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THESIS TOPIC

Impact of Export Quality Upgrading on Environmental Sustainability: Evidence from the East Asia and Pacific Region

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Declaration and Acknowledgments

The study is the result of my thesis research stay for the Erasmus Mundus master program of GLODEP International Development Studies, class of 2019.

I declare in lieu of an oath that I have written this thesis myself. I swear that the research has not been submitted for any other degree or professional qualification except for the GLODEP International Development Studies master program. I promise under oath that all the included publications are summarized, clearly cited and identified on the declarations page of the thesis. All information derived from the work of others has been acknowledged in the text and the list of references is given.

I started this research from October 2018 to May 2019 in three different cities of Pavia (Italy), Clermont-Ferrand (France) and Prague (Czech Republic). Several steps of research have been passed through, including coming up with new research ideas; contacting professors for supervision; finalizing the research question; making a research proposal; compiling the literature review; selecting data, empirical model and estimation methods; interpreting the estimation results along with performing the robustness check; making the conclusion and policy implications; as well as fully being aware of the limitations of my thesis research.

I am sincerely thankful to my supervisor, **Full Professor. Pascale Combes-Motel** for her endless support, care and guidance. Without her detail supervision, I could not have finished this thesis on time with a substantial contribution to the existing literature of international trade, export quality and environmental sustainability. I also would like to thank **Mohamed Boly** and **Azizbek Tokhirov** for their supports about econometric estimation issues. Last but not least, I am deeply indebted to **my beloved parents**, **little sisters Duong and Ruby**, **family members** and **good friends** in all the European cities that I have been living over the last two years. Without their unconditional love and support, I could not have enough bravery, strength and determination to complete the interesting and challenging two-year journey of the Erasmus Mundus GLODEP master program.

Prague, 28/05/2019

Signature

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Abstract: In the international economy, export quality is considered to be one of the most critical elements to promote sustainable growth, exercising country comparative advantages and integrating fully into the globalization process. Countries could choose to specialize in exporting either manufactured goods or raw materials based on their comparative advantages in the different stages of economic growth. However, a currently arising concern is whether export quality improvement has any impact on the environment quality. This research investigates the effect of export quality upgrading on environmental sustainability measured by CO_2 emissions. With the empirical evidence from a panel data of ten East Asian and Pacific countries during the 40-year period of 1975-2014, the author has suggested the findings that the export quality amelioration of goods and services increases the production-based CO_2 emissions in both the long run and short run. The robustness check confirms this result and infers that squared export quality index could probably have a significantly negative effect upon CO_2 emissions in the long run.

JEL Classification: F18, O44, P28, Q59.

Keywords: Export quality index, export quality upgrading, CO_2 emissions, environmental sustainability, East Asia and Pacific region.

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List of Abbreviations

Abbreviation	Meaning
CO_2 emissions	Carbon dioxide emissions
ADF regression	Augmented Dickey-Fuller regression
DOLS model	Dynamic Ordinary Least Squares model
EAP region	East Asia and Pacific region
ECI	Economic Complexity Index
EKC hypothesis	Environmental Kuznets Curve hypothesis
EQI	Export Quality Index
FDI	Foreign direct investment
FMOLS model	Fully Modified Ordinary Least Squares model
GDP	Gross Domestic Product
GMM instrument	Generalized Method of Moments instrument
Ha	Alternative hypothesis
Ho	Null hypothesis
VAR model	Vector Autoregression model

1 Introduction

The inter-linkage between economic development and environment protection was first discussed officially in the 1978 “Our Common Future” Brundtland Report and at the 1972 United Nations Conference on the Human Environment in Stockholm (Combes Motel *et al.*, 2014). This relationship has become an important tradeoff in the pursuit for sustainability. Several notable studies have been conducted to confirm the effects of key economic activities on the environment.

Export quality upgrading is considered as a key vehicle in the new agenda of economic growth, trade, and sustainable development. At the United Nations Sustainable Development Summit in New York 2015, state members together adopted 17 Sustainable Development Goals (SDGs), with several targets related to export quality transformation. Export quality upgrading, including broad areas of production cycle management, input sources, technology, highly-skilled labor force and financial flows, are highlighted much in the SDGs targets, such as Goal 8.a “Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries”, Goal 8.2 “Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors”, Goal 8.4 “Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead”, Goal 12.1 “Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries”, and Goal 12.4 “By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment”.

The economic growth lessons learnt in developing countries has implicated that “what really matters to a country’s economic growth in the long-term is not purely how much it exports, but what it exports” (Zhu and Fu, 2013). The sophistication of high-quality export products seems to be a vital motive for countries to grow faster and more sustainability.

From these analytics, the author would like to measure the effects of export quality strengthening on environmental sustainability. The countries located in the East Asia and Pacific region are chosen to study. With interest in supporting emerging countries, the author realizes that there is still much room for research this global linkage in EAP nations while countries in Africa and Latin America have gained more attention (Arouri *et al.*, 2012). Therefore, which impacts of export quality upgrading on the environment in the EAP region will be the core idea of research.

2 Overview of Export Quality - Environment Sustainability Nexus and Study Region

2.1 Brief Synthesis of Export Quality - Environment Sustainability Nexus

Export quality upgrading is defined as shifting the traditional production chains to higher-value goods, better value chains or modernizing the production techniques in the apparel sector (Lopez-Acevedo, 2012). Export quality upgrading occurs when (i) current export products should be processed and innovated further before exporting, and/or (ii) when new and highly-processed export products are added with more values (Firebaugh and Bullock, 1987).

Followingly, manufactures and policymakers could upgrade the export quality through these major channels: (i) enhancing the quality of physical and human capital endowments (Hausmann, Hwang and Rodrik, 2007); (ii) improving the matrix of "Process - Product - Function – Intersection" in the production line of firms (Humphrey and Schmitz, 2002); promoting the trade liberalization in the global scale through the comprehensive methods of reduced tariffs, free trade agreements, deeper integration, FDI movements, North-South and South-South movements (Grossman and Krueger, 1991; Antweiler, Copeland and Taylor, 2001; Zhu and Fu, 2013; Amighini and Sanfilippo, 2014, 2014; Fan, Li and Yeaple, 2015); exploring the production embeddedness and exclusiveness of industrial sectors (Hidalgo and Hausmann, 2009; Poncet and Starosta de Waldemar, 2013); and enhancing the complexity, volatility and comparative advantage in manufacturing (Lee, 2010; Krishna and Levchenko, 2013; Maggioni, Lo Turco and Gallegati, 2016). Therefore, the quality of export products is often associated with the structural transformation of countries, especially in the middle stages of economic development (Gozgor and Can, 2017). Export quality upgrading leads to economic growth, which eventually could bear some effects on the environment. As a result, this economic activity would possibly bring on some environmental impacts in the context of globalization.

Moreover, to consider the nexus between export quality upgrading and environment, it is vital to distinguish the differences between three mechanisms in which international trade and goods quality improvements could make an impact on the environment. Firstly, we have the "scale" effect that describes the intuition of increasing trade volume and environmental pollution. According to the "scale" effect, a freer trade flow will lead to higher greenhouse gas emissions due to an increase in energy consumption and manufacturing outputs. Controlling for other fixed factors, a surge in the scale of economic activities and energy use will lead to a higher volume of greenhouse gas emissions (WTO, 2019). In the meantime, the "composition" impact contends that the trade exchange will change the inclination of a nation's production towards those items, of which it has more comparative advantages. A country could enhance economic efficiency through re-allocating its human and production resources for trade activities. The fluctuation of greenhouse effects and climate change relies upon the manufacturing areas where a nation prefers to focus on. If the country expands toward the less energy-intensive sectors, it could reduce the CO_2 emissions and other greenhouse gas emissions. Oppositely, if it emphasizes on producing more raw materials, the manufacturing segments will create more ozoneharming substance discharges (WTO, 2019). Lastly, trade opening is said to be able to foster the improvements in energy efficiency through the “technique” effect. Followingly, the production of highly-advanced goods and services will generate less greenhouse gas emissions and protect human beings from negative impacts of climate change. Theoretically, there are two mechanisms in which we could decrease energy intensity. Firstly, a more liberated exchange in international trade will provide more accessibility and lower environmentally-friendly merchandise expenses. This is especially significant for nations that cannot produce or approach these products efficiently through an adequate scale or at moderate costs. Additionally, exporters and manufacturers have more incentives to innovate more environmental-friendly products to attract customers with environmental protection. Secondly, international trade brings wealth and income expansion, which then can lead societies to request products with a better quality to protect the environment (WTO, 2019).

However, the overall impact of international trade on the environment cannot be predicted in advance without investigating empirically. The reason is that the scale and technique effects tend to move in opposite directions, while the composition effect depends heavily on the comparative advantages of nations. Hence, the effect of trade openness on environmental quality is still ambiguous to many scholars.

On the other hand, there exists no distinct relationship between trade openness and export quality upgrading, despite the fact that trade openness and export quality upgrading both are the new variables for globalization aspects at the time being (Hausmann, Hwang and Rodrik, 2007; Christian Henn, Chris Papageorgiou and Nicola Spatafora, 2013; Gozgor and Can, 2016; Henn *et al.*, 2017). Therefore, both trade openness and export quality upgrading might have effects on the environment or not. We do not have the evidence to confirm it yet. Indeed, the role of export quality upgrading has been underestimated in the existing literature over the years (Gozgor and Can, 2017). Up to now, there is no theoretical point of view of affecting the export upgrading (both in quality and in diversification) on the environment. Combining these facts and evidence, it could be theoretically presumed that the impact of export quality upgrading on the environment might still be an ambiguous problem.

Therefore, to the best of my knowledge, to measure the impact of export quality upgrading on environment sustainability, we need to apply empirical methods. In this study, I consider the export quality index as an explanatory variable, representing for export quality upgrading, and carbon dioxide emissions as the dependent variable, measuring for the environmental performance. Two main variables, along with other control variables, are used to test the effect of export quality upgrading on the environment. Moreover, they also could be used to check the validity of the Environmental Kuznets Curve hypothesis in the studied region.

2.2 Introduction of the East Asia and Pacific region and studied countries

(History evolution, trade situation, export quality, environmental status, development targets)

The East Asia and Pacific (EAP) region is considered as the most dynamic economic zone in the world nowadays. According to the World Bank, its regional economic growth reached the point of 6.3 percent in 2018, accounting for nearly two-fifths of the global economic growth. Thanks to the large share of the global gross domestic product, the region plays an important central role in shaping the international order of the economy market. In which, China plays a significant role in economic growth, with the continuously high annual rate, starting at above 14% in 1992 and keeping moving forward during nearly the last 30 years. In 2018, China's annual economic growth rate came in at 6.6%, which is the lowest point pace since 1990 (CNBC, 2019) due to the on-going trade war between this giant country and the U.S, its largest trading partner, along with the rebalancing strategies away from foreign investment and towards domestic consumption boosting.

The EAP is an immense region, encompassing three geographical parts of "East Asia", "Southeast Asia" and "Pacific". The EAP region is located in a strategic position, having several points of access to large bodies of water on Earth, such as the Pacific Ocean, the Indian Ocean, the Bay of Bengal, and the Tasman Sea. This geographical characteristic enables the EAP countries to enjoy the comparative advantages of international trade and global forwardings, such as ocean freight and air transportations. Singapore, Hong Kong, China and Australia are the most typical examples to effectively develop the logistics industry and business activities of the EAP region with other trading partners in the world.

To give a clearer view of the EAP region location, I provide the map as below (**Figure 1**). This region contains 29 countries and territories. Its contribution to human development is very meaningful, especially to the creation and enhancement of world civilization. From the Silk Road trading era up to now, China and East Asian countries have built trading links between the EAP region and Europe to exchange goods and services across neighboring regions, as well as share cultures and social norms among different people groups. This practice has helped China and some East Asian countries, such as Vietnam and Thailand, to become the most ancient East Asian civilizations and earliest cradles of civilization in human evolution. East Asian countries and neighbors in the Pacific have been strongly influenced by the old Chinese culture and then developed their own beautiful customs, ideas and social norms. Together the regional members promoted to create the diverse arts and other manifestations of collective human intellectual achievements in the enormous EAP region. Furthermore, the activities of maritime shipping and export trade also help to enhance the economic and political position of EAP countries in the world order, increasing GDP per capita and improving the wellbeing.

Figure 1: Map of East Asia and Pacific Region

Source: US Department of State

The alphabet symbols and numbers in the map stand for the following countries in the EAP region:

A. China B. Mongolia C. North Korea D. South Korea E. Japan F. Burma G. Laos H. Thailand I. Cambodia J. Vietnam	K. Philippines L. Malaysia M. Brunei N. Indonesia O. East Timor P. Australia Q. Papua New Guinea R. Palau S. Federated States of Micronesia	T. Marshall Islands U. Nauru V. Kiribati W. Solomon Islands X. Tuvalu Y. Vanuatu Z. Fiji 1. Samoa 2. Tonga 3. New Zealand

Accounting for around one-third of the global population, the EAP region has a huge supply and demand for exchanging goods and services overseas. International trade becomes one of the most dynamic drivers of prosperity and inclusive wellbeing development in the region. The "Pacific" part has often been considered to have a small proportion of people, compared to the population of "East Asia" and "Southeast Asia" part. It is due to the existence of big names in the Eastern Asian location, such as China, Indonesia, Vietnam, Malaysia, and Japan. However, some popular countries, like Australia and New Zealand, could cover the large volume of international trade for the Pacific area.

At a glance, the EAP region is dominant with the largest share of the international exporting market. In 2017, the exports are valued at US$ 5,201,355 million, with more than 230 trading partners and 4,617 products (World Integrated Trade Solution, the World Bank, 2019).

However, in terms of environmental sustainability, the EAP region is seen to contribute the much largest part to global greenhouse gas emissions (World Bank, 2018). In comparison with other regions, the EAP accounts for an approximate part of one-third of the world's CO_2 emissions and more than half of the global coal consumption (World Bank, 2018). Therefore, environmental pollution is one of the biggest issues in the massive region, not only for developing members like China, Indonesia, Vietnam, Malaysia, but also for more developed neighbors like Singapore, Australia and New Zealand. The reason is that CO_2 emissions and environmental pollution could be trans-boundary and affect the public health of people in every single country.

In addition, the EAP region is also expected to be the most vulnerable to climate change, since two major reasons. The first cause is due to the geographic characteristics of many small Pacific countries and islands, with low-lying atolls and fragile lands. The second is because of many big megacities in the world, with the large populations of over 10 million people, lying along the coastal areas of the East Asia and Pacific, or in the river deltas close to the coast, such as Mekong Delta, Red River Delta. Named among them are Hanoi, Ho Chi Minh City, Singapore, Jakarta, Bangkok and Hong Kong (Eades and Cooper, 2010). Therefore, environmental protection and degradation reduction are a strategic priority in this region. There needs to have many efforts to engage country members to cooperative activities and initiatives to protect this vulnerable watershed from the climatic stresses of climate change, greenhouse effect and CO_2 emissions.

This environmental challenge goes in line with the unique advantages of the East Asia and Pacific region in modern export trade, which strongly reinvigorates me to conduct the research topic of export upgrading and environmental performance. Export upgrading is one of the newest driving components of international trade and industry development, creating more added values in trade activities. That is why export upgrading matters for EAP's economy. However, as mentioned above, in the industrial transformation of the economic growth, the EAP keeps playing the position of the heaviest contributor to the greenhouse gas emissions in the globe. Therefore, the analysis of economic elements affecting environment sustainability is one of the critical targets to advance the 2030 United Nations Sustainable Development agenda in this dynamic region. This paper focuses on the "export quality upgrading" factor, which matters to the international trade and economic growth of EAP countries, such as China, Malaysia, South Korea and the Philippines, especially in the era of Industrial Revolution 4.0.

3 Review of Relevant Literature

My study considers the existing literature under five strands of research. The first strand discusses the seminal papers which put the seeds for the research on the international trade effects on the environment. Some studies on examining the empirical hypotheses of trade and environment in different locations of the globe are also provided afterward. Then, I will dig deep into the empirical researches of international trade impacts on the environment in different countries as well as in the EAP region. The third session focuses on the determinants of export quality upgrading in the context of technological advances and globalization. For this reason, it is also important to investigate the effects of export quality upgrading on the other factors of economic development. Last but not least, I will review the rare papers on the effect of export quality upgrading on the environmental quality in the existing literature.

Firstly, the pioneering ideas of researching international trade effects on the environment will be discussed. The targets of promoting international trade in response to the United Nations Agenda 2030 to Sustainable Development have reopened the classical topic of international trade impacts on the environment in academia. Back to the initial discussion, international trade was always believed to bring the significant effects on the environment (namely Grossman and Krueger, 1991; Copeland and Taylor, 1995; Antweiler, Copeland and Taylor, 2001).

To explain this nexus, trade economists have built up a trade-environment framework through three independent effects: scale, composition and technique (WTO, 2019). The first application of this framework was by (Grossman and Krueger, 1991), studying the environmental effects of the North American Free Trade Agreement (NAFTA). The NAFTA provided a "free trade" platform among Canada, Mexico and the United States, which was expected to create a giant trade zone from the Arctic Circle to below the Tropic of Cancer with the total value of six trillion U.S. dollars. In fact, Mexico and the United States were the most favorable members in this trading negotiation while Canada contributed a less active role as an observer in the agreement. The United State was the biggest trading partner of Canada, accounting for around 65% of Mexico's export volumes in 1987 (US Department of State, 2001). This regional trading bloc was believed to support a better commercial market for more than 360 million customers in North America, with the scale effect and composition effect of economic growth and expanding demand and supply of exports and imports. At the same time, a change in techniques of manufacturing also promoted the production more efficiently. However, at the same time, the expansion of production and trade openness also could destroy the environmental sustainability terribly, due to the over-exploitation of "maquiladoras" assembly plants, which were known as the foreign American-owned factories run in Mexico to produce and export their raw-material products back to the U.S. As a result, the environmental problems and transboundary pollution of air, water and hazardous waste dumping would possible exacerbate the public health of people not only in Mexico but also in the U.S. and Canada. Thanks to Grossman and Krueger, who have put a foundation link to the empirical literature, we have the first case study of the NAFTA to sharpen the theoretical points of view of three types of the trade effects on the environment in a developing country (Mexico) and a developed country (the United States).

Afterward, in 1994, (Copeland and Taylor, 1994) presented a formalized definition of these effects through developing a simple static model of North-South trade, with the view to examine the relationship between national income level, international trade, and environmental pollution. The authors chose two manufacturing countries with the difference in pollution intensity. The results implied that the richer country, the North, adopted the stronger environmental protection policies and specialized in producing relatively clean non-polluting goods. Meanwhile, the poor one, called the South, focused on more raw material-based goods. Controlling three effects of international trade on the environment, the authors confirmed that the waves of free trade would foster global pollution. The North countries with higher production possibilities also could increase the pollution, while the South countries could lower the pollution with the same growth rate. Lastly, the author found out that world-level pollution could be reduced through unilateral transfers from North to South.

Later, (Antweiler, Copeland and Taylor, 2001) answered the question of whether free trade would be a good credential to the environment or not. Like the pioneering papers mentioning above, this study at first developed a theoretical model of three trade impacts on the environment, through scale, technique and composition. Then, the authors examined the empirical evidence by using the data of sulfur dioxide concentrations. The results suggested that with the combination between the scale, technique and composition impacts of the trade-environment nexus, free trade will bring a good benefit to the environment.

The second strand of study will provide the empirical evidence of international trade impacts on the environment. I would like to review the situation in different countries as well as the countries of the EAP region. From the foundations of these seminal papers, current authors have developed the existing empirical literature through numerous studies with the hypotheses of impacting trade openness (both exports and imports) on environmental sustainability *(for example (Le, Chang and Park, 2016), (Kais and Sami, 2016), (Kais and Sami, 2016) (Ertugrul et al., 2016), (Shahzad et al., 2017), (Al-Mulali and Ozturk, 2015)(Al-mulali, 2012), (Frankel and Rose, 2005), (Al-mulali, 2012), ,etc.)*. Both theory and empirical shreds of evidence suggest three potential hypotheses of trade - environment interface as follows.

The first hypothesis says that trade openness harms environmental quality, supporting the *race-to-the-bottom hypothesis.* (Al-Mulali and Ozturk, 2015) tested the panel-data evidence of environmental impacts in the MENA region from 1996 to 2002. It concluded that the elements of energy consumption, urbanization, trade openness, and industrial development increased the environmental damage while the political stability could turn it down in the long run. (Al-mulali, 2012) confirmed the negative impact of total trade on increasing carbon emission amount in 12 Middle Eastern countries during the period 1990-2009, thus advocated the adoption of trade-related quality controls and policies to protect the environment. The non-linear causality analytics of (Shahzad *et al.*, 2017) also confirmed that trade openness caused carbon emission in Pakistan, through measuring the impacts of energy consumption, financial development, and trade-to-GDP ratio.

The second hypothesis supports the *gains-from-trade hypothesis* that trade openness improves environmental quality. (Le, Chang and Park, 2016) rechecked the relationship between trade and the environment through the international empirical evidence of 98 countries. They concluded that the trade openness upgrading played a big role in the environmental quality with the measurement of "emission of particulate matter - PM10" as the dependent variable. Trade promotion benefits the environment in high-income countries while degrading the environment in middle-income and low-income countries.

The third hypothesis states that trade opening has no conclusive impact on environmental quality. Departing from the theory that evidences ambiguous effects of trade opening on the environment, (Frankel and Rose, 2005) seek for the answer through measuring impacts of trade on three measurements of environmental damages, namely SO_2, NO_2 and PM2, with a control for income and other factors of political structure of the government and the ration of land area per population. The authors also used exogenous geographic determinants of international trade as instrumental variables to control the endogeneity problem of trade on the environment. The obtained results were mixed: trade openness, ceteris paribus, seemed to be beneficial to some environmental quality measures, such as SO_2; however, other measures show opposite results or no clear clue to make a conclusion. Therefore, the authors believed that the relationship between trade and the environmental quality was quite "theoretically ambiguous". Also empirically, (Sharma, 2011) conducted a dynamic panel-data analysis of several elements' impact on the CO_2 emissions. The data analysis described that trade openness had no statistically significant impact on CO_2 emissions in the global panel of 69 countries, and three income-based panels of high income, middle income, and low income.

Interestingly, I could not find any papers focusing on the EAP region in the existing literature. Therefore, my research can also be considered as the first study to examine the relationship between international trade and the environment in the EAP region.

The third strand of research focuses on the literature explaining drivers of export quality upgrading. (Christian Henn, Chris Papageorgiou and Nicola Spatafora, 2013) gave the first ideas of export quality upgrading determinants by harvesting the quality dataset of developing countries. For individual products, the growth rate of quality exports in a country was believed to depend heavily on its initial quality level and converged across countries over time at the annual speed of 5%. However, newcomers into a certain sector obtained their quality increasing over time toward the international goods standards. The convergence speed within manufacturing was much higher at the point of 7% per annum. Both quality growth rates were stable cross specifications of export goods. For other control variables, we had initial institutional quality and initial human capital positively and significantly associated with the export quality upgrading. Interestingly, the authors confirmed that the potentials to enhance the export quality in developing countries seemed not to be limited by the low demand for goods quality in their destination markets. It meant that the economic growth factors could not affect the export quality upgrading rate. Poorer exporting countries still could have a high export quality growth rate, despite the gap between their export quality and the quality of average goods in importing countries. Based on the results collected, the authors implied that policymakers should focus firstly on building up a domestic environment that is broadly conducive to quality upgrading, then secondly on lowering trade barriers of tariff and non- tariff to entry into higher-quality export markets. However, domestic factors in the investment and manufacturing environment is an urgent priority.

In a regional scale, (Amighini and Sanfilippo, 2014) examined the impacts of South-South FDI and imports on the export upgrading of African Economics through three main hypotheses. They include (i) exploring whether the recent increase in economic integration between Southern countries has brought positive impacts on the export upgrading for African countries or not; (ii) making a comparison between South-South and North-South foreign direct flows into these economies to check whether these flows affect their export performance or not; and (iii) investigating the impacts of different types of foreign flows from the North and from the South based on the distinct stage of export diversification of the recipients. The results released the supporting ideas that South-South integration brought a strong impact into promoting the structural transformation of goods and services exported in Africa, while inside-continent FDI exerted export diversification in low-tech industries, such as agro-production and textiles as well as upgraded the average quality of manufacturing export. One key finding was that the importing activities from the South has promoted the expansion of several manufactured exports and inaugurated more advanced goods and services traded to other less-diversified economics.

In a different perspective, (Fan, Li and Yeaple, 2015) brought a new outlook of export upgrading from manufacturing firms in the context of trade liberalization. The research question is whether the reduced tariffs on imported intermediates promote firms and companies to upgrade their goods and services for export or not. By applying the theory and empirical evidence of the disaggregated firm-level production data and custom data in the China economy, the authors suggested the result that a reduction in import tariffs could lead to manufacturers' reaction to increase export quality, surge export prices in the industries which have the large scope for quality differentiation, and lower export prices in the areas which have small scope. In addition, the presence of foreign direct investment makes a positive and significant impact on industrial export quality. (Anwar and Sun, 2018) analyzed China's industry-level panel data over the 2005-2007 period, concluding that the more foreign firms appear in China, the higher the export quality increases.

Then, we will consider the effect mechanisms of export quality upgrading on the other economics-related factors. In other words, the fourth strand of literature review emphasizes on the studies considering export quality upgrading as an explanatory variable. In detail, I would like to know about the effects of export quality upgrading on economic growth, energy use, and other macro factors. (Gnangnon and Brun, 2017) examined the impact of export upgrading in quality and in quantity on non-resource tax revenue, with the multivariate framework of other factors, including the overall level of development, the sectoral composition of domestic output and demographic characteristics. The authors analyzed the empirical evidence in both the entire sample and sub-samples of 172 developing and high-income countries from 1980-2010 and concluded that export product upgrading employed a positive and statistically significant effect on tax revenue in all the sub-sample expect for the group of low-income countries, which witnessed mixed results. Moreover, in the context of trade openness, export upgrading countries keep moving their non-resource tax revenue forward a higher level in both the short and long term.

Meanwhile, (Rahman, 2017) included exports (exports of goods and services per capita measured in the constant US$2005 price), energy use, income growth and population density as explanatory variables to investigate the uni-directional relationship with CO_2 emissions, with the empirical panel evidence of 11 Asian populous countries from 1960-2014. Applying econometric techniques into data analysis (such as panel cointegration tests and panel Granger causality test), the authors concluded the main results that (i) exports, energy consumption, and population density have an adverse impact on environmental sustainability in the long run; (ii) GDP per capita, exports and energy consumption has a short-run Granger panel causality and a unidirectional causality among independent variables; and (iii) there exists a long-run bidirectional Granger causality between elements in the multivariate framework.

Under the last strand of research, I would like to review the researches that have the same research question as my thesis. That is, it tests the nexus of export quality upgrading and environmental sustainability in several countries and at different periods of time. As export quality upgrading is a quite new macro indicator to measure an impact on the environment, there are not many similar studies conducted in the existing literature. The majority is currently focused on the empirical evidence from China, the biggest exporter in the global trading market nowadays. As disclaimed above, my research ideas are inspired by (Gozgor and Can, 2017), who have observed that export product quality was statistically significant to CO_2 emissions. The "export quality index" extracted from the International Monetary Fund database is chosen to measure the export product quality variable. By using the Zivot-Andrews unit root test to account for structural breaks, and Pesaran-Shin autoregressive-distributed lag model to estimate the short-term and long-term coefficient dynamics, the authors found out that the EKC hypothesis is applicable to China for the period of 1971-2010. In the long run, income per capita is elastic and positive to CO_2 emissions, trade openness is inelastically and positively associated with CO_2 emissions, implying the existence of "pollution haven" hypothesis and energy consumption has an elastic and positive effect on China's CO_2 emissions. Meanwhile, the log export quality index has a negative and elastic impact on the log CO_2 emissions, which can be interpreted that the higher export quality upgrading is, the lower CO_2 emissions are in China for the study period.

Similarly, Mao and He (2017) also declared that export quality upgrading improved the environmental performance on a local scale of China. The product-specific data of exports obtained from the China Customs Statistics Office is chosen to measure the "export quality" variable. However, different from the econometric methods of (Gozgor and Can, 2017), the authors used the decomposition of export sophistication to quantify the diversification of upgraded export products. Firstly, identification of pollution-intensive sectors was measured by taking the multi-year average of pollution intensity (the annual average SO_2 emissions per industrial output from 2003-2011) to re-group the manufacturing sectors at the two-digit level and divide the polluting sectors from their non-polluting counterparts. Secondly, the changing level of export sophistication was measured by the TECH index (2011) and export decomposition was divided into 7 terms, following Foster et al.'s decomposition rule (1998). One big contribution of this study to the existing literature is the construction of a 'city–year' panel for empirical analysis, with the coverage of 261 China's prefectural-level cities from 2003 to 2011. The authors divided the sample cities into groups and used the fixed-effect regression by groups to investigate the role of local linkages. As a result, empirical findings indicate that environmental improvement associated with export upgrading in China has mostly relied on changing the product mix to avoid environmental costs, exhibiting a significant displacement effect. However, the role of efficiency promotion of production process is still insignificant.

These two first articles directly measure the impact of export quality on the environment in the local linkage. However, any similar study has not yet to be conducted in the global and regional levels. To the best of my knowledge, this thesis will be the first study to estimate the impact of export quality upgrading on the environment on a regional scale in the current literature. The EAP region is chosen to research since two main reasons. First, in the aspects of international trade and export upgrading, the EAP region is considered as the most dynamic partner in the global trade market, with the big suppliers like China, South Korea, Vietnam, Indonesia, Malaysia, Australia, and Japan. Many global trading logistics hubs are also located in this region, such as Singapore and Hong Kong. From the 1960s until now, many countries in the EAP region have woke up quickly from the failure of War World II, changing the export development strategy from raw material exploitation to high technology industries, climbed on the "Flying Geese" pattern of structural transformation (Akamatsu, 1961, 1962) to the become "Tiger Cub Economies". Second, in terms of environmental sustainability, the price to be paid for economic growth is environmental degradation. Many EAP countries with long coasts and many marine borders are ranked the first to the sensitivity and vulnerability of climate change in the world. In fact, the members like Vietnam, Singapore, and Pacific islands have been severely affected by the rising sea level, global warming and threats to extinct species. One more additional point is that exports always outnumber imports in the EAP region, which make their countries net exporters in most of the time (World Integrated Trade Solution, the World Bank, 2019). Therefore, I would like to draw public attention to the relationships between export quality upgrading and environmental performance through filling the gap of research in the EAP region. The most target is towards the sustainable development for countries in this region in both perspectives of economic growth and environmental protection.

4 Model, Data and Methodology Framework

4.1 The Empirical Model

From the summary of the previous studies, the measurement of environmental impacts of export quality upgrading cannot be conducted solely and only from the theoretical point of view. Hence, it is necessary to include other trade-related variables along with apply new modern econometric techniques in order to explain the moving dynamics of environmental quality.

To investigate the impacts of export quality upgrading on the environment, I construct a multi-variate framework which includes real income per capita (real GDP), squared real income per capita (squared real GDP), trade openness, energy consumption, and export quality index (EQI) as the independent variables and carbon dioxide emissions (CO_2 emissions) as the dependent variable. The study uses a log-linear specification to examine the relationship in a panel data of ten EAP countries during the period of 1975-2014. The research question is whether upgrading of export quality in EAP countries could lead to environmental improvement. From that, we also could check the validity of the EKC hypothesis in this region to see the effect of income growth on the environmental performance at different levels.

In this model, real GDP per capita, squared real GDP per capita and energy consumption per capita play the role as the fundamental drivers of CO_2 emissions while trade openness and export quality are the significant elements affecting the level of CO_2 emissions. Followingly, the long-run relationship of these variables is demonstrated in an empirical model as follows:

Equation 1:

$$\ln CO2_{it} = \alpha + \beta_1 * \ln EXQUA_{it} + \beta_2 * \ln \mathrm{RGDP}_{it} + \beta_3 * \ln RGDP_{it}^2 + \beta_4 * TRADE_{it} + \beta_5 * \ln ENER_{it} + \varepsilon_{it} \quad (1)$$

In which:

- CO_2 is carbon dioxide emissions per capita
- EXQUA is export quality index (EQI)
- RGDP and $RGDP^2$ real GDP and squared real GDP per capita
- TRADE is trade openness ratio; ENER stands for energy consumption per capita
- Two indices “i” and “t” represent studied countries and years, respectively.
- “ln” stands for the natural logarithm form.

All the variables are considered in the natural logarithm form at the time “t” in the benchmark model. The identically and independently distributed error term is represented by ε_{it}. The coefficients β_1, β_2, β_3, β_4, and β_5 represent the long-run elasticities of CO_2 emissions with respect to EQI, real GDP per capita, squared real GDP per capita, trade openness and energy use per capita, respectively.

Based on the main hypothesis of this research and reviewed literature, I expect that the coefficients of real GDP per capita, trade openness and energy consumption should be positive while the coefficient of EQI is negative.

In detail, "$\beta_1 < 0$" is expected statistically significant to demonstrate the "pollution-intensive goods" exporting-importing policies between developing and more developed countries. When nations are in the first stage of economic growth, they could compensate with producing pollution-intensive goods. Then when they move to the higher stages, they will remove these goods from their export basket. Therefore, when a country upgrades its export quality, the amount of CO_2 emissions could be expected to reduce.

Moreover, we could say that $\beta_2 > 0$, $\beta_4 > 0$ and $\beta_5 > 0$. The price of intensive economic growth is probably worsening environmental quality in first periods and improving in next periods ($\beta_2 > 0$ and $\beta_3 < 0$). "$\beta_4 > 0$" could confirm the validity of the race-to-the-bottom hypothesis that trade openness harms environmental quality. Moreover, the higher energy consumption in developing countries also probably leads to higher CO_2 emissions ($\beta_5 > 0$).

4.2 Data

I construct a "country-year" panel for empirical analysis. The data is collected from reliable sources of the World Development Indicator (WDI) database, the World Bank and International Monetary Fund (IMF). In the EAP region, there are currently 29 countries and territories, in which only 10 nations have enough data and information of variables used for my empirical model. Therefore, to have a strongly balanced panel data, I have obtained a sample of ten EAP countries available for the 40-year period from 1975 to 2014. Ten countries include Australia, China (P.R.: Mainland), Hong Kong, Indonesia, Japan, South Korea (Republic of Korea), Malaysia, New Zealand, the Philippines, and Singapore.

In this study, CO_2 emissions are used as an indicator to measure environmental performance. CO_2 emissions are those extracted from "burning oil, coal and gas for energy use, burning wood and waste materials, and from industrial processes such as cement production" (World Bank, 2019). CO_2 is considered as an externality of environmental effects through economic growth and export trade activities. CO_2 contributes the largest share of the greenhouse gases to the severity of global warming and climate change. The summary of variables is presented in **Table 1**.

4.3 Econometric Methodology

The analysis of elements affecting the environment quality has become comparatively important in the last few decades. Several studies have been conducted in this field with the inclusion of multivariate frameworks. The skeletons could use different environment quality indexes, such as CO_2, SO_2, PM2 and PM10 as dependent variables, and several economics-related indicators, such as income per capita, trade openness, trade volume, energy use, population density as independent variables. Due to the differences in variable coverage in both sides of econometric equations, estimation methods and outlooks of trade advocates and environment supporters, the existing studies generate biased results of the relationship between international trade openness and CO_2 emissions (Ertugrul *et al.*, 2016, p. 10). However, thanks to the updated econometric techniques and availability of longer datasets, it appears that we could likely obtain more consistent results.

Table 1. *List of variables and sources*

Variables	Unit	Data source	Available Time Period*
Independent variables			
Export quality index **	Ratio	IMF Data	1963-2014
Real GDP	Constant US$ 2010 per capita	WDI Database	1960-2017
Squared real GDP	Constant US$ 2010 per capita	WDI Database	1960-2017
Trade openness	% of GDP	WDI Database	1960-2017
Energy use/consumption	Kg of oil equivalent per capita	WDI Database	1960-2015
Dependent variable			
CO_2 Emissions	Kt Metric tons per capita	WDI Database	1960-2014

Source: Compiled by the author

*Updated as at the date of April 15, 2019

**Export quality upgrading is measured by the export quality index, containing "indicators of export quality for over 800 exported products that can be aggregated at various levels. It also covers 166 countries' data from 1963 to 2014, with over 1.7 million observations at the most disaggregate level. Higher values correspond to higher quality levels of products. The index is normalized, with a value of 1 signifying a quality level in line with the world frontier, taken to the quality score at the 90th percentile observed among all exporters" (IMF, 2018). This index is an important contribution of (Henn *et al.*, 2017) to measure export quality, through new estimates covering 178 countries and a large number of export products from 1962 to 2010.

Theoretically, there often exists a problem of endogeneity between international trade and growth variables in panel data. To overcome it, we could either choose good instrumental variables that are highly exogenous related to the trade-related variables or perform the econometric three-step estimation strategy. In this study, I use the latter econometric method to prevent my model from the bias problems of choosing instrumental variables. In addition, this application allows me to explore the time series properties of variables right in the first step.

The three-step estimation procedure includes (i) panel unit root tests of stationary variable properties, (ii) panel cointegration analysis and long-run estimation, (iii) panel vector autoregressive model (VAR) estimation and post-estimation of Granger causality test. Unit root tests help examine whether the variables are stationary at different levels. If the variables are stationary at the first difference level, we will use cointegration tests to check the cointegration, then examine the long-run relationship between variables with panel models. In the case of cointegration, panel VAR estimation and Granger causality test will be applied to investigate the short-term causality relationship dynamics.

(i) Panel Unit Root Tests of Stationary Variable Properties

In detail, the first step is to run the panel unit root tests to explore the time series properties of variables. Following the works of (Rahman, 2017; Gozgor and Can, 2017; and Ertugrul *et al.*, 2016), I have adopted 03 panel root tests as follows:

1. **Augmented Dickey-Fuller (ADF) Fisher-type unit-root test (Choi, 2001)**

Ho: All panels contain unit roots

Ha: At least one panel is stationary

With option in STATA 15: lags(1)

2. **Im, Persasan & Shin unit-root test** (Im, Pesaran and Shin, 2003)

Ho: All panels contain unit roots

Ha: Some panels are stationary

With option in STATA 15: lags(1) trend

3. **Hadri Lagrange Multiplier stationarity unit-root test** (Hadri, 2000)

Ho: All panels are stationary

Ha: Some panels contain unit roots

With option in STATA 15: trend

It is noted that the null hypothesis of the Hadri Lagrange Multiplier stationarity unit-root test is opposite to that of two tests above. Compared to other alternative tests, these three tests enable the autoregressive parameter to be country-specific and do not require panels to be strongly balanced. Also, the Im, Persasan & Shin unit-root test has an advantage that it does not have an assumption of all countries converging into an equilibrium value at the same speed under the alternative hypothesis then less restriction (Rahman, 2017).

(ii) Panel Cointegration Tests

In case that the variables are non-stationary and integrated of the same order, I shall perform the second step to examine the panel variable cointegration. Using the equation (1), the study examines the cointegration relationship between CO_2 emissions, real GDP per capita, energy consumption per capita, trade openness and export quality index. There are several ways of testing panel cointegration in the existing literature. In this study, we proposed the use of the Kao test (Kao, 1999) and Westerlund test (Westerlund, 2007) to investigate the panel cointegration relationship and perform a robustness check, respectively. Both tests propose the same null hypothesis of no cointegration between variables.

With the more powerful command STATA 15, I run the Kao test, which includes five sub-test versions, namely the Modified Dickey-Fuller test, Dickey-Fuller test, Augmented Dickey-Fuller test, Unadjusted modified Dickey-Fuller test and Unadjusted Dickey-Fuller test. The option of "lags(AIC)" is used to automatically choose and specify the lag structure for the augmented Dickey-Fuller regression that will minimize the Akaike information criterion. Then, the Westerlund test is used for the robustness check, with the assumption of "somepanels" to indicate the alternative hypothesis of cointegration in some panels. In STATA 15, no option of lags is included in this test.

If the tests reveal the existence of panel cointegration, I would use the panel Fully Modified Ordinary Least Squares (FMOLS) and panel Dynamic Ordinary Least Squares (DOLS) to examine the single cointegration vector and find out whether the independent variables have a positive or negative long-run relationship with CO_2 emissions or not. At first, the panel FMOLS model of Pedroni is used to correct both endogeneity bias and serial correlation problem in the panel data (Pedroni, 2000). This method is considered the most suitable technique to estimate long-run relationships when it comes to the existence of cointegrated panels (Hamit-Haggar, 2012). Then, the panel DOLS model is applied for a robustness check. The panel DOLS has some better sample properties than the panel FMOLS, such as a less bias estimator in small sample size, thanks to using the Monte Carlo simulations ((Rahman, 2017), (Kasman and Duman, 2015)).

I would use the "xtcointreg" command in Stata (Khodzhimatov, 2018), which helps to estimate the long-run relationship between panel variables, using two options of the panel FMOLS and DOLS model. This command is effective from 01/01/2018 and well certified.

(iii) Panel Vector Autoregressive Model Estimation and Granger Causality Test

According to the Monte Carlo simulations, we should not use the ordinary least squares (OLS) estimation in the situation of unit root progress and cointegration relationships as OLS result will no longer be consistent and test-statistics will be non-valid (with a very high R squared, a very high individual t-statistic and a low Durbin-Watson statistic). Therefore, in this case, I will estimate the relationship through the panel vector autoregression (VAR) model. Following the suggestions of (Holtz-Eakin, Newey and Rosen, 1988) and (Abrigo and Love, 2016), I use using generalized method of moments (GMM) instruments to maximize the estimation sample, avoid the dropping of missing data and obtain a better efficient estimate.

By fitting a multivariate panel regression of each dependent variable on lags of itself and lags of all other dependent variables and exogenous variables (Abrigo and Love, 2016), the panel VAR model could take a distinct advantage to estimate the short-run relationship dynamics between variables in a panel dataset.

In addition, according to (Engle and Granger, 1987), when it comes to the cointegration relationship between variables, there must definitely be either unidirectional or bidirectional Granger-causality in the short run. Hence, after the panel VAR estimation for the individual short-run relationship, the Granger causality test would be applied to investigate the causality direction among variables.

5 Empirical results and analysis

Table 2 provides a statistical summary of variables in the whole sample, including CO_2 emissions, EQI, real GDP per capita, energy use per capita and trade openness. I decomposed the standard deviation into two distinct dimensions with the view to providing a comparable insight of within *(intra-country)* and between *(inter-country)* values of mean, standard deviation, minimum and maximum of variables in the panel.

The overall is calculated based on 400 country-year observations while the between is calculated over 10 countries and the within is observed from 40 years of data.

It could be seen that the overall panel mean of CO_2 emissions is 6.59 Kt Metric tons per capita. The average value fluctuates largely among each EAP individual members (from 0.80 to 15.96). Meanwhile, the "CO_2 emissions within" is observed between -0.74 and 12.96 during the 40 years, which however could not jump into the conclusion that every country has a negative value of CO_2 emissions.

Similarly, EQI has a sample mean of 0.92, which shows quite a high value of export quality in this region. There is a gap between countries, the lowest EQI value is 0.69 while the highest is 1.04.

Over 40 years, the EQI value has a nearly double climb. This within-country change could be explained by the result of (Henn *et al.*, 2017): "when controlling for the country fixed-effects, export quality increases as countries grow richer".

Table 2: *Descriptive Statistics of Variables between and within the whole sample (1975-2014)*

Variable		Mean	Standard Deviation	Min	Max	Observations
CO_2 emissions *(Kt Metric tons per capita)*	overall	6.59	4.81	0.41	18.20	N = 400
	between		4.71	0.80	15.96	n = 10
	within		1.77	(0.74)	12.96	T = 40
Export quality index *(Ratio)*	overall	0.92	0.12	0.41	1.07	N = 400
	between		0.11	0.69	1.04	n = 10
	within		0.06	0.64	1.08	T = 40
Real GDP *(Constant US$ 2010 per capita)*	overall	17,706.02	15,676.35	263.23	54,546.20	N = 400
	between		14,926.73	1,699.27	39,785.69	n = 10
	within		6,687.21	(967.44)	41,881.42	T = 40
Energy usage *(Kg of oil equivalent per capita)*	overall	2,492.55	1,741.21	314.62	7,370.65	N = 400
	between		1,624.60	459.17	5,173.46	n = 10
	within		806.53	70.20	5,800.37	T = 40
Trade openness *(% of GDP)*	overall	110.76	111.19	8.38	442.62	N = 400
	between		111.52	23.55	353.05	n = 10
	within		33.78	9.75	292.18	T = 40

Table 3 gives a lens on the mean and standard deviation statistics of variables in each individual EAP countries. The Philippines and Australia hold the lowest and highest positions in the mean of environmental performance, economic growth, and energy use. Specifically, the Philippines has the lowest mean value of CO_2 emissions (0.80 Kt Metric tons per capita) and Australia is the highest polluting country (15.96 Kt Metric tons per capita). In terms of real GDP, the lowest income growth is 1,699.27 constant US$ 2010 per capita in the Philippines and the highest income value of 39,785.69 constant US$ 2010 per capita belongs to Australia. Similarly, as for energy usage, the mean value of the Philippines is the least, at the level of 459.17 kg of oil equivalent per capita whiles that of Australia reaches a peak of 5,173.46 kg of oil equivalent per capita. This level of energy use is considered very high, approximately doubling the average mean of the overall panel of 2,492.55 kg.

Regarding EQI - my main interest variable, it is witnessed that Japan has the highest quality score of 1.04 while Indonesia owns the lowest quality value of 0.69 in the panel. Interestingly, when looking at the standard deviations of China and Indonesia (0.07 and 0.13), we realize that values over the years are most spread out. Meanwhile, the measurements for Australia, Hong Kong, and Japan are least spread out from the expected value (standard error = 0.01).

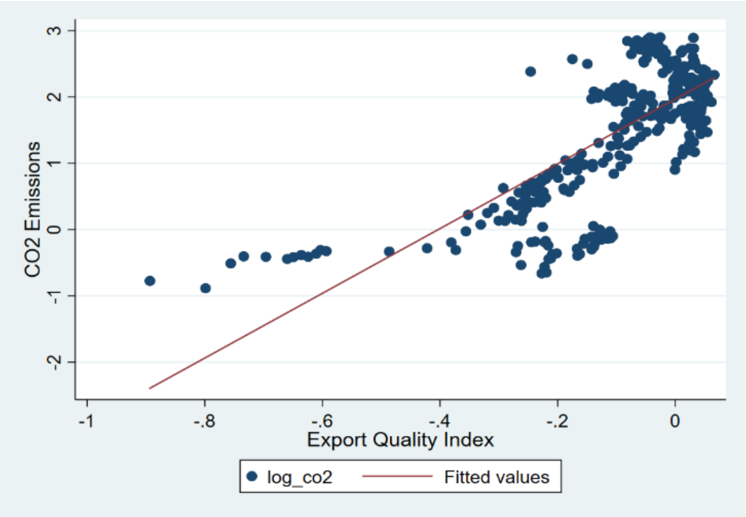
Table 3: Summary statistics of variables by individual countries

Unit		CO_2 Kt Metric tons per capita	EQI Ratio	GDP Constant US$ 2010 per capita	ENERGY Kg of oil equivalent per capita	TRADE % of GDP
Australia	Mean	15.96	0.95	39,785.69	5,173.46	36.17
	St.Dv	1.43	**0.01**	8,887.64	472.17	5.40
China	Mean	3.23	0.84	1,818.72	1,037.44	33.37
	St.Dv	1.96	**0.07**	1,699.29	526.46	16.40
Hong Kong	Mean	5.09	1.03	20,800.01	1,625.04	261.20
	St.Dv	1.19	**0.01**	8,331.16	432.75	85.29
Indonesia	Mean	1.17	0.69	2,048.58	605.37	53.58
	St.Dv	0.53	**0.13**	754.97	190.03	9.78
Japan	Mean	8.83	1.04	37,135.43	3,517.76	23.55
	St.Dv	0.82	**0.01**	7,852.46	466.88	5.71
South Korea	Mean	7.26	0.98	12,081.42	2,940.70	66.69
	St.Dv	3.08	0.04	7,026.15	1,568.86	17.57
Malaysia	Mean	4.60	0.88	5,942.02	1,715.42	152.40
	St.Dv	2.19	0.06	2,356.50	756.17	41.47
New Zealand	Mean	7.25	0.93	27,680.01	3,788.27	57.54
	St.Dv	0.99	0.04	4,617.63	546.20	4.31
Philippines	Mean	0.80	0.85	1,699.27	459.17	70.05
	St.Dv	0.13	0.04	282.22	23.76	21.07
Singapore	Mean	11.67	1.01	28,069.04	4,062.83	353.05
	St.Dv	2.90	0.06	12,948.68	1,543.20	38.54

Note: CO_2, EQI, GDP, ENERGY, TRADE, and St.Dv stand for the CO_2 emissions per capita, export quality index, real GDP per capita, energy usage per capita, trade openness level and standard deviation, respectively.

A correlation pattern between the two main variables of research is graphed in **Figure 2**. The higher EQI is, the larger CO_2 emissions volume gets. In the panel, CO_2 emissions appear to converge in a high positive level between 1 and 3 Kt Metric tons per capita during the study period.

Figure 2: Premilitary Correlation between EQI and CO_2 Emissions



Source: Author

5.1 Panel unit root tests

To assess the stationarity properties of model variables, the unit-root test results are presented in **Table 4**. The Augmented Dickey-Fuller (ADF) Fisher-type test and Im-Pesaran-Shin (IPS) test have the same null hypothesis of a unit root process while the Hadri Lagrange Multiplier (Hadri) test indicates the opposite null hypothesis of stationary variables.

The results of log EQI in **Table 4** say that there is an unclear conclusion for the ADF Fisher-type unit root test while the other two tests show that log EQI contains a unit root process. To have a robustness check for this variable's result, I use one extra unit root test, namely "Breitung" [1]. The robustness check result dictates that the log EQI has a unit root process at both the 99% and 95% confidence level (see **Table 5**). In addition, the low p-value of the first difference of log EQI shows that this variable is stationary at the first difference. From these results, we finally could make a sound conclusion that log EQI has a unit root process and is cointegrated into the order one [I(1)].

The other variables are confirmed to have a panel unit root and be stationary at the first difference, thanks to the consistent results obtained in **Table 4**.

To sum up, all of the empirical variables have a unit root process and are found as I(1) in the panel.

5.2 Panel Cointegration Tests

The results of three cointegration tests are demonstrated in **Table 6**.

In the (Kao, 1999) test, the optimal lag length number is specified based on the minimum value of AIC. With the low p-value record of five Kao statistics tests (p-value = 0.00), there is strong evidence to reject the null hypothesis of no cointegration between variables at the 91% and 95% confidence level.

In the (Pedroni, 1999, 2004) test, we include three separate statistic tests, namely Modified Phillips-Perron, Phillips-Perron and Augmented Dickey-Fuller (ADF). All of them have the same null hypothesis of no cointegration and the alternative hypothesis of cointegration in all panels. The panel-specific linear time trends and AIC lag structure are specified for the dependent variable on the covariates and for the ADF regressions performed in computing the test statistic.

Shown in **Table 6**, it could be confirmed that the null hypothesis of no cointegration in the panel is rejected with the two test statistics of Phillips-Perron and ADF regressions at the 95% and 91% confidence level (p-value equal to 0.04 and 0.01, respectively). Lastly, the test statistic of Modified Phillips-Perron regression exhibits that the null hypothesis could be rejected at the 90% confidence level (p-value = 0.08 < 0.1).

(Westerlund, 2005) cointegration test is used to check the robustness of the results above. It offers the residual-based panel data testing and no correction requirement for the temporal dependencies of the data. The null hypothesis is the same as the first two cointegration tests above. We obtain the Westerlund variance ratio of 0.03, meaning that we could reject the null hypothesis of no integration at the 95% confidence level.

[1] The advantage of Breitung test is that it has the highest power of checking unit root and smallest distortion of small size problem in a panel data (Rahman, 2017). The null hypothesis of Breitung test is similar with the ADF Fisher-type, saying that there exists a unit root in the panel.

Table 4: *Results of panel unit root tests*

Variables	**ADF Fisher-type**			**IPS**			**Hadri**		
		Statistic	p-value	Statistic		p-value	Statistic		p-value
Log of CO_2 emissions	P	26.56	0.15	W-T-bar	(0.36)	0.36	z	27.84	0.00
	Z	(0.30)	0.38						
	L*	(0.59)	0.28						
	Pm	1.04	0.15						
D. Log of CO_2 emissions	P	154.28	0.00	W-T-bar	(9.61)	0.00	z	1.25	0.90
	Z	(9.95)	0.00						
	L*	(13.56)	0.00						
	Pm	21.23	0.00						
Log of EQI	P	39.98	**0.01**	W-T-bar	(1.57)	0.06	z	44.78	0.00
	Z	(1.61)	**0.05**						
	L*	(2.00)	**0.03**						
	Pm	3.16	**0.00**						
D. Log of EQI	P	184.21	0.00	W-T-bar	(11.06)	0.00	z	(0.24)	0.59
	Z	(11.33)	0.00						
	L*	(16.19)	0.00						
	Pm	25.96	0.00						
Log of real GDP	P	12.16	0.91	W-T-bar	1.20	0.88	z	48.84	0.00
	Z	1.28	0.90						
	L*	1.36	0.91						
	Pm	(1.24)	0.89						
D. Log of real GDP	P	128.26	0.00	W-T-bar	(8.59)	0.00	z	1.58	0.06
	Z	(9.08)	0.00						
	L*	(11.28)	0.00						
	Pm	17.12	0.00						
Log of trade openness	P	14.52	0.80	W-T-bar	1.38	0.92	z	40.62	0.00
	Z	1.43	0.92						
	L*	1.56	0.94						
	Pm	(0.87)	0.81						
D. Log of trade openness	P	152.06	0.00	W-T-bar	9.75	0.00	z	(0.72)	0.76
	Z	(10.18)	0.00						
	L*	(13.38)	0.00						
	Pm	20.88	0.00						
Log of Energy use	P	4.18	1.00	W-T-bar	3.73	1.00	z	49.03	0.00
	Z	3.92	1.00						
	L*	4.04	1.00						
	Pm	(2.50)	0.99						
D. Log of energy use	P	132.81	0.00	W-T-bar	8.65	0.00	z	(1.55)	0.94
	Z	(9.08)	0.00						
	L*	(11.66)	0.00						
	Pm	17.84	0.00						

Note: "D." and "Log" stands for the first difference and natural logarithm of variables, respectively. In the ADF Fisher-type test, "P" is the inverse chi-squared statistic, "Z" is the inverse normal statistic, "L*" is the inverse logit statistic and "Pm" is the modified inverse chi-squared. The null hypothesis of four ADF statistics is "all panel contain unit roots". For three of the unit root tests, we include the specification of a "trend" and 1 lag.

Table 5: Robustness check for log export quality index

Variables	Breitung unit-root test *H0: Panels contain unit roots* *Ha: Panels are stationary*		
	Test Statistic		p-value
Log of EQI	lambda	0.48	0.68
D. Log of EQI	lambda	(7.32)	0.00

To sum up, we make a conclusion that there exists a long-run cointegration relationship between the variables in the panel, namely CO_2 emissions, EQI, energy consumption, economic growth, and trade openness.

This finding also confirms empirically the theoretical channels of trade impacts on the environment, including scale, technique and composition effects. This conclusion of the long-run cointegration relationship is similar to (Le, Chang and Park, 2016) and seminal discoveries of (Copeland and Taylor, 1995; Antweiler, Copeland and Taylor, 2001). The overall impact of EQI, international trade and economic growth on the environment depends on the net combination of three effects.

Table 6: *Results of panel cointegration tests*

No	Cointegration Test	Test Statistic	p-value
KAO Test			
Ho: No cointegration - Ha: All panels are cointegrated			
1.	Modified Dickey-Fuller regression	(3.39)	0.00***
2.	Dickey-Fuller regression	(2.80)	0.00***
3.	Augmented Dickey-Fuller regression	(2.64)	0.00***
4.	Unadjusted modified Dickey-Fuller regression	(3.44)	0.00***
5.	Unadjusted Dickey-Fuller regression	(2.81)	0.00***
Pedroni Test			
Ho: No cointegration - Ha: All panels are cointegrated			
1.	Modified Phillips-Perron regression	1.43	0.08*
2.	Phillips-Perron regression	(1.75)	0.04**
3.	Augmented Dickey-Fuller regression	(2.33)	0.01**
Westerlund Test			
Ho: No cointegration - Ha: Some panels are cointegrated			
1.	Group-mean variance-ratio variance ratio	1.87	0.03**

Note: ***, **, * stand for the significance level at 1%, 5% and 10%, respectively.
Ho and Ha are the null hypothesis and alternative hypothesis, respectively.

5.3 Long-run Dynamics Estimation

Given the fact that all the variables in the panel are in a unit root process and I(1), the long-run cointegration relationship dynamics between variables will be estimated.

The results of the panel FMOLS method are reported in **Table 7** as below. The impact of EQI on CO_2 emissions is positive and significant in the long run (coefficient = 0.71). It can also be interpreted that a 1% rise in export quality index will increase CO_2 emissions per capita by 0.71% in the panel. This result is quite surprising since I have expected that export quality upgrading could reduce CO_2 volume emitted in the long run (see Section **4.1**). **Figure 2** shows a positive correlation. The econometric result here shows that other things held equal, i.e. controlling for other determinants of CO_2 emissions, this positive relationship is not altered. This regional-level finding is opposite to the result of export quality and environmental performance in China of (Gozgor and Can, 2017) and (Mao and He, 2017).

Meanwhile, trade openness confirms a negative relationship with CO_2 emissions (-0.09) and the energy use shows a positive signal with the pollution emissions (0.75).

For economic growth, there is a positive and significant relationship between CO_2 emissions and real GDP per capita in the long run. In other words, the long-term environmental impact of income is elastic and positive (3.13), suggesting that higher income growth will deteriorate environmental quality steadily. The coefficient of squared real GDP per capita is negative and significant at the 99% confidence level, which infers that at a certain level of income growth, a 1% increase in squared income per capita could lead to the 0.17% decrease in the volume of CO_2 emissions per capita in the EAP region. This result is relevant to the inverted U-shaped relationship between economic growth and environmental performance in the EKC hypothesis. This finding is in line with many previous studies, such as (Grossman and Krueger, 1995; Farhani *et al.*, 2014; Kasman and Duman, 2015). However, it is opposite to the conclusion of (Wang *et al.*, 2011; Ozcan, 2013; Gozgor and Can, 2017; Rahman, 2017), who found a U-shape relationship between two variables.

Table 7: *Estimation Results of Panel FMOLS and Panel DOLS methods*

Method	**Panel FMOLS**		**Panel DOLS**	
Variables	beta	t-statistics	beta	t-statistics
Log of EQI	**0.71**	7.09***	**2.22**	19.68***
Log of real GDP	**3.13**	8.25***	**4.59**	2.54**
Log of squared real GDP	**-0.17**	-7.73***	**-0.32**	-2.45**
Log of trade openness	-0.09	-1.49	-0.41	-16.49***
Log of energy use	**0.75**	36.94***	**0.84**	34.37***

Note: ***, ** and * denote the significance level at 1%, 5% and 10%, respectively.

The panel DOLS estimation results are also presented in **Table 7** for easy comparison. Accordingly, the panel DOLS finding is consistent with the panel FMOLS one.

According to the argument of (Ozcan, 2013), the variable relationship declaration in a country level is necessary under the appearance of heterogeneity of long-run parameters. Therefore, the comparative results are also illustrated for each individual country (**Table 8**).

The main interest variable, EQI, extracts a number of interesting insights on its impact on CO_2 emissions. First of all, only 6 out of 10 countries have the EQI variable correlated with CO_2 emissions at the usual significance level (namely China, Hong Kong, Japan, Malaysia, New Zealand, and the Philippines). In which, the elastically negative relationship is only observed in China. A 1% increase in EQI value could reduce the CO_2 emissions level by 1.08%. Worth notedly, this finding is totally in line with the result of China's EQI - environment linkage in the recent papers. (Mao and He, 2017) gave the explanations that the changing product mix at a firm level and industrial mix at a city level to avoid environmental costs and stringent environmental regulations at a country level have helped to "prevent export quality upgrading from an environmental downgrading". Meanwhile, despite not bringing on expositions for this negative and elastic relationship, (Gozgor and Can, 2017) argued the policy implications that require Chinese firms to produce environment-friendly goods and import pollution-intensive products from other less developed countries, where environmental policies have fewer restrictions. Moreover, industry-specified regulations also need to be launched to control an exhaustive level of CO_2 emissions for each sector in China.

The five other countries in the significant list have an elastic and positive relationship, meaning that EQI upgrading creates more CO_2 emissions over the times (beta > 1). This finding has caught my arousing curiosity to conduct further studies in every single country to unlock hidden reasons for the EQI - CO_2 emissions relationship.

Second, as for international trade, despite the insignificance in the entire panel data, some countries witness the significantly positive relationship between trade and the environment (Hong Kong and South Korea). This implies the "pollution haven" hypothesis validity in both countries. Meanwhile, the international trade of New Zealand and Singapore could promote pollution abatement.

The inverted U-shaped EKC hypothesis of income growth and environmental performance is also confirmed in most countries in the panel. Australia, China, Hong Kong, South Korea, New Zealand, and the Philippines). The energy use has a positive impact on all the countries in the panel, except for Malaysia and Singapore.

5.4 Panel Vector Autoregression Model Estimation Results

The existence of a long-run cointegration vector between variables necessitates the exploration of their short-run and causal relationships (Granger, 1969). Therefore, the short-run relationship dynamics between cointegrating panel variables will be estimated since my empirical variables are cointegrated into the same order of one and the first difference of variables are stationary.

The first-order panel VAR model is chosen to estimate upon the result of the stationarity of variables in the first difference above.

The results of estimating the first-order panel VAR model in the GMM pattern are displayed in **Table 9**. It is seen that EQI upgrading in a year brings on a statistically and significantly positive effect on the CO_2 emissions in the next year for the short-run dynamics. Particularly, one percentage surge in EQI in the year "t" could increase the CO_2 emissions level by 1.154% in the next year "t+1". This result helps to answer my research question in the short run, export quality upgrading increases the CO_2 emissions. The reasons could be the lack of stringent environmental regulations at both country and industry levels, which manufacturing firms have fully exploited to upgrade their export quality and maximize their profit. One more explanation could possibly be the cost-benefit analysis in a firm level: producers will consider sub-costs of quality upgrading (i.e. human cost, technology cost, physical costs, etc.) and the environment-related costs with the benefits that they could earn from the exporting of higher-quality products. Then, they will choose the optimal combination points in which they could maximize their revenue from exports and minimize the environmental expenses. As a result, export quality upgrading will downgrade environmental sustainability.

A similar pattern could be observed in the impacts of real GDP per capita and trade openness on CO_2 emissions. Meanwhile, energy use per capita has a significantly negative relationship to CO_2 emissions in the short-run period (coefficient = -0.262). Moreover, it is worth noted that when income growth increases to a certain level, the emitted CO_2 volume will decrease gradually, which confirms the validity of the inversed-U EKC hypothesis in the EAP region in the short run.

Table 8: *FMOLS estimation results in the long run (country-wise)*

		Dependent variable: Log of CO_2 emissions				
	Independent variables	**Log of EQI**	**Log of Real GDP**	**Log of Squared real GDP**	**Log of Trade openness**	**Log of Energy use**
Australia	**beta**	0.06	10.19	-0.48	0.06	0.62
	Se.	0.22	1.92	0.09	0.06	0.09
	t-stat	0.27	5.3***	-5.33***	1.06	6.99***
China	**beta**	**-1.08**	1.33	-0.09	-0.03	1.37
	Se.	0.15	0.12	0.01	0.02	0.04
	t-stat	-7.03***	11.07***	-9.84***	-1.54	31.25***
Hong Kong	**beta**	1.05	6.81	-0.36	0.61	0.7
	Se.	0.59	0.98	0.05	0.09	0.06
	t-stat	1.78*	6.93***	-7.02***	6.48***	11.44***
Indonesia	**beta**	-0.11	-2.77	0.21	-0.1	0.85
	Se.	0.36	2.87	0.18	0.1	0.21
	t-stat	-0.29	-0.97	1.2	-0.91	4.1***
Japan	**beta**	1.27	-21.06	1.02	0.01	0.44
	Se.	0.45	2.6	0.13	0.02	0.05
	t-stat	2.82***	-8.1***	8.09***	0.61	7.96***
South Korea	**beta**	-0.02	0.79	-0.05	0.07	0.79
	Se.	0.44	0.32	0.02	0.03	0.06
	t-stat	-0.06	2.43**	-2.7***	2.17**	12.16***
Malaysia	**beta**	1.41	-2.52	0.2	0.15	-0.01
	Se.	0.48	2.01	0.11	0.09	0.16
	t-stat	2.96***	-1.26	1.85*	1.62	-0.04
New Zealand	**beta**	1.59	18.08	-0.88	-0.19	1.2
	Se.	0.09	2.5	0.12	0.03	0.04
	t-stat	16.98***	7.23***	-7.23***	-7.48***	34.16***
Philippines	**beta**	1.52	19.05	-1.23	-0.08	1.4
	Se.	0.4	6.23	0.42	0.07	0.18
	t-stat	3.82***	3.06***	-2.95***	-1.2	7.66***
Singapore	**beta**	1.41	1.43	-0.09	-1.42	0.16
	Se.	1.19	3.69	0.18	0.26	0.14
	t-stat	1.19	0.39	-0.52	-5.52***	1.13

Note: ***, ** and * denote the significance level at 1%, 5% and 10%, respectively.
Beta, Se., and t-stat stand for beta of coefficient, standard error and t-statistics, respectively.

Table 9: *Results of first-order panel VAR model estimation in the GMM framework*

	Dependent variables					
Independent variables	(1) **CO_2 emissions**	(2) **EQI**	(3) **Real GDP**	(4) **Squared real GDP**	(5) **Trade openness**	(6) **Energy use**
L. CO_2 emissions	0.652***	0.106***	-0.0650***	-1.476***	-0.297***	0.224***
	(0.0424)	(0.0128)	(0.0139)	(0.250)	(0.0509)	(0.0264)
L. EQI	1.154***	0.662***	0.361***	6.486***	0.336***	-0.305***
	(0.124)	(0.0290)	(0.0353)	(0.641)	(0.0819)	(0.0466)
L. Real GDP	0.365***	-0.0398	1.099***	2.549***	-0.0847	0.0676
	(0.123)	(0.0330)	(0.0363)	(0.662)	(0.149)	(0.0658)
L.Squared real GDP	-0.00940	0.00286*	-0.00334*	0.890***	-0.0157**	0.00343
	(0.00655)	(0.00154)	(0.00187)	(0.0339)	(0.00681)	(0.00301)
L. Trade openness	0.115*	-0.0817***	0.0268	0.666**	1.411***	-0.237***
	(0.0669)	(0.0172)	(0.0186)	(0.338)	(0.0731)	(0.0315)
L. Energy use	-0.262***	-0.0295	-0.0866***	-1.109**	0.473***	0.753***
	(0.0906)	(0.0215)	(0.0264)	(0.480)	(0.0677)	(0.0399)

Note: ***, **, * stand for the significance level at 1%, 5% and 10%. Figures in parentheses are standard errors. L. stands for the one lag of variables. All variables are in the natural logarithm form.

Next step, I will examine the Granger causality for the first-order panel VAR model. Although it is possible to make an inference of causality relationship between variables from the results presented in **Table 9**, I would like to perform the Granger causality test for a more robust illustration. The significance of the causality tests is determined by the Wald F-test (by comparing p-value). The results of the Granger causality test [2] indicate that there is a uni-directional Granger causality running from CO_2 emissions to EQI, real GDP per capita, squared real GDP per capita, trade openness and energy use per capita at the usual confidence levels (99%, 95%, and 90%).

6 Robustness check

To check the robustness of my empirical results, the equation (1) is re-estimated with the alternatives for the dependent variable "CO_2 emissions" and the explanatory variable "EQI".

For the "CO_2 emissions" robustness check, I replace with "Consumption Emissions (GCB)" variable. The data of Consumption Emissions (GCB) [3] from 1990 to 2008 is the contribution of (Peters *et al.*, 2011) in the "Global Carbon Budget" project (Le Quéré *et al.*, 2018). There exist a unit root process and cointegration relationship among variables. The re-estimation results [4] of environmental impacts of interest variable, EQI, and other exogenous variables on "Consumption Emissions (GCB)" are identical to the empirical results of "CO_2 emissions". Therefore, it could be concluded that my estimated results for production-based CO_2 emissions are comparatively robust to alternative measurements of Consumption Emissions (GCB).

[2] The Granger causality test results are displayed in **Appendix 10.1**: Panel VAR-Granger causality results**.**

[3] The values of Consumption Emissions (GCB) are measured in million tonnes of carbon per year. For the values in million tonnes of CO_2 per annum, we need to multiply the values below by 3.664 (the computation will be: 1MtC = 1 million tonne of Carbon = 3.664 million tonnes of CO_2) (Peters, Davis and Andrew, 2012).

[4] The detail of robustness check results with "Consumption Emissions (GCB)" are shown in **Appendix 10.2**: Robustness check results with "Consumption Emissions (GCB)" variable.

For the "EQI" robustness check, I suggest one alternative possibility of the "Economic Complexity Index". "Economic Complexity Index" [5] (ECI) measures the productive capabilities of an economy by examining the relative knowledge intensity of the products that it exports. This index has been validated as a relevant economic measure of export quality since it could predict the future economic growth situations (Hidalgo and Hausmann, 2009) and explain the dynamics of international variations in income inequality (Hartmann *et al.*, 2017). The robustness results [6] show that ECI has a unit root process in the panel and the stationarity is observed at the first difference level of the variables. The cointegration relationship between variables in the panel is confirmed through the KAO cointegration tests. However, WESTERLUND and PEDRONI tests suggest no cointegration relationship. As a result, the long-run estimation results of impacting ECI on CO_2 emissions is not statistically significant (the t-statistics are -0.86 and -0.13 in the FMOLS and DOLS estimations, respectively). Since we cannot confirm the long-run cointegration relationship between variables, it is unnecessary to further estimate the short-run dynamics.

One more possibility to check the robustness of EQI is the addition of the new variable of "squared EQI" to the vector of exogenous variables. Its purpose is to examine the evolution of export quality upgrading along with environmental performance through answering the question of whether the squared value of my interest variable influences CO_2 emissions or not. This idea stems from (Cadot, Carrere and Strauss-Khan, 2011).

A preliminary relationship between squared EQI and CO_2 emissions are presented in **Figure 3**. It can be easily realized that when export quality upgrading grows to a certain high level, CO_2 emissions will be reduced to below 0. Therefore, the model to be estimated is as follows:

Equation 2:

$$lnCO2_{it} = \alpha + \beta_{11} * lnEQI_{it} + \beta_{12} * lnEQI_{it}^{2} + \beta_2 * lnRGDP_{it} + \beta_3 * lnRGDP_{it}^2 + \beta_4 * TRADE_{it} + \beta_5 * lnENER_{it} + \varepsilon_{it} \quad (2)$$

and we jointly check whether $\beta_{11} > 0$ and $\beta_{12} < 0$

The robustness check results [7] show that squared EQI, EQI, CO_2 emissions, and other exogenous variables have a unit root process and a cointegration relationship at the same order of one. EQI has a significantly positive long-term relationship ($\beta_{11} > 0$). Squared EQI has a negative and statistically significant impact on CO_2 emissions in the long run (with the FMOLS estimation: coefficient = -18.75 and t-statistic = -4.46). The DOLS estimation result for robustness check does not show a statistical significance, though (t-statistic = 0.74).

Therefore, we could say that an inverted-U relationship between EQI and CO_2 emissions might exist to some extent in the long run. This could, in a certain degree, lead to some implications for export

[5] The ECI data is download at the website: https://atlas.media.mit.edu/en/rankings/country/eci/.

[6] The detail of robustness check results with "Economic Complexity Index" are shown in **Appendix 10.3**: Robustness check results with "Economic Complexity Index" variable.

[7] The detail of robustness check results with "Squared EQI" are shown in **Appendix 10.4**: Robustness check results with "Squared EQI" variable.

quality and environment policies. The EQI turning point is the peak of the graph, in which the marginal effect of EQI downgrades CO_2 emissions. We can calculate the turning point value of EQI as follows:

$$\frac{\partial \ln CO2}{\partial \ln EQI} = 0 \Leftrightarrow \hat{\beta}_{11} + 2\hat{\beta}_{12} \ln EQI = 0$$

$$\ln EQI = -\frac{\hat{\beta}_{11}}{2\hat{\beta}_{12}}$$

Then:

$$EQI = e^{-\frac{\hat{\beta}_{11}}{2\hat{\beta}_{12}}}$$

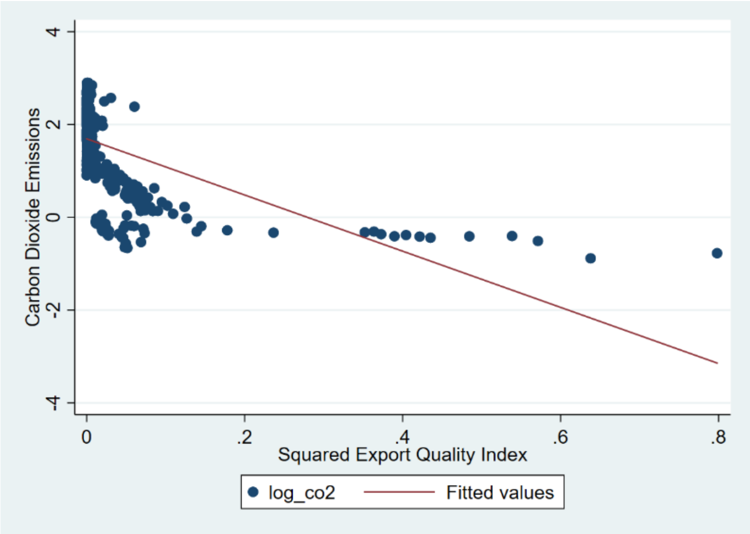
Replacing the FMOLS-estimated values of β_{11} and β_{12}, which are displayed in **Table 14**, we obtain the turning point of EQI in the long run from the formula (5) as follows:

$$EQI = e^{-\frac{\hat{\beta}_{11}}{2\hat{\beta}_{12}}} = e^{-\frac{1.25}{2*(-18.75)}} = e^{0.033} = 1.034$$

Therefore, at the EQI turning point equal to 1.034, the downward trend will be observed between EQI and CO_2 emissions. This turning value is higher than the average EQI of the whole sample (the sample mean = 0.92, see **Table 2**). For an individual comparison, only Japan has a higher EQI value than this turning point (Japan's EQI = 1.04, see **Table 3**).

However, admittedly, in the short run, the effects of squared EQI on CO_2 emissions is still similar to that of EQI. At the 99% confidence level, a 1% extension in the squared EQI value this year "t" could increase the volume of carbon dioxide emissions by 0.454% in the next year "t+1".

Figure 3: *Premilitary Correlation between Squared EQI and CO_2 Emissions*



Source: Author

7 Conclusion and policy implications

This study scrutinizes the nexus between export quality upgrading, economic growth, trade openness, energy use and CO_2 emissions for a panel of 10 countries in the EAP region over the 40 years. The primary contribution of this research is to raise the first awareness of the importance of export quality upgrading towards the environment on a regional scale. Additionally, the validity of the EKC hypothesis is also examined in the panel. The econometric procedures of panel unit root tests, panel cointegration tests, panel VAR estimation, and panel Granger causality tests are employed to examine the relationship between variables in the long run and short run.

In summary, EQI has a positive and statistically significant impact on the CO_2 emissions through the estimation results of panel FMOLS, DOLS and VAR models. Given the EKC hypothesis, at the low level of income, the economic growth would increase the environmental pollution; however, when countries move to the higher certain level of income, the reversed relationship would happen.

Some policy implications can be derived from these findings. Given the fact that export quality upgrading is a globalization trend of manufacturing and international trade, countries could not deny this movement. However, to protect the environment, reduce greenhouse effects and cope with climate change, policymakers need to reinforce regulations on the limitation levels of greenhouse emissions and CO_2 emissions in producing export goods and services. The quality upgrading should be considered with highly-advanced technology to protect the environment, reduce emitted toxic substances, and protect the living environment of the human being in all the administrative and sectoral levels.

In addition, since CO_2 emissions is the main externality of global warming and greenhouse effects, no single country could deal with these environmental problems without seeking cooperation from others. Therefore, international agreements of trade and environmental sustainability are in urgent need to address the negative effects of export quality upgrading on the environment. That is also one of the major reasons for countries to fight for the achievement of targets and goals in the 2030 Agenda for Sustainable Development together. Since 2015, more than 190 countries have ratified the Paris agreement to take a world action plan in together reducing dangerous substance emissions, limiting global warming to below 2°C and pursuing further efforts to limit it to 1.5°C. Therefore, stringent management of export quality upgrading process via strict regulations could become one of the practical methods for countries to reach this target, together with protecting the environment and the Mother Earth.

8 Limitations of the study

Despite several efforts to investigate the relationship between export quality upgrading, economic growth, trade openness, energy use, and CO_2 emissions, the study still has some limitations as follows.

The first one is about providing more explanations for the positive relationship between EQI and CO_2 emissions on a regional level. The research also does not have more opportunities to analyze and give reasons for the heterogeneity of environmental impacts of EQI in different countries of the panel.

The second limitation is about some econometric procedures related to the panel VAR model estimation. The author has chosen the first-lag order version of the panel VAR model without performing the lag order model selection for the panel VAR model with the STATA command: "pvarsoc". However, it is acceptable since the previous estimations have been using the lag(1) structure. The author also did not run the post-estimation command: "pvarirf" to calculate and plot impulse-response functions (IRF) for the selected panel VAR model. In addition, the computation of forecast-error variance decomposition (FEVD), based on a Cholesky decomposition of the residual covariance matrix of the underlying panel VAR model, has not been executed since the author did not have enough proficiency to analyze obtained results.

The next research limitation is about not using the Panel Vector Error Correction Model (VECM) to estimate both the long-run and short-run relationship dynamics of variables. The panel VAR model and Granger causality tests, which have been used in this thesis, only allow the short-run estimation. They do not cover the long-run relationship estimation for variables. Therefore, the procedure for estimating the Panel VECM model should have been applied. However, the author could not find a good procedure in the STATA program to run this model in a panel setting. To the best of my knowledge, the execution of panel VECM estimation could be done quite easily in the EVIEWS software, but not in the STATA. As a result, the Granger Causality test based on the vector error-correction model (VECM) cannot be performed.

Therefore, further studies can try to overcome these constraints to obtain better findings of the relationship between export quality upgrading and the environment in a regional and national level.

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10 Appendices

Appendix 10.1: Panel VAR-Granger causality results

Table 10: *Results of panel VAR-Granger causality Wald test*

Equation \ Excluded	chi2	Degree of freedom	Prob > chi2
Log of CO_2 emissions			
Log of real GDP	8.77	1.00	0.00
Log of squared real GDP	2.06	1.00	0.15
Log of trade openness	2.96	1.00	0.09
Log of energy use	8.36	1.00	0.00
Log of EQI	87.26	1.00	0.00
ALL	202.36	5.00	0.00
Log of real GDP			
Log of CO2 emissions	22.02	1.00	0.00
Log of squared real GDP	3.19	1.00	0.07
Log of trade openness	2.07	1.00	0.15
Log of energy use	10.73	1.00	0.00
Log of EQI	104.88	1.00	0.00
ALL	313.34	5.00	0.00
Log of squared real GDP			
Log of CO2 emissions	34.87	1.00	0.00
Log of real GDP	14.82	1.00	0.00
Log of trade openness	3.89	1.00	0.05
Log of energy use	5.34	1.00	0.02
Log of EQI	102.25	1.00	0.00
ALL	365.98	5.00	0.00
Log of trade openness			
Log of CO2 emissions	34.17	1.00	0.00
Log of real GDP	0.32	1.00	0.57
Log of squared real GDP	5.35	1.00	0.02
Log of energy use	48.75	1.00	0.00
Log of EQI	16.86	1.00	0.00
ALL	92.68	5.00	0.00
Log of energy use			
Log of CO2 emissions	72.21	1.00	0.00
Log of real GDP	1.06	1.00	0.30
Log of squared real GDP	1.29	1.00	0.26
Log of trade openness	56.50	1.00	0.00
Log of EQI	42.82	1.00	0.00
ALL	178.03	5.00	0.00
Log of EQI			
Log of CO2 emissions	69.41	1.00	0.00
Log of real GDP	1.46	1.00	0.23
Log of squared real GDP	3.44	1.00	0.06
Log of trade openness	22.63	1.00	0.00
Log of energy use	1.89	1.00	0.17
ALL	140.27	5.00	0.00

Note:

Null hypothesis: Excluded variable does not Granger-cause Equation variable
Alternative hypothesis: Excluded variable Granger-causes Equation variable

Appendix 10.2: Robustness check results with "Consumption Emissions (GCB)" variable

Table 11: *Robustness re-estimation results of panel FMOLS and DOLS methods with "Consumption Emissions (GCB)" variable*

Method	Panel FMOLS		Panel DOLS	
Variables	beta	t-statistics	beta	t-statistics
Log of EQI	**1.47**	**18.48*****	**2.94**	**13.81*****
Log of real GDP	-5.93	-15.16***	-35.89	105.38***
Log of squared real GDP	0.34	18.22***	2.48	33.92***
Log of trade openness	-0.24	-15.2***	0.11	-14.57***
Log of energy use	0.47	34.48***	-0.32	68.95***

Note: ***, ** and * denote the significance level at 1%, 5% and 10%, respectively.

Table 12: *Robustness re-estimation results of first-order panel VAR model estimation in the GMM framework with "Consumption Emissions (GCB)" variable*

	Dependent variables					
Independent variables	(1) **GCB**	(2) **EQI**	(3) **Real GDP**	(4) **Squared real GDP**	(5) **Trade openness**	(6) **Energy use**
L. GCB	0.823***	0.107***	0.274***	5.115***	-0.149***	0.658***
	(0.0322)	(0.00950)	(0.0179)	(0.342)	(0.0306)	(0.0470)
L. EQI	-0.299	0.727***	-0.406***	-7.608***	1.224***	-0.214
	(0.254)	(0.0592)	(0.114)	(2.132)	(0.230)	(0.351)
L. Real GDP	0.295***	0.0476*	0.921***	-1.210	-0.756***	0.619***
	(0.107)	(0.0283)	(0.0466)	(0.880)	(0.0841)	(0.137)
L.Squared real GDP	-0.00618	-0.00787***	-0.00961***	0.802***	0.0346***	-0.0569***
	(0.00638)	(0.00166)	(0.00265)	(0.0505)	(0.00472)	(0.00767)
L. Trade openness	-0.105***	0.0234***	0.0149	0.304	1.017***	0.128***
	(0.0165)	(0.00667)	(0.0129)	(0.249)	(0.0238)	(0.0352)
L. Energy use	-0.0299	-0.0206	0.00364	0.351	0.264***	0.446***
	(0.0389)	(0.0132)	(0.0326)	(0.637)	(0.0450)	(0.0782)

Note: ***, **, * stand for the significance level at 1%, 5% and 10%. Figures in parentheses are standard errors. L. stands for the one lag of variables. All variables are in the natural logarithm form.

Appendix 10.3: Robustness check results with "Economic Complexity Index" variable

Table 13: *Robustness re-estimation results of panel FMOLS and DOLS methods with "Economic Complexity Index" variable*

Method	**Panel FMOLS**		**Panel DOLS**	
Variables	beta	t-statistics	beta	t-statistics
Log of Economic Complexity Index	**-0.04**	**-0.86**	**-0.04**	**-0.13**
Log of real GDP	-0.84	2.31**	1.83	-70***
Log of squared real GDP	0.02	-2.09**	-0.2	70.6***
Log of trade openness	-0.13	-0.82	-0.49	-34.65***
Log of energy use	0.78	20.14***	0.99	48.45***

Note: ***, ** and * denote the significance level at 1%, 5% and 10%, respectively.

Appendix 10.4: Robustness check results with "Squared EQI" variable

Table 14: *Robustness re-estimation results of panel FMOLS and DOLS methods with "Squared EQI" variable*

	Method	Panel FMOLS		Panel DOLS	
Variables		beta	t-statistics	beta	t-statistics
Log of EQI		**1.25**	**2.09****	**1.5**	**9.95*****
Log of squared EQI		**-18.75**	**-4.46*****	**-69.66**	**0.74**
Log of real GDP		1.74	5.79***	0.74	3.1***
Log of squared real GDP		-0.1	-5.31***	-0.13	-2.56**
Log of trade openness		-0.11	-1.31	-0.43	-15.8***
Log of energy use		0.74	41.31***	0.92	21.22***

Note: ***, ** and * denote the significance level at 1%, 5% and 10%, respectively.

Table 15: *Robustness re-estimation results of first-order panel VAR model estimation in the GMM framework with "Squared EQI" variable*

	Dependent variables						
Independent variables	(1) **CO_2 emissions**	(2) **EQI**	(3) **Squared EQI**	(4) **Real GDP**	(5) **Squared real GDP**	(6) **Trade openness**	(7) **Energy use**
L. CO_2 emissions	0.593***	0.114***	-0.103***	-0.0736***	-1.555***	-0.285***	0.199***
	(0.0317)	(0.0105)	(0.0104)	(0.00828)	(0.146)	(0.0349)	(0.0261)
L. EQI	1.639***	0.439***	-0.736***	0.0865	0.676	0.654***	-1.252***
	(0.212)	(0.0514)	(0.0717)	(0.0609)	(1.097)	(0.192)	(0.106)
L. Squared EQI	0.454***	-0.233***	-0.288***	-0.319***	-6.704***	0.313**	-1.020***
	(0.151)	(0.0357)	(0.0527)	(0.0446)	(0.800)	(0.139)	(0.0783)
L. Real GDP	0.483***	-0.0262	0.322***	1.209***	4.563***	-0.192	0.274***
	(0.121)	(0.0347)	(0.0270)	(0.0313)	(0.560)	(0.124)	(0.0817)
L. Squared real GDP	-0.00803	0.000879	-0.0122***	-0.00574***	0.847***	-0.00754	-0.00636*
	(0.00660)	(0.00164)	(0.00142)	(0.00153)	(0.0272)	(0.00582)	(0.00378)
L. Trade openness	0.0404	-0.0754***	-0.0680***	-0.0352***	-0.554***	1.421***	-0.292***
	(0.0459)	(0.0147)	(0.00972)	(0.0120)	(0.210)	(0.0570)	(0.0348)
L. Energy use	-0.420***	0.0120	-0.0119	-0.128***	-1.900***	0.373***	0.829***
	(0.0802)	(0.0192)	(0.0181)	(0.0179)	(0.319)	(0.0599)	(0.0416)

Note: ***, **, * stand for the significance level at 1%, 5% and 10%. Figures in parentheses are standard errors. L. stands for the one lag of variables. All variables are in the natural logarithm form.