Environmental Safety"*	Biosphere and Environmental Safety VI.th International Symposium-2022	ISBN: 978-963-449-285-6 Online May 5-6, 2022 ICEEE, Óbuda University, Budapest, Hungary

ECO-INNOVATION AND ENVIRONMENTAL AND ECONOMIC MANAGEMENT

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The concept of eco-innovation has begun to be considered as a solution to preventing environmental damage, since the 1990s. However, the effect of eco-innovation on environmental and financial performance has received limited attention. Eco-innovation is defined as new ideas, behavior, products, and processes that contribute to a decreased environmental burden as well as the economic management. Eco-innovation is expected to reduce amounts of environmental wastes in soil and water, air pollution, and material resource usage from economical point of view. However, the effect of eco-innovation on environmental and financial performance has received limited attention. Eco-innovation is considered as effective tools as it enhances energy efficiency and cleaner production, which in turn lowers carbon emission. Quality institutions have been considered as it enhances the quality of environment. Green technology innovation is essential to reducing the pollution emissions of enterprises. Under stronger environmental regulation, import trade has a significantly positive effect on green technology eco-innovation. Environmental regulation can enhance the technology spillover effect of import trade in high absorptive capacity regions and high R&D investment regions. How does environmental regulation affect green technology eco-innovation? Under different levels of environmental regulation, do the import trade behaviors of enterprises have different impacts on green technology eco-innovation? What influencing mechanisms are involved? The work of this thesis will try to answer these questions. How environmental regulation affects green technology eco-innovation needs more discussion. Moreover, few scholars have analyzed how environmental regulation affects green technology innovation from the perspective of import trade. The results of this paper show the following: First, there is a nonlinear relationship between environmental regulation and green technology innovation. When environmental regulation intensity is lower than the inflection point, environmental regulation will promote green technology innovation; when environmental regulation intensity is higher than the inflection point, environmental regulation will inhibit green technology innovation. Second, environmental regulations affect the technology spillover effects of import trade. When stricter environmental regulations are in place, import trade can significantly promote regional green technology innovation. Third, there is significant regional heterogeneity in the impacts of environmental regulation on the technology spillover effects of import trade. In regions with high levels of absorptive capacity and high R&D investment, the interaction between environmental regulation and import trade has a significantly positive effect on green technology innovation. This paper analyses the nonlinear relationship between environmental regulation and green technology innovation and discusses which kind of environmental regulation intensity is most beneficial to green technology innovation.

***Keywords**: eco-innovation, environmental management, economic management*

INTRODUCTION

The achievement of sustainable economic growth and green growth is the critical policy of many countries worldwide, and they are trying to eliminate this environmental pollution in their countries. To develop green growth strategies for emission control, it is necessary to adopt new technologies that reduce environmental pollution. Globally, many countries are trying to achieve carbon (C) neutrality targets by using environment-friendly technology and green growth. This study investigates the impact of green growth, income, environmental taxes, environment-friendly technology, renewable energy, and financial development. Environmental degradation can be controlled by environment-friendly technologies, renewable energy resources, and green growth strategies.

The combined effects of climate change, land degradation, cropland losses, water scarcity and species infestations may cause projected yields to be 5-25% short of demand by 2050, and 600 million additional people could be affected by malnutrition as a direct result of climate change by 2080. The rapid increases in ecological footprint and air pollution have followed the fast expansion of the global economy. Population and income growth, urbanization, changing consumption patterns, stagnant yields, demand for land, feed, and biofuels, and the impact of climate change, biodiversity loss and environmental degradation are driving limited resources of food, energy, water and materials towards critical thresholds. Additionally, various factors, e.g., energy supply security, energy dependency, climate change, energy price volatility, and environmental disasters, encouraged many developed and emerging economies to divert their attention to green growth and sustainable economic growth.

The adoption of green growth strategies and technologies is playing an inevitable role globally, and protecting the environment and natural resources is essential for future generations because future generations must be provided with a pollution-free environment. Sustainable economic growth and poverty reduction objectives can be achieved through green growth strategies.

The concept of eco-innovation has begun to be considered as a solution to preventing environmental damage, especially since the 1990s. Eco-innovation is expected to reduce amounts of environmental wastes in soil and water, air pollution, and material resource usage from economical point of view. However, the effect of eco-innovation on environmental and financial performance has received limited attention (Liu et al., 2022). There are three main reasons for conducting this study:

The first is concern about the need to reduce environmental impacts. The concept of eco-innovation emerges when business practices are harmonized with environmental expectations. Eco-innovation is defined as new ideas, behavior, products, and processes that contribute to a decreased environmental burden (Rennings, 2000). While factors such as global agreements, market conditions, technologies, and regulations have important implications for the environment, eco-friendly investment can still be considered an additional charge for companies. New technologies have significantly changed production concepts. It has been a matter of curiosity to us how this situation will change financial and environmental performance. There is ambiguity as to whether eco-innovation creates a positive environmental and financial contribution. Since businesses are economic units, cost must be the priority in all their investment decisions. Therefore, determining whether eco-innovation meets economic expectations as well as environmental expectations is of great importance to decision-makers.

A second reason for this study is to explore this question. However, Porter & Linde (1995) claim that these investments can be turned to an advantage through eco-innovation. Porter's hypothesis has been corroborated in terms of eco-product innovation by the research of Cleff & Rennings (1999). Horbach et al. (2012) determined that the cost saving is a motivation for the introduction of eco-innovation. Cheng et al. (2014) illustrated the influence of eco-innovation on financial performance. Costantini et al. (2018) identified that eco-innovation, which directly reduces the environmental impacts of production, also creates an indirect positive environmental impact in other sectors through intermarket transactions. There are some studies showing that eco-innovation affects performance, the literature evaluating the effect of eco-innovation on performance is insufficient (Munodawafa & Johl, 2019).

Within the scope of the study, we investigate the effect of eco-innovation on the performance of companies. Researchers investigate different aspects of eco-innovation in the literature. While eco-innovation has been measured as eco-product and eco-process innovation by Horbach et al. (2012) and Rennings & Rammer (2011), it has been measured as eco-product, eco-process, and eco-organizational innovation by Cheng & Shiu (2012), Cheng et al. (2014), and Rennings et al. (2006). A large part of the literature on eco-innovation is about product, process, and organization (García-Granero et al., 2018). As distinct from these studies, it was consider eco-innovation in terms of "eco-product," "eco-process," "eco-organizational," and "eco-marketing," from a holistic perspective. On the other hand, the impact of eco-innovation on financial and environmental performance has not been thoroughly researched in developing countries. A significant number of eco-innovation studies have been conducted in developed countries by Horbach et al. (2012) and Lee & Min (2015).

The third reason for this study is to contribute to filling this gap. Thus, the aim of this research work is to determine the impact of eco-innovation on environmental and financial performance in a developing country and contribute to the Porter's hypothesis.

RESEARCH HYPOTHESES

H1: Eco-innovation has positive effects on increasing economic performance.
H2: Eco-innovation has positive effects on increasing cost performance.
H3: Eco-innovation has positive effects on increasing resource saving.
H4: Eco-innovation has positive effects on pollution prevention.
H5: Eco-innovation has positive effects on increasing recycling.
Overall, these research hypotheses enable the study to determine the effects of eco-innovation on performance. Eco-innovation improves businesses' economic (H1) and cost (H2) performance. These factors are considered as financial performance in the study. Moreover, eco-innovation improves businesses' environmental performance (H3, H4 and H5). Environmental performance is evaluated as resource saving, pollution prevention, and recycling in the study. Accordingly, a research conceptual model is presented in Figure 1.

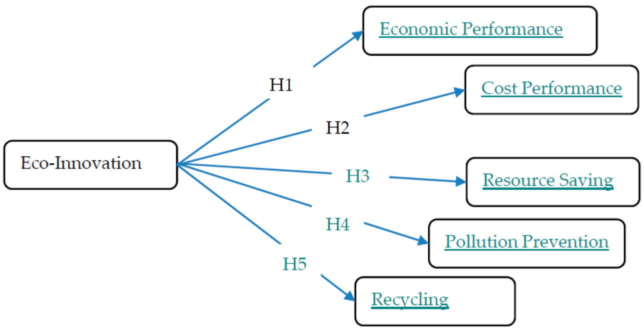

Figure 1. Conceptual model

In line with this research, it will be clarified whether eco-innovation will create financial benefits along with environmental benefits within the framework of economic and cost performance, resource saving, pollution prevention, and recycling. It has been determined that research in this area is inadequate in developing countries. Drawing on these insights and the identified research gap, this diplom-research work seeks to understand whether eco-innovation has an impact on the environmental and financial performance.
Measuring environmental issues on sustainability and their influence on economic, social, and human wellbeing becomes clear; particularly while considering both economic growth and quality life together (Jordan et al. 2010). Quality of life-wellbeing could be compromised due to some socioeconomic and environmental factors, i.e., inequality, poverty, and environmental change, etc. At present, the growth scenario has failed to address environmental pollution and income inequality issues that hamper the sustainability of the environment (Zhao et al. 2021). Conversely, objective wellbeing takes account of fundamental economic, social, and environmental essentials, therefore, directly measurable (Talberth et al. 2007).
Sustainable development is termed as satisfying human needs without compromising natural and social capital. Therefore, the goal of sustainability is to achieve wellbeing by preserving the natural environment. There are different schools of thought in environmental sociology regarding the interactions between economic growth, degradation of the environment, and wellbeing. Modernization theories, including economic and ecological modernization, are in favor of the positive role of economic growth in achieving sustainability and wellbeing (Knight & Rosa 2011).
Urbanization means shifting rural population to urban areas for better living standards (Wang et al., 2020a, 2020b, 2020c), which is closely linked with environmental pollution (Wang et al., 2018a, 2018b, 2018c). Industrial activity in urban areas attracts more people for jobs, leading to increased

population density in the cities. Due to urban agglomeration in different cities, it demands more energy, groundwater, and land, which in turn affects the environment and air quality of urban population. As the urban area population increases, it may extract natural resources and severe impact on the ecosystem by reducing the carrying capacity (Coffin, 2007). However, urban expansion still has a titrative effect on emissions in order reduce the environmental impact it should to switch its activities from metropolitan areas to marginal regions (Wang et al., 2018a, 2018b, 2018c).

Similarly, economic growth may harm the ecology and air quality of a country (Ahmad et al., 2021). The growth of country depends on the scale production of goods and services, and it has a closely link with energy consumption and efficient technology (Plank et al., 2020). The different modes of urbanization may thus have different types of urbanization PM2.5 pollution roles. Therefore, it is important to recognize the various impacts of different urbanizations Factors related to PM2.5 and carbon dioxide (CO_2) emissions (Zhu et al., 2019).

The relationship between economic growth and air pollution has long-standing debate among the researchers. The pioneered work by Grossman & Krueger (1991) was the first study to examine the Environmental Kuznets Curve (EKC) empirically and found its existence. Globalization helps developing nations to deal with the rest of the world by improving their economic development and addressing their nation's deprivations (Kabeer, 2004).

Endogenous growth theory believes that innovation is the most important source of productivity growth, and a large volume of empirical research has proved that innovation has a significant and positive effect on productivity growth (Baumann & Kritikos 2016; Lopez-Rodriguez & Martinez-Lopez, 2017). In recent years, there has been a growing body of studies paying attention to the influence of innovation on green total factor productivity (GTFP). However, the extant research conclusions regarding the relationship between innovation and GTFP are relatively mixed. Most empirical studies show that innovation is a critical driver of GTFP growth. Additionally, several studies proved that different types of innovations had distinct influences on GTFP. Cheng et al. (2018) used China's manufacturing panel data to test the effects of three different types of research and development (R&D) investment (i.e., independent R&D, domestic technology introduction, and foreign technology introduction) on GTFP and found that there was a significant industrial heterogeneity in the effects of various kinds of R&D investment on the green growth of China's manufacturing. More recently, some scholars realized that the relationship between innovation and GTFP may be non-linear. That is, the effect of innovation on GTFP would be contingent on other factors. However, the estimation strategy of constructing a linear interaction term between technological innovation and environmental regulation cannot effectively solve the problem of a structural break in the impact of innovation on GTFE (Huang et al. 2019a; Zhou et al. 2019).

DEFINITIONS AND CONCEPTS OF ECO-INNOVATION

Eco-innovation is the process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact (James, 1997). Eco-innovation is one of several approaches towards sustainable design. The concept of eco-innovation was first developed by Fussler & James in 1996 and defined as the reduction of negative environmental impacts while providing new products and processes as a benefit to the customer and the business (Hojnik & Ruzzier, 2016). Eco-innovation contributes to environmental responsibility and sustainability goals through the realization of new ideas, behavior, products, and processes (Rennings, 2000). Arundel & Kemp (2018) described eco-innovation as a new or significantly improved product, process, or business method that helps to reduce environmental risks, pollution, and the negative effects of resource use instead of traditional methods that do not take into account environmental impacts. Schumpeter (2017) defined innovation as a new product, process, or method of production; a new market or source of supply; or a new form of commercial business or organization. Thus, eco-innovation differs from traditional innovation practices because of the environmental perspective.

The resource-based view (RBV) asserts that the maintaining of firms' competitive advantage lies in it having heterogeneous resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). The resource-based view (RBV) provides a valid theoretical basis for examining the relationship between resources, capabilities, and performance. This theory provides a holistic view of eco-innovation (Cheng et al., 2014). Hart (1995) argued that RBV involves an omission since it systematically ignores the natural environment. This omission rendered the existing theory insufficient to identify sources of competitive advantage. Thus, Hart (1995) developed the natural-resource-based view (NRBV) of the firm to overcome this shortcoming. Hart (1995) indicated that strategy and competitive advantage are rooted in capabilities that facilitate environmentally sustainable economic activity. Businesses that develop their skills toward addressing environmental problems in the face of natural environmental challenges will achieve a competitive advantage. This results in lower production costs. Along with pollution prevention and product stewardship capabilities, businesses should work on introducing cleaner production methods. Developing or using cleaner production technologies requires companies to have eco-innovation capability (Munodawafa & Johl, 2019). Most OECD (Organisation for Economic Co-operation and Development) countries recognize eco-innovation as an important solution for today's environmental challenges such as climate change and energy security. In addition, many countries are considering eco-innovation as a source of competitive advantage in the market of rapidly growing environmental products and services (Ekins, 2010)

Eco-innovation is valuable by companies seeking for a way to reduce negative environmental impacts whilst creating a positive competitive advantage. While eco-innovation was handled by Rennings & Rammer (2011) and Horbach et al. (2012) through the subcategories of eco-product and eco-process, it was considered by Cheng & Shiu (2012), Cheng et al. (2014), and Rennings et al. (2006) as eco-product, eco-process and eco-organizational innovation.

Eco-product innovation refers to the reduction of environmental impacts through the significant improvement of new or existing products or services (Reid & Miedzinski, 2018). This innovation aims to reduce environmental impacts (Cheng et al., 2014), improve environmental performance, meet the market's environmental expectations, and increase resource efficiency whilst achieving optimal environmental benefits in the whole product life cycle (Dong et al., 2014). Cleff & Rennings (1999) conducted research in the German industry to determine the dynamics of eco-product and process innovations. Data were collected from the Mannheim Innovation Panel and a telephone survey. Multivariate analysis findings indicated that more than 50% of the companies were focusing on environmental product innovation and there was a significant relationship between environmental products and market objectives.

Eco-process innovation, which requires a change in business processes and systems (Cheng et al., 2014), increases productivity, reduces greenhouse gas emissions, and reduces resource costs (Kemp & Arundel, 1998). Additionally, it replaces harmful inputs, optimizes the production process, and reduces the negative effects of production output. Clean production, zero emissions, zero waste, and material efficiency are realized within the scope of this kind of innovation (Sehnem et al., 2016). Horbach et al. (2012) illustrated that energy and cost savings are the main motivation of the eco-process.

Eco-organizational innovation refers to the business method, process redesign, and responsibilities within the company to reduce environmental impacts (Rennings et al., 2006). This innovation contributes to the technological development of the company and supports the technological innovation factors (Frondel et al., 2007). The business method is the way of doing business in organizations and supports the emergence of product and process innovations; thus, it is important for creating a positive environmental impact. As a result of research conducted for 245 companies in China, Dong et al. (2014) found that eco-organizational innovation had a significant effect on environmental performance and competition. Eco-organizational innovation offers the required infrastructure to gain an environmental perspective and implement innovative applications.

Eco-marketing innovation involves all dimensions of product design or packaging, product placement, product promotion, and prices. According to this, the techniques that lead people to buy eco-innovative products are the main subject of eco-marketing innovation (Sehnem et al., 2016). The buying decision of customers is not only affected by cost, quality, and delivery, but also by the firm's green image and sustainability. Despite its importance, eco-marketing innovation is one of the least emphasized eco-innovation types in the literature (García-Granero et al., 2018). The business may fail because the market is not ready to accept the use of eco-innovative products since these products are not adequately promoted to customers or the eco-marketing activities are inadequate (Fisk, 2010). Characterizing a new product or service as an innovation depends on market success.

Marketing plays an important role in changing consumer behaviors towards ecological products, raising consumers' awareness of resource-saving products, and transferring the benefits of products with reduced environmental impact to consumers. With eco-marketing, consumer-buying behavior is affected in the desired direction and the product can hold on to the market. Therefore, eco-marketing innovation plays an important role in the success of eco-innovation applications.

Porter & Linde (1995) argued that the environmental investments imposed by environmental regulations are seen as costly by companies, but it is possible to turn this into an advantage with eco-innovation. Accordingly, innovative solutions bring about material and energy productivity and reduce the costs incurred by environmental investments. In another study by Cleff & Rennings (1999), the Porter hypothesis is only validated within the scope of product innovation. Pujari (2006) revealed that a new eco-product influences the marketing performance in North American companies. Similarly, Setiawan, et al (2019) determined a positive impact of eco-innovation on marketing performance for Indonesian food SMEs (Small & medium-sized enterprises). Eco-organizational innovation has a positive effect on financial performance in German companies according to Rennings et al. (2006). Aboelmaged (2018) indicated that eco-innovation has a direct impact on hotel performance in the United Arab Emirates. Accordingly, decision-makers can contribute to the hotel's financial (market share, sales) and nonfinancial (image, loyalty) performance through eco-innovation. Rabadan (2019) determined that cooperation in the development and use of eco-innovation is important for performance in the small Spanish companies. Accordingly, companies can improve the sales, profitability, and cost reduction through eco-innovation. Doran & Ryan (2012) found that eco-innovation is more important than non-eco-innovation in determining the Irish company's performance. Cheng et al (2014) and Cheng & Shiu (2012) argue that all eco-innovation types contribute to the financial performance composed of return investment, profits, market share, and sales. Zhang et al. (2019) revealed a positive and significant relationship between green innovation and company performance, as measured by net profitability and growth sales in Chinese manufacturing companies. Despite all these findings, Ghisetti & Rennings (2014) determined that eco-innovation has no profound effect on profitability in the German industry. This is supported by the literature finding that eco-innovation provides positive financial outcomes. It was considered that eco-innovation as economical; the following hypotheses are proposed.

Eco-approaches bring the advantage of economic savings based on sustainable mobility and resource productivity. Accordingly, eco-innovations create a positive environmental benefit along with economic savings. Business methods, products, and processes that decrease environmental impacts lead to a reduced ecological footprint. Eco-innovation ensures the reuse of waste or prevents waste at the beginning of the production process. Eco-innovation applications are aimed at reducing costs or material consumption, minimizing management costs, and utilizing energy and resources more efficiently. These produce a longer product life and financial and environmental benefits (Authority & Alle, 2012).

Eco-efficiency practices caused by eco-innovation create less resource use in terms of products and services, as well as less waste and pollution (Carrillo-Hermosilla et al., 2010) As a result of eco-innovation, internal costs and material consumption are reduced, management costs are minimized, and energy and resources are used more efficiently. Eco-innovation brings about a positive environmental impact along with resource saving (OECD, 2012).

According to the study conducted by Lee & Min (2015) on the Japanese production industry, eco-innovation applications seem to reduce carbon emissions and improve financial performance. Dong et al. (2014) revealed that eco-organizational innovation is most common in Chinese companies, followed by eco-process, product, and end-of-pipe innovation. The results of the research illustrate that all types of eco-innovation have a significant effect on environmental performance and competitiveness. Costantini et al. (2018) determined that eco-innovation is effective in the transition to a sustainable low-carbon economy for production companies in EU countries. According, the eco-innovation directly and indirectly affects the reduction of environmental pressures. The power of this effect differs in the entire supply chain depending on the type of technology used and the level of pollution. As a result of their work to explain the relationship between eco-innovation and "eco-preneurship" Collaboration between eco-preneurs, consumers, and producers leads to long-term sustainability. Fernando & Wah (2017) argue that eco-innovation creates a positive environmental impact. As a result of their study of Malaysian GreenTech companies, they identified a positive relationship between eco-innovation dynamics and environmental performance.

Accordingly, market focus, regulation, and technology positively affect environmental performance. Thus, eco-innovation improves business sustainability. It was explained that environmental performance through resource saving, pollution prevention, and recycling dimensions. According to the literature, eco-innovation has the potential to contribute to environmental performance, so it creates positive environmental effects. Environmental impact can be estimated through evidence and should not be made on assumptions, and these need to be based on a robust understanding of the socio-economic effects of public and industrial intervention. Innovation is expected to diminish amounts of waste, air pollution, and material resource exhaustion and to increase the reuse of other materials, in order to facilitate in the successful transition to circular economy.

CIRCULAR ECONOMY AND BLUE ECONOMY

Waste volumes can be looked on as a resource. Such thinking would also lead us closer to solving the problem of waste. The concept of waste management is alone becoming insufficient for solving waste problems and is even likely to be replaced with the concept of resource management in the future. The circular economy is a regenerative system in which resource input and waste, emissions and energy leakage are minimized by slowing, closing and narrowing energy and material loops. This can be achieved via long-lasting design, maintenance, and repair, reuse, remanufacturing, refurbishing, recycling and up-cycling. This contrasts with the linear economy, which is a 'take, make, dispose' model of production (Figure 2).

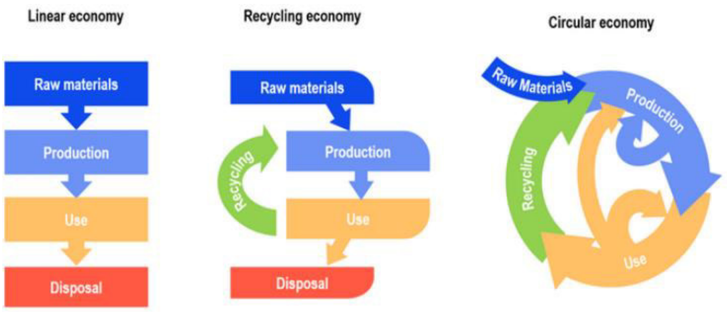

Figure 2. From linear economy to circular economy (Source: https://theconversation.com/the-planned-national-waste-policy-wont-deliver-a-truly-circular-economy-103908)

The circular economy is based on three following principles:
Design out waste and pollution
Keep products and materials in use
Regenerate natural systems

ENVIRONMENTAL INNOVATION

Environmental degradation is an important issue in the field of economics and has got considerable attention from different researchers and economists since decades. Countries are facing major problems of global warming due to continue increase in carbon emission. Several factors have been identified recently that cause environmental degradation where governments are trying to tackle these problems that influence environmental quality by Shahbaz et al. (2013). The impact of trade openness on environment has also explored by enormous researchers in the prevailing studies but got mixed results and conclusions.

Le et al. (2016) illustrate that openness to trade increase carbon emission and degrade environmental quality. On the other hand, Jayanthakumaran & Liu (2012) argue that openness to trade is an important factor that enhances environmental quality through composition, trade and technique effect. It was argued that trade openness positively affects carbon emission, and this effect varies on different levels of carbon emission; however, they show that the indirect effect of trade openness on emission is positive while indirect effect is negative. The impact of innovation on environmental quality has also been debated by several scholars in the preceding literature. Rennings (2000) argues that environmental innovation is a modified process, systems or practices which give benefits to the environment. It was emphasized that innovation increases sustainable development toward cleaner production. Dauda et al. (2019) illustrated that innovation reduces carbon emission. Yuan et al. (2021) studied green innovation and institutional quality on carbon emission. They have found that green innovation reduces carbon emission and that institutional quality has a moderating negative association between carbon emission and innovation. Hodson et al. (2018) noted that energy efficiency is increased by innovation, and then, it in turn reduces carbon emission. While Mensah et al. (2018) studied this association and found inconclusive outcomes for some individual countries in their sample. Additionally, some studies argued that excessive innovation may increase emission; however, if there is strict regulation regarding environmental quality in countries, it will lead to green paradox and will effect economic growth negatively. However, if there is a high potential, it will lower carbon emission though excessive innovation by Huiqing Wang & Wei (2019).

Economic growth has been considered as a key driver of emission over the past several decades. Grossman & Krueger (1995) argue that the relationship of economic growth and carbon emission depicts a U-shaper reversed link. The EKC (environmental Kuznets curve) suggests that there is environmental issue in countries in the early phase of growth by Liang and Yang (2019). On the other hand, some researchers have shown interest in the linkage between financial development and carbon emission such as Shahbaz et al. (2013). Some studies illustrate that an increase in financial development increases carbon emission such as Diallo & Masih (2017), while some argues that financial development is an important factor for economic growth of a country. Likewise, some environmental economists argue that financial development enhances the quality of environment because well-structured financial institutions with sound policies provide support to green technological innovation and renewable energy projects, which are useful to protect environmental quality. However, some authors support the negative impact of financial development on environmental quality such as Lee et al. (2015); Khan et al. (2020a, b); Jiang & Ma (2019).

Likewise, the impact of foreign direct investment on carbon emission has also been investigated widely by several researchers.

Some researchers show that the inflow of foreign direct investment is harmful for environmental quality such as Zhu et al. (2019); however, some researchers state that the inflow of foreign direct investment (FDI) reduces emission by Huang et al. (2019). Institutional quality is another crucial factor that positively contributes to environmental quality. Normally, environmental degradation in developing countries is associated with the poor quality of institutions such as political institutions because poor level of institutions weakens the regulations regarding environment by showing a bias implementation of environmental regulation and policies. The institutions and governance might be required to efficiently explore the trade environment relationship (Bekhet et al., (2020) as institutions of a country play an important role to provide policies related to trade, which might be helpful to protect environmental quality. A lot of researchers are in favor of positive impact of institutional quality on environmental quality such as Ali et al. (2019) and Ibrahim and Law (2016) argue that high-quality institutions and good governance enhance the quality of environment. Wu et al. (2021) illustrated that quality institutions above the threshold level do not contribute significantly for environmental deterioration in spite of growing transportation and increasing industrialization. Based on the ongoing debate on trade environment relationship, the current study explores the association of innovation, quality institutions and trade openness with carbon emission. Therefore, it has been a challenge for the government and policy makers of a country that how to protect the quality of environment as well to ensure higher economic growth through trade openness. The findings of Khan et al. (2022) showed that trade openness have a negative impact on carbon emission in our sample and models in the presence of innovation and institutional variables. We also explore the role played by institutions in this association to know whether the quality of institutions is important to protect and enhance environmental quality as well to achieve the economic growth in the presence of high level of trade.

INNOVATION AND CO_2 EMISSION

Europe is the world's third-largest carbon emitter after China and the USA. However, it takes steps for environmental protection by implementing effective limitations on greenhouse gases. The ecological concerns of the central-eastern region are quite similar to pan-European ones. The most important of them is climate change, caused by CO_2 emissions increasing the greenhouse effect in the atmosphere. These are expected to be 50% higher than preindustrial levels by 2030, with a temperature rise of 1.5 to 4.5°C (Qiang et al. 2019).

Innovation has been considered one of a new factor in the growth environment nexus, and it has been argued that it significantly contributes to environmental quality. For instance, a study conducted by Hodson et al. (2018) states that innovation reduces carbon emissions owing to efficient use of energy and cost-effective ways to lower the emissions of carbon dioxide. Similarly, Cagno et al. (2015) have conducted a study where they illustrate that innovation advances the efficiency of energy and thus reduces the use of nonrenewable energy use, which in turn reduce pollution. Alvarez-Herranz et al. (2017) studied the nexus between economic growth, innovation and carbon emission. They state that innovation helps move the economy to the use of sustainable energy sources and production.

Likewise, Cai and Zhou (2014) argue that innovation is an important factor which helps mitigate environmental pollution. Countries are trying to enhance innovations to response climate changes Carraro & Siniscalco (1994). However, on the other hand, Dauda et al. (2021) have studied innovation, carbon emission and trade openness in African countries for the period of 1990–2016. They have employed fixed-effect and GMM models where their findings validate an inverted U-shape association between carbon emission and innovation at the panel level in some countries, while renewable energy use reduces emission in the panel. They also found that human capital reduces carbon emission in some individual countries as well in the panel. Their results also confirm pollution haven hypothesis, halo effect and environmental Kuznets curve. Similarly, Mushtaq et al. (2020) have studied the impact of economic growth and income inequality on carbon emission in China through the moderating role of innovation at regional and national levels. They have collected data for the period of 1995–2015 and employed panel econometric techniques. They found that income inequality and economic growth affect carbon emission in China where innovation has a moderating role in this association. Consequently, Tobelmann & Wendler (2020) have studied the impact of innovation on carbon emission in EU-27 countries for the period of 1992–2014. They have employed GMM model and proxies patent application for innovation. They found that innovation has no contribution to reduce carbon emission, while general innovative activities do not influence carbon emission. They further indicate that this effect might be small comparatively to the effects of increased economic activities. They also conclude that the effect of innovation varies across different countries and regions with less developed countries showing higher level of heterogeneity. Likewise, Cansino et al. (2019) have studied technological progress and quality institutions on environment. They have found that income and greenhouse gas emission are adjusted to traditional EKC hypothesis. They states that technological progress and quality institutions enhance environmental sustainability, while foreign direct investment (FDI) and international trade have a negative impact on environment.

ECONOMIC GROWTH AND CARBON EMISSION

Over the last few decades, environmental deterioration has accelerated significantly. Environmental degradation has been a subject of research across the world because of its impact on billions of people. However, there has been no international agreement on lowering the utilization of energy and CO_2 emissions (CO_2), while demand for fossil fuels grows in emerging economies. On the other hand, the recent COP26 summit brought all parties together to accelerate action toward reaching the goals of the Paris Agreement and the UN Framework Convention on Climate Change. Although previous research shows that international trade promotes positive socioeconomic outcomes, other experts argue that it contributes to natural resource shortages and ecological deterioration. Thus, the current research considers the effect of international trade, renewable energy use and technological innovation on consumption-based carbon emissions (CCO_2), coupled with the role of financial development and

economic growth in the BRICS economies between 1990 and 2018. Moreover, this research utilizes the common correlated effects mean group (CCEMG), augmented mean group (AMG) and Dumitrescu and Hurlin (2012) causality methods to assess these interrelationships.
The relationship between environmental quality and economic growth is widely studied by large number of researchers by using EKC (environmental Kuznets curve) framework. Based on the EKC framework, real output degrades environmental quality till a certain level of growth and then pollution becomes decreasing when GDP reaches a certain level. Hence, such association is an inverted U-shape Grossman & Krueger (1995). As a result, people of countries demand the government for environmental laws to enhance the quality of environment. Individuals turn to be highly concerned at a higher income level about health issues and hence insist on environmental quality that leads to policy implication to restrain carbon emission and enhance environmental quality. Additionally, if there is a smooth development of the economy composition, which is largely moved from polluted industries to innovative activities and production, as well service-oriented production, the pollution in those countries will have enough minimization. Some other studies have used the absence or presence of EKC using different methods and pollutants. Osobajo et al. (2020) examine the impact of energy consumption and GDP on carbon emission. They employed fixed-effect and OLS models to the data for 1994–2013. They found a bidirectional causal relationship of these variables with carbon emission while unidirectional relationship of energy with carbon emission. The findings of OLS model and fixed-effect model show that GDP and energy consumption increase carbon emission. Abid (2016) has tested environmental Kuznets curve in MENA and European Union counties. They have used GMM model where their findings show a monotonic increasing impact of GDP on carbon emission in both samples. Tamazian & Rao (2010) studied the relationship between economic growth and environmental quality. They have also focused on the impact of financial and institutional quality on environment as well. Their findings support the EKC hypothesis and state that financial development and institutional quality are important for environmental quality development. Since the last few years, the CO_2 emission-economic growth nexus (with other variables) have been discussed internationally with its importance for human wellbeing.

ECODESIGN AND ECO-INNOVATION

Ecodesign aims to reduce the environmental impact of the product throughout its life cycle: from materials extraction, through production processes, packaging and transport, product use phase, and finally to end-of-life disposal. Ecodesign includes the use of quantitative environmental analysis tools such as Life Cycle Analysis (LCA) tools. The results from Ecodesign are limited because it is a design specific activity that focuses on the redesign or optimisation of existing products. The changes to the products tend to be incremental and result only in percentile reduction of the overall environmental impact of the products (Hoed, 1997). Ecodesign can improve a company's competitive advantage by supporting expansion into new markets, through the launch of new versions of products with environmental attributes which consumer's desire.

LIFE CYCLE THINKING

The depletion of some natural resources, rising commodity prices, environmental regulations that constrain the use of the artefact, in line with the requirements of eco-compliance and the need to continually reduce costs are driving companies to seek new ways to optimize their consumption that can be controlled from the design phase through a PLM environment.
Sustainable design is not one-size-fits- all concepts, but must be adapted on the life cycle (Figure 4) profile of the specific product, the business strategy, and the culture and capabilities of the organization. Further, it can be applied to both goods and services (Dobbs & Cormican, 2007). In this study, drawing on the insights of the DATA: Oslo Manual (2005) prepared by the OECD and European Commission, it was evaluated eco-innovation as including the concepts of eco-product, eco-process, eco-organizational, and eco-marketing innovation dimensions.

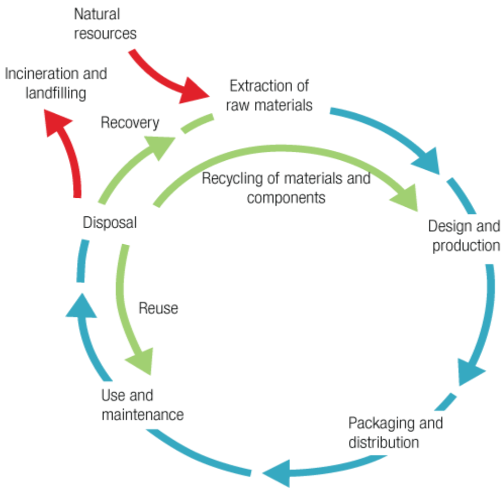

Figure 4. Life Cycle Thinking (Source:www.lifecycleinitative.org)

GREEN GROWTH

Sustainable economic growth and poverty reduction objectives can be achieved through green growth strategies. The economic growth and development of any economy can be threatened by the Depletion of natural resources and envi ronmental destruction. In 2005, the United Nations proposed green growth as the ultimate solution to achieve sustainable development. The Organisation for Economic Co-operation Development (OECD), 2012 defines green growth as a new means of fostering development and economic growth in a country while causing no harmful impact on the environment or people living in it (Wang et al. 2020).

Green growth has drawn the attention of the masses around the world, and a plethora of research has been conducted to understand the concept of green growth in different countries across the globe (Wang & Shao 2019). Green growth provides a solution to the environmental crisis and helps achieve sustainable economic growth while flourishing the interests of the population (Barbier 2016). Green growth promotes cleaner energy sources and reduces environmental pollution by lowering the emission of CO_2 and other GHGs (Sandberg et al. 2019). Several authors have argued about multiple determinants of green growth, but have agreed on all factors that help develop and sustain economic, environmental, and social interests (Hao et al. 2021).

Scholars (Hao et al. 2021) have recently emphasized the role of technology in promoting green growth development. However, the effect of technological innovation on green growth is much debated in the field. Therefore, based on the aforementioned contradictory literature and with purpose of exploring the impact of technological innovation on green growth in the context of a developing country, Abid et al. (2022) propose the following hypotheses:

Hp1: Patent application is positively related to green growth.

Hp2: R&D is positively related to green growth.

Hp3: Green forms of organizational innovation (i.e., Environmental Management Systems: EMS) are positively related to green growth.

Hp4: Energy consumption is negatively related to green growth.

Hp5: Population growth is negatively related to green growth.

GREEN ORGANIZATIONAL INNOVATION AND GREEN GROWTH

Daunting environmental challenges call for organizational support to preserve and protect the environment. Environmental Management Systems (EMSs) are the environmental sustainability tools that help organizations address environmental challenges and ensure environmental sustainability. A number of EMSs exist, but ISO 14001 is the most adapted management standard worldwide.

ISO 14001 was established in 1996 by the International Organization for Standardization (ISO), and it has been revised over the years. ISO 14001:2015 is the latest version with a set of updated requirements to improve environmental performance (da Fonseca 2015). After ISO 14001, the second most famous EMS standard is the Eco-Management and Audit Scheme (EMAS) designed and established by the European
Regulation EC 1221. EMSs make organizations follow specific rules to handle environmental management aspects both internally and externally (Chiarini 2017).
According to Könnölä & Unruh (2007), EMS is a substantial part of managerial innovation, ensuring efficiency in process control, production improvement, and product quality. Hence, EMS can be seen as a management standard applied to the whole industrial network. Curkovic & Sroufe (2011) argued that EMS is not just a part of environmental improvement; an organization can also use EMS to create a positive public image and involve managers from different hierarchical levels to engage in innovation.
Similarly, the said EMS is a key instrument introduced to promote product innovation. The research conducted by Kammerer (2009) reveals that green practices (drawn from EMS) and innovations in an organization share a positive relationship. EMS ensures environmental efficiency and enhances organizational innovation capabilities (Darnall 2006).
The literature shows the importance of EMS in environmental protection and sustainable development, but despite adopting ISO-14001, contradictory results worldwide make it controversial. There is no globally unified EMS result (D'Souza et al. 2019), which has forced this study to incorporate EMS into its framework and verify its role in green growth development in Pakistan with other variables. There is a direct relationship between EMS and green growth, and it is presented in Figure 5.

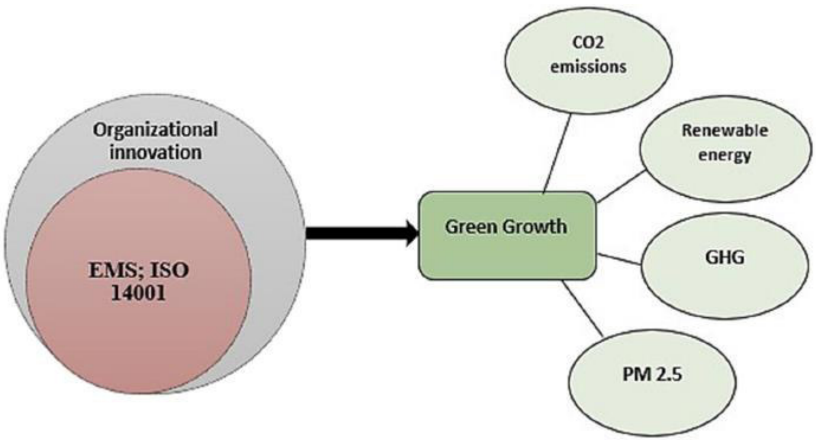

Figure 5. EMS and green growth (Source: Abid et al., 2022)

Air pollution is the most important driver of global warming, despite the fact that there are numerous forms of pollution. Greenhouse gas emissions (GHGs) are at the heart of air pollution, which are largely propelled by CO_2 emissions. Because CO_2 is seen as the greatest threat to the environment, governments have established commitments through the recent COP26 to further accelerate their efforts toward achieving the objective of the Paris Agreement and the UN Framework Convention on Climate Change, which is to minimize the emission level. CO_2 emissions have become the subject of numerous studies aimed at comprehending the factors that drive it. The bulk of this research used the STIR-PAT or Environmental Kuznets Curve (EKC) frameworks to examine population and income, concluding that these economic indicators are the primary cause of CO_2 emissions. However, these studies are not completely helpful, considering that the ultimate objective of any study is to advise policymakers on the implementation of relevant policies.
Abid et al. (2022) used the following analytical model summarizing all the hypotheses and variables used in the study which is reported in Figure 6.

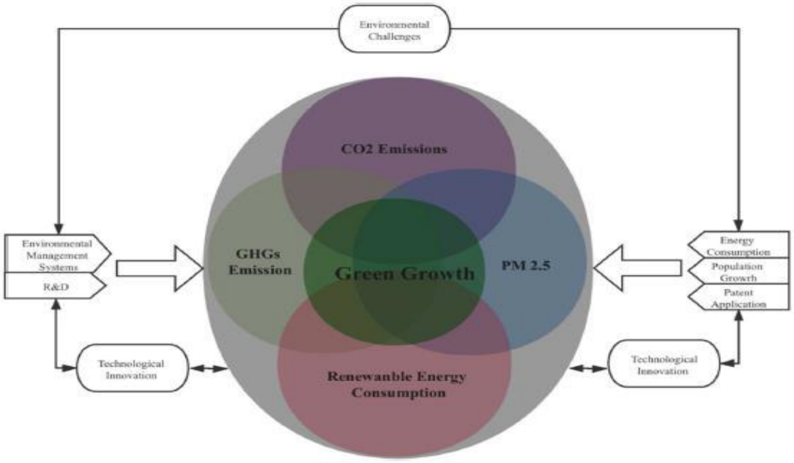

Figure 6. Conceptual model (Source: Abid et al., 2022)

TECHNOLOGICAL INNOVATION AND ENVIRONMENTAL CHALLENGES

Technology is one of the prime factors that organizations have been using to excel in performance and constantly impact humans and the environment (Li et al. 2019). Environmental awareness has made policymakers realize that technology intensifies environmental issues, and progress leading to environmental catastrophes is not advisable. Therefore, a shift has been observed to upgrade traditional technology to green or clean technology through resource efficient innovation and to substantially reduce environmental pollution (Schiederig et al. 2012).

Green innovation(Tseng et al. 2013) is divided into four categories:

managerial,
product,
process, and
technological innovation.

Technological innovation preserves environmental interests through the deployment of green technology that accelerates the process of green growth, which ultimately reduces the potential threats of climate change to human lives (Li & Long 2020). Johnstone et al. (2010) suggested that technological innovation is imperative for green growth development. Danish & Ulucak (2020) examined how technological change affects green growth in BRICS countries.

Using CO_2 as a proxy for green growth, the authors argued that technology is critical in green growth transition.

Ahmad et al. (2020) considered technological innovation to be an essential determinant of green growth. They stated that technological innovations transform traditional technology into a cleaner one to protect the environment and improve operational efficiency. This study is endorsed by previous research by Aghion et al. (2016) who argued that technological innovation should be blended into policy plans to promote green growth. Figure 7 presents the relationship between technological innovation and green growth.

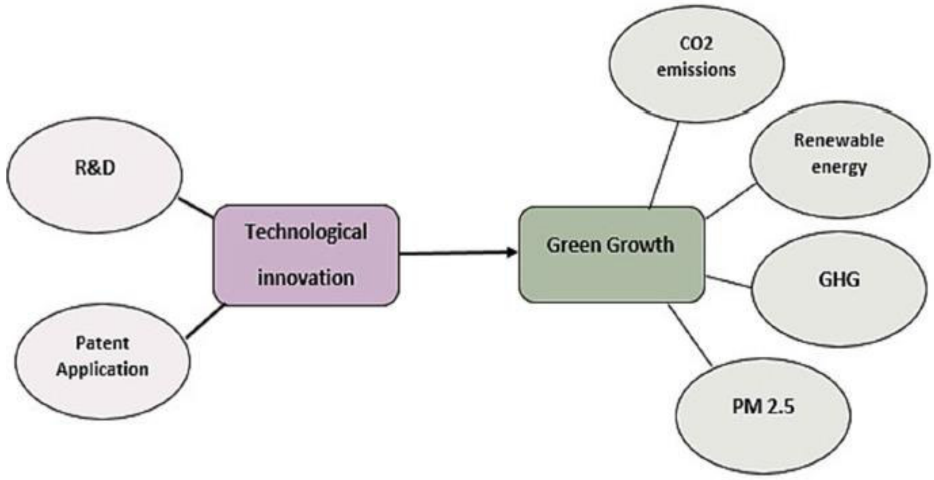

Figure 7. Technological innovation and green growth (Source: Abid et al., 2022)

Technological innovation is a tool to address environmental challenges, reduce the potential climate change threats posed to human lives, and sustain economic interests (Li & Long 2020). Technological innovations have played a crucial role in transitioning society from a traditional economy to a green one. Technological innovation supports green energy production so as to channel the development of green growth and help transform technological practices in operations and production processes within organizations (Umar et al. 2020).

According to Song et al. (2019), transformative technology innovation helps meet national energy demands by promoting cleaner technologies that reduce CO_2 and other harmful emissions.

Wang et al. (2021) suggested that technological innovation acts as a catalyst to boost green growth. In addition to technological innovation, some organizational innovations, such as Environmental Management System (EMS), can help firms reduce the impact of their production. EMS is one of the widely adapted environmental sustainability tools that help public or private organizations engage in systematic processes to tackle and solve environmental issues and lower harmful impacts (Coccia & Watts 2020). However, many researchers have given less attention to renewable energy sources and green growth and their impact on CO_2 emission. More attention is warranted to assess the impact of technological innovation, green growth, and renewable energy sources on CO_2 emissions. Less energy is used when an economy adopts efficient technology. Changing the energy structure and adopting renewable energy are highly associated with technological innovation. Renewable energy sources are the fastest-growing energy sources.

Although the nexus between CO_2 emission-growth-environmental taxes and renewable energy is well studied in various analyses, their results are inconclusive; a more deep investigation is required to re-examine the association between energy-growth and CO_2 emission.

COOPERATIVE GREEN INNOVATION

Environmental quality development is one of the most important environmental challenges that have been confronted by innovations (Zhang et al. 2017). The green innovations, environmental policies, and carbon taxes are the tools to achieve sustainable development goals (SDGs) in the mitigation process. Cooperative green innovation is an important tool to cope with global climate change and this study highlights cooperative green innovation with game theory. Some interesting conclusions are achieved. First, emission tax stimulates the innovation for all firms. Second, free-rider phenomena appear in cooperative green innovation. When the cooperative green innovation requires big investment, firms have intention to launch free-rider. Finally, the underinvestment of cooperative green innovation exists (Nie1 et al., 2022). Therefore, cooperative green innovation seems very popular and pushes the technologies to reduce emission. It is necessary to further investigate cooperative green innovation to dig out the difficulties in cooperative green innovation and to encourage cooperative green innovation.

Green innovation is attracting more and more importance all over the world in recent years (Bhatt & Singh 2020; Wang et al. 2020). On one hand, green innovation both improves energy intensity to a great degree (Wurlod & Noailly 2018; Wen et al. 2021) firm's performance (Zhang et al. 2019) and promotes corporate advantages in competition (Nie et al. 2021b). On the other hand, green innovation is affected by multiple factors, including social preference (Bhowmik et al. 2018), corporate governance (Amore & Bennedsen 2016), taxes (Chen & Nie 2016), subsidy policies (Chen et al. 2020a; Yang et al. 2019b), environmental policies (Chen et al. 2017; Brunel 2019; Chen et al. 2020b), market power (Nie et al. 2021a; Chen et al. 2021) and so on (Sun & Nie 2015).

Acemoglu et al. (2016) considered green innovation and suggested policies combined with subsidy and environmental tax to improve green innovation. Wang et al. (2017) argued that green insurance improves green innovation investment because insurance reduces the risk of uncertainty in innovation. Nie & Wang (2019) argued that resource constraints deter innovative investment, including green innovation and cost reduction R&D.

Yang et al. (2020) recently developed optimal subsidy policy to promote green technology. Nie et al. (2019a) considered green innovation under trading energy efficiency and concluded that trading energy efficiency improves green innovation. Moreover, Nie et al. (2019a) argued that trading energy efficiency combined with carbon tax promotes innovation to a great degree. Chen et al. (2020b) compared the effects of tax on green innovation with cap-and-trade system and concluded that cap-and-trade system is more efficient than carbon tax to stimulate green innovation. Wang et al. (2021) addressed green finance affecting innovation and found that ordering finance promotes innovation. Recently, Song et al. (2019) examined the large-scale data affecting green innovation. Martínez-Ros & Kunapatarawong (2019) found that knowledge has significant impact on green innovative investment and suggested to make use of all information.

Actually, institution affects green innovation extensively and it is important to establish mechanisms to incentive green innovation. Yuan & Xiang (2018) identified that environmental regulation improves green innovation for Chinese manufacturing. Sun et al. (2019) further argue institutional quality has significant effects on green innovation and energy efficiency. Stucki et al. (2018) summarized various institutions impacting green innovation and proposed some new policies. Nie et al. (2017) compared various types of subsidy affecting green innovation and show that output subsidy is better than input subsidy. Contrary to the complete information, under uncertain situation, Chen et al. (2020a) showed that input subsidy reduces the risk and recommended input subsidy for agricultural sector and other industries with high risk to promote innovation intention.

Especially, because renewable energy consumption has very low emission in practice, a special type of green innovation, renewable energy development, is attached importance by scholars (Yang et al. 2019a). Sun & Nie (2015) addressed the policies to develop green energy under oligopoly market structures and found that market power has significant impact on the efficiency of policies. Sun & Nie (2015) stressed that the subsidy should consider market structure to improve subsidy efficiency. To avoid cheat behaviors in subsidy, Yang et al. (2016) designed subsidy mechanism for renewable energy based on outputs under incomplete information and argued that the designed mechanism can avoid cheat behaviors to a certain degree. Yang et al. (2018) identified the projection competition between regions to launch green innovation with renewable energy. Taken the time cost into account, Yang et al. (2019) considered optimal subsidy time to develop renewable energy and concluded that the subsidy patterns heavily depend on the dynamic properties of projects in detail.

A typical example about cooperative innovation is CERN (European Organization for Nuclear Research), which was established in 1954 by 12 founding states and made significant achievements in physics, computer fields and so on. Now, CERN owns 23 members. (https://home.cern/ about/ who-we-are/our-governance/member-states) Thus, cooperative innovation is an important issue in both economics and society (Nie et al. 2019b), and the theory about cooperative innovation is developed in recent years. For example, Acemoglu & Wolitzky (2020) recently compared community enforcement with specialized enforcement to promote cooperative innovation and argued that the equilibrium depends on the properties of agents.

Bosch-Sijtsema & Postma (2009) developed the theory about cooperative innovation, including stimulating polies and governance mechanism. By compared cooperation with non-cooperation, Karbowski (2019) highlighted the effects of cooperative R&D on firms' performance and identified that profit-incentive firms prefer cooperative R&D and cooperative innovation promotes the outcomes of innovation. Rare literature about cooperative green innovation is launched in recent years. In practice, to cope with global climatic change, it is crucially necessary to launch cooperative green innovation.

CONCLUSIONS AND SUGGESTIONS

Financial inclusion is a vital organ in the development of any financial structure and helps the economy to grow. On one side, it is mandatory for the growth of any economy due to the increased availability of financial services and products to the majority of the population in the country. On the other side, due to improved financial inclusion, the consumption and production activities in the economy also increase which causes the energy demand to rise and consequently the CO_2 emissions in the economy rise. Perhaps, nothing is more important today for businesses and societies than the management of the global and local environmental changes that are degrading all aspects of life—a trend at risk of worsening for future generations. As major polluters, enterprises are expected to behave responsibly toward the natural environment. However, enterprises often do not pay enough attention to the environment and may even be environmentally irresponsible. Encouraging enterprises to actively accept environmental responsibility is the key to solving the problem of environmental pollution. Innovation is an important factor for environmental quality is it brings new technological innovation and it increases energy efficiency, which is beneficial for environmental quality improvement. The study investigated different factors associated with environmental quality. It was found that innovation positively affects carbon emission, while it enhances environmental quality when it reaches a certain level. Countries should focus to enhance innovation and green technologies, considering that global warming and environmental problems encounter. The findings indicate that trade openness is negatively associated with carbon emission, which evidences that trade is related to the advance method of production and stimulates environment. Countries should further encourage globalization and trade openness, which can transfer green technology and new knowledge, which are beneficial for environmental quality. Therefore, the policies related to climate change alleviation in most countries should widely concentrate to convert nonrenewable energy to renewable energy since it is environmentally favourable. Financial development in panel countries is still weak to provide funding to environment-friendly projects; however, financial development should give special focus to facilitate green projects in countries and provide incentives for the improvement of environmental quality. Financial institutions and banks should engage in those activities and projects, which recognize the importance of environmental problems. These investigations illustrate that financial development is positively associated with carbon emission; however, financial institutions can play an important role in establishing policies regarding environmental quality. The study on the impact of institutional quality on environment indicates that strong institutions boost environmental performance, while weak institutions are associated with environmental harm. The improvement of national laws and regulations are important to enhance environmental quality. The quality institutions may also encourage the spill over of technology through the inflow of foreign direct investment (FDI) because quality institutions control other related factors including service quality, civil rights, corruption, politics and accountability and play an important role in enhancing environmental governance to maintain resource utilization. It is suggested for the countries that strengthening institutions are the most important factors that enhance environmental quality because institutions quality is associated with other factors such as foreign direct investment, energy usage and financial development. The findings suggest the panel countries to focus on institutional quality factors as these factors are important in safeguarding environmental quality. This study is important for the countries to concentrate on these factors to achieve higher level of environmental quality as well as to enhance economic growth as well as it suggests to regulate innovative investment and to subsidize to improve cooperative green innovation. Future empirical studies can examine the nonlinear impact of financial inclusion on green growth and the environment. The future comparative country-wise empirical analysis will be more helpful in the context of economic and environmental implications.

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