THE IMPACT OF ENVIRONMENTAL POLICY STRINGENCY ON KOREAN EXPORTS OF ENVIRONMENTAL GOODS

By

LEE, Minkyung

THESIS

Submitted to

KDI School of Public Policy and Management

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ABSTRACT

THE IMPACT OF ENVIRONMENTAL POLICY STRINGENCY ON KOREAN EXPORTS OF ENVIRONMENTAL GOODS

BY

Minkyung Lee

This paper studies the effects of two aspects of stringent environmental policy on Korea’s exports of environmental goods: 1. The effects of a trade partner’s environmental policy stringency; and 2. The effects of Korea’s environmental policy stringency. This paper uses panel data from 2002 to 2012 for OECD and BRIICS countries. The gravity model is implemented, with EPS index (OECD) serving as an indicator for environmental policy stringency. Based on the effects being analyzed by this paper, the empirical results show: 1. The stringent environmental policy of a trade partner has a positive effect on Korea’s exports because the market is greater in countries with stricter environmental policy; 2. Korea’s environmental policy has a decisive influence on the increase in Korea’s exports of environmental goods, which is consistent with the Porter Hypothesis. Stringent environmental policies should therefore be utilized to strengthen the competitiveness of Korea's environmental goods and a certain level must be maintained to promote the export of environmental goods.

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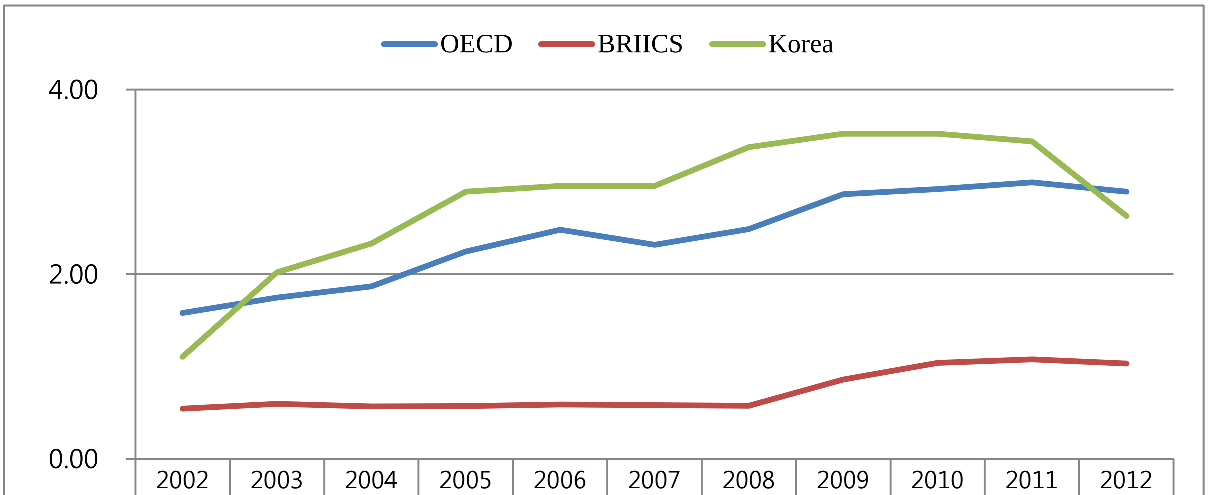
I. Introduction

Stringent environmental policy has become a global trend. Environmental policy stringency is defined as "the degree to which environmental policies put an explicit or implicit price on environmentally harmful behavior"(BottaEnrico & KoźlukTomasz, 2014). Due to the increasing environmental challenges and growing scientific evidence that earth is nearing its environmental tipping point, more and more countries have enforced stringent environmental policies to mitigate environmental impacts locally and globally(OECD, 2012). According to the Environmental Policy Stringency (EPS) Index developed by the OECD, governments in the OECD[1] and BRIICS[2] countries have constantly increased the stringency of environmental policies as shown in Graph 1. The Republic of Korea has rapidly increased its environmental policy stringency and generally kept a more stringent level than the OECD average since 2003.

Graph 1 *Trends of Environmental Policy Stringency (OECD, BRIICS and Korea)*



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OECD	1.58	1.75	1.87	2.25	2.48	2.32	2.49	2.87	2.92	2.99	2.90
BRIICS	0.55	0.59	0.57	0.57	0.59	0.58	0.57	0.86	1.04	1.08	1.03
Korea	1.10	2.02	2.33	2.90	2.96	2.96	3.38	3.52	3.52	3.44	2.63

Source: OECD Stat: http://stats.oecd.org/

In this trend of increasing environmental policy stringency, there is a large quantity of literature which studies whether environmental policy stringency would enhance country's competitiveness. Most of the empirical literature deals with the Pollution Haven Hypothesis that stringent environmental policy would weaken the domestic economic performance(FrankelJ., 2005; BommerR., 1999; CopelandB., 2004;

[1] Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, South Korea, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

[2] Brazil, Russia Federation, India, Indonesia, China and South Africa

LevinsonA.,, 2008). When it comes to environmental industry, however, Porter Hypothesis (1991) now seems more compelling. Environmental policy makes firms reduce negative environmental effects during the process of economic activities and motivates them to develop the environmental industry. It hence induces the innovation which leads the industry to a shift in cleaner production technologies, thereby enhancing a country’s competitiveness.

Implementing robust level of environmental policy has proven to play a vital role to strengthen trade competitiveness of environmental goods(PorterM., 1991; Jaffeand K.PalmerA.B, 1997; Albrizioand Kozluk TomaszSilvia, 2014). In the past, policy makers focused on liberalizing trade of environmental goods to create benefits through an international diffusion of these goods. However, environmental policy should be accompanied to promote the trade performance of environmental goods as the demand for environmental products is essentially determined by stringency of environmental policy(SauvageJ., 2014).

With this background, understanding the effect of environmental policy stringency on trade of environmental goods is meaningful to grasp the potential of a growing environmental industry and to inform countries’ strategies for trade competitiveness of environmental goods. However, a properly designed environmental policy should be facilitated to raise the competitiveness of environmental goods for innovation. The effect of environmental policy stringency is significantly dependent on a country’s policy context (AlbrizioSilvia, KozlukTomasz, ZippererVera, 2017). It is therefore important to look at whether each country has developed appropriate environmental policies in a way that increases the trade competitiveness of environmental goods (i.e. whether the Porter Hypothesis is applicable to each country’s policy context).

In case of the Republic of Korea, the stringency of environmental policy has increased rapidly. Korea announced its commitment to reducing Greenhouse gas (GHG) emissions by 37% below business as usual (BAU) levels by 2030(Ministry of Environment, 2015). To achieve this goal, Korea has set green growth national strategies and has actively implemented environmental policies to create new industrial growth engines for a green economy. Since the potential of environmental industry is increasing with the rising social awareness of environmental protection, the role of environmental policy stringency becomes a significant issue in order for economic and environmental benefits to coexist. Thus, this paper analyzes how Korea’s export performance of environmental goods are influenced by environmental policy stringency and what the role of Korea's environmental policy should be. Also it will be empirically studied whether the Porter Hypothesis can be applied to the Korean export of environmental goods.

The aim of this paper is twofold. First, it will estimate how bilateral export patterns of Korea's environmental goods are affected by the environmental policies stringency of trade partners. Second, the effect of Korea's environmental policy stringency on Korean environmental goods will be studied. Through this research, the paper will test the validity of the Porter Hypothesis and find the implication of the role of Korea's environmental policy stringency for enhancing export competitiveness of domestic environmental goods.

The rest of the paper is structured as follows: Section 2 provides literature review for the relationship between environmental policy stringency and trade competitiveness of environmental industry; Section 3 describes Korea's environmental policy stringency and trade of environmental goods; Section 4 presents the details of empirical models using gravity equation; Section 5 reports the main empirical results; and Section 6 concludes with policy implications.

II. Theories and Literature Review

1. Theories

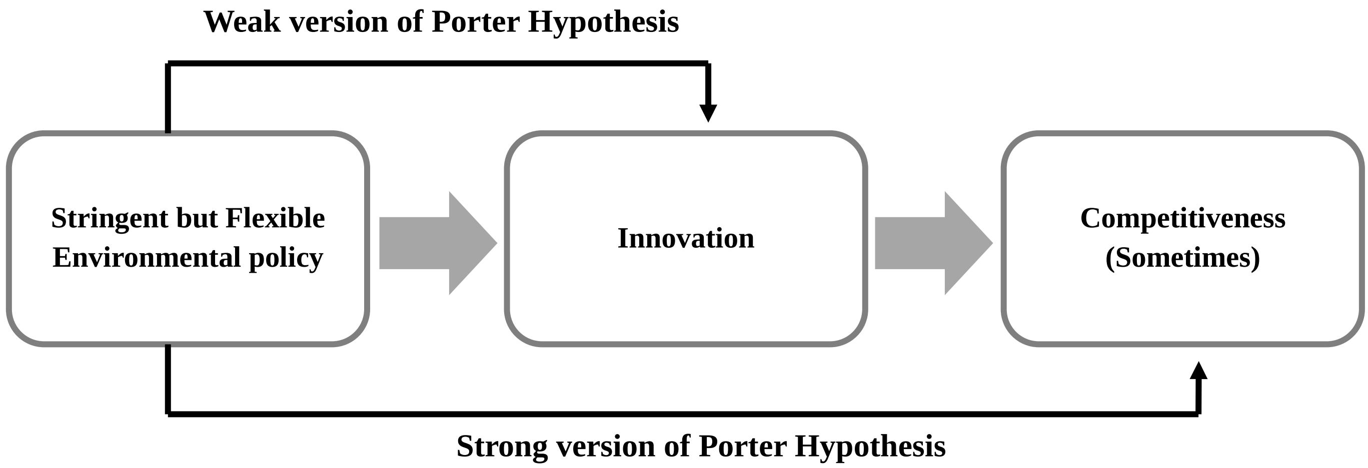
As the importance of environmental policy increases, there has been growing attention to test whether environmental policy stringency enhances a country's competitiveness. It has been a long debate on the necessity of stringent environmental policy because the relationship between economic growth and environmental benefits is recognized as a trade-off, rather than coexistence. There are two conflicting theories dealing with this issue, which are, Porter Hypothesis and Pollution Haven Hypothesis.

The Porter Hypothesis holds the view that stricter environmental policy does not undermine industry competitiveness, but rather enhances productivity against other countries through innovation. This view contradicts the Pollution Haven Hypothesis, which was traditionally held by many economists. The Pollution Haven Hypothesis supports that the stringent environmental policy increases the cost of economic activity which provides incentives for industries to relocate their stage of productions to countries with laxer environmental regulations. Thus, the pollution Haven Hypothesis basically proposes that environmental policy requires firms to reduce a negative externality, which eventually would restrict firms' options and decrease its productivity(FrankelJ., 2005; BommerR., 1999; CopelandB., 2004; LevinsonA.,, 2008).

The Porter Hypothesis, however, suggests that the stringent environmental policy encourages the innovation and enhances the competitiveness of an industry (LanoiePaul, PartyMicheal, LajeunesseRichard, 2008; PalmerKaren, OatesWallace, PortneyPaul, 1995; PorterMichael & LindeClaas, 1995; VriesFrans, WithagenCees, VolleberghHerman, 2005). Porter and Van der Linde(1995) criticized the existing concept of static competitiveness, and supported the dynamic competitiveness, which is induced by the increase in productivity through innovation, rather than low-cost inputs or economies of scales. Porter Hypothesis explains that environmental policy can induce dynamic competitiveness, which eventually offsets the cost of compliance of environmental policy. The Porter Hypothesis is generally regarded as a win-win opportunity because environmental policy not only improves the industry competitiveness but also achieves the original purpose of environmental benefit without incurring cost (PalmerKaren, OatesWallace, PortneyPaul, 1995)

Porter Hypothesis can be analyzed empirically in two ways: the weak version and the strong version. First, the weak version of Porter Hypothesis is examining the relationship between environmental policy and technological innovation, being the effect of environmental policy stringency on technological innovation. Most of the empirical studies focus on validating the weak version of Hypothesis, and the results generally show a positive relationship between environmental policy stringency and innovation(JaffeAdam & PalmerKaren, 1997; VriesdeFrans, 2005; LanoiePaul, PartyMicheal, LajeunesseRichard, 2008; VriesdeFrans, 2005; LeeMihong, 2002; KangOkMan, 2006) Second, the strong version of Porter Hypothesis points to a direct relationship between the environmental policy stringency and competitiveness. Unlike the weak version, the result of strong version of Porter Hypothesis does not sum up in a uniform fashion. The overall content and process of the Porter Hypothesis is illustrated in Figure 1.

Figure 1 *Process of the Porter Hypothesis*



Source: Stefan Ambec, Mark A. Cohen (2011), “The Porter Hypothesis at 20; Can environmental Regulation enhance Innovation and Competitiveness?”

The competitiveness depends significantly on the context. It is clear from both the original Porter Hypothesis and empirical evidence that if the policy is designed properly, the instruments laid out by the policy will prompt firms to modify their production techniques and adopt more differentiated environmental goods through innovation(AlbrizioSilvia, KozlukTomasz, ZippererVera, 2017). In that sense, it is important to examine whether each country has developed proper environmental policies in a way to increase the country’s competitiveness, and whether the porter’s Hypothesis is applicable to that country’s specific environment. Since there are few researches on domestic environmental goods, it is necessary to conduct empirical studies on the strong version of Porter Hypothesis in order to draw an appropriate implication for Korea environmental policy.

2. Literature Reviews

(1) Foreign Studies

Until today, a plethora of studies have dealt with the issue of relationship between environmental policy and industry competitiveness. In terms of country's competitiveness, Porter Hypothesis proposed that environmental policy stringency would increase trade competitiveness in the global market. According to Porter and ven(1995), a well-designed environmental policy can provide domestic companies with an early mover advantage in international markets. To be specific, when domestic environmental policy stringency meets the international standard, as domestic market conditions for environmental industry becomes mature, and the market demand for additional innovation becomes greater. In this respect, environmental policy works as a crucial factor in attaining international competitiveness.

As increasing attention is given to establishing effective environmental policies, many empirical studies have been conducted in diverse ways to validate Porter Hypothesis. Most focus on the weak version of Porter Hypothesis and generally find a positive relationship between environmental policy stringency and innovation. However, not many researches have been done on the strong version of porter Hypothesis, which is in fact the ultimate goal of Porter Hypothesis.

The strong version of Porter Hypothesis posits the efficacy of environmental policy stringency on international competitiveness which takes into consideration the competition with other nations. Bhanagar and Cohen(1997) has empirically studied the strong version of Porter Hypothesis, and found that stringent environmental policy exerts a positive influence on the country's export performance to the extent that is far greater than that on the productivity performance. They analyzed the effects of stringent environmental policy on the industry's profits through the 2SLS method, and indirectly affirmed that not only the environmental regulations but also the technological innovations incurred by regulation positively affect the industry's profits. As a result, the study concluded that the environmental policy stringency does indeed promote environmental innovation. On the other hand, no statistically significant results were obtained to verify the hypothesis that environmental innovation increases the profitability.

Lanoie et al. (2008) also studied the strong version of Porter Hypothesis; the impact of environmental policy stringency on factor productivity. Their study shows that environmental policy stringency increases productivity, especially in sectors where international competition is comparatively high. Thus, environmental policy stringency may speed up innovation efforts, which consequently enhances economic performance.

Although studies that test strong version of Porter Hypothesis do not concluded in univocal way, a more stringent environmental policy is known to have particularly positive influence on the green side of the economy. This specific focus is made to capture more precise conditions of environmental industry where the profit of environmental policy stringency is gauged in dynamic competitiveness context(WagnerUlrich & TimminsChristopher, 2009).

Costantini and Crespi (2007) found a positive relationship between environmental policy stringency and trade competitiveness in environmental sectors. The authors gathered 148 countries, and discovered a positive relationship between pollution abatement cost intensity and export flows in renewable energy sector. The analysis adopts a gravity model based on the data on the CO2 emission, current environmental protection expenditure, revenues from environmental taxes, and public environmental investment for proxy of environmental policy stringency. The result indicates that environmental policy stringency strengthens the export competitiveness of renewable energy technology.

Furthermore, Costantini and Mazzanti (2011) tests the applicability of strong versions of Porter Hypothesis. By using the gravity model, they identified that the environmental and energy taxes levied in EU-15 countries have propelled innovation and increased exports of environmental goods over the 1996-2007 period. However, the results are yet conclusive since the study deals with only a small number of samples and limited range of regulatory instruments.

Recently, Jehan Sauvage (2014) employed the Revealed Comparative Advantage (RCA) Index, and asserted that stringent environmental policy increases a country’s trade competitiveness. The author found that the stringent environmental policy partly allows for countries’ specialization in environmental products, even in the sectors such as solid-waste management or wastewater treatment. This paper maintains that the environmental policy stringency drives the development of market for equipment specifically designed for preventing and abating pollution.

(2) Korean Studies

Only a few empirical studies have tested the applicability of the strong version of Porter Hypothesis in context of Republic of Korea. Instead, many studies are centered around examining the direct relationship between trade partner’s environmental policy stringency and Korean exports competitiveness. This study only shows an inconsistent result because most of the findings in the past only match the pollution Haven

Hypothesis. Nevertheless, studies supporting Porter Hypothesis have been increasing nowadays.

In the past, many studies preserved a rather narrow perspective in exploring the effect of environmental policy stringency on Korea's international competitiveness since most of them adhered to pollution Haven Hypothesis. Oh and Myung(2005) carries an empirical study on this issue using gravity model for the year 2001. They posited that more stringent environmental policy of the trade partners have positive effect on the Korean exports due to negative effect on trade partner's price competitiveness. The result indicates that the amount of Korean exports increased to countries with high environmental policy stringency. In addition, Shim and Jeong(2009) used the RCA Index to analyze the effect of greenhouse gas reduction on Korea's export volume, and concluded that Korea's stringent environmental policy harms the export of Korean industries. The rationale behind such argument is regulations on greenhouse gas emission increases the production cost, which in turn lowers the competitiveness of polluting industries located in advanced countries.

On the other hand, several studies support the Porter Hypothesis and argue for the positive effect of environmental policy stringency on export competitiveness. Shim and Jung(2009) explores the case of Korea's renewable energy and energy saving industries by analyzing the impact of importing country's environmental policy stringency on Korean and Japan's export flows using the gravity model. They selected some energy related items from the ESI index set of the years 2001, 2002, and 2005, and compared the results of Korea and Japan. Although the result only holds a low significance, it allows for a comparative analysis of Korea and Japan. Stringent environmental policy of trade partner more adversely impacts the Korean exports of energy saving technologies than in the case of Japan. This is because Japan practices a more stringent environmental policy which ensures their export competitiveness. However, Shim and Jung(2009) used cross sectional analysis without time series data. Thus, it does not consider long term effects of environmental policy stringency on the trade flow.

In a similar vein, Hyuk-Ki Min (2010) stepped further by using the panel data from 1995 to 2007 of 20 European Countries, US and Japan. The finding illustrates that Korea export to countries with stringent environmental policy decreased and environmental policies exert more influence on environment-related sectors than total industries. The result verifies the Porter's Hypothesis and logically traces that the trade partner's environmental policy functions as trade barrier against products from the countries with lower level of environmental policy stringency.

Moon-hyun Jung (2011) attempts a more sector-specific research, thus first categorizes various industries into pollution and non-pollution sectors. Their research touches both the Porter Hypothesis and Pollution Haven Hypothesis. They analyze the balanced panel data using gravity models to test whether the stringent environmental policy of EU affects Korean exports. The overall results concur with the Porter Hypothesis and imply that the amount of Korean exports decreased when the stringent environment policy of EU are in the common operation for the EU members. However, such effects are reversed when the environmental policy is selectively practices only in specific areas within respective countries, which supports the effect of pollution Haven Hypothesis.

However, Il Chung Kim (2013) contends that Porter Hypothesis loses its explanatory power when a larger number of countries are taken into consideration. He argues that the Hypothesis does not explain for the case of Korean trade flows of pollution industries, except for a few cases once the sample size is increased to 120 largest trading partners of Korea. The study uses the panel data from the period of 2000 to 2010 with gravity model. The result contradicts with the Porter Hypothesis by showing that the strict environmental policy of the importing country is a trade barrier to the Korean pollution industries, but not a definite one for the non-pollution industries,.

The previous studies conducted in Korea have only focused on how Korea's export competitiveness has been affected by their trade partner's stringent environmental policy. However, Korea's environmental policy has rapidly increased more than any other countries in the OECD and the role of environmental policy has become more important with the rising social consensus on environmental protection. Thus, there is a need to investigate the impact of Korea's environmental policy stringency on Korea's export of environmental goods in consideration with the global context of an increasing spotlight on environmental policy. In addition, it is necessary to test the strong version of Porter Hypothesis in the policy context of Korea in order to check whether Korea's environmental policy has been properly developed to lead the growth of export competitiveness of environmental industry.

III.Environmental Policy Stringency and Trade of environmental goods in Republic of Korea

1. The scope of environmental goods and CLEG

International consensus on the list of environmental goods and services let alone the definition does not exist. A number of practical barriers to achieving international agreement were addressed in the process of settling a comprehensive list of environmental goods (SteenblikRonald, 2005): first, existing classification of HS code is not diverse enough to classify all environmental goods; second, the characteristics of products can be of multiple purposes apart from environmental uses; third, the range of environmental goods cannot be clearly designated due to factors such as different levels of environmental performance in use; and lastly, the technological innovations frequently bring about the changes in terms of the scope of environmental goods which does not fall into the existing category. .

Despite such difficulties, several attempts have been made to draw up the list of environmental goods as environmental conditions become a frequent topic in trade negotiations. Among many, the lists from OECD, WTO and APEC are the most widely used ones in trade negotiations. OECD (2010) set up a list of climate-change-relevant goods Plurilateral Environmental Goods and Services (PEGS[3]) agreement, which covers 150 products. In addition, WTO Committee on Trade and Environment meeting in Special Session (CTE-SS) (2009) comprises the list of 154 environmental goods which is shared among the member of Friends Group[4]. Moreover, APEC (2012)[5] agreed on a set of environmental goods, among which a list of 54 products was announced at the 2012 at Vladivostok summit to have reduced applied tariff rates to 5% or less.

Recently, OECD (2015) combined three prominent existing lists of OECD (2010), WTO (2009) and APEC (2012). Also, they devised a customized set of 248 environmental goods called CLEG (Combined List of Environmental Goods) using the HS 2007 classification at the six-digit level. CLEG includes a broad scope of

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[3] This PEGS list was initially prepared by the OECD for the 2010 Toronto summit of the G20 such as Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, United Kingdom United States and European Union.

[4] The Friends group is composed of Canada, the European Union, Japan, Korea, New Zealand, Norway, Switzerland, Chinese Taipei, and the United States

[5] Australia; Canada; China; Costa Rica; the European Union; Hong Kong, China; Japan; Korea; New Zealand; Norway; Singapore; Switzerland; Chinese Taipei; and the United States.

environmental goods, which accounts for the 4.9% of total number of HS 2007 codes[6], and this paper uses all codes proposed in the CLEG list. This paper also uses an alternative, narrower list of environmental goods[7], the Core CLEG (11 products) which takes up 0.79% of the total 2007 HS codes, and the Core CLEG+ (40 products) which accounts for 0.22% of the total 2007 HS codes.

Table 1 *List of Environmental Goods*

List	Purpose of environmental list	Number of HS Codes
WTO (2009)	WTO Committee on Trade and Environment meeting in Special Session (CTE-SS) comprises the 154 products as environmental goods	154
OECD (2012)	OECD defines the Climate-change-relevant goods for a plurilateral environmental goods and services (PEGS[8]) agreement	150
APEC (2012)	APEC made agreement on 54 products at 2012 Vladivostok summit to reduce applied tariff rates to 5% on environmental goods	54
OECD (2015)	OECD combines three existing lists from OECD (2010), WTO (2009) and APEC (2012)	248

The CLEG contains various environmental themes and media. Renewable energy plant accounts for the largest share from the list (22%), followed by cleaner or more resource efficient technologies and products (19%), Environmental monitoring, analysis and assessment equipment (15%), Waste water management and potable water treatment (13%), Heat and energy management (10%) and so on. A description on the composition of the list is shown in Table 2.

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[6] HS 2007 code has total 5,052 classifications.

[7] Environmental Business International Inc.(EBI) selected Core CLEG and Core CLEG+ by assessing the likely environmental content of the corresponding HS line against proprietary data from EBI on the size of the global market for various environmental pieces of equipment.

[8] This PEGS list was initially prepared by the OECD for the 2010 Toronto summit of the G20 such as Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, United Kingdom United States and European Union.

Table 2 *The Environmental Themes and Media of CLEG (Among 254 codes in total)*

Code	Environmental theme or medium	Share of HS lines
APC	Air pollution control	5%
CRE	Cleaner or more resource efficient technologies and products	19%
EPP	Environmentally preferable products based on end use or disposal characteristics	2%
HEM	Heat and energy management	10%
MON	Environmental monitoring, analysis and assessment equipment	15%
NRP	Natural resources protection	< 2%
NVA	Noise and vibration abatement	< 2%
REP	Renewable energy plant	22%
SWM	Management of solid and hazardous waste and recycling systems	10%
SWR	Clean up or remediation of soil and water	< 2%
WAT	Waste water management and potable water treatment	13%

Source: OECD (2015) "The Stringency of Environmental Regulations and trade in environmental goods"

2. Environmental Policy Stringency of Republic of Korea

Korea achieved a rapid economic growth, but it had to face a considerable trade-off such as severe environmental pollution and drastic consumption of resources. As environmental issues gain more significance, the Korean government committed to reducing the GHG emissions by 37% below business as usual (BAU) levels by 2030 in 2015(Ministry of Environment, 2015). It also exerts its full effort in prompting environmental sectors to take part in its long-term mission through environmental policies.

Environmental policies in Republic of Korea are designed to promote healthy and pleasant lives of all the people by protecting them from environmental pollution and damages and by managing and preserving the environment in a sustainable manner. In order to do so, it defines the rights and duties of a citizen and the obligation of the state with regard to environmental preservation, and determines fundamental matters Also, the government is obligated to develop methods with which the environment and economy are evaluated in an integrated manner, and refers to the those observations when it devises various policies (Framework Act on Environmental Policy, Chapter1, Article 7-3).

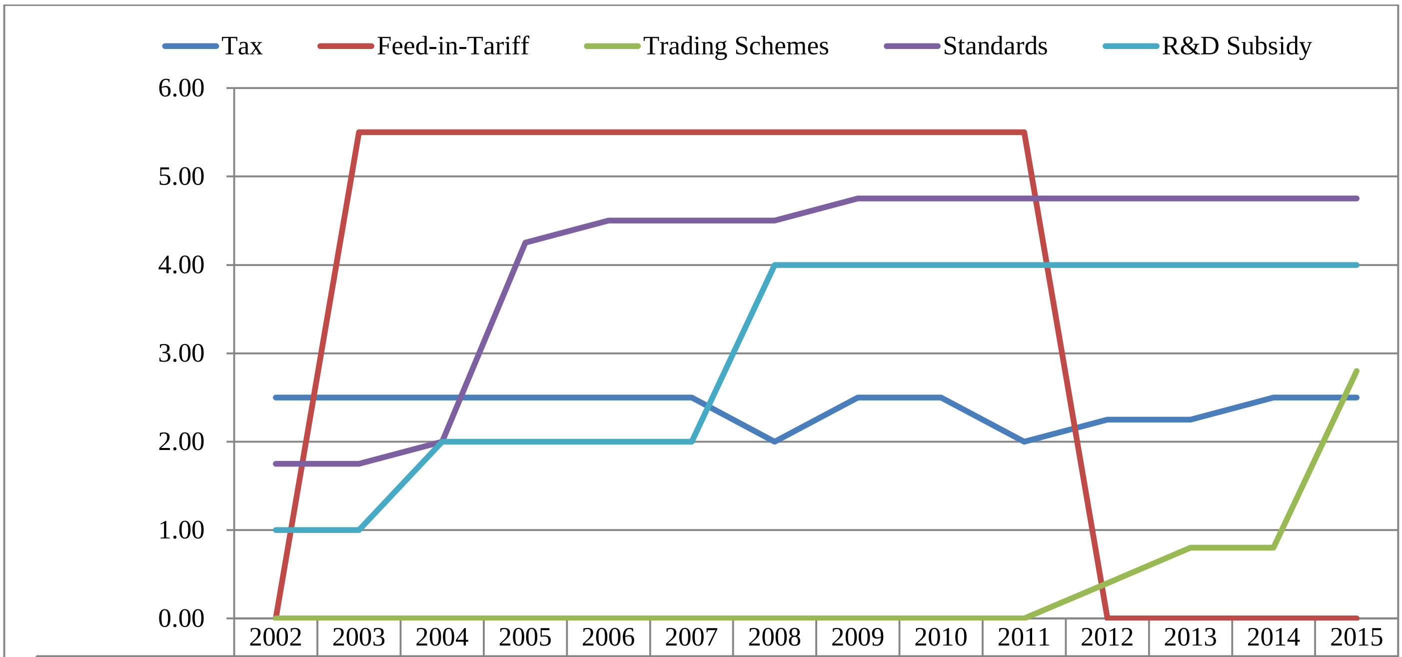
Within the grand framework of its environmental policies, the Korean government has been implementing various environment policy instruments not only to protect the environment but also to raise the status of the country's environmental industry in the global market and to promote economic growth. The country has designed a strong green growth policy framework and adopted a national strategy for green growth with specific five-year implementation plans in 2009. A year later, it passed the framework act on low carbon, Green Growth, thereby stimulating investment in green infrastructure.

A number of environmental policies have been tightened gradually over the recent years. OECD evaluated that Korea's environmental policy is creative in use of policy instruments to boost industries in environment sector(OECD, 2017). The policy instrument with which OECD measures the stringency of Korea's environmental policy includes market-based instruments such as environmental related tax, Trading schemes and Feed-in-tariff, and non-market based instruments such as standards and R&D subsidy. The indicator scored on a 0 to 6 scale, with 6 being the most stringent policies.

According to the market-based instrument in EPS index, environmental tax including CO_2tax, NO_xtax and SO_xtax maintains 2.5 level of stringency despite minimal fluctuations in years 2008 and 2012. In addition, Korea had implemented Feed-in-tariff for the period from 2002 to 2012, but it was replaced by the trading schemes from year 2012 on. Feed-in-tariff policy supports high stringency of Korea's environmental policy by offering the cost-based compensation for renewable energy producer based on the generation cost of technology. However, Korea launched national emissions trading schemes from 2012 due to the financial burdens caused by the Feed-in-tariff. Emission trading scheme that was launched in 2012 provides companies with a certain amount of greenhouse gas emission allowance. Although the stringency of trading schemes was low at the beginning of policy implementation, the stringency has gradually increased since then.

The stringency of non-market based instrument in EPS index has considerably raised both in Standards and R&D subsidy. Standards include particulate matter emission limit, SO_x emission limit and NO_x emission limit for newly built coal-fired plant. It exhibits a sharp increase to 4.75 levels of stringency in 2009 and remains steady from then on. Also, the R&D subsidies have continued to increase stringency gradually. The government's R&D expenditures reached the 4.0 levels in 2008 and continue to maintain that level of stringency.

Graph 2 *Korea's Environmental Policy Stringency by Instrument*



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Tax	2.50	2.50	2.50	2.50	2.50	2.50	2.00	2.50	2.50	2.00	2.25	2.25	2.50	2.50
Feed-in-Tariff	0.00	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	0.00	0.00	0.00	0.00
Trading Schemes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.80	0.80	2.80
Standards	1.75	1.75	2.00	4.25	4.50	4.50	4.50	4.75	4.75	4.75	4.75	4.75	4.75	4.75
R&D Subsidy	1.00	1.00	2.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Source : OECD Stat : http://stats.oecd.org/

3. Trade competitiveness of Korea Environmental goods

a. Korea's domestic market for Environmental goods

The environmental industry in domestic market has been steadily growing. The market size was KRW 44.6 trillion in 2009, KRW 55.5 trillion in 2010, KRW 59.3 trillion in 2011 and KRW 82.2 trillion in 2012(Ministry of Environment, Republic of Korea, 2015). An increase in market size has implications for the international trade of environmental goods as evidenced by some empirical studies which suggest that a larger home market increases exports more than imports in cases where products are differentiated(SauvageJ., 2014). The Korean government has concluded that domestic environmental businesses have reached the saturation point since the growth rate of the environmental good in domestic market is decreasing(Ministry of Environment, Republic of Korea, 2015). Therefore, the government figures that it is time for Korea's environmental industry to advance into overseas markets(Ministry of Environment, Republic of Korea, 2015).

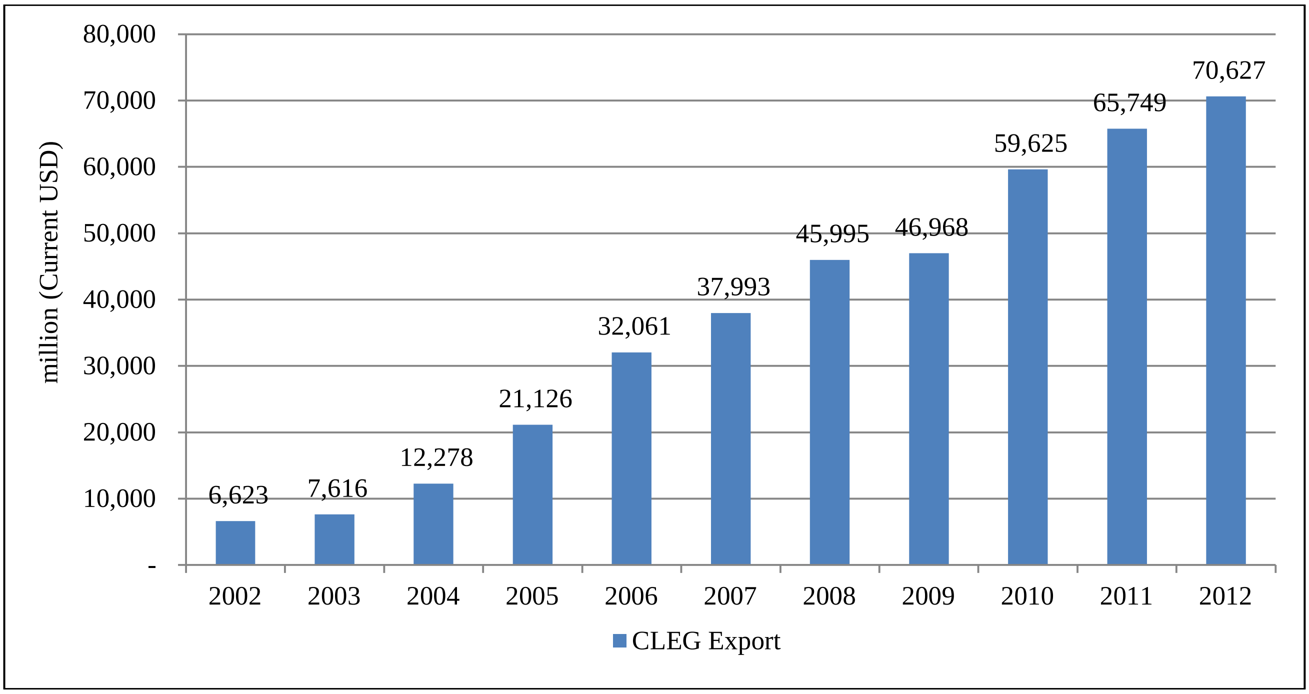
b. Recent trends of environmental good's trade in Korea

In terms of the import of environmental goods, OECD and BRIICS have emerged as major trading partners of Korea. As of 2007, OECD countries accounted for as much as 71% of the worldwide imports in environmental goods(SauvageJ., 2014). However, the percentage considerably decreased to 64% of world imports in CLEG products in 2011 as BRIICS countries appeared as a viable counterpart (20% in 2011) along with other developing countries (16% in 2011)(SauvageJ., 2014). The world's single largest importer of CLEG products in 2011 is China (13%), followed by the United States (12%), Germany (8%), France (4%), the United Kingdom (3%), and Japan (3%). In total, OECD and BRIICS countries lead most trades of environmental goods which accounts for more than 90% of world imports(SauvageJ., 2014).

In addition, when it comes to the exports of environmental goods, OECD countries accounted for 72% of the world CLEG exports in 2011, thereby making the OECD as a whole a net exporter of environmental products(Ministry of Environment, Republic of Korea, 2015). In terms of individual countries, China (17%) is ranked as first, again, followed by Germany (15%), the United States (10%), Japan (8%), and Korea (5%).

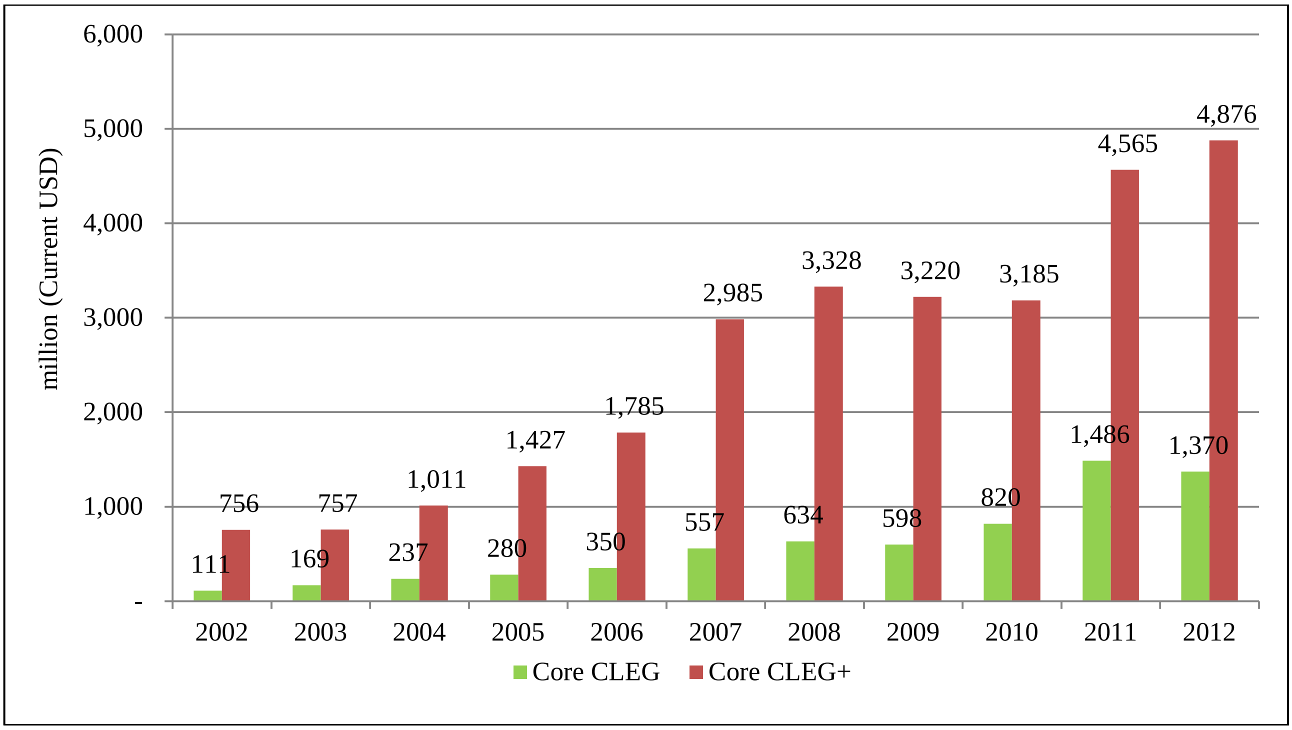
Korean export flows of environmental goods have rapidly increased over decades. According to data from UN Comtrade, total exports for CLEG products in Republic of Korea was USD 6,623 million in 2002, an increase of more than 10 times in a decade to USD 65,749 million, and reaching USD 70,627 million in 2012. In addition, the total exports for Core CLEG and Core CLEG+ show a similar trend. Total exports for Core CLEG have constantly increased with little decrease in 2009 and 2010, and it reached over USD 4500 million from 2011. Exports for Core CLEG have also increased 10 times greater, reaching an export volume of USD 1482 millions in 2011. Therefore, the trade of environmental goods is also considered as an emerging industry in Korean economic context.

Graph 3 *Korean Export volumes of CLEG Products*



Source : UN Combtrade

Graph 4 *Korean Export volumes of Core CLEG and Core CLEG+ Products*



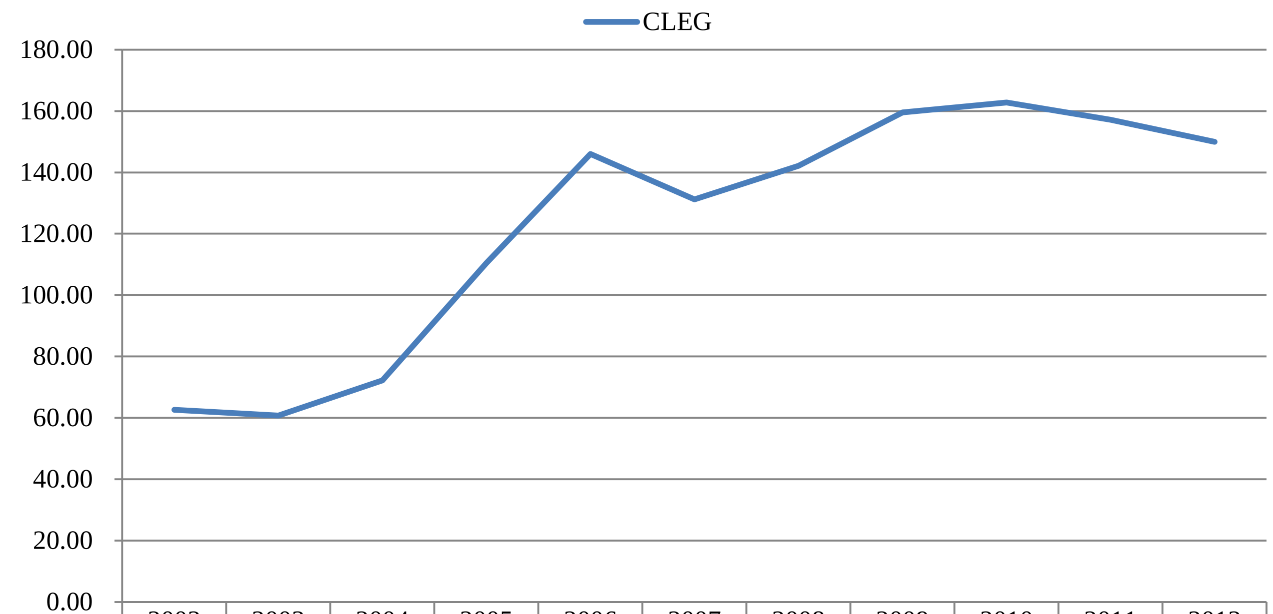
Source : UN Combtrade

c. Trade Competitiveness of Korean Environmental Goods

Trade competitiveness of Korean environmental goods has been constantly growing for a decade as evidenced by the increasing export volume of environmental goods. RCA (Revealed Comparative Advantage)[9] is frequently used in research on international trade to provide a concise picture of country's trade competitiveness. It allows comparison between a country's share of world exports for a particular set of goods and that country's share of world exports for all goods.

The graph below illustrates that Korea RCA of CLEG Products has consistently been increasing since 2003 until it exceeds the unity value of 100% in 2005. The country can be said to have a revealed comparative advantage in CLEG products.

Graph 5 *Korea RCA Index of CLEG Products*



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CLEG	62.60	60.71	72.21	110.42	145.97	131.18	142.10	159.54	162.75	157.11	149.93

Source : UN Combtrade

When a narrower scope of environmental goods is considered by using the list of Core CLEG and Core CLEG+ as in Graph 5, it did not reach the point of unity value 100%, which implies that the country has a

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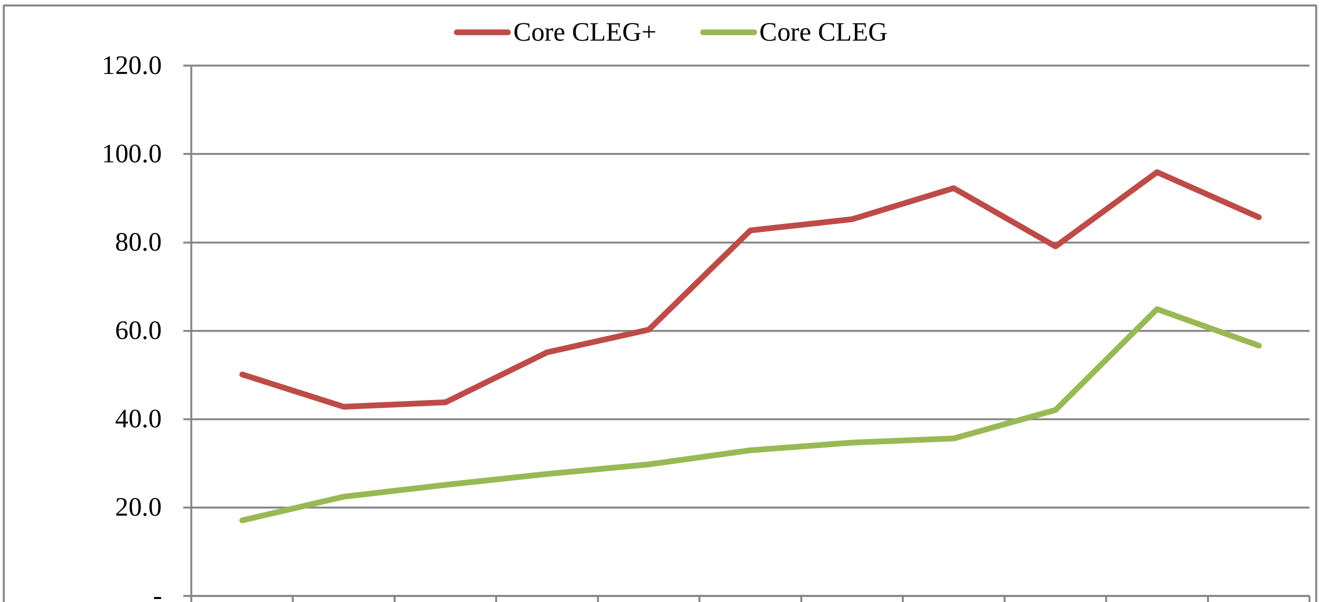
[9] Revealed Comparative Advantage (RCA) index is to assess a country's export potential. RCA index estimates product's share in the country's exports in relation to its share in world trade.

$$RCA_{ij} = (x_{ij}/X_{it}) / (x_{wj}/X_{wt}) * 100$$

, where x_{ij} and x_{wj} are the values of country i's exports of product j and world exports of product j and where X_{it} and X_{wt} refer to the country's total exports and world total exports. A value of less than unity implies that the country has a revealed comparative disadvantage in the product. Similarly, if the index exceeds unity, the country is said to have a revealed comparative advantage in the product.

revealed comparative disadvantage of Core CLEG and Core CLEG plus products. Even though Korea did not reach the point of revealed comparative advantage, the value of RCA is rapidly growing. The RCA results show that Korean environmental goods have potential in global market and that a well-designed environmental policy could support this growing trend of revealed comparative advantages even in Core CLEG and Core CLEG + products.

Graph 6 *Korea RCA Index of Core CLEG and Core CLEG+ Products*



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Core CLEG+	50.1	42.8	43.8	55.1	60.2	82.7	85.3	92.3	79.1	95.9	85.7
Core CLEG	17.1	22.4	25.1	27.6	29.8	33.0	34.7	35.6	42.1	64.9	56.6

Source : UNCombtrade

IV. Methodology and Data

1. Gravity Model

Gravity model has been widely used in many empirical researches on international trade analysis. Tinbergen (1962) and Leamer and Levinson (1995) used Gravity equation to test the determinants of the international trade. Similar to the functional form of Newton's Law of Universal Gravitation, the gravity equation of trade predicts that the volume of bilateral trade is positively related to the product of the countries' GDP and negatively related to trade barriers between trade partners. The typical gravity equation is as follows;

$$\text{Trade Flows}_{\text{ij}} = \alpha \frac{\text{Y}_{\text{i}}\text{Y}_{\text{j}}}{\text{D}_{\text{ij}}} \times \text{Z}_{\text{ij}}$$

, where $Trade\ Flows_{\text{ij}}$ indicates the amount of the trade flow from country i to country j, Y_i and Y_j the economic sizes of country i and j, D_{ij} the distance between country I and j, Z_{ij} any other factors affecting trade flows between country i and country j.

The empirical studies that adopt the gravity model in analyzing the relationship between environmental policy stringency and international trade cannot be summed up in a uniform fashion, and at times, they do not even produce robust findings. Despite such inconsistency, the research still adheres to the gravity model since it becomes useful tool in testing whether the current environmental policy is properly designed in Korean context and in searching for the determinants of Korea bilateral export performance of environmental industry, with a particular focus on Korean exports of environmental goods. Hence, this paper modifies gravity equation by using bilateral export flows of Korea environmental goods and EPS index which were newly developed by OECD.

2. Model specification

The equation below is set up to test the effect of environmental policy stringency on Korea's export of environment goods. Equations include variables from gravity model such as GDP for economic size and distance between Korea and trade partners, and other control variables such as existence of RTA (regional trade agreement). EPS index from the OECD database is used for measurement of environmental policy stringency. All the variables mentioned in these models are transforming it in the log terms to facilitate the empirical analysis.

The paper selectively examines the cases of OECD and BRIICS for the empirical analysis to overcome data deficiency of EPS index. However, OECD and BRIICS countries accounts for more than 90% of total export of Korea's environmental goods(Ministry of Environment, Republic of Korea, 2015). Thus, it is within bounds to say that this paper investigates the effects of environmental policy stringency on almost all the countries where the Korean environmental good is mainly exported. The models use panel data which covers the periods from 2002 to 2012.

The effect of environmental policy stringency is analyzed in three ways; First, Model (1) tests the effect of environmental policy stringency of trade partners on Korean bilateral export of environmental goods. Second, Model (2) studies the effect of environmental policy stringency of Korea. Lastly, Model (3) tests whether the Korean export of environmental goods is affected by relative environmental policy stringency between Korea and trade partners. The exact formulation is as follows:

(1) The Effect of Environmental Policy Stringency of Trade Partner

$$\mathbf{ln(EXP_t) = \alpha + \beta_1 ln(\mathit{GDP}_{it}) + \beta_2 ln(DIST_i) + \beta_3 ln(EPS_{it}) + \beta_4 X_{it}}$$

$\mathbf{EXP_t}$ **:** Bilateral export of Korean environmental goods

$\boldsymbol{GDP}_{\mathbf{it}}$ **:** GDP per capita of trading partner country at time t

$\mathbf{DIS_i}$ **:** Distance between Korea and trading partner country

$\mathbf{EPS_{it}}$ **:** Environmental policy stringency of trading partner country at time t

$\mathbf{X_{it}}$ **:** Control variables (Regional Trade Agreement)

Model (1) is to test whether the environmental policy stringency of trade partners affects Korean export of environmental goods. It hypothesizes that the stricter environmental policy of trade partner increases the Korean export of environmental goods. According to the previous studies, in case of environmental goods, the country's environmental policy stringency is a determinant factor of the size of domestic market (SauvageJ., 2014). The USITC study maintains a similar note by articulating that the scale of a country's production or economic activity interacts with stringent environmental policy in jointly determining the size of environmental good's domestic market(USITC, 2004). That is, if the estimate of trade partner's environmental policy stringency in model (1) is positive, Korean export volume is meant to increase with a rise in the environmental stringency of trade partners.

(2) The Effect of Environmental Policy Stringency of Korea

$$\ln(\mathbf{EXP_t}) = \alpha + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(\mathbf{DIST_i}) + \beta_4 \ln(\mathbf{EPSK_t}) + \beta_3 \ln(\mathbf{EPS_{it}}) + \beta_5 \mathbf{X_{it}}$$

$\mathbf{EXP_t}$ **:** Bilateral export of Korean environmental goods
GDP_{it} **:** GDP per capita of trading partner country at time t
$\mathbf{DIS_i}$ **:** Distance between Korea and trading partner country
$\mathbf{EPS_{it}}$ **:** Environmental policy stringency of trading partner country at time t
$\mathbf{EPSK_{it}}$ **:** Environmental policy stringency of South Korea at time t
$\mathbf{X_{it}}$ **:** Control variables (Regional Trade Agreement)

Model (2) studies the effect of Korea's environmental policy stringency on export of environmental goods. The Korea's EPS variable is newly added to the Model (1) to examine the effect of Korea's environmental policy stringency in consideration with the change in trade partner's environmental policy stringency. The Hypothesis is that the stricter environmental policy of Korea increases the export of environmental goods. If the estimate turns out to be positive, it implies that Korean exports of environmental goods would be facilitated by the increased stringency in Korea's environmental policies, which in turn supports the Porter Hypothesis.

a. *Dependent Variable*

The dependent variable $\mathrm{EXP_t}$ represents the bilateral export flows from Republic of Korea to OECD and BRIICS country at time t (calculated at constant 2010 USD). Korea export flow data is extracted from UNCOMTRADE database (UNCTAD) based on the Harmonized Commodity Description and Coding System (HS 2007), but the export figures from 2002 to 2006 uses the form of HS 2002 code.

The environmental goods are well classified under the *Combined list of Environmental Goods (CLEG)* by OECD (see Appendix Table 1) using HS 2007 code. In this paper, $\mathrm{EXP1_t}$ represents the exports of environmental goods listed in CLEG and $\mathrm{EXP2_t}$ and $\mathrm{EXP3_t}$ is the export of the environmental goods from Core CLEG+ and Core CLEG, which is a narrower scope of the CLEG products.

b. *Independent Variable*

- **Environmental Policy Stringency (EPS) Index from OECD**

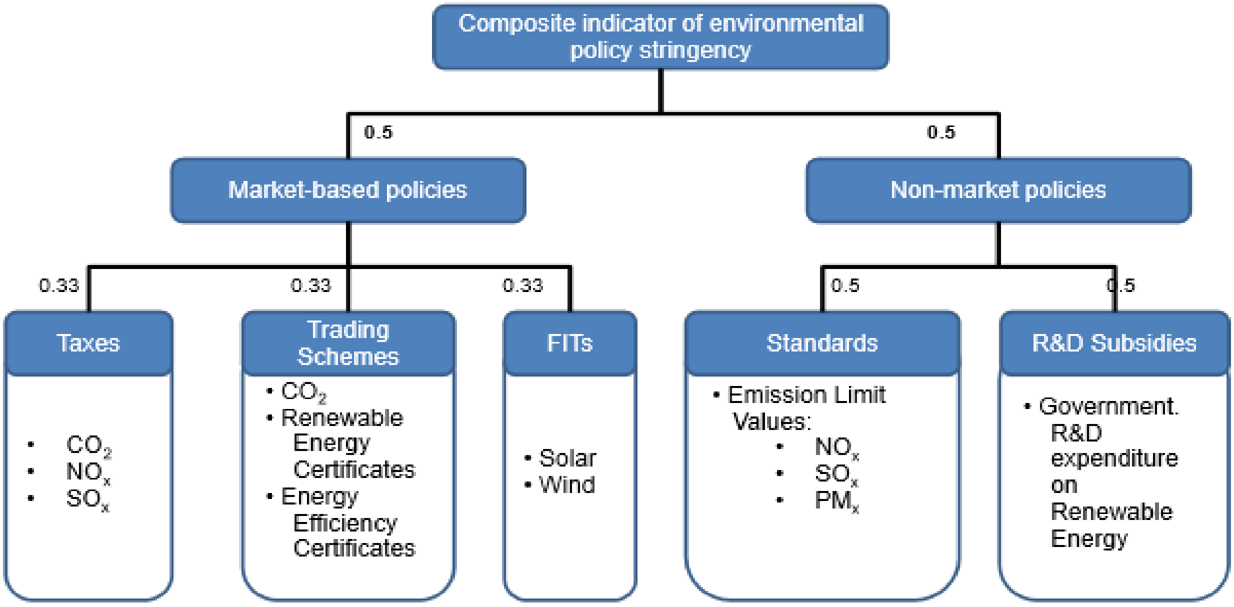
Prior to estimating the impact of environmental policies, an adequate proxy for measuring the environmental stringency should first be devised. The hitherto attempts to measure environmental policy stringency across countries have yet allowed an empirical application since most of them lack time-series dimension. (DasguptaS.,, 2001; ElisteP.,, 2002; EBRD, 2011). The Environmental policy stringency (EPS) index developed by the OECD is the first tangible efforts to measure environmental policy stringency internationally and over a relatively long period of time (KoźlukT.,, 2016).

The EPS index is a policy-based composite indicator that measures the degree of environmental policy stringency of most OECD and BRIICS countries from 1990s to 2012. The indicator is scored on a scale of 0 to 6, with 6 indicating the most stringent policies. All variables comprising the indicator are law-based elements of regulations with a specific focus on environmentally important sectors such as energy and transport while ensuring a similar degree of relevance across countries. It aggregates the selected environmental policy instruments by using equal scoring and weighting.

The instrument has been selected from as wide range as possible in order to account for both market and non-market approaches to environmental policies. To be specific, the policies not only covers market-based instrument such as environmentally-related taxes, trading schemes and Feed-in-tariffs but also the non-market based instrument such as standards and R&D subsidy.

However, the EPS index has a few limitations(BrunelC.,, 2013; Silvia AlbrizioTomasz, 2014). It overlooks some area of policy that has an impact over the energy sector, and a number of instrument types have also been ignored in EPS index. Despite such limitations, this index includes the broadest range of policies in energy sector based on the available cross country data, so that it can provide a basis for empirical cross-country analysis.

Figure 2 *Structure of EPS Index*



Source : Botta, E. and T. Koźluk (2014) "Measuring Environmental Policy Stringency in OECD Countries", OECD Economics Department Working Papers, OECD

Control Variable

- **RTA_t (Regional Trade Agreement)**

While there is no specific agreement on how to manage the sustainability of the environment, countries can adopt trade-related measures aimed at protecting the environment by adopting a number of requirements under WTO rules. These rules are providing an increasingly prevalent option for countries that opt to pursue liberalization of certain environmental goods through Regional Trade Agreements (UNEP, 2012). Therefore, the equation includes RTA as a control variable which has taken effect prior to 2012. It is a dummy variable depending on the existence of RTA between Korea and trade partner at time t (RTA=1, 0).

Table 3 *Regional Trade Agreement from 2002 to 2012*

RTA	Member countries in OECD and BRIICS
EFTA (2006)	Norway, Switzerland
ASEAN FTA(2007)	Indonesia
CEPA(2010)	India
EU FTA(2011)	European Union; Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
USA FTA(2012)	USA

3. Data

This paper includes 25 OECD countries and 6 BRIICS countries in its analysis. These countries are relatively large trade partners of Korea, which accounts for more than 90% of exports of environmental goods(Ministry of Environment, Republic of Korea, 2015). However, one of the OECD countries (Slovenia) is excluded since the dataset does not provide information on that specific country. Data for Korean exports are extracted from UN Comtrade and transferred into real 2010 constant USD using CPI (Consumer Price Index). This paper uses CLEG, Core CLEG and Core CLEG+ products, each having its respective scope of environmental goods classified by OECD.

Data on the countries' GDP is extracted from the WDI database of World Bank from the year 2002 to 2012. The distance variable employs the data from CEPII and indicates the distance between capital cities of respective countries in kilometers. Also, Environment policy stringency (EPS) index from OECD is used to measure the environmental policy stringency. The existence of Regional Trade Agreement between Korea and trade partners is identified by Korea's Ministry of Trade, Industry and Energy.

Table 4 *Definition of Variables, Statistics Source and Acronyms*

Variable	Definition	Source
	Dependent variable	
EXP_{it}	Bilateral export flows of Environmental goods from Republic of Korea (constant 2010 USD)	UNCTAD
	Gravity Equation	
$PCGDP_{ikt}$	Natural Logarithm of trade partner's real GDP per capita (Constant 2010 USD)	WDI
POP_{it}	Natural Logarithm of total population	WDI
$DIST_{i}$	Natural Logarithm of Geographic distances	CEPII
	Independent Variable	
EPS_{it}	Natural Logarithm of Composite indicator of environmental policy stringency of Trade partners	OECD
$EPSK_{t}$	Natural Logarithm of Composite indicator of environmental policy stringency of Korea	OECD
$REPS_{it}$	Natural Logarithm of Relative EPS between Korea and Trade partners $REPS_{it} = EPSK_t/EPS_{it}$	OECD
	Control variable	
RTA_{it}	Regional Trade Agreement between Korea and trade partners	MoTIE

Ⅴ. Results

To control for the unobserved effect of individual country data, this study uses fixed effect model and the random effect model. After running respective models, a more appropriate one between the two is chosen through the Huasman test. If the test result shows significance, the fixed effect model is deemed appropriate because the countries' individual effects are relevant in this analysis. In addition, in case of the distance variables from gravity equation, its coefficient cannot be estimated by using fixed effect since it is time-invariant data. Thus, random effect model is used to estimate the distance variable

(1) The impact of trade partner's environmental policy stringency on Korea export of environmental goods

The empirical results for the effect of trade partner's environmental policy stringency on Korean exports of environmental goods are shown in Table 5. The significance of the statistics identified through the Hausman test gives a clear indication that the countries' individual effects are relevant with this model, therefore the fixed effect estimates are preferred to the random effects ones.

The regression analysis on the effect of environmental policy stringency of trade partner with fixed effect model shows that there is statistically significant positive relationship with Korean export of environmental goods. If the environmental policy stringency of trade partner increases by 1%, the Korea export of environmental goods would increase by 0.757% of CLEG products, by 0.923% for the Core CLEG+ product and 1.025% for the Core CLEG product. Thus, the result shows that environmental policy stringency of trade partners has positively influenced the Korean export of environmental goods. Also, the effect of trade partner's environmental policy stringency on Korea's export of environmental goods is greater as the scope of environmental goods becomes narrower.

In terms of gravity model, the GDP of trade partners shows a significantly positive relationship with Korean exports in cases of all three categories of environmental goods (CLEG, Core CLEG and Core CLEG Plus). As GDP increases by 1%, Korean export of CLEG products increases by 5.641% with 0.01% significance level and Core CLEG+ and Core CLEG products increases by 4.013% and 5.267% respectively with 0.05% of significance level. These results imply that the Korea's exports of environmental goods would be greater in the cases of trade partners with larger economic size.

In addition, when the distance variable is added in gravity model by using random effect, it shows significantly negative relationship, meaning that the Korea's export of environmental goods would decrease as the distance between trade partner and Korea become longer. As distance between Korea and trade partner increase by 1%, the Korean export of environmental goods decrease to -1.552%, -1.514%, and -1.594%. Hence, all variables from gravity equation such as GDP and distance form a positive relationship with Korean export of environmental goods. However, the control variable, existence of RTA between Korea and trade partner, does not have statistically significant relationship with Korean export of environmental goods.

To sum up, the environmental policy stringency of trade partners has positively influenced Korea's export of environmental goods. The result is consistent with the model (1) hypothesis in that stricter environmental policy creates demand for environmental products in trade partner's domestic market. Thus, the environmental policy not only boosts their export performance but also increases the import volume, which prompts an increase in Korea's export of environmental goods. This result indicates that the market of environmental goods expands in countries with stricter environmental policy and Korea's export of environmental goods is also increase with a rise in trade partner's environmental policy.

Table 5 *The effect of Trade Partner's Environmental Policy Stringency*

Variable	Fixed Effect			Random Effect		
	ln(CLEG)	ln(Core CLET+)	ln(Core CLEG)	ln(CLEG)	ln(Core CLEG+)	ln(Core CLEG)
$\ln(GDP_{it})$	5.641** (3.60)	4.013* (2.48)	5.267* (2.44)	0.115 (0.68)	0.118 (0.67)	0.112 (0.63)
$\ln(DIS_{ik})$	-	-	-	-1.552* (-2.27)	-1.514** (-2.76)	-1.594** (-2.88)
$\ln(EPS_{it})$	0.757** (2.82)	0.923*** (3.86)	1.025** (2.96)	1.366** (3.21)	1.101** (2.78)	1.304* (2.51)
RTA	-0.0724 (-0.35)	0.199 (1.17)	0.187 (0.90)	0.179 (1.20)	0.426** (3.04)	0.480* (2.30)
C	-132.7** (-3.16)	-92.25* (-2.13)	-127.2* (-2.20)	28.78** (3.29)	25.50** (3.21)	24.90** (3.11)
Observation	341	341	341	341	341	341
R^2	0.088	0.085	0.087	0.095	0.081	0.097

*** p<0.001", ** p<0.01, "* p<0.05

(2) The impact of Korea's environmental policy stringency on Korea export of environmental goods

Model (2) tests the effects of Korea's environmental policy stringency on Korea's bilateral export flows of environmental goods and the result is demonstrated in Table 6. The variable of Korea environmental policy stringency is added to the existing Model (1) to gauge the effect of Korea's environmental policy stringency on Korean export of environmental goods while taking into consideration the trade partner's environmental policy stringency. Hausman test shows statistically significant figures, so individual country effects are relevant to our analysis. Thus, fixed effect model instead of random effects model is more appropriate for the analysis

In terms of Korea's environmental policy stringency, the result with fixed effect model shows that there is significantly positive relationship with Korean export of environmental goods. To be specific, as the environmental policy stringency of Korea increases by 1%, the Korea export of environmental goods increases by 1.029% for CLEG products, 0.924% for Core CLEG+ product and 0.899% for Core CLEG product supported by the 0.001% significance level. Thus, the result indicates that the Korean export of environmental goods is positively affected by the Korea's environmental policy stringency. Also, the effect of Korea's environmental policy stringency on export of environmental goods is greater as the scope of environmental goods becomes broader.

The result regarding the effect of trade partner's environmental policy stringency shows that it has the positive yet not as significant influence on the Korea export of environmental goods. The increase in the environmental policy stringency of trade partner by 1% increases Core CLEG+ product by 0.532% and Core CLEG product by 0.649% with significance level of 0.05%. Also, it has statistically insignificant positive influence on Korean export of CLEG products. The effect of trade partner's environmental policy stringency in model (2) is comparatively less significant than the results from model (1). The previous findings in model (1) show that the stricter environmental policy stringency of trade partner statistically spurs the export of environmental goods. Taking into consideration the effect of Korea's environmental policy stringency on Korean export of environmental goods, however, trade partner's environmental policy stringency became lesser of a determining factor of the Korean export of environmental goods than the previous model (1). Thus, it implies that the Korea's environmental policy stringency is determinant of Korean export of environmental goods, even in the context where the trade partner's environmental policy is regulative.

In addition, as generally outlined by the gravity model, the GDP of trade partners has positive relationship with Korea's export flows of environmental goods supported by statistical significance of levels 0.01%, 0.05% and 0.05% respectively for all categories of environmental goods (CLEG, Core CLEG and Core CLEG Plus). As the GDP increases by 1%, Korean export of CLEG products also increase by 4.474% and Core CLEG+ and Core CLEG products increase by 2.961% and 4.249% respectively. The distance variables using the random effect model confirm a negative relationship in all three cases of environmental goods, and this result denotes that the farther away the trade partners are the smaller the country's export of environmental goods become. Thus, while all variables utilized in the gravity model forms a positive relationship with Korean export of environmental goods, the existence of RTA between Korea and trade partners forms a negative relationship.

In summary, the Korean environmental policy is instatistically positive relationship with Korean export of environmental goods. Through the results, it can be implied that stringent environmental policy of Korea would strengthen the country's export competitiveness of environmental goods. The results also state that Korea's environmental policy plays a more viable role in increasing Korea's export of environmental goods rather than the trade partner's environmental policy stringency factor. Overall results support the Porter's Hypothesis in that the stringent environmental policy would strengthen the trade competitiveness of environmental products.

Table 6 *The effect of Korea's Environmental Policy Stringency*

Variable	Fixed Effect			Random Effect		
	ln(CLEG)	ln(Core CLET+)	ln(Core CLEG)	ln(CLEG)	ln(Core CLEG+)	ln(Core CLEG)
$\ln(GDP_{it})$	4.474** (3.07)	2.961* (2.12)	4.249* (2.05)	0.135 (1.01)	0.135 (0.92)	0.134 (0.90)
$\ln(DIS_{ik})$	-	-	-	-1.418** (-2.84)	-1.401*** (-3.44)	-1.465*** (-3.65)
$\ln(EPSK_t)$	1.029*** (4.52)	0.924** (2.96)	0.899*** (3.65)	1.840*** (7.07)	1.610*** (4.22)	1.822*** (5.30)
$\ln(EPS_{it})$	0.298 (1.41)	0.532* (2.63)	0.649* (2.25)	0.376 (1.23)	0.274 (1.32)	0.423 (1.28)
RTA	-0.00619 (-0.04)	0.235 (1.55)	0.206 (1.02)	0.139 (0.90)	0.360* (2.48)	0.375 (1.75)
C	-102.2* (-2.62)	-64.73 (-1.73)	-100.6 (-1.81)	25.82*** (3.90)	22.95*** (3.61)	21.92*** (3.47)
Observation	341	341	341	341	341	341
R^2	0.0934	0.0912	0.0916	0.2905	0.2403	0.2504

*** p<0.001", ** p<0.01, "* p<0.05

Ⅵ. Conclusion

This paper studies the effects of environmental policy stringency on Korea’s exports of environmental goods, particularly the effect of trade partner’s environmental policy stringency and the effect of Korea’s environmental policy stringency. Through empirical research, this paper found that the Porter Hypothesis is plausible according to the results of Model (1) and (2).

Model (1) finds that higher environmental policy stringency of a trade partner positively affects Korea’s exports of environmental goods. Since the stricter environmental policy of trade partner has spurred the creation of a market for environmental goods, the Korean export of environmental goods may also have been influenced by an increasing demand for environmental goods in their trade partner’s market. This result reflects the fact that the market for environmental goods has become larger in countries with stricter environmental policy if the policy is properly designed(SauvageJ., 2014). Also, it implies that Korean environmental goods have properly followed the international standards of environmental commodities through innovation because the export of Korean environmental goods then becomes greater with the increase in trade partner’s market size. Based on the results, increasing trade partner’s environmental policy stringency has provided a chance for Korean environmental goods to advance to foreign markets. Thus, the increasing environmental policy stringency of trade partners could potentially benefit Korea’s environmental goods, rather than act as a barrier.

In Model (2), the increase in Korea’s environmental policy stringency positively affects the export of Korea’s environmental goods. The model finds that Korea’s environmental policy has a statistically significant positive relationship with Korea’s exports of environmental goods, and is also more influential than the effect of trade partner’s environmental policy stringency. Moreover, the effect of Korea’s environmental policy stringency is greater as the scope of environmental goods broadens. The results suggest that stringent environmental policies would strengthen the export competitiveness of Korea’s environmental goods. Furthermore, the role of Korea’s environmental policy stringency is a greater determinant for export competitiveness of environmental goods than that of its trade partner’s environmental policy stringency. The findings of Model (2) show that the strong version of the Porter Hypothesis is applicable in Korea’s environmental sector, as environmental policy stringency enhances the trade competitiveness of Korea’s environmental goods.

In summary, the empirical results show that the Porter Hypothesis does appears in the Korean trade of environmental goods during the period from 2002 to 2012. Korea's environmental policy stringency not only has had a positive impact on Korea export of environmental goods, but also it becomes more influential when environmental policy stringency is stricter than other trade partners in the case of environmental goods listed in CLEG. Although previous empirical studies do not demonstrate univocal results of the Porter Hypothesis in the Korean context, the finding of this study shows the positive impact of Korea's stringent environmental policy on export competitiveness of environmental goods.

This paper, however, has limitations in three areas. First, the scope of the analysis does not include developing countries due to the deficiency of data. The target country is limited to OECD and BRIICS countries, which generally adopt stricter environmental policies and have environmentally advanced technologies. Second, the paper considers a limited range of environmental policy instruments mainly focused on the energy sector, such as taxes, trading schemes, Feed-in-Tariffs, Standards and R&D subsidies. Lastly, the EPS index utilized in this paper does not count the difference of each instrument to environmental policy stringency; equal weight is given to all instruments despite their different effects on environmental policy stringency.

Despite these limitations, the finding of this paper would contribute to exploring the Porter Hypothesis in the Korean context and empirically shows that stringent environmental policy could play a role in increasing the export competitiveness of Korea's environmental goods. The results of this study imply that the stringent environmental policies of Korea positively affect Korea's exports of environmental goods by improving international competitiveness. In general, the findings in this paper show the compatibility between trade and environmental policy and it may help ease the pressure between environmental protection and trade in the environmental sector. In addition, the trade benefits from the implementation of stringent environmental policies could counter the traditional concern of the Pollution Haven Hypothesis and could promote environmental sectors as a new industrial growth engine for green growth in Korea.

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APPENDICES

APPENDIX A

Foreign Literature on Strong version of Porter Hypothesis

Author	Contents	EPS Proxy
Bhanagar and Cohen (1997)	The stringent environmental policy has a positive influence on export performance which is far greater than on productivity performance	PACE
Lanoie et al. (2008)	The environmental policy positively impacts on productivity, especially in sectors which are exposed to international competition	Changes in the ratio of the investment in pollution control cost
Costantini and Crespi (2007)	The environmental policy positively affects export flows in renewable energy sector.	Pollution abatement cost intensity
Costantini and Mazzanti (2011)	The environmental and energy taxes in EU-15 countries have positively affected to innovation and exports of environmental goods	Energy and Environmental tax
Jehan Sauvage (2014)	The stringent environmental policy increase country's trade competitiveness using RCA	EPS (OECD)

APPENDIX B

Korea's Literatures on the effect of Environmental Policy Stringency on Export

Author	Contents	EPS Proxy	Result
Oh and Myung (2005)	Korea exports increase to countries with high environmental policy stringency due to negative effect on trade partner's price competitiveness.	Environmental Sustainable Index (WEF)[10]	Pollution Haven Hypothesis
Shim and Jeong (2009)	The stringent environmental policy more negatively affects to Korea exports of energy saving technologies than countries with stricter environmental policy.	Environmental Sustainable Index (WEF)	Porter Hypothesis
Hyuk ki Min (2010)	Korea export decrease to countries with stringent environmental policy and the effect of environmental policy is greater to environmental-related industry than total industry.	Pollution abatement cost	Porter Hypothesis
Moon-hyun Jung (2011)	Korean export decreased if the stringent environment policy of EU is in common operation for the EU members, But it increase when the environmental policy operates independently for the specific areas	Pollution abatement cost	Both
Il Chung Kim (2013)	Korean export of non-pollution industry does not decrease when the environmental policy of the importing country is stringent.	Environmental Performance Index (Yale Univ)[11]	Pollution Haven Hypothesis
Shim (2011)	The greenhouse gas reduction has negatively influence on production cost, and it decrease the RCA of polluting industry in advanced countries.	Greenhouse gas emission reduction	Pollution Haven Hypothesis

[10] World Economic Forum

[11] Yale University

APPENDIX C

Summary Statistics

Variable	Observation	Mean	Standard Deviation	Min	Max
EXP1	341	1.31e+09	5.19e+09	608220.5	4.86e+10
EXP2	341	4.75e+07	1.07e+08	1.278943	7.28e+08
EXP3	341	1.46e+07	3.96e+07	1.235516	3.40e+08
$\mathbf{GDP_{ikt}}$	341	1.63e+12	2.73e+12	6201.163	1.55e+13
$\mathbf{DIS_{it}}$	341	8361.779	3044.451	955.6511	18364.51
$\mathbf{EPS_{it}}$	341	2.074829	0.9370398	0.375	4.133333
$\mathbf{EPSK_{t}}$	12	2.795833	0.7123359	1.104167	3.520833
$\mathbf{EPSK_{t}/EPS_{it}}$	341	1.861375	1.583151	0.4274194	9.166667
RTA	341	0.1730205	0.3788209	0	1

APPENDIX D

Environmental Policy Stringency of OECD and BRIICS

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Australia	1.21	1.21	1.17	1.55	2.01	2.01	2.26	2.69	2.50	3.34	3.72
Austria	2.20	2.48	2.40	2.86	2.82	2.44	2.91	3.33	3.33	3.08	2.95
Belgium	1.21	1.17	1.98	2.45	2.40	2.20	2.34	2.58	2.60	2.53	2.47
Canada	0.90	1.58	1.58	1.54	2.17	3.27	3.31	3.85	3.35	3.67	3.42
Czech Republic	1.58	1.58	1.63	2.05	2.88	2.55	2.72	2.89	2.89	2.37	2.38
Denmark	2.11	2.09	2.59	3.13	3.16	2.83	2.96	4.07	4.03	3.98	3.85
Finland	1.98	2.48	2.48	2.44	3.15	2.82	3.08	3.25	3.21	3.48	3.43
France	1.56	1.56	2.13	2.71	3.28	2.86	2.90	3.69	3.15	3.70	3.57
Germany	2.54	2.54	2.67	3.05	3.00	2.67	2.64	3.06	3.02	3.14	2.92
Greece	1.77	1.77	1.73	1.84	1.84	1.92	1.83	2.08	2.33	2.33	2.13
Hungary	1.98	2.13	2.33	2.63	2.59	2.30	2.55	2.66	2.77	2.68	2.63
Ireland	0.85	1.42	1.46	1.88	2.23	1.71	2.05	2.16	2.22	2.43	2.05
Italy	1.35	1.42	1.49	2.22	2.72	2.34	2.60	2.73	2.84	2.79	2.77
Japan	1.58	1.65	1.90	1.67	1.63	1.69	1.69	1.73	2.03	2.96	3.50
Korea	1.10	2.02	2.33	2.90	2.96	2.96	3.38	3.52	3.52	3.44	2.63
Netherlands	1.78	2.20	1.90	2.80	2.80	2.64	3.23	3.69	4.13	3.51	3.63
Norway	1.67	1.42	1.42	1.88	2.13	2.05	2.34	3.19	3.19	3.19	3.26
Poland	1.19	1.19	1.27	2.13	2.26	2.08	2.26	2.96	2.96	2.96	2.58
Portugal	1.56	2.13	2.13	2.71	2.71	2.21	2.26	2.47	2.54	2.27	2.13
Slovak Republic	1.10	1.10	1.10	1.78	1.78	1.40	1.53	2.39	2.30	3.05	2.99
Spain	2.19	2.19	2.75	2.96	2.96	2.75	2.70	3.00	2.72	2.85	2.22
Sweden	2.58	2.43	2.75	2.71	3.03	2.70	2.92	3.34	3.09	3.23	3.10
Switzerland	1.94	1.94	1.69	2.38	2.13	2.13	2.67	3.19	3.33	3.29	3.29
Turkey	0.69	0.69	0.88	0.83	1.50	1.50	1.50	1.54	2.06	2.21	1.83
United Kingdom	1.10	1.73	1.73	2.23	2.29	1.95	2.40	2.58	3.62	3.47	3.29
United States	1.30	1.30	1.05	1.09	2.13	2.34	2.47	2.93	2.68	2.47	3.17
Brazil	0.63	0.58	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.38	0.38
China	0.65	0.85	0.85	0.85	0.77	0.77	0.81	0.98	1.10	1.35	2.04
India	0.60	0.60	0.60	0.67	0.67	0.63	0.63	1.13	1.20	1.26	1.30
Indonesia	0.44	0.44	0.44	0.44	0.50	0.50	0.50	0.50	1.17	1.17	1.17
Russia	0.52	0.65	0.65	0.65	0.65	0.65	0.60	0.60	0.60	0.60	0.60
South Africa	0.44	0.44	0.44	0.40	0.52	0.52	0.48	1.52	1.75	1.71	0.71

APPENDIX E

HS code; Environmental Goods classification classified by OECD

HS Code	Medium	Friends	PEGS	APEC	Core CLEG+	Core CLEG
380210	WAT		X		X	
390940	HEM		X			
392010	SWM	X	X			
392030	HEM		X			
392111	HEM		X			
392113	HEM		X			
392510	REP		X			
400259	SWM		X			
441872	EPP			X		
450410	NVA	X	X			
450490	HEM		X			
530310	EPP	X				
530500	EPP	X				
540500	HEM		X			
560314	WAT	X	X			
560721	EPP	X				
560790	EPP	X				
560811	NRP	X				
560890	NRP	X				
630510	EPP	X				
680610	HEM		X			
680690	HEM		X			
680800	HEM		X			
681011	HEM		X			
681019	HEM		X			
681091	HEM		X			
691010	WAT	X				
700800	HEM		X			
700991	REP		X			
700992	REP		X			
701931	HEM	X	X			
701939	HEM		X			
730210	CRE		X			
730230	CRE		X			
730240	CRE		X			
730290	CRE		X			
730300	WAT	X			X	
730431	WAT	X			X	
730490	WAT	X			X	

730630	WAT	X			X	
730690	WAT	X			X	
730820	REP	X	X			
730890	REP		X			
730900	WAT	X			X	
731010	WAT	X			X	
731029	WAT	X			X	
732111	CRE	X	X			
732119	REP		X			
732189	REP		X			
732190	CRE	X	X			
732490	WAT	X			X	
732510	WAT	X				
732690	WAT	X				
761090	REP		X			
761100	REP	X	X			
761290	SWM	X			X	
830630	REP		X			
840219	SWM	X				
840290	SWM	X		X		
840410	APC	X		X	X	
840420	APC	X		X	X	
840490	APC	X		X		
840510	APC	X	X		X	
840681	REP	X	X			
840682	REP	X	X	X		
840690	REP	X	X			
840991	NVA	X	X			
840999	NVA	X	X			
841011	REP	X	X			
841012	REP		X			
841013	REP		X			
841090	REP	X	X			
841181	REP	X	X			
841182	REP	X	X	X		
841199	REP			X		
841280	REP		X			
841290	REP		X	X		
841320	WAT	X				
841350	WAT	X				
841360	WAT	X				
841370	WAT	X				
841381	WAT	X	X			
841410	APC	X			X	

841430	APC	X				
841440	APC	X				
841459	APC	X				
841480	APC	X				
841490	APC	X				
841581	REP	X	X			
841780	SWM	X		X	X	X
841790	SWM	X		X	X	X
841861	REP	X	X			
841869	REP	X	X			
841919	REP	X	X	X		
841939	WAT	X		X		
841940	SWM	X				
841950	HEM	X	X			
841960	APC	X		X		
841989	WAT	X	X	X	X	
841990	REP	X	X	X		
842119	SWR	X				
842121	WAT	X		X	X	X
842129	WAT	X		X	X	X
842139	APC	X	X	X	X	X
842191	SWR	X				
842199	WAT	X		X	X	X
842220	SWM	X				
842290	SWM	X				
842833	SWM	X			X	
842940	SWM	X				
846291	SWM	X			X	
846596	SWM	X				
846599	SWM	X				
846694	SWM	X				
847420	SWM	X		X		
847982	SWM	X		X	X	
847989	SWM	X	X	X		
847990	SWM	X		X		
848110	WAT	X			X	
848130	WAT	X			X	
848140	WAT	X			X	
848180	WAT	X				
848190	WAT	X				
848340	REP	X	X			
848360	REP	X	X			
850161	REP	X	X			
850162	REP	X	X			

850163	REP	X	X			
850164	REP	X	X	X		
850220	HEM		X			
850231	REP	X	X	X		
850239	REP	X	X	X		
850300	REP	X	X	X		
850421	REP		X			
850422	REP		X			
850423	REP		X			
850431	REP		X			
850432	REP		X			
850433	REP		X			
850434	REP		X			
850440	REP	X	X			
850490	REP			X		
850590	SWM	X			X	
850680	CRE	X	X			
850720	REP	X	X			
850980	CRE	X				
851410	SWM	X		X		
851420	SWM	X		X		
851430	SWM	X		X		
851490	SWM	X		X		
851629	SWR	X				
853010	CRE		X			
853080	CRE		X			
853090	CRE		X			
853710	REP	X	X			
853720	REP		X			
853921	HEM		X			
853931	HEM		X			
853932	HEM		X			
854140	REP	X	X	X		
854370	WAT	X				
854390	WAT	X		X		
860110	CRE		X			
860120	CRE		X			
860210	CRE		X			
860290	CRE		X			
860310	CRE		X			
860390	CRE		X			
860400	CRE		X			
860500	CRE		X			
860610	CRE		X			

860630	CRE		X			
860691	CRE		X			
860692	CRE		X			
860699	CRE		X			
860711	CRE		X			
860712	CRE		X			
860719	CRE		X			
860721	CRE		X			
860729	CRE		X			
860730	CRE		X			
860791	CRE		X			
860799	CRE		X			
860800	CRE		X			
870290	CRE		X			
870390	CRE		X			
871200	CRE		X			
871411	CRE		X			
871419	CRE		X			
871420	CRE		X			
871491	CRE		X			
871492	CRE		X			
871493	CRE		X			
871494	CRE		X			
871495	CRE		X			
871496	CRE		X			
871499	CRE		X			
871639	CRE		X			
890790	SWR	X				
900190	REP	X	X			
900290	REP	X	X			
900580	MON		X			
901380	REP			X		
901390	REP			X		
901530	MON	X	X			
901540	MON	X			X	
901580	MON	X		X	X	
901590	MON	X	X			
902511	MON		X			
902519	MON		X			
902610	MON	X	X	X	X	
902620	MON	X	X	X		
902680	MON	X	X	X	X	
902690	MON	X	X	X		
902710	MON	X	X	X	X	X

902720	MON	X	X	X	X	X
902730	MON	X	X	X	X	X
902750	MON	X	X	X	X	X
902780	MON	X	X	X	X	X
902790	MON	X	X	X		
902810	MON	X			X	
902820	MON	X			X	
902830	HEM	X	X			
902890	HEM	X				
903010	MON	X	X			
903020	MON	X	X			
903031	MON	X	X			
903032	MON	X	X			
903033	MON	X	X			
903039	MON	X	X			
903084	MON	X	X			
903089	MON	X	X			
903090	MON	X	X			
903110	NVA	X				
903120	MON	X	X			
903149	MON	X	X	X		
903180	MON	X	X	X		
903190	MON	X	X	X		
903210	MON	X	X			
903220	MON	X	X			
903281	MON	X	X			
903289	REP	X	X	X		
903290	MON	X	X	X		
903300	MON	X	X	X		
940510	HEM		X			
940520	HEM		X			
940540	HEM		X			
950720	NRP	X				

Note: **Friends** (OECD, 150 climate change relevant products), **PEGS** (WTO, 154 environmental goods), **APEC** (APEC, 54 environmental products to reduce applied tariff rates to 5% at 2012 Vladivostok summit)

APPENDIX F

Conversion Tables of CLEG products From HS 2007 to HS 2002

From HS 2007	To HS 2002
441872	**441830**
530500	**530590**
732119	**732113**
732189	**732183**
854370	**854389**
903032	**903083**
903033	**903039**
903039	**903083**
903084	**903083**