Green Trade Patterns and the Transboundary Transmission of Greenhouse Gas Emissions

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By classifying international green and non-green trade for the period 1980–2015, this study investigates trends in green trade, exports, and imports as shares of total trade, exports, and imports, respectively. The general findings are that these green shares increased during the review period, albeit with the green shares for member countries of the Organisation for Economic Co-operation and Development showing different trends than those of nonmember countries. Further, three countries at different stages of economic development—the People's Republic of China, the Republic of Korea, and the United States—each exhibit different trends in green trade over time. In particular, the green trade, export, and import shares of the People's Republic of China decreased over time, which is in contrast to the increases observed for the Republic of Korea and the United States during the review period. The findings suggest that efforts to persuade developing countries to accept international agreements to reduce greenhouse gas emissions should also consider the transboundary transmission of these emissions and their health effects.

Keywords: green industry, green trade, greenhouse gas emissions
JEL codes: F14, Q27, Q56

I. Introduction

Hydrocarbon-based technological progress opened up an opportunity for mass production. As a result, unprecedented global economic growth has improved the quality of life significantly. However, the benefits of rapid economic growth have not been achieved without a cost. The heavy consumption of fossil fuels as a growth engine has led to the possible exhaustion of these resources in the near future, while climate change has been intensified by the accumulation of greenhouse gas (GHG) emissions. Accumulated GHG emissions have serious effects on human beings, ranging from individual health to national security (Kang 2015). Zhang et al. (2017) found that about 3.45 million premature deaths in 2007 were related to fine particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$).

The international community has been discussing whether sustainable development can be achieved by switching from the traditional economic growth strategy to an eco-friendly one. The new growth strategy has been named the "green economy" by the United Nations Environment Programme (2011) and "green growth" by the Republic of Korea's Presidential Commission of Future and Vision (2009) and the Organisation for Economic Co-operation and Development (OECD) (2012) (Kang 2015).

Since a large portion of GHG emissions originate from developing countries (and is doing so at an increasing rate), international efforts, which are being led mainly by developed countries, also require the active participation of developing countries. Therefore, implementation of the Paris Agreement, which is also referred to as the post-2020 new climate regime, cannot be successful without the collaborative efforts of both developed and developing countries. Fortunately, developing countries have agreed to join the global agenda to reduce GHG emissions. However, they argue that developed countries should provide various kinds of international support to them based on the fact that the current status of climate change is a result of the historical GHG emissions of developed countries (Munasinghe 1995, Kang 2015).

Another important assertion made by developing countries is that a sizable amount of the products made in developing countries are consumed by developed countries through international trade. Thus, developing countries argue that consumers in developed countries are partially responsible for the GHG emissions in developing countries (Kang 2015). Several recent studies show how GHG emissions have transboundary transmissions through international trade (Yunfeng and Laike 2010, Peters et al. 2011, Lin et al. 2014). Zhang et al. (2017) show that 22% of the 3.45 million premature deaths (762,400) due to $PM_{2.5}$ in 2007 were related to the production of goods and services in one region for consumption in another.

Due to the negative effects of imported products, developed countries have suggested policies to promote imports of eco-friendly products, which is often referred to as "green protectionism" (Bello 1997, Kang 2015). These policies impose penalties on non-green products such as cars with less efficient fuel usage.

There is high global demand for products produced by multinational companies in developing countries that are imported by developed countries. Thus, developing countries need more investment in green products to account for global trading trends and to promote economic growth through exports. This new trade–economic growth nexus can be used to persuade developing countries to join the international effort to reduce GHG emissions (Munasinghe 1995, Stern 2004, Kang 2015).

By examining the trade patterns of green and non-green products using international trade data categorized by industries, I investigate the general trends of global green and non-green trades that provide an insight into the possible channels

of economic growth for developing countries. For international trade, the United Nations (UN) Comtrade database is used, which applies the Standard International Trade Classification (SITC) Rev.2 to classify industries. Green and non-green industries are categorized by the classification of green goods and services (GGS) used by the United States (US) Bureau of Labor Statistics (BLS). Since the GGS is identified by the North American Industry Classification System (NAICS) 2012 and the UN Comtrade data follow the SITC Rev.2 classification, several correspondence tables are required to match the two different codes (Muendler 2009).

Identifying the trade patterns of green and non-green industries reveals that the economic growth strategies of developing countries should focus on promoting more exports. Thus, it can be inferred that developing countries need to invest more in producing exportable goods. This paper's general finding is that the world shares of green trade, exports, and imports are increasing relative to total trade, exports, and imports, respectively. Also, the respective shares of OECD countries are relatively higher than those of non-OECD countries. Further, the share of green imports in non-OECD countries fluctuated from 1980 to 2015—rising in the 1980s from a low of about 31% to more than 35% by the end of the decade, before dipping slightly in the 1990s and then increasing again beginning in 2005. At about 37% in 2015, the green imports share of non-OECD countries was still lower than that of OECD countries at the end of the review period.

The respective trends for the People's Republic of China (PRC), the Republic of Korea, and the US raise interesting issues that need to be further examined. For the Republic of Korea, the share of green exports increased from about 28% in 1980 to 45% in 2015, while the share of green imports decreased from 35% to 33% in the same period. In the US, the shares of green exports and imports in 1981 were about 38% and 28%, respectively, increasing to about 52% and 44% in 2015. However, the PRC experienced different trends from those observed in the Republic of Korea and the US during the review period. The shares of green exports and imports decreased from about 40% and 33%, respectively, in 1986 to about 32% and 30% in 2015.

This paper is organized as follows. Section II presents the background of the study by discussing the green trade and the new climate regime. Section III introduces data sources and summary statistics. Section IV presents various graphical analyses for green and non-green trade. Section V concludes.

II. International Trade and Transboundary Transmission of Greenhouse Gas Emissions

The world has experienced unprecedented growth in per capita income since the Industrial Revolution, which has contributed to a worldwide improvement in the standard of living. However, because the prevailing economic development strategy relies heavily on fossil fuels as the main production resource, the consumption of

Figure 1. **Carbon Dioxide Emission Trends**
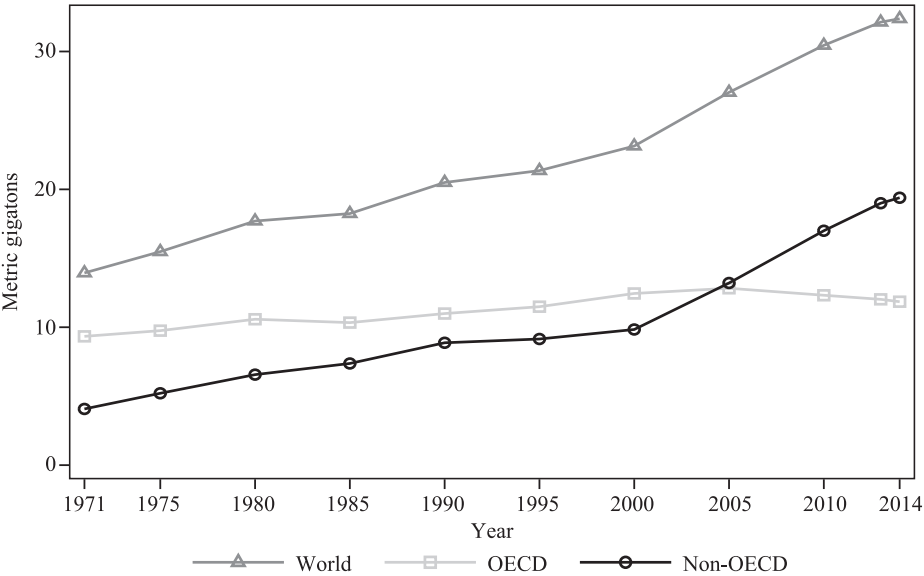
OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

fossil fuels has significantly increased to a point where the global environment can no longer sustain the accompanying GHG emissions. Since the 1980s, concerns for a sustainable future have gradually coalesced to form a global consensus on the need to take action against climate change. After a series of global initiatives, in 2015, the representatives of 195 countries agreed on the Paris Agreement at the 21st Conference of the Parties to the UN Framework Convention on Climate Change. The Paris Agreement has three main objectives: (i) limit the increase of the global average temperature to less than 2°C above preindustrial levels, (ii) support adaptation and foster climate resilience, and (iii) assist financial flows toward mitigation and adaptation (UN 2015).

Because of the negative externalities associated with GHG emissions, people outside the source country are also affected by GHG emissions. Therefore, the international community needs to cooperate to combat climate change.

Efforts to reduce carbon dioxide (CO_2) emissions by developed countries alone are not enough to achieve the objectives of the Paris Agreement. Rather, every country needs to pull its weight, whether it is a developed or developing country. Figure 1 shows the global, OECD, and non-OECD trends of CO_2 emissions, which clearly demonstrate that the efforts of developing countries are equally important as those of developed countries. Global CO_2 emissions from fuel combustion increased from 13.9 metric gigatons (GT) in 1971 to 20.5 GT in 1990, and

further to 32.4 GT in 2014 for an increase of 57.9% from 1990 to 2014. For the period 1990–2014, OECD countries' total CO_2 emissions increased by 7.8%, while non-OECD countries' total CO_2 emissions increased by 118.5%. In 2014, the total CO_2 emissions of the PRC reached 9.1 GT, which was an increase of 333.1% over 1971 levels. Total CO_2 emissions of the US (5.2 GT) and India (2 GT) increased by 7.8% and 280.8%, respectively, from 1991 to 2014 (IEA and OECD 2016). The data show that developing countries have been emitting CO_2 at an increasing rate since 2000, with non-OECD aggregate emissions exceeding those of OECD countries since 2005.

Developing countries are resisting the notion that all countries should bear an equal burden in combating climate change (Page 2008). They argue that as the current climate crisis has been triggered by the past activities of developed countries, these countries should accept their historical responsibility and bear a greater burden of the efforts toward emissions reduction, mitigation, and adaptation. Furthermore, developed countries have already accumulated sufficient wealth and technological assets to adapt to climate change, whereas developing countries are at greater risk and without adequate adaptation capacities (Ikeme 2003). Another important argument made by developing countries relates to the sources of CO_2 emissions. Historically, developing countries, especially the PRC, have acted as the factory of the world, capitalizing on cheaper labor and more abundant resources than found in developed countries. Therefore, while CO_2 emissions may originate in developing countries, in many cases the final products were exported to and consumed by citizens of developed countries.

There have been several studies on the transboundary transfers of GHG and CO_2 emissions embodied in export products. Yunfeng and Laike (2010) examine the PRC's international trade and report that 10% of the PRC's annual CO_2 emissions in 1997 resulted from manufacturing exported goods; this share had increased to 26.5% by 2007. On the other hand, the CO_2 emissions generated in the production of the PRC's imported goods were equivalent to only 4.4% of the PRC's total CO_2 emissions in 1997 and 9.1% in 2007. Thus, the rest of the world avoided producing 150.2 million tons of CO_2 emissions in 1997 and 593 million tons of CO_2 emissions in 2007 through trade with the PRC.

By using a trade-linked global database for CO_2 emissions for 113 countries and 57 economic sectors between 1990 and 2008, Peters et al. (2011) show that CO_2 emissions from the production of goods and services increased from 4.3 GT in 1980 to 7.8 GT in 2008. Further, CO_2 emissions from trade in goods and services as a share of global CO_2 emissions increased from about 20% in 1990 to about 26% in 2008. Wiebe et al. (2012) examine the amount of CO_2 emissions embodied in international trade for 48 sectors in 53 countries and two regions from 1995 to 2005. They report that the net CO_2 imports of OECD countries increased by about 80% during the review period, meaning that developed countries are externalizing their environmental burden through international trade.

Guan and Reiner (2009) assert that a significant share of the PRC's carbon emissions comes from the production of goods for exporting. Using atmospheric modeling, Lin et al. (2014) show that 36% of carbon monoxide and 17% of black carbon emitted in the PRC in 2006 resulted mainly from the production of goods for export.

By using input–output analysis, Meng et al. (2018) analyze the relationship between bilateral trade and GHG emissions. They show that trade among developing countries more than doubled from 2004 to 2011, while some production activities, especially raw materials and intermediate goods production in energy-intensive sectors, relocated from the PRC and India to other developing countries. As a result, CO_2 emissions generated in the production of goods from less developed countries such as Bangladesh and Viet Nam are increasing.

Other research has shown that global emission transfers through trade affect the health of people in the partner countries, even if the partner countries are not producing goods. Thus, global emission transfers through international trade are associated with transboundary health effects as well. As mentioned above, a recent study by Zhang et al. (2017) shows that about 3.45 million premature deaths in 2007 were related to $PM_{2.5}$. Out of total worldwide deaths caused by $PM_{2.5}$, about 12% (411,100) were caused by air pollutants emitted by goods and services produced in regions other than where the deaths occurred, and 22% (762,400) were related to the production of goods and services in one region for consumption in another.

The argument of developing countries—that it would be unfair to point fingers at developing countries for emitting large amounts of CO_2 without examining the context—is not unfounded. In fact, developing countries are not opposing the global efforts to tackle climate change, but rather are asking developed countries to support their efforts by means of financing, capacity building, and technology transfer. If appropriate support can be given to developing countries, not only would international cooperation on climate change progress, but developing countries would be provided with an opportunity to employ environmentally friendly growth strategies.

Munasinghe (1995) suggests the concept of "sustainomics," meaning that developing countries do not necessarily have to follow the traditional path of development that developed countries have pursued. Based on the Environment Kuznets Curve hypothesis, the relationship between the environment and per capita income is an inverted-U shape. When per capita income is low, economic activities have minimal effect on the environment, but as the economy grows, environmental degradation is accelerated by exploiting more natural resources and emitting more pollutants. Only at the peak of the inverted-U does the economic transition to the service sector and the desire for a better environment gain strength (Stern 2004).

Therefore, Munasinghe (1995) argues that rather than reaching the peak turning point of the Environment Kuznets Curve, developing countries could lower the inflection point by tunneling through the curve. Furthermore, developed

countries should aid developing countries in decoupling economic growth from environmental degradation. International cooperation can help developing countries follow a new path that guarantees less environmental pollution for the same level of production.

In order to persuade developing countries to join international agreements supporting the new climate regime and encouraging them to reduce GHG emissions, it is important to provide various international cooperative policy strategies. Global international trade in green products has been steadily increasing amid global efforts to tackle climate change. However, green industries are scarce in developing countries because of the lack of experts and technological assets. Since innovative activities for promoting green technologies and green industries require more financial investment and are relatively risky, developing countries with less technology than that of developed countries will face challenges. Thus, developed countries should assist developing countries through technology transfers and capacity building in green industries.

Furthermore, an export-led economic growth strategy would be more beneficial for developing countries than a traditional growth strategy of developing domestic markets. If developing countries invest more in products with lower levels of GHG emissions, they can realize the advantage of exporting products to further promote economic growth. Thus, international cooperation and investment by developing countries in green industries to promote exports can lead to economic growth, which is another justification to initiate green growth.

III. Classification of Green and Non-Green Industries

Developing countries are relying heavily on trade to promote export-oriented industries by producing cheap products and seeking a comparative advantage in the world market. However, unless there is a real increase in exports, export-led economic growth will not be possible. Therefore, the opportunity to increase the actual volume of export products serves as a strong incentive for developing countries. In other words, developed countries should persuade developing countries to participate in the global agenda to reduce GHG emissions by promoting the concept that investments in green industries will provide more export opportunities in the markets of developed countries, which will eventually lead to economic growth.

Even with the importance of green and non-green trade patterns, it is quite difficult to classify industries as either green or non-green. It might be similar to difficulties in defining intra-industry trade versus interindustry trade, or creating an environmental marker definition for foreign aid. For international trade, the trade pattern that is defined as intra-industry trade can be reclassified as interindustry trade if a more detailed industry classification is used (e.g., expanding a 3-digit

industry classification system to a 7-digit system). For foreign aid, the OECD Development Assistance Committee classifies environmental aid by using the Rio Convention markers, which define foreign aid as a "principal objective" if it shares the objectives of the convention on biological diversity, climate change mitigation, climate change adaptation, or the convention to combat desertification (OECD 2018). Even with this definition and eligibility criteria, it is quite difficult to classify a certain project as environmental aid because the decision can be made subjectively.

In order to find the international trade pattern of green goods and services, I have matched the SITC Rev.2 code with the GGS classification of the NAICS 2012.[1] The US BLS classifies the GGS to find the employment share in GGS out of total employment (US BLS 2012). This study uses the industry classification based on the GGS survey result.[2] For international trade data, I use the UN Comtrade database for the period 1976–2015, which is released by the UN Statistics Division. Then, for the classification of goods and services, I use the GGS survey conducted by the US BLS in 2011. However, because the two datasets—SITC Rev.2 and the GGS classification—cannot be directly matched, several intermediate steps are required, as described below.

First, the correspondence table of SITC Rev.2 (4-digit) and the International Standard Industrial Classification of All Economic Activities (ISIC) Rev.2 provided by Muendler (2009) was used to match the classification codes. Second, I matched the classification codes by using the correspondence table of ISIC Rev.2 and ISIC Rev.3.1.[3] Third, the classification codes were matched using the correspondence table of ISIC Rev.3.1 and NAICS 2002. Finally, the correspondence table of NAICS 2002 and 2007 was matched with the correspondence table of NAICS 2007 and 2012 (US Census Bureau 2012). After a series of classification code matching, the corresponding classification codes of NAICS 2012 and SITC Rev.2 were ready for use.

The GGS section of NAICS 2012 classifies industries into five different categories:

(i) energy from renewable resources (BLS1);

(ii) energy efficiency (BLS2);

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[1] Another classification by the Science and Technology Policy Institute in the Republic of Korea, which is based on the number of patent citations of 77 green technologies, also gives a useful definition of green industries. For example, there were 219 green industries with more than 250 citations out of the 1,145 industry codes of the 5-digit Korea Standard Industry Classification. However, this definition includes relatively more manufacturing industries. See Kang (2011) for a more detailed explanation.

[2] The BLS estimated that GGS jobs comprised 2.4% of total employment in the US in 2012. The private and public sectors accounted for 2.3 million and 860,300 GGS jobs, respectively; manufacturing industries accounted for 461,800 GGS jobs (US BLS 2012).

[3] UN Statistics Division. Central Product Classification. https://unstats.un.org/unsd/cr/registry/regso.asp?Ci =25&Lg=1 (accessed 10 April 2017).

Table 1. **Distribution of Various Definitions of Green Industry**

Definition (Code)	Goods	Services	Total
United States Bureau of Labor Statistics (BLS)	229	96	325
Energy from renewable resources (BLS1)	50	10	60
Energy efficiency (BLS2)	99	33	132
Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse (BLS3)	88	34	122
Natural resources (BLS4)	66	8	74
Environmental compliance, education and training, and public awareness (BLS5)	0	45	45

NAICS = North American Industry Classification System.
Note: The codes presented in the table are based upon the 6-digit NAICS classification.
Source: United States Bureau of Labor Statistics. Green Goods and Services. https://www.bls.gov/ggs/ (accessed 30 May 2017).

(iii) pollution reduction and removal, greenhouse gas reduction, and recycling and reuse (BLS3);

(iv) natural resources (BLS4); and

(v) environmental compliance, education and training, and public awareness (BLS5).[4]

Table 1 summarizes the distribution of various definitions of GGS. Out of 1,082 industries in the 6-digit NAICS classification, 325 industries were identified as GGS by the US BLS. By aggregate definition, 229 industries in goods production and 96 industries in the service sector were identified as GGS. For other classifications, BLS1 includes 50 industries in goods production and 10 industries in the service sector, whereas BLS5 includes only 45 industries in the service sector.

In order to examine the shares of green and non-green industries, the GGS classification was transformed into the 2-digit NAICS classification based on green and non-green classification (Table 2). Under the 2-digit NAICS classification, 56 out of 63 agriculture, forestry, fishing, and hunting industries are identified as GGS. Furthermore, 115 out of 365 manufacturing industries are identified as GGS. However, since the SITC Rev.2 does not include service sector classification codes, the detailed classifications for the service sector are not discussed in this study.

The 4-digit SITC Rev.2 classification was then transformed into the 1-digit SITC Rev.2 classification based on green and non-green classification (Table 3). Out of a total of 788 industries, the number of green industries is 290 (36.8%).

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[4]The US BLS defines GGS as "goods and services produced by an establishment that benefit the environment or conserve natural resources" (US BLS 2012, p. 6). The US BLS consults with industry groups, government agencies, stakeholders, and the public to identify the industries that potentially provide GGS. Establishments report whether they produce GGS and, if so, the percentage of their revenue and employment associated with GGS products. The US BLS website provides a more detailed definition of GGS (https://www.bls.gov/ggs/).

Table 2. **Green and Non-Green Classification by NAICS 2012**

Code	Description	Green	Non-Green	Total
11	Agriculture, forestry, fishing, and hunting	56	7	63 (88.9%)
21	Mining, quarrying, and oil and gas extraction	0	29	29 (0.0%)
22	Utilities	10	4	14 (71.4%)
23	Construction	48	2	50 (96.0%)
31–33	Manufacturing	115	250	365 (31.5%)
Others	Service	96	466	562 (17.1%)
Total		**325**	**758**	**1,083 (30.1%)**

NAICS = North American Industry Classification System.
Note: The codes presented in the table are based upon the 2-digit NAICS classification.
Source: United States Bureau of Labor Statistics. Green Goods and Services. https://www.bls.gov/ggs/ (accessed 30 May 2017).

Table 3. **Green and Non-Green Classification by SITC Rev.2**

Sector	Description	Green	Non-Green	Total
0	Food and live animals chiefly for food	51	43	94 (11.9%)
1	Beverages and tobacco	0	11	11 (1.4%)
2	Crude materials, inedible, except fuels	43	61	104 (13.2%)
3	Mineral fuels, lubricants and related materials	0	20	20 (2.5%)
4	Animal and vegetable oils, fats and waxes	0	18	18 (2.3%)
5	Chemicals and related products, nes	62	33	95 (12.1%)
6	Manufactured goods classified chiefly by materials	67	124	191 (24.2%)
7	Machinery and transport equipment	50	109	159 (20.2%)
8	Miscellaneous manufactured articles	16	72	88 (11.2%)
9	Not classified elsewhere	1	7	8 (1.0%)
Total		**290 (36.8%)**	**498 (63.2%)**	**788 (100.0%)**

nes = not elsewhere specified, SITC = Standard International Trade Classification.
Note: The codes presented in the table are based upon the 1-digit SITC Rev.2 classification.
Source: United Nations Statistics Division. Correspondence Tables. https://unstats.un.org/unsd/trade/classifications /correspondence-tables.asp (accessed 20 May 2017).

The highest shares of green industries are found among chemicals and related products (SITC5), manufactured goods classified chiefly by materials (SITC6), and machinery and transport equipment (SITC7).

IV. Empirical Results

A. General Trends of Trade, Exports, and Imports

Since the number of countries with data available from the 1970s is less than 50, the sample for the analysis in this study is restricted to the period after 1980. Figure 2 shows the generally increasing trends in global exports, imports, and trade since 1980. For the countries covered in this study, the total amount of world trade

Figure 2.   **Trends of World Exports, Imports, and Trade**
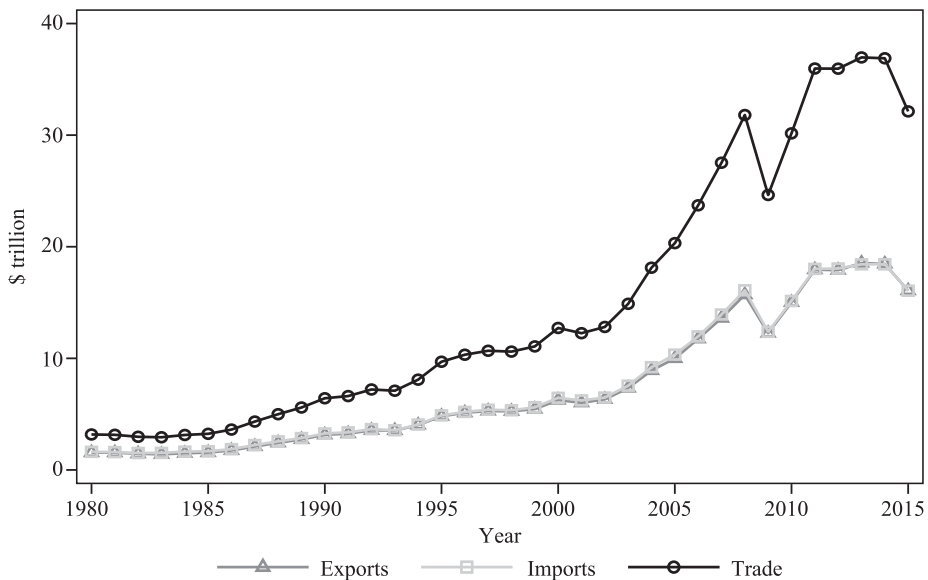
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

was about $2.9 trillion in 1980. This increased more than 13 times to about $37 trillion in 2014.

Figure 3 presents the OECD shares of global exports, imports, and trade since 1980.[5] In 2000, OECD countries accounted for about 77% of world trade. This share fell steadily from 2000 to 2013 before increasing slightly, with trends in the shares of exports and imports both following a similar pattern during the review period.

B.   General Trends of Green Trade, Exports, and Imports

Figure 4 shows the generally increasing trends in the green shares of world exports, imports, and trade since 1980. There was a higher share of green exports than green imports in each year during the review period.[6]

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[5]This study considers OECD countries to be those that were members of the OECD in 2010: Australia, Austria, Belgium, Canada, Chile, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, the Republic of Korea, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[6]The shares are calculated by dividing world green exports, imports, and trade by total world exports, imports, and trade, respectively.

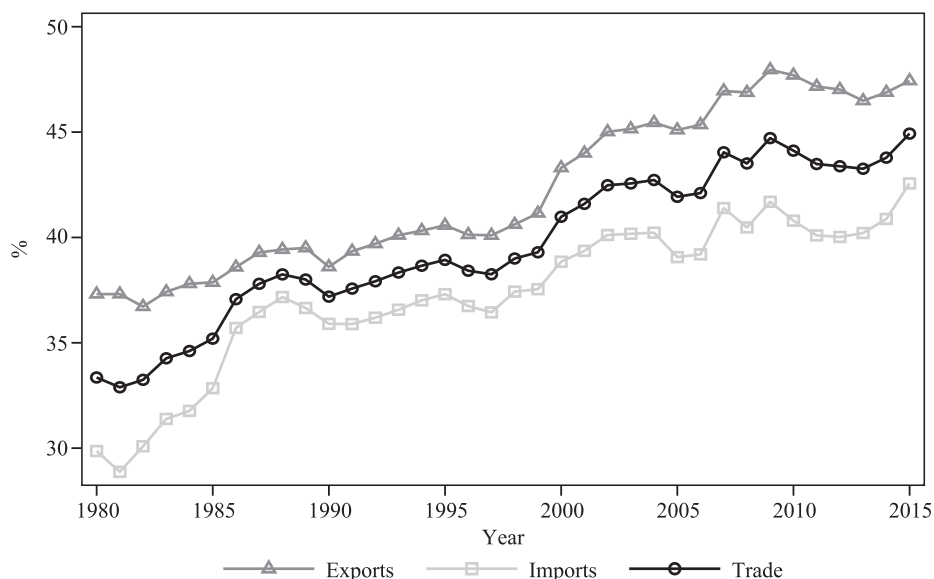Figure 3.   **OECD Shares of Global Exports, Imports, and Trade**
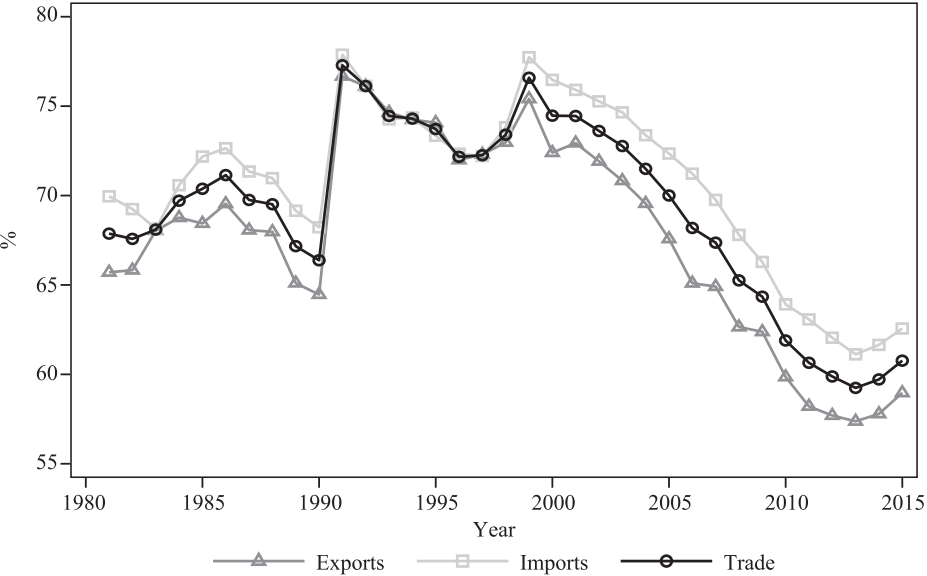
OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

Figure 4.   **Shares of World Green Exports, Imports, and Trade**
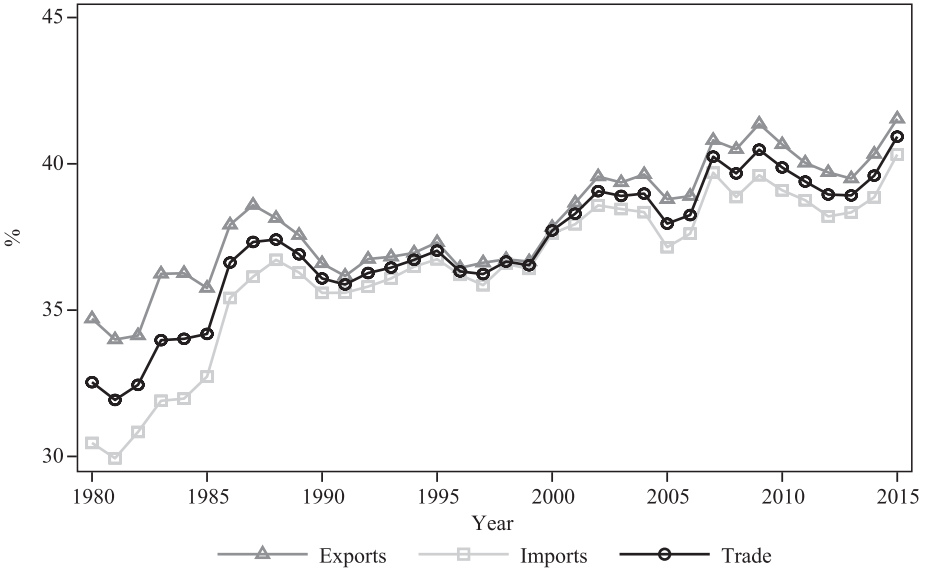
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

Figure 5. **OECD Shares of Green Exports, Imports, and Trade**

OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

The share of green exports in total exports was 34.7% in 1980 and 38.6% in 1987. While there were fluctuations over the years, an overall increasing trend was maintained, with the green share of total exports reaching 41.5% in 2015. The share of green imports in total imports shows a similar trend. In 1980, this share was 30.5% and by 2015, it had reached 40.3%. Similarly, the green share of trade in overall trade increased from 32.5% in 1980 to 40.9% in 2015.

Figures 5 and 6 show the trends of green exports, imports, and trade of OECD and non-OECD countries, respectively, between 1980 and 2015. These categories are used as proxies for developed and developing countries. OECD countries show a consistent increasing trend in green trade during the review period, whereas green trade shares among non-OECD countries fluctuated more.

For OECD countries, the shares of green exports and green imports were 37.3% and 29.9%, respectively, in 1980. These shares increased to 47.4% and 42.6%, respectively, in 2015, reflecting a significant increase in green trade during the review period. Meanwhile, the share of green trade in total trade increased from 33.4% in 1980 to 44.9% in 2015.

As mentioned above, the shares of green exports and imports among non-OECD countries fluctuated significantly between 1980 and 2015. In particular, the share of green exports decreased from 1980 to 1999 and then increased afterward. The non-OECD share of green exports in total exports in 1980 was 32%; this share

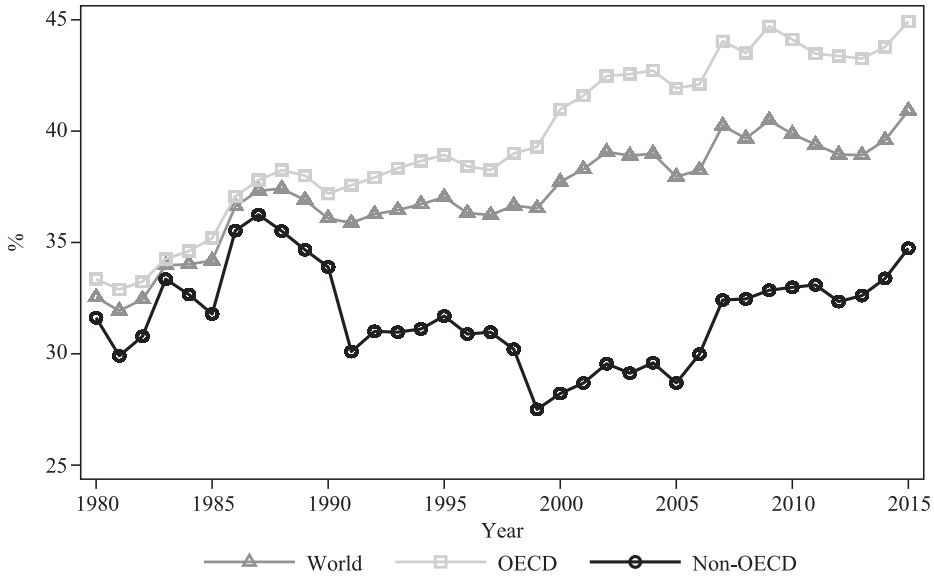Figure 6. **Non-OECD Shares of Green Exports, Imports, and Trade**
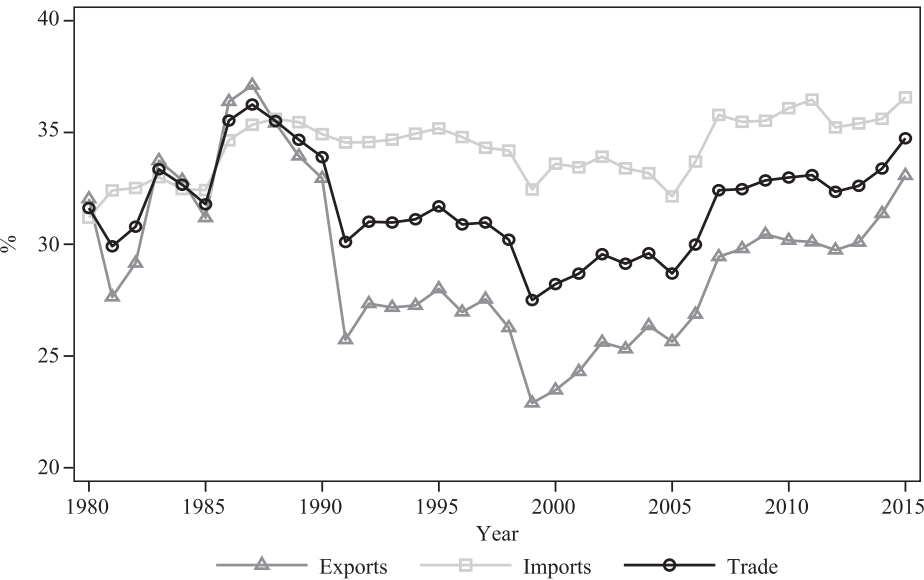
OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

dipped to 27.6% in 1981 and reached a peak of 36.4% in 1986 before falling again to 22.9% in 1999. From 1999 to 2015, the non-OECD share of green exports rose consistently, reaching 33.1% at the end of the review period. Compared with the share of green exports, the share of green imports showed less fluctuation during the review period, increasing gradually from 31.2% in 1980 to 36.6% in 2015.

Figures 7, 8, and 9 show trends in the shares of green trade, exports, and imports, respectively, for the world, OECD, and non-OECD countries. From 1980 to 2015, the shares of green trade, exports, and imports for OECD countries were higher and increased more rapidly than those for non-OECD countries. For example, the share of green trade among OECD countries in 1980 (33.4%) was slightly higher than that for non-OECD countries (31.6%). The green trade share of OECD countries increased on a relatively steady path to 44.9% in 2015, while the green trade share of non-OECD countries decreased to 27.5% in 1999 before eventually rising to 34.7% in 2015. Thus, the trends imply that the share of green trade of non-OECD countries fluctuated more than that of OECD countries and with no significant overall increase over time.

The trends of green exports and imports show patterns similar to those of green trade for both OECD and non-OECD countries from 1980 to 2015. For example, the share of green exports of OECD countries consistently increased with
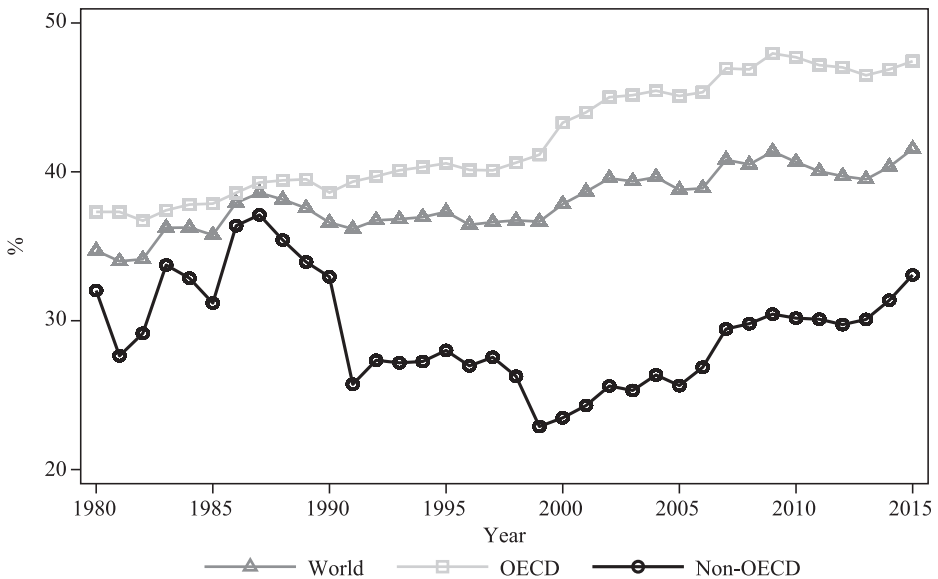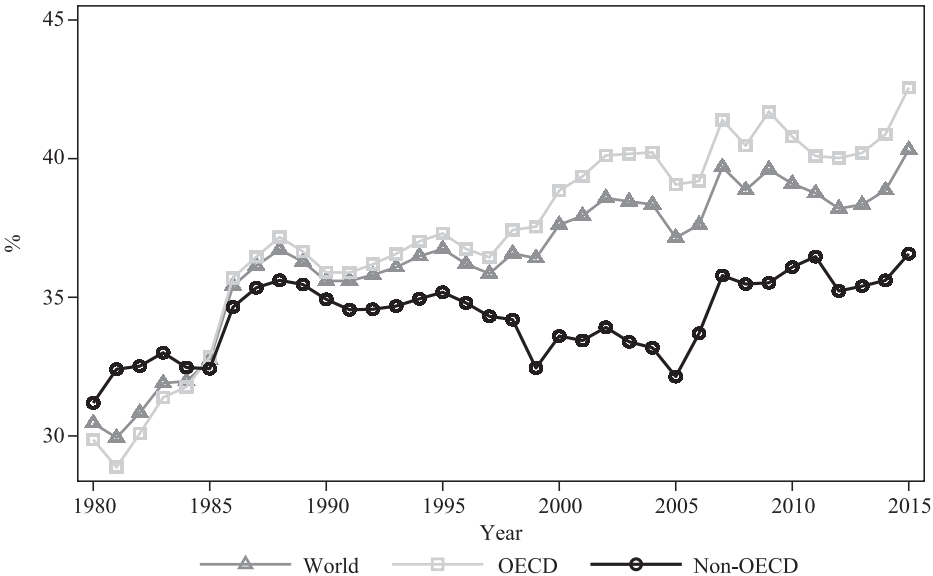
Figure 7.   **Green Trade Shares of the World, OECD, and Non-OECD Countries**

OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

Figure 8.   **Green Export Shares of the World, OECD, and Non-OECD Countries**

OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

Figure 9.   **Shares of Green Imports of the World, OECD, and Non-OECD Countries**

OECD = Organisation for Economic Co-operation and Development.
Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

only minor exceptions during the review period, but that of non-OECD countries fluctuated, initially decreasing and then increasing.

C.   Share of Green Trade, Exports, and Imports by Countries

Figures 10, 11, and 12 show the trends of green exports, imports, and trade of three countries—the Republic of Korea, the US, and the PRC—that are each at different stages of economic development. Economic growth rates in the Republic of Korea were among the fastest in the world during the 1970s and 1980s. Even though the PRC would also exhibit some of the fastest economic growth in world history, real per capita income (in 2010 US dollars) in the PRC was still about $6,484 in 2015, which was below that of the Republic of Korea ($24,871).[7] Meanwhile, the US was already one of the world's leading developed countries by the beginning of the review period in 1980.

Figure 10 shows an overall increasing trend in the green trade share for the Republic of Korea from 1980 to 2015, with more fluctuations prior to 1998. The shares of green exports, imports, and trade all fluctuated between about 25% and
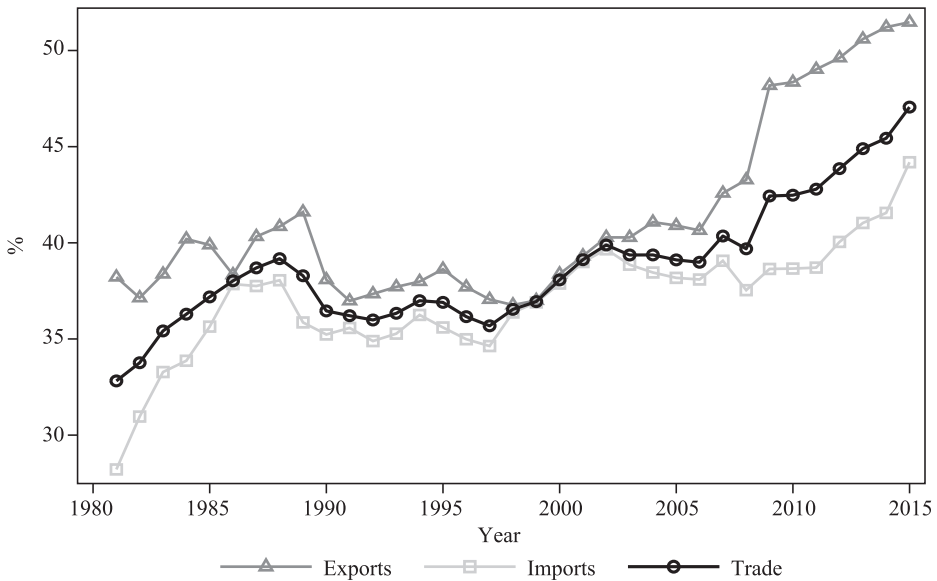
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[7]World Bank. World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 2 September 2019).

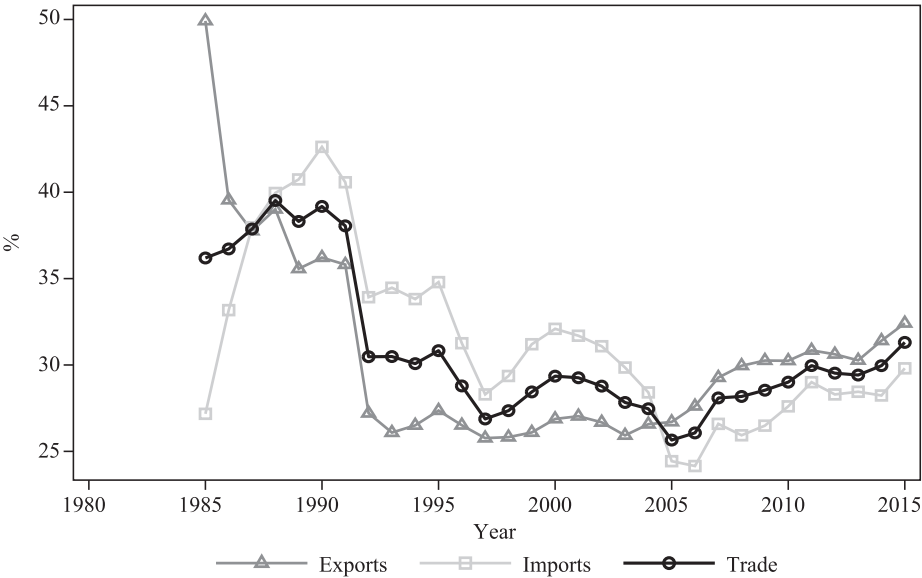Figure 10.   **Green Export, Import, and Trade Shares of the Republic of Korea**
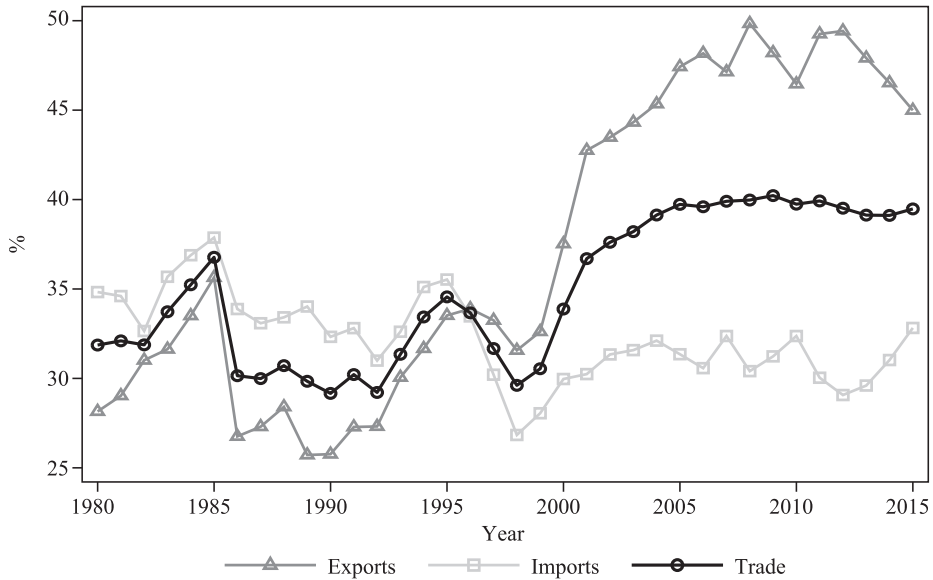
Figure 11.   **Green Export, Import, and Trade Shares of the United States**

Figure 12. **Green Export, Import, and Trade Shares of the People's Republic of China**

Source: United Nations (UN) Statistics Division. UN Comtrade Database. https://comtrade.un.org (accessed 1 March 2018).

40% in the 1980s and 1990s. The share of green exports increased significantly after 2000 to reach a peak of 49.4% in 2012 before dipping slightly, whereas the share of green imports bottomed out in 1998 and then hovered between 30% and 35% from 2000 until the end of the review period. The shares of green exports and imports in 2015 were 44.9% and 32.8%, respectively.

The green export, import, and trade shares of the US are slightly different from those of the Republic of Korea. Figure 11 shows that the share of green exports and imports tended to increase significantly in the 1980s, remained relatively stable in the 1990s, and then increased again from 2000 to 2015. The shares of green exports and imports in 1981 were about 38.2% and 28.2%, respectively, rising to 51.5% and 44.2% in 2015. These shares began to increase more rapidly after 2005.

Figure 12 shows that the trends in the green shares of the PRC contrast those of both the Republic of Korea and the US. Since 1985, the earliest year for which bilateral trade data for the PRC are available, the shares of green exports and imports largely decreased until 2005 before starting to pick up. Furthermore, the green share values for the PRC remained lower than those of the other two countries in the study. The PRC's shares of green exports and imports were consistently below 30% throughout the review period. Meanwhile, the shares of green exports of the Republic of Korea and the US in 2015 were 45% and 51.5%, respectively; the shares of green imports were 32.8% and 44.2%, respectively, in the same year. In contrast,

the PRC's respective shares in 2015 were 32.4% for green exports and 29.8% for green imports.

The varying trends observed in the shares of green trade, imports, and exports are largely due to the different environmental restrictions applied within each of these three countries. For example, in 1970, the Environmental Protection Agency was established in the US to regulate issues related to health and the environment. The agency implemented several major federal laws to protect the environment, including the Clean Air Act Amendments 1970 and the Global Climate Protection Act 1987 (Hahn 1994). Similarly, the Republic of Korea implemented a series of policies to protect the environment and transition to green industries. The Framework Act on Low Carbon, Green Growth currently serves as the cornerstone for the country's environmental protection policies (Presidential Commission of Future and Vision 2009).

The PRC is considered a developing country and therefore has prioritized economic growth over environmental concerns. One example of this consideration is the Kyoto Protocol, under which the PRC is listed as a non-Annex I country, meaning it has no GHG emissions reduction targets. Therefore, differences in the development status of countries, levels of concern for the environment, and international pressure to protect the environment are reflected in differences in the shares of green trade, exports, and imports between developed and developing countries

V. Conclusion

This study aims to investigate global and country-level trends in green trade, exports, and imports by using international bilateral trade data and GGS classifications. I found that from 1980 to 2015 the world share of green trade, exports, and imports increased relative to total trade, exports, and imports, respectively. Further, the green shares of OECD countries, as high-income countries, are relatively higher than those of non-OECD countries.

Three countries at different stages of economic development—the Republic of Korea, the US, and the PRC—were examined individually, revealing different trends during the review period in their respective shares of both green exports and green imports. The share of green exports of the Republic of Korea increased from 28.2% in 1980 to 44.9% in 2015, while the share of green imports decreased from 34.8% to 32.8% in the same period. For the US, the shares of green exports and imports rose from 38.2% and 28.2%, respectively, in 1981 to 51.5% and 44.2% in 2015. On the other hand, the PRC's trends were very different from those of the Republic of Korea and the US. The shares of green exports and imports in the PRC decreased from 39.5% and 33.2%, respectively, in 1986 to 32.4% and 29.8% in 2015.

The findings of this study contribute to the literature discussed in section II. Using various methodologies and trade-related data and input–output tables, while also taking into consideration the environmental effects, previous research showed that international trade results in the transboundary transmission of GHG emissions that are harmful to human health. Thus, a high share of exports of non-green goods is closely related to the transfer of GHG-embodied products.

The country-level shares of green trade, exports, and imports have demonstrated different trends and values since 1980, even though the overall world shares have increased during the review period. Hence, it is necessary to investigate the factors that determine these different patterns of green trade, exports, and imports by using more sophisticated econometric methodology that controls for the independent country-specific variables. The traditional gravity model originated by Isard (1954) can be a useful empirical model specification in this regard. Based on the findings of this study, promoting and supporting investment in GGS can be a useful tool for persuading developing countries to actively participate in international agreements to reduce GHG emissions and achieve the new climate regime's global temperature target.

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