ASIA'S LOW-CARBON TRANSITION

OPPORTUNITIES AND CHALLENGES FOR TRADE

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ABSTRACT

The central objective of our paper is to assess the opportunities and challenges for trade for Asian economies during the low-carbon transition. To do so, we examine the green trade patterns of Asian Development Bank member economies in the Asia and Pacific region between 1990 and 2019 based on three widely used green industry classifications, namely US BLS GGS, OECD ENV-TECH, and OECD CLEG classifications.

Our analysis yields three key findings. First, the share of green goods in the exports of Asian economies has consistently increased since the early 2010s. Second, the share of Asian economies in global green exports has grown rapidly in recent years. Third, manufacturing products, especially machinery and electric equipment, account for the largest share of green trade. In fact, since the early 2010s, the shares of Asian economies in world manufacturing green exports and imports have increased. However, the green imports share showed faster growth than the exports share. Finally, the pattern of green trade differs depending on green industry definition, pointing to a need for international consensus on defining green trade in order to measure and analyze green trade patterns more accurately.

Keywords: low-carbon transition, green, trade, environment, Asia

JEL Code: F18

I. INTRODUCTION

Since 1750, human activity has been the main driver of an increase in global greenhouse gas (GHG) concentrations, contributing to an unprecedented increase in global temperature (IPCC 2021). A number of reputable reports point to the need to limit human-induced global warming and eventually achieve net zero emissions (IEA 2021; IMF 2021; IPCC 2021; UNEP 2021). As of 2022, 17 economies, including four Asian Development Bank (ADB) member economies, have written net zero emission targets into their law. Among the human-induced drivers, it is estimated that international trade is associated with 20%–30% of global carbon emissions (WTO 2021a; Sato 2014).

Therefore, greening trade is important to reach net zero emissions since trade affects the flows of many kinds of goods and capital, from energy-intensive consumption goods to environment-friendly capital goods. Greening trade presents both challenges and opportunities. However, there is no international consensus on the definition of green industries and, hence, green trade.[1] Therefore, in the context of measuring green trade more accurately, an important medium- to long-term objective is to achieve an international consensus on the definition of green trade. In this paper, despite the lack of a consensus, we will use three definitions of green industries to analyze the trends of green growth in developing Asia. Based on our analysis, we will explore the opportunities and challenges for the region's trade during its low-carbon transition.

The rest of this paper is organized as follows. Section II briefly reviews the literature on international trade and carbon emissions, along with some relevant descriptive statistics. Section III describes three widely used classifications of green industry and compares them. Section IV provides a detailed analysis of green trade patterns for each sector and subregion. In addition, the section examines the opportunities and challenges that green trade poses for developing Asia. Finally, section V concludes.

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[1] In this paper, we linked green trade to low-carbon transition since green trade is relatively low-carbon emitting trade compared to non-green trade. Moreover, in the case of Organisation for Economic Co-operation and Development (OECD) environment-related technologies (ENV-TECH) classification, carbon technology—i.e., climate change mitigation and adaptation—is matched to trade classification. Also, OECD Combined List of Environmental Goods (CLEG) classification is also related to air/atmosphere in the classification, so it is possible to interpret that products in the green sector belong to low-carbon sectors.

II. LITERATURE REVIEW

A. Carbon Footprint of Trade

International trade leads to carbon emissions not only through production and consumption of traded goods and services, but also through the distribution and transportation process. Carbon emission accounting studies suggest that about 20%–30% of total carbon emissions are associated with international trade (WTO 2021a; Sato 2014), and the transport sector accounts for 21% of global carbon emissions (Brand 2021). WTO (2021a) finds that indirect emissions associated with the production are relatively greater than direct emissions associated with the production of goods.

Tables 1 and 2 show the carbon emissions embodied in international trade, in gross exports, and net gross exports (balance), respectively, by subregion between 1995 and 2018 from the database of the Organisation for Economic Co-operation and Development (OECD).[2] Table 1 shows that the amount of total carbon emissions embodied in gross exports of East Asia and Southeast Asia increases in unprecedented pace throughout the period, surpassing that of Europe since 2005 and the People's Republic of China (PRC) contributing to most of the emissions. Europe's carbon emissions embodied in gross exports seem to increase until 2006, but then remain stable since then.

The amount of emissions embodied in gross exports of the United States is higher than that of North America throughout the period, and this is because exports within the subregion economies is not considered in the subregion estimation. By economy, in 1995, the Russian Federation, the United States, the PRC, Germany, and Canada were the most exporter of carbon emissions embodied in international trade, respectively; while in 2010, it was led by the PRC, the United States, the Russian Federation, Germany, and the Republic of Korea (ROK), respectively; and, in 2018, the PRC, the United States, the Russian Federation, India, and Germany, respectively.

[2] OECD data on carbon dioxide (CO_2) emissions embodied in international trade (2021 ed.) are estimated by combining the OECD Inter-Country Input-Output (ICIO) Database and International Energy Agency (IEA) statistics on CO_2 emissions from fuel combustion. Further details are in Yamano and Guilhoto (2020).

Table 1: Carbon Dioxide Emissions Embodied in Gross Exports to World
(million tons)

	1995	2000	2005	2010	2015	2016	2017	2018
East and Southeast Asia	657.8	981.7	1,884.1	2,139.8	2,216.5	2,040.3	2,162.1	2,207.5
- East Asia	592.9	862.6	1,765.3	2,071.6	2,164.7	1,988.0	2,111.2	2,147.2
- China, People's Republic of	442.5	616.8	1,691.2	1,918.3	1,958.0	1,805.1	1,926.5	1,948.0
Europe	792.9	1,037.1	981.9	988.9	1,084.0	995.9	1,030.7	1,064.2
- European Union (28 economies)	517.9	652.0	734.5	798.1	820.9	782.2	818.4	822.2
North America	483.1	516.2	478.0	540.9	572.5	533.6	549.7	575.1
- United States	558.9	662.2	585.7	630.2	630.1	581.2	589.9	607.5
South and Central America	72.4	106.3	168.0	164.4	193.4	185.4	187.1	202.6

Source: Organisation for Economic Co-operation and Development. Trade in Embodied CO_2 Database ($TECO_2$). https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2021 (accessed 6 September 2022).

Table 2 shows the carbon emissions embodied in international trade in net gross exports balance by subregion between 1995 and 2018. East Asia and Southeast Asia were net importers of carbon emissions embodied in international trade in 1995, but then transformed to net exporter since 2000, while Europe shows the reverse trend changing from the net exporter to the net importer since 2005. The European Union (EU) and North America remain as the net importers throughout the period.

By economy, in 1995, the Russian Federation, the PRC, Poland, South Africa, and Canada, respectively, were the biggest net exporters of carbon emissions embodied in international trade, while in 2018, it was led by the PRC; the Russian Federation; South Africa; India; and Taipei,China, respectively. In addition, in 1995, Japan, the United States, Germany, Italy, and France, respectively, were the biggest net importers of carbon emissions embodied in international trade, while in 2018, it was led by the United States, Japan, Germany, the United Kingdom, and France, respectively.

Table 2: Carbon Dioxide Emissions Embodied in Net Gross Exports Balance
(million tons)

	1995	2000	2005	2010	2015	2016	2017	2018
East and Southeast Asia	-21.2	239.5	1,060.0	1,175.3	1,015.4	933.9	982.3	933.4
- East Asia	-36.9	116.3	917.0	1,068.1	888.1	809.1	861.6	796.1
- China, People's Republic of	325.9	398.4	1,242.5	1,280.4	923.2	870.6	945.2	895.5

	1995	2000	2005	2010	2015	2016	2017	2018
Europe	72.1	147.7	-314.2	-402.3	-96.9	-179.4	-230.3	-245.9
- European Union (28 economies)	-427.0	-504.4	-717.0	-680.3	-431.5	-458.4	-470.1	-526.4
North America	-171.5	-588.2	-979.9	-676.8	-688.4	-660.7	-700.2	-704.1
- United States	-220.3	-611.9	-959.3	-625.8	-719.0	-708.6	-743.1	-752.1
South and Central America	-48.0	-44.5	3.2	-107.0	-69.6	-51.2	-66.9	-59.3

Source: Organisation for Economic Co-operation and Development. Trade in Embodied CO_2 Database ($TECO_2$). https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2021 (accessed 6 September 2022).

Tables 1 and 2 indicate that the trade sector is largely associated with global carbon emission and that the responsibility and efforts are needed not only from the one side of the emission but from both of the production- and consumption-based emission economies. The Asia and Pacific region dominates global manufacturing production, and thus global manufacturing emissions (UNECE 2019). East Asia and Southeast Asia produce more than 50% of global manufacturing emissions. By 2015, the Asia and Pacific region was engaged in 50%–71% of the virtual flows of water, energy, GHG, $PM_{2.5}$, labor, and value added embodied in international trade (Yang et al. 2020). Developed economies tend to be net importers of the emissions, while developing and commodity dependent economies tend to be net exporters of the emissions (WTO 2021a). Economies more integrated in global value chains (GVCs) have increased their imports of intermediate inputs, and thus the amount of the emissions embedded in those imports.

B. Low-Carbon Transition Policies

To combat climate change, economies are engaging in low-carbon transition where transforming economy depends heavily on fossil fuel to a sustainable, low-carbon economy. Low-carbon transition policies in international trade can largely be classified to two types: tax/tariffs and nontariff measures (NTMs) that include technical barriers to trade (TBTs). Within the increasingly interconnected global economy, low-carbon transition policies influence the decision-making processes and operation of all economic stakeholders, and trade flows (Vrontisi et al. 2020).

According to the World Bank database, global trade-to-gross domestic product share has increased from 38% in 1990 to 57% in 2018, which implies that the trade regime will be affected greatly by the transition policies. In this regard, Brandi (2017) finds that 45% of

Nationally Determined Contributions (NDCs) include a direct reference to trade or trade measures. Policies include not only market regulations, i.e., decommissioning fossil fuel power plants; implementing carbon tax, emission limit, and Carbon Border Adjustment Mechanism (CBAM); and enhancing goods performance standards, but also include incentive policies such as investing in clean energy technologies and digitalization, providing subsidies for e-mobility, and fostering green jobs.

In general, low-carbon transition plan of major economies includes cutting emissions, maintaining secure energy supplies, maximizing economic opportunities, and protecting the most vulnerable, e.g., ROK’s Carbon Neutrality Bill (2021), France 2030 (2022), Australia Net Zero (2022), and Canada Climate Plan (2021). The most representative transition measure is the EU CBAM, which is a carbon tariff to address the risks of carbon leakage targeting on imports of carbon-intensive products. EU introduced CBAM as part of the European Green Deal in 2021 with an enforcement year in 2026 (Schott and Hogan 2022).

Carbon-intensive imports should purchase emissions trading system permits to cover their embedded carbon emissions, and covered industries include iron and steel, cement, electricity, fertilizers, aluminum, organic chemicals, polymers, hydrogen, ammonia, and indirect emissions. Hufbauer et al. (2021) suggest that the Russian Federation, the PRC, Türkiye, the United Kingdom, Ukraine, the ROK, and India are the economies that will be most affected by the EU CBAM, while Eicke et al. (2021) suggest that the most affected region will be Africa. The United Nations Asia–Pacific Trade and Investment Report (ESCAP 2021) states that the EU CBAM will most significantly and negatively affect trade and gross domestic product of South Asia and Southwest Asia compared to other regions.

Similarly, United States Clean Competition Act that was introduced in June 2022 includes a proposal for a CBAM and a domestic carbon tax, inferring that major economies are now taking practical and strong actions toward net zero transition (Reinsch 2022). While Mörsdorf (2022) predicts that the carbon leakage rate will reduce from 22% to 7%–15% through the EU CBAM, developing economies with less-stringent climate regulations than the EU or the United States could face adverse impacts of the CBAM implementation.

These low-carbon transition movements offer opportunities to developing Asia in developing international competitiveness through comparative advantages in producing green goods and in the new markets for clean energy goods. On the other hand, challenges include increased costs of factors of production, replacing infrastructure that support carbon-intensive activities, increased transport costs, and lose of industry competitiveness in brown sectors and stranded industries.

For example, Schott and Hogan (2022) show that low-carbon transition can bring both challenges and opportunities in steel industry. Steel industry accounts for about 8% of global emissions and, as of 2020, the ROK was the fifth largest iron and steel exporter to the EU. Between 2019 and 2021, the ROK exported 7.9 million metric tons of steel to the EU and 6.7 million metric tons to the United States, valued at $7.8 billion and $6.7 billion, respectively. The problem is that the current ROK steel production is carbon-intensive because the ROK's traditional blast furnace and basic oxygen furnace (BF-BOF) steel production generates about one-third higher carbon dioxide (CO_2) emissions per metric ton of steel produced than the United States and French producers and about 20% higher than German and Italian firms (Schott and Hogan 2022).

Therefore, to sustain its industry competitiveness during the transition and achieve NDC target, the ROK steel industry should switch its production method from traditional BF-BOF production to electric arc furnace (EAF) and newer production technologies. As a result, the ROK steelmaker POSCO announced new investments in EAF and green hydrogen production aiming to reduce emissions by 20% from the 2017–2019 levels by the end of this decade. This example of steel industry clearly shows that low-carbon transition offers both challenges and opportunities in each sector of industries, including the stranded industries.

C. Impact of Low-Carbon Transition on Trade

A number of studies address that global trade volume and especially emissions-intensive sectors (such as chemical, steel, and carbon-intensive fossil fuels) get damages as a result of the transition. However, trade volume in green sectors and technologies increases, thus implying growing opportunities in green trade from the emergence of new markets for green goods and services (GGS) (Huxham et al. 2019; Vrontisi et al. 2020; Eicke et al. 2021; Chepeliv 2022). Vrontisi et al. (2020) examine the impacts of climate policies (i.e., NDCs and well below 2°C mitigation policies) on trade. The study finds that the global trade volume decreases are attributed to decreasing global demand of fossil fuels, while trade in energy-intensive industries and low-carbon technologies increases (i.e., clean energy, agriculture, and biofuel sectors). It emphasizes that regional effects on competitiveness depend on the design of national climate policy. Therefore, decision-making of economic agents are important to sustain or reinforce the industry competitiveness.

As the globalization of production and fragmentation of production processes underpinned the growth in international trade, the impact of low-carbon transition on global supply chains should be analyzed in detail also. In fact, because of complex and borderless business networks and production systems, GVC is difficult to be quantitatively analyzed in volume or growth (Blanchard et al. 2021).

Dincer and Tekin-Koru (2020) and Webb et al. (2020) examine the impact of trade policy on GVCs, in which the former focuses on impact of policy-induced barriers (PIBs)[3] and the latter focuses on NTMs. Both studies find that trade policy, i.e., PIBs and NTMs, have adverse effect on GVCs. Webb et al. (2020) examine the impact of NTMs on GVCs in the six largest economies of the Association of Southeast Asian Nations. The study finds that about 20% of NTMs are found to have a statistically significant negative effect on trade. And of the NTMs that have a statistically significant impact, the study finds that the effect is greatest on agricultural intermediates (an average impact of 74% on affected products) and smallest for nonagricultural products for final consumption (an average of 49% on affected products). Therefore, liberalization and harmonization of these measures are

[3] Policy-induced barriers (PIB) include not only the tariff and nontariff barriers, but also other multifaceted barriers coming from the services side that affect GVCs, such as sector-specific regulations, the lack of enforcement of competition, rules related to data localization, commercial presence requirements, or restrictions on movement of people. PIBs can take three forms: (i) domestic regulations, (ii) discriminatory barriers against all foreign suppliers, and (iii) economy-specific barriers. While the World Bank Services Trade Restrictions Indices (STRI) and the OECD STRI account for domestic regulations and discriminatory barriers against all foreign suppliers, PIBs in this study are comprised of only discriminatory barriers (to all foreign suppliers and economy-specific ones) (Dincer and Tekin-Koru 2020).

required to foster, and develop resilience of, global supply chain and international trade in low-carbon transition.

III. CLASSIFICATION OF GREEN INDUSTRY

A. Various Classifications of Green Industry

Traditionally, trade has been considered as a main engine of economic growth. However, recent climate change agenda and thus low-carbon transition result in differentiated approach on the relation between trade and economic growth. The investment and exports of eco-friendly product (sectors) should be promoted, and thus it will contribute to economic growth. Therefore, low-carbon transition policies will affect industry production and exports. To consider the relation between trade and economic growth, very detailed trade pattern with sectors and subregion breakdown needs to be analyzed.

This study utilizes the previous classification of the United States Bureau of Labor Statistics Green Goods and Services (BLS GGS), the OECD environment-related technologies (ENV-TECH), and the OECD Combined List of Environmental Goods (CLEG) classifications to define and classify the green trade. International trade is a growth engine for developing economies that adopt export promotion strategies. Especially for developing economies, trading in environmental or climate products may not be the case. However, the extent of the classification of green industry affects the diversity of industries involved in environmental and trade policies. The recent global movement to tackle the climate crisis considers eco-friendly industries, which are described as green industries and encompass industries that are broader than the environment and climate industries (Kang 2011, 2020). Further, because of the lack of international consensus on the definition of the green industry, there are various definitions of climate, environment, and green industry.

In order to define the green trade, the existing classifications such as the US BLS GGS, the OECD ENV-TECH, and the OECD CLEG correspond to the Harmonized System (HS) code. The HS is a standardized international code system for the purpose of customs classification for traded goods that can be used by participating economies that was first launched in 1988.[4]

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[4] Refer to UN Statistics Wiki, Harmonized Commodity Description and Coding Systems (HS). Retrieved from https://unstats.un.org/wiki/pages/viewpage.action?pageId=87426301 (accessed 26 August 2022).

There have been several changes in the classification of products known as revisions. These revisions went into effect in 1996, 2002, 2007, 2012, 2017, and 2022. The six digits can be divided into three parts: the first two are HS 2-digit, the next two are HS 4-digit, and the last two are HS 6-digit. Thus, it can be interpreted that HS 2-digit indicates the division in which the goods are classified, HS 4-digit defines the groupings in the division where the goods are classified, and HS 6-digit is more narrowly identified.

1. US BLS GGS

The scope of green trade defined in this study differs from existing studies. First of all, this study defines and estimates a broader definition of green trade from the US BLS GGS.[5] The US BLS conducted an annual survey identifying organizations producing GGS and estimating the number of jobs associated with GGS production. 325 detailed GGS industries with 6-digits of North American Industry Classification System (NAICS) were determined by result. Additionally, GGS is defined as goods and services produced by an organization that benefits the environment or conserves natural resources, and falls into one or more of the following five groups:

(i) energy from renewable resources;

(ii) energy efficiency equipment, appliances, buildings and vehicles, and goods and services that improve the energy efficiency of buildings and the efficiency of energy storage and distribution;

(iii) pollution reduction and removal, GHG reduction, and recycling and reuse goods and services;

[5] Although the BLS GGS was released in 2011 and discontinued since 2013 due to federal budget cut, its significance lies in identifying and classifying green goods and services using an internationally accepted standard classification, i.e. NAICS. Since the classification of green goods has not changed since then, studies on green growth still frequently use the BLS GLS classification. Furthermore, one key aim of this study is to compare the BLS GGS classification with other recently released classifications. The BLS GGS utilizes company survey data that excludes businesses which earns less than 50% of their revenues from green goods and services, so it covers only a portion of national employment, leading to an underestimation of green jobs (Pollack 2012). On the other hand, our study utilizes the UN Comtrade commodity data that covers every trade transaction. When matched with HS 6-digit code, green industry using the BLS GGS classification includes 39.13% of total industries (1,972 out of 5,040 industries). Therefore, world green exports reaching about $6 trillion in 2019 is not an implausible estimate. We can similarly look at the two other classifications. When matched with HS code, green industry under the OECD ENV-TECH classification includes 19.25% of total industries and green industry under the OECD CLEG classification includes 3.60% of total industries. Therefore, the estimates of green exports under two classifications are not implausible. It is possible that the green export goods of developed and emerging economies could differ. However, these measures are classified by industry commodity codes. Therefore, it is difficult to clearly distinguish between green goods exported by developed and developing countries.

(iv) organic agriculture; sustainable forestry; and soil, water, and wildlife conservation; and

(iv) government and regulatory administration; and education, training, and advocacy goods and service.

GGS businesses are found in industries that produce goods and provide services that benefit the environment or conserve natural resources. The organization's percentage of revenue related to the sale of GGS is used to estimate GGS jobs, defined as employment related to producing GGS at the organizational level. Sample organizations that do not generate income are asked to report their employment shares associated with GGS production. For example, research and development-related employment, nonprofits, government agencies, and new businesses can provide GGS without generating income. The GGS survey included about 120,000 business and government organizations in 333 industries from 1,193 detailed industries in the 2007 NAICS that provide goods and services that potentially directly benefit the environment or conserve natural resources.

Matching US BLS to HS is referred to as the code linkage method of Kang (2020) and Kang and Lee (2021). Since BLS GGS is classified into NAICS 2007 (6-digits), the NAICS codes are matched to the HS 1992 codes through the matching process from NAICS 2007 (6-digits) to ISIC Rev.4 (4-digits) with the US BLS concordance table and then to ISIC Rev.3.1 and ISIC Rev.2 and HS 1992 codes (6-digits) with the UN Comtrade concordance table.

2. OECD ENV-TECH

The definition of green trade identified by the OECD ENV-TECH and OECD CLEG classifications includes more stringent scope than the US BLS GGS. The OECD ENV-TECH is a classification based on green technologies related to climate change mitigation and adaptation in the ENV-TECH policy objectives (Haščič and Migotto 2015; OECD 2020). Table 3 shows a list of four objectives and strategies: environmental health, climate change mitigation, climate change adaptation, and improving the sustainable ocean economy. This study considers the technologies related to the climate change mitigation and adaptation technologies as follows.

(i) climate change mitigation activities (groups 2, 3, 4, 5, 6, 7, 8, 10.3, and 10.4); and

(ii) climate change adaptation technologies (groups 9, 10.4, and 10.6).

Table 3: OECD ENV-TECH Policy Objective and Patent Search Strategies

Policy Objective	Patent Search Strategy
Environmental health (human health impacts)	1. Environmental management
Climate change mitigation	2. Energy generation, transmission, or distribution
	3. Capture, storage, sequestration, or disposal of greenhouse gases
	4. Climate change mitigation technologies related to transportation
	5. Climate change mitigation technologies related to buildings
	6. Climate change mitigation technologies related to wastewater treatment or waste management
	7. Climate change mitigation technologies in the production or processing of goods
	8. Climate change mitigation in information and communication technologies
Climate change adaptation	9. Climate change adaptation technologies
Improving the sustainable ocean economy	10. Sustainable ocean economy (including climate change mitigation and adaptation) 10.1 Ocean renewable energy generation 10.2 Ocean pollution abatement 10.3. Climate change mitigation in maritime transport 10.4. Climate change mitigation and adaptation in fishing, aquaculture and aquafarming 10.5 Desalination of seawater 10.6. Climate change adaptation in coastal zones

Source: Organisation for Economic Co-operation and Development, Environment Directorate. *Green Growth Indicators*. Retrieved from https://www.oecd.org/env/indicators-modelling-outlooks/green-patents.htm (accessed 19 August 2022).

The Cooperative Patent Classification (CPC) codes (4-digits) for patent search strategies in OECD (2020) are matched to the HS 2002 code (6-digits) (Goldschlag et al. 2020). Since the utilized Comtrade trade data follows the HS 1992 classification, the HS 2002 codes are matched to the HS 1992 codes through HS2002 to HS 1996 to HS 1992 process.[6]

[6] The HS codes matching concordance is from the UN Statistics Division. Retrieved from https://unstats.un.org/unsd/classifications/Econ#Correspondences (accessed 21 June 2022). The detailed description of the classification and the matching process is in Kang et al. (2021).

3. OECD CLEG

The OECD CLEG lists the total of 248 environmental commodities by integrating three environmental products by the HS 2002 codes (6-digit) (OECD 2019):

(i) more than 150 climate-related products presented in the OECD Plurilateral Environmental Goods and Services (PEGS) (OECD 2010),

(ii) 154 products presented by the Friends group as a subgroup of environmental products submitted by the World Trade Organization (WTO) members to the trade and environmental section of Doha Round negotiations (WTO 2009), and

(iii) 54 environmental products negotiated by the Asia–Pacific Economic Cooperation (APEC) economies to reduce tariffs (APEC List of Environmental Goods that contribute to green growth and sustainable development objectives directly and positively).

The OECD CLEG and related environmental commodities are summarized in Table 4. The OECD CLEG is classified by the HS 2002 (6-digits) and the HS 1992 codes.

Table 4: OECD CLEG Classification and Description

Classification	Description
APC	Air pollution control
CRE	Cleaner or more resource-efficient technologies and products
EPP	Environmentally preferable products based on end use or disposal characteristics
HEM	Heat and energy management
MON	Environmental monitoring, analysis, and assessment equipment
NRP	Natural resources protection
NVA	Noise and vibration abatement
REP	Renewable energy plant
SWM	Management of solid and hazardous waste and recycling systems
SWR	Clean up or remediation of soil and water
WAT	Wastewater management and potable water treatment

Source: Garsous (2019).

4. Comparison of Three Classifications

Many existing studies use interchangeably environmental industry, climate industry, green industry, and green growth industry. However, the specific classifications and scopes differ.[7] In particular, environmental and climate industries should be differentiated from the green industry. The green industry should further be defined as a broader scope, including the eco-friendly industry even in the manufacturing industry. Through this, not only the products produced in developed economies, but also the products produced in low-income developing economies should be able to be classified as green trade. Accordingly, trade occurring from—multinational companies entering into developing economies should be promoted as green industry trade and become a driving force of economic growth.

Table 5 summarizes the matching result of three green industry classifications which represent the number of HS 6-digit commodities according to the definition of green industry classifications (US BLS GGS, OECD ENV-TECH, and OECD CLEG). The share of green industry based on HS 1992 (6-digits) are 1,972 (39.13%), 970 (19.25%), and 232 (3.60%) belonging to the US BLS GGS, the OECD ENV-TECH, and the OECD CLEG, respectively. Therefore, it is essential to compare the three categories to estimate the trend of green trade in the ADB member economies.

Table 5: Summary of Three Green Industry Classification

Sector		GGS BLS	OECD ENV-TECH	OECD CLEG	Total
I (01~05)	Animal	22	4	0	194
II (06~15)	Vegetable	200	54	0	323
III (16~24)	Food products	19	19	0	181
IV (25~26)	Minerals	13	93	0	111

[7] Based on the Korea Standard Industry Code (KSIC), the Korea Employment Information Service (KEIS), the Korea Environmental Industry & Technology Institute (KEITI), and the Science & Technology Policy Institute (STEPI) define green industry (Kang 2011). Jang et al. (2010) identify 27 major green technologies in accordance with the patent classification, and establish the Green Innovation Index (GII). Kang (2011) investigates economic spillover effect of green investments on green and non-green industries by setting two different scenarios from combination of the above three green industry classifications. Similarly, Aghion et al. (2016) classify green and polluting patents in automobile industry using the patent classification of the International Patent Classification (IPC).

Sector		GGS BLS	OECD ENV-TECH	OECD CLEG	Total
V (27)	Chemicals	65	179	1	760
VI (28~38)	Plastic or rubber	44	50	3	189
VII (39~40)	Hides and skins	19	1	0	74
VIII (41~43)	Wood	153	12	2	228
IX (44~49)	Fuels	1	29	0	59
X (50~63)	Textiles and clothing	630	53	17	809
XI (64~67)	Footwear	22	1	0	55
XII (68~71)	Stone and glass	107	31	12	190
XIII (72~83)	Metals	330	159	26	587
XIV (84~85)	Machinery and electronics	200	240	87	762
XV (86~89)	Transportation	67	18	38	132
XVI (90~99)	Miscellaneous	80	27	46	386
Total		**1,972 (39.13%)**	**970 (19.25%)**	**232 (3.60%)**	**5,040**

Sources: Authors' calculation using the US BLS (2012), Haščič and Migotto (2015), OECD (2020), Goldschlag et al. (2020), Garsous (2019), and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

Among the three classifications, the OECD CLEG includes the smallest range of the green industries, that is 3.60% of the total industry. The OECD CLEG does not include any industry in sectors I, II, III, and IV, indicating that the primary industry is not classified as a green industry. The OECD ENV-TECH defines green industry in terms of technology perspective originating from patents classification, so the proportion of manufacturing is relatively high. On the other hand, the OECD CLEG mainly includes industries in sectors XV, XVI, and XVII. Therefore, it is more appropriate to identify the OECD CLEG classification as an environmental industry rather than a generally defined green industry. Regarding these characteristics, the following export and import trends of these three classifications could exhibit different patterns.

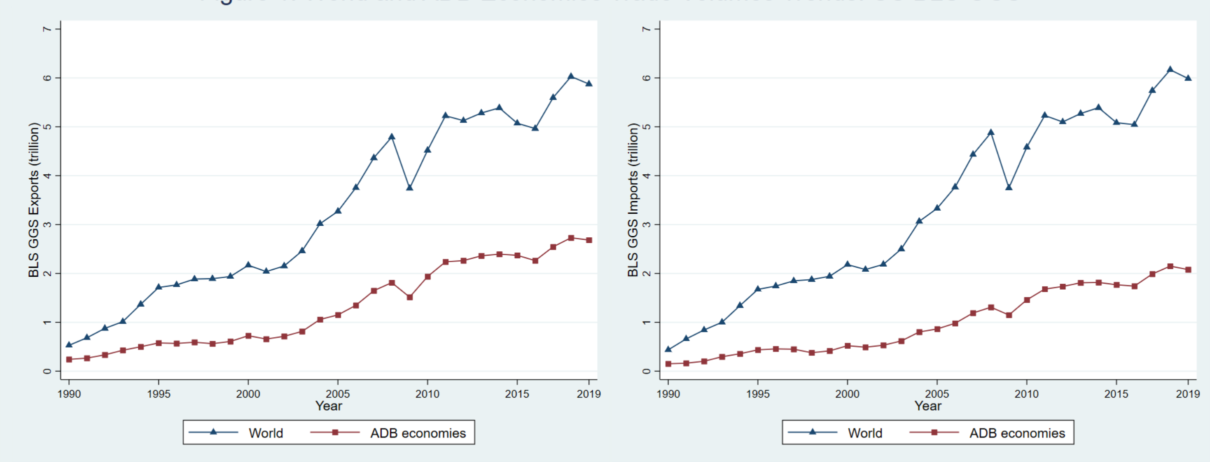
IV. GREEN TRADE PATTERNS AND A GROWTH OPPORTUNITY IN DEVELOPING ASIA

A. Green Trade Patterns of ADB Economies

1. Green Trade Volume

Figures 1–9 show the trends of green trade from 1990 to 2019 based on the abovementioned definition and classifications. The ADB economies are defined as Asia and the Pacific economies.[8] First, the US BLS GGS trade volume of World and ADB economies indicate similar patterns (Figure 1). World and ADB trade (sum of exports and imports) in the BLS GGS goods increased from about $0.97 trillion and $0.39 trillion in 1990 to $12.20 trillion and $4.72 trillion in 2018. Afterward, it decreased in 2019 (World: $11.87 trillion; ADB economies: $4.76 trillion).

Figure 1: World and ADB Economies Trade Volumes Trends: US BLS GGS



	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	0.53	1.71	2.17	3.27	4.52	5.07	4.96	5.60	6.03	5.88
	ADB	0.24	0.58	0.73	1.15	1.94	2.37	2.26	2.55	2.73	2.68
Imports	World	0.44	1.67	2.18	3.33	4.58	5.08	5.04	5.74	6.17	5.99
	ADB	0.15	0.44	0.52	0.86	1.46	1.77	1.74	1.99	2.15	2.08

ADB = Asian Development Bank, BLS = Bureau of Labor Statistics, GGS = Green Goods and Services, US = United States.

Source: Authors' calculation using the US BLS (2012) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

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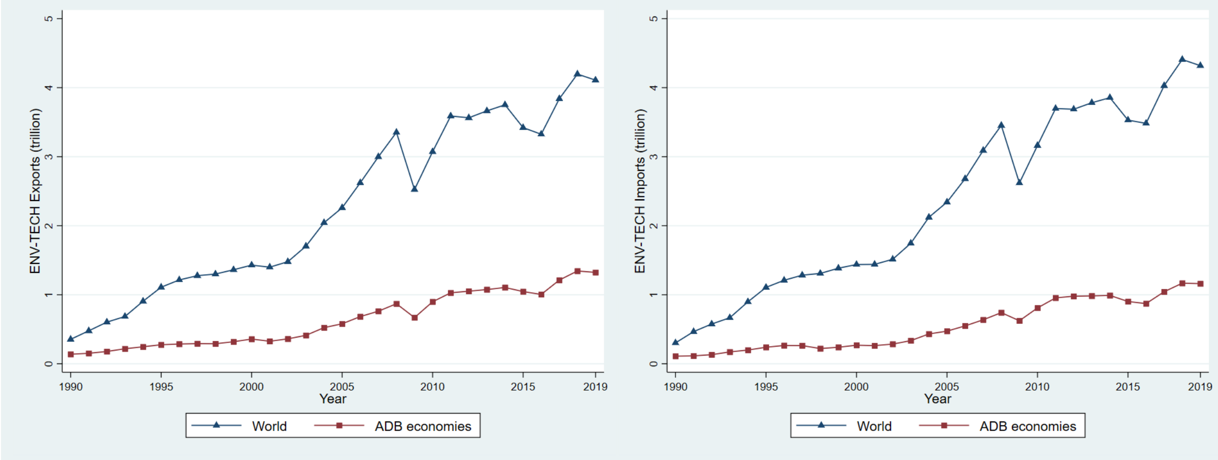
[8] Three-letter codes of the included economies: AFG, ARM, AUS, AZE, BAN, BHU, BRU, CAM, PRC, FIJ, GEO, HKG, IND, INO, JPN, KAZ, KIR, KOR, KGZ, LAO, MAL, MLD, RMI, FSM, MON, MYA, NAU, NEP, NZL, PAK, PAL, PNG, PHI, SAM, SIN, SOL, SRI, TAJ, THA, TIM, TON, TKM, TUV, UZB, VAN, VIE. Refer to the ADB Handbook of Style and Usage for the corresponding ADB member names: https://www.adb.org/documents/handbook-style-and-usage.

Second, the green trade volume of ADB economies accounts for more than half of the world's green trade volume between 1990 and 2019, according to the OECD ENV-TECH classification (Figure 2). Moreover, the green trade volume of both groups shows similar trends. World and ADB economies' green trade increased by about 12.92 times and 10.03 times, respectively, compared to the 1990 level.

Figure 2: Trade Volumes Trends of World and ADB Economies: OECD ENV-TECH



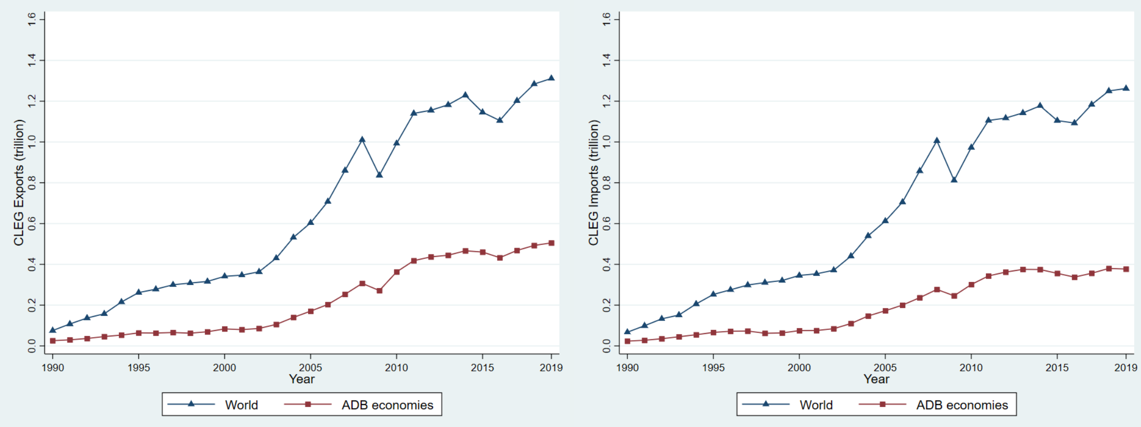
	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	0.35	1.11	1.43	2.26	3.07	3.42	3.33	3.84	4.20	4.11
	ADB	0.14	0.28	0.36	0.58	0.90	1.05	1.00	1.21	1.34	1.32
Imports	World	0.30	1.11	1.44	2.34	3.16	3.53	3.48	4.03	4.41	4.32
	ADB	0.11	0.24	0.27	0.47	0.81	0.90	0.87	1.04	1.17	1.16

ADB = Asian Development Bank, ENV-TECH = environment-related technologies,
OECD = Organisation for Economic Co-operation and Development.

Source: Authors' calculation using Haščič and Migotto (2015), OECD (2020), Goldschlag et al. (2020), and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

According to Figure 3, the OECD CLEG trade volume of ADB economies accounts for about 39% of the World's exports volume and 30% of the World's imports volume by 2019. Although both groups exhibit similar trends in terms of exports and imports volume, they show varying degrees of fluctuation in 2009 and 2016.

Figure 3: Trade Volume Trends of World and ADB Economies: OECD CLEG



	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	0.08	0.26	0.34	0.60	0.99	1.15	1.10	1.20	1.28	1.31
	ADB	0.03	0.06	0.08	0.17	0.36	0.46	0.43	0.47	0.49	0.51
Imports	World	0.07	0.25	0.35	0.61	0.97	1.11	1.09	1.18	1.25	1.26
	ADB	0.02	0.07	0.08	0.17	0.30	0.36	0.34	0.36	0.38	0.38

ADB = Asian Development Bank, CLEG = Combined List of Environmental Goods, OECD = Organisation for Economic Co-operation and Development.

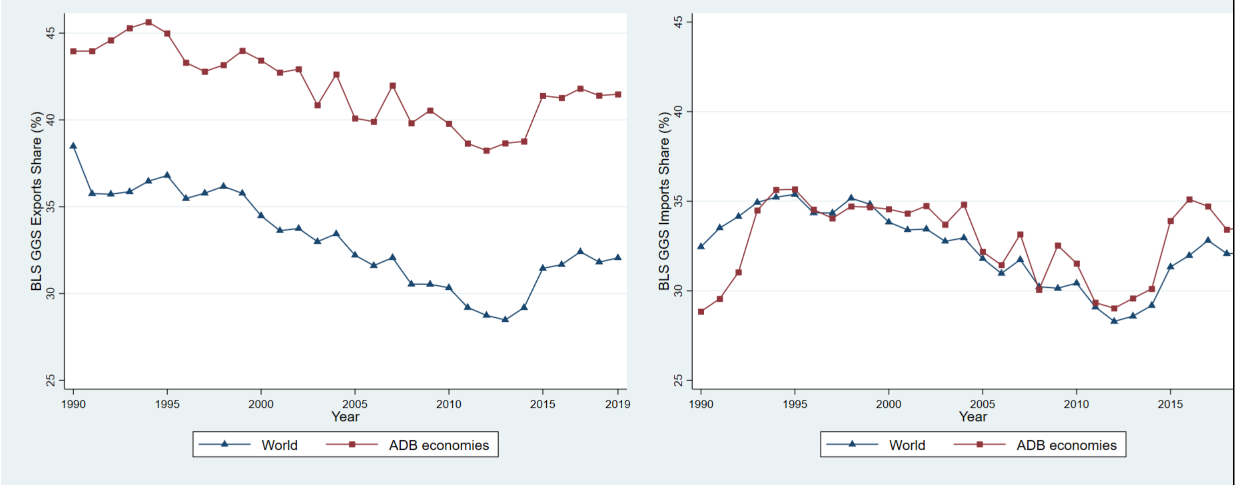
Source: Authors' calculation using Garsous (2019) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

2. Green Trade Share

Figure 4 presents the trade shares of World and ADB economies based on the US BLS GGS classification. Since 1990, US BLS GGS exports share of both World and ADB economies have decreased with fluctuations until 2015 and both are increasing afterward. And US BLS GGS import share with World and ADB economies show similar trends during the same period. In certain periods, ADB economies' green import share surpasses the World share.

Specifically, the decrease of exports share of the ADB economies in the early period is attributed to sector 87 (vehicles; other than railway or tramway rolling stock, and parts and accessories thereof), while the increase since the mid-2010s is attributed to sector 85 (electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, parts and accessories of such articles). In addition, the trend of the imports share of the ADB economies follows the pattern of that of sector 85, which dominates the green imports share of the ADB economies. Green imports share of sector 85 increased from 7.42% in 1990 to 19.67% in 2019.

Figure 4: World and ADB Economies Trade Share Trends: US BLS GGS



	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	38.49	36.80	34.48	32.21	30.34	31.45	31.67	32.40	31.81	32.05
	ADB	43.96	44.98	43.43	40.09	39.78	41.39	41.27	41.80	41.40	41.48
Imports	World	32.46	35.38	33.83	31.79	30.43	31.33	31.97	32.81	32.08	32.10
	ADB	28.85	35.66	34.56	32.18	31.53	33.91	35.10	34.71	33.42	33.55

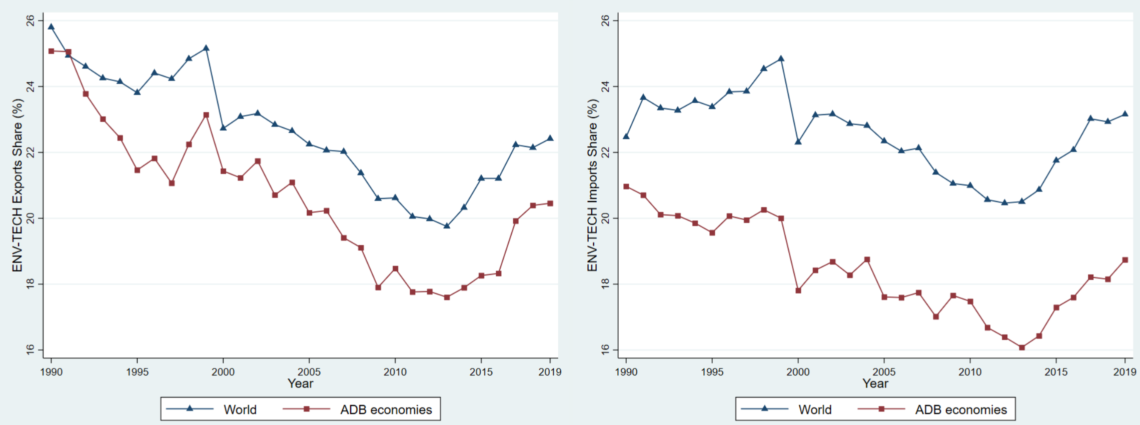
ADB = Asian Development Bank, BLS = Bureau of Labor Statistics, GGS = Green Goods and Services, US = United States.

Source: Authors' calculation using the US BLS (2012) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

Overall, the OECD ENV-TECH green exports shares of the World and ADB economies were 25.80% and 25.08% in 1990 and decreased to 22.42% and 20.46% in 2019, respectively. Figure 5 shows that both exports and imports shares of the World and ADB economies had a deteriorating trend until 2013 and recovery afterward. To be specific, the main attributes of the decrease in exports share of the ADB economies until 2013 are sectors 84 (nuclear reactors, boilers, machinery and mechanical appliances; parts thereof) and 87 (mainly sector 87 in the early 1990s). Moreover, the increase in the exports share of the ADB economies since 2016 is contributed by the increase in that of sector 84. The green exports share of sector 84 increased from 6.05% in 2016 to 6.77% in 2019.

In terms of the imports share of the ADB economies, the reduction in the early 1990s is because of sector 87, while the rapid fall since 2000 is attributed to sector 84. The imports share of sector 84 decreased from 7.04% in 1998 to 4.22% in 2013. The recovery since 2014 is contributed by sectors 84 and 26 (ores, slag and ash) (mainly by sector 84). The imports share of sectors 84 and 26 increased from 4.23%, and 1.18% in 2014 to 5.89%, and 1.44% in 2019, respectively.

Figure 5: Trade Share Trends of World and ADB Economies: OECD ENV-TECH



	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	25.80	23.81	22.73	22.25	20.62	21.21	21.21	22.23	22.14	22.42
	ADB	25.08	21.46	21.44	20.17	18.48	18.26	18.33	19.92	20.39	20.46
Imports	World	22.47	23.38	22.31	22.35	20.99	21.76	22.07	23.02	22.93	23.15
	ADB	20.97	19.56	17.81	17.61	17.48	17.30	17.60	18.21	18.15	18.74

ADB = Asian Development Bank, ENV-TECH = environment-related technologies, OECD = Organisation for Economic Co-operation and Development.

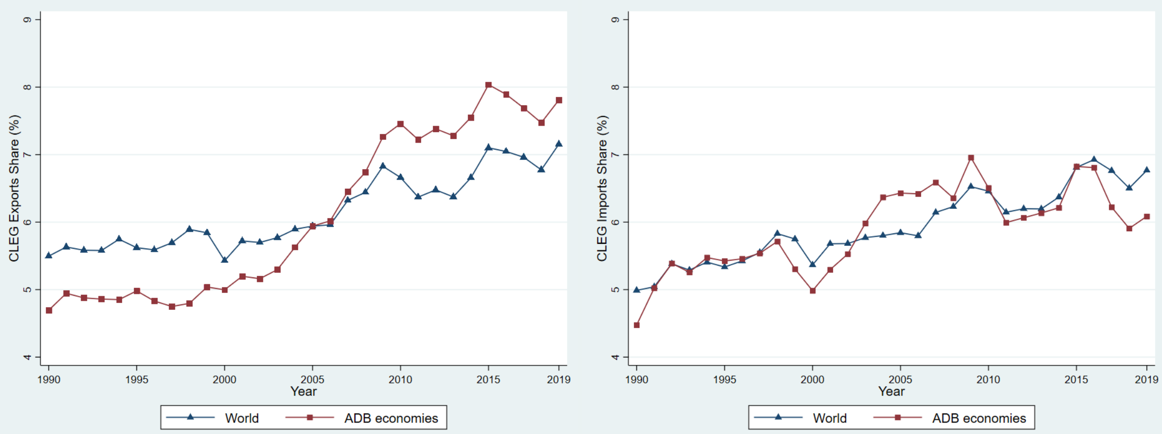
Source: Authors' calculation using Haščič and Migotto (2015), OECD (2020), Goldschlag et al. (2020), and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

Overall, from Figure 6, exports and imports share of both groups have increased between 1990 and 2019: World OECD CLEG exports and imports shares increased by 1.66% and 3.11%, respectively. ADB economies' OECD CLEG exports and imports shares increased by 1.78% and 1.61%, respectively. Specifically, the increase in the exports share of the ADB economies until 2015 is contributed by sectors 84, 85, and 90 (optical, photographic, cinematographic, measuring, checking, medical or surgical instruments and apparatus; parts and accessories) (mainly by sector 90). The exports share of sectors 84, 85, and

90 increased from 1.96%, 0.91%, and 0.75% in 1990 to 1.93%, 2.04%, and 2.05% in 2015, then decreased to 1.91%, 1.89%, and 1.73% in 2018, respectively. The slight increase in 2019 is attributed to sectors 84 and 85.

In terms of imports share of the ADB economies, the fall in late 1990s is mainly because of sector 84, which decreased from 1.98% in 1998 to 1.61% in 2000. Afterwards, the increase is contributed by sector 90 that increased from 1.22% in 2000 to 2.56% in 2007. Further, sectors 84, 85, and 90 contributed to the decrease in the mid-2010s, while sectors 84 and 85 affected to the slight increase in 2019.

Figure 6: Trade Share Trends of World and ADB Economies: OECD CLEG



	Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Exports	World	5.50	5.62	5.43	5.94	6.66	7.10	7.05	6.96	6.77	7.15
	ADB	4.69	4.98	5.00	5.94	7.46	8.04	7.89	7.69	7.47	7.81
Imports	World	4.99	5.34	5.37	5.84	6.46	6.81	6.93	6.76	6.50	6.77
	ADB	4.48	5.42	4.98	6.43	6.51	6.82	6.81	6.22	5.91	6.09

ADB = Asian Development Bank, CLEG = Combined List of Environmental Goods,
OECD = Organisation for Economic Co-operation and Development.

Source: Authors' calculation using Garsous (2019) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

3. Bilateral Green Trade Share

Figures 7–9 describe the bilateral exports trends between ADB economies, ADB to Non-ADB, Non-ADB to ADB, and between Non-ADBs. First of all, Figure 7 shows the bilateral exports between the groups using classification defined by the US BLS GGS. While the US BLS GGS exports volume from Non-ADB to Non-ADB is the largest as $2,625.91 billion, Non-ADB to ADB exports volume is the smallest at $564.68 billion by 2019. The BLS GGS bilateral exports share shows about 41.5% from ADB to ADB/non-ADB and about 27.0% from Non-ADB to ADB/Non-ADB in 2019.

(i) ADB to ADB: $76.12 billion (36.78%) in 1990, $1,423.68 billion (41.15%) in 2019;

(ii) ADB to Non-ADB: $166.67 billion (48.27%) in 1990, $1,261.28 billion (41.85%) in 2019;

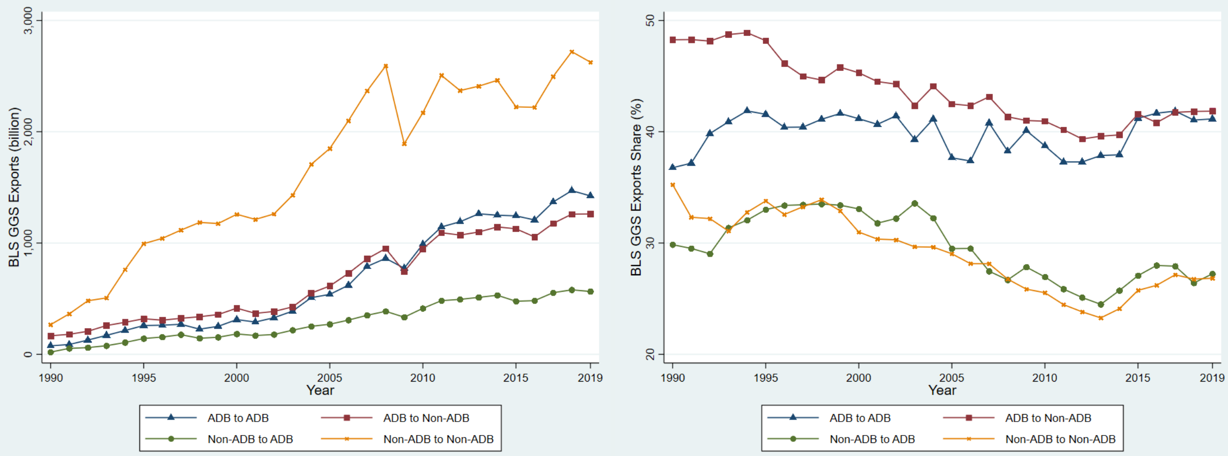
(iii) Non-ADB to ADB: $19.90 billion (29.85%) in 1990, $564.68 billion (27.23%) in 2019; and

(iv) Non-ADB to Non-ADB: $266.57 billion (35.25%) in 1990, $2,625.91 billion (26.84%) in 2019.

This implies that ADB's economic influence in World is expanding mainly within the regions of ADB economies, thus the more stringent environmental regulations could cause relatively more adverse impact to the trade of the ADB economies. In terms of bilateral exports share from ADB to ADB economies, the trend shows similar pattern to that of sector 85 because sector 85 dominates the exports share between the ADB economies. In addition, the decrease of exports share from ADB to Non-ADB economies until 2013 is attributed to sectors 85 and 87, which decreased from 15.68% and 13.59% in 1990 to 12.81% and 5.73% in 2013, respectively. Afterwards, the increase is contributed by the increase in sector 85 that increased to 16.65% in 2019.

In terms of bilateral exports share from Non-ADB to ADB economies, the decrease until 1993 is because of sectors 72 (iron and steel) and 87. The recovery afterwards is because of sector 85. However, the exports share of sector 85 showed notable fall since 2003, followed by sectors 72 and 87. Then, the recovery since 2013 is mainly attributed to sector 85, which increased from 12.81% in 2013 to 16.65% in 2019, followed by sectors 12 (oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit, industrial or medicinal plants; straw and fodder) and 87. In terms of bilateral exports share from Non-ADB to Non-ADB economies, it decreased continuously until 2013 mainly attributed to sectors 72, 85, and 87. The exports shares of sectors 72, 85, and 87 decreased from 2.78%, 5.47%, and 9.11% in 1990 to 1.97%, 4.81%, and 5.35% in 2013, respectively. Afterwards, sectors 85 and 87 contributed to the recovery.

Figure 7: Bilateral Exports Trend: US BLS GGS



	ADB to ADB		ADB to Non-ADB		Non-ADB to ADB		Non-ADB to Non-ADB	
	Volume	**Share**	**Volume**	**Share**	**Volume**	**Share**	**Volume**	**Share**
1990	76.12	36.77	166.67	48.27	19.90	29.85	266.57	35.25
1995	258.91	41.57	319.71	48.19	141.95	33.00	994.05	33.78
2000	312.20	41.17	414.33	45.30	183.19	33.07	1,258.45	30.99
2005	538.43	37.66	614.11	42.50	270.69	29.50	1,849.76	29.04
2010	989.28	38.73	947.13	40.95	412.89	26.95	2,171.15	25.54
2015	1,243.82	41.21	1,128.08	41.60	477.14	27.07	2,224.31	25.75
2019	1,423.68	41.15	1,261.28	41.85	564.68	27.23	2,625.91	26.84

ADB = Asian Development Bank, BLS = Bureau of Labor Statistics, GGS = Green Goods and Services, US = United States.

Source: Authors' calculation using the US BLS (2012) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

Regarding bilateral exports volumes defined by the OECD ENV-TECH, all groups (ADB to ADB/Non-ADB, Non-ADB to ADB/Non-ADB) show an increasing trend from 1990 to 2019 (Figure 8). Even though all groups show U-shaped trends between 1990 and 2019, these trends began to reverse in 2009, 2016, and 2013, from ADB to Non-ADB, from ADB to ADB, and from Non-ADB to ADB/Non-ADB, respectively.

(i) ADB to ADB: $46.43 billion (22.43%) in 1990, $614.83 billion (17.77%) in 2019;

(ii) ADB to Non-ADB: $92.09 billion (26.67%) in 1990, $709.27 billion (23.54%) in 2019;

(iii) Non-ADB to ADB: $16.81 billion (25.21%) in 1990, $424.67 billion (20.48%) in 2019; and

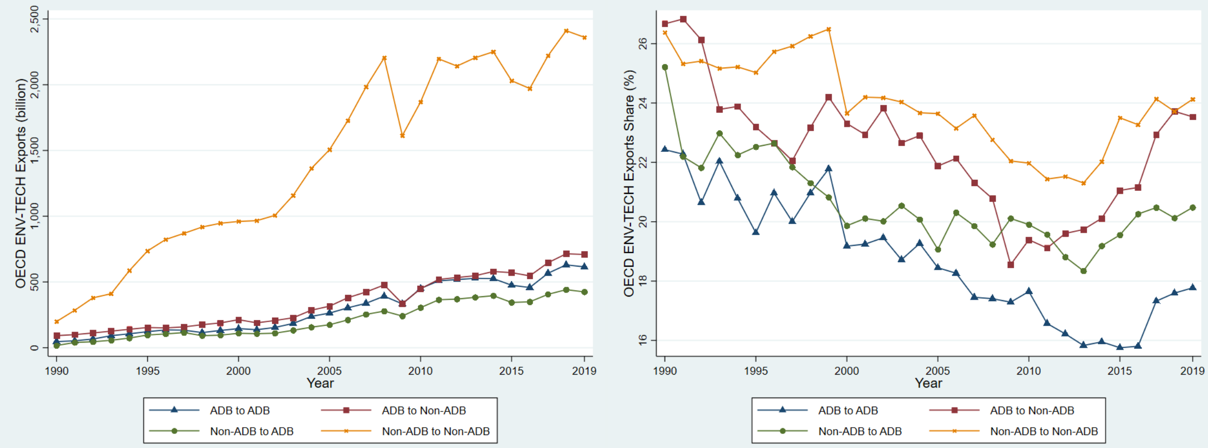
(iv) Non-ADB to Non-ADB: $199.49 billion (26.38%) in 1990, $2,360.85 billion (24.13%) in 2019.

To be specific, in terms of exports share between the ADB economies, the shares of sectors 84 and 85 increased until 2000. However, the shares of sectors 27 (mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes) and 87 decreased, therefore contributing to the overall deterioration of the exports share until 2000. Afterwards, the share of sector 84 decreased noticeably from 7.64% in 2000 to 4.74% in 2015, followed by sectors 39 and 85, worsening the overall deterioration. Then, since 2016, the exports share between the ADB economies increased attributed to sectors 84 and 39 (mainly by sector 84).

In terms of exports share from ADB to Non-ADB economies, the decrease until 1997 was mainly attributed to sector 87, partly attributed to sector 84. Afterwards, both sectors 84 and 87 increased until 1999, but decreased soon after 1999. Since 2009, the overall exports share from ADB to Non-ADB economies showed improvement contributed by sectors 84 and 85 that increased from 5.38%, and 2.52% in 2009 to 7.17%, and 3.49% in 2019, respectively.

In terms of exports share from Non-ADB to ADB economies, the major decreasing factor until 1992 is sector 87 that decreased from 7.24% in 1990 to 4.00% in 1992, followed by sector 26. Then, the decreasing factors until 2014 are sectors 84 and 87. Afterwards, the improvement are driven by sectors 26, 30 (pharmaceutical products), 84, and 87. Further, the trend of exports share between the Non-ADB economies follows the similar patterns to that of sectors 84 and 87, which occupy the biggest proportion.

Figure 8: Bilateral Export Trend: OECD ENV-TECH



	ADB to ADB		ADB to Non-ADB		Non-ADB to ADB		Non-ADB to Non-ADB	
	Volume	Share	Volume	Share	Volume	Share	Volume	Share
1990	46.43	22.43	92.09	26.67	16.81	25.21	199.49	26.38
1995	122.25	19.63	153.86	23.19	96.86	22.52	736.49	25.03
2000	145.41	19.18	213.19	23.31	110.05	19.86	960.64	23.65
2005	263.76	18.45	316.08	21.87	175.00	19.07	1506.27	23.64
2010	450.78	17.65	448.54	19.39	304.90	19.90	1868.42	21.97
2015	475.51	15.75	571.02	21.06	344.63	19.55	2030.45	23.50
2019	614.83	17.77	709.27	23.54	424.67	20.48	2360.85	24.13

ADB = Asian Development Bank, ENV-TECH = environment-related technologies,
OECD = Organisation for Economic Co-operation and Development.

Source: Authors' calculation using Haščič and Migotto (2015), OECD (2020), Goldschlag et al. (2020), and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

In terms of OECD CLEG bilateral exports share in Figure 9, the values of ADB to Non-ADB exceeded those of ADB to ADB in 2003, 2008, and 2016. By 2019, the share of OECD CLEG bilateral exports from ADB to ADB is about 6.88%, while the bilateral share of ADB to Non-ADB is 8.88%.

(i) ADB to ADB: $10.26 billion (4.96%) in 1990, $237.94 billion (6.88%) in 2019;

(ii) ADB to Non-ADB: $15.67 billion (4.54%) in 1990, $267.55 billion (8.88%) in 2019;

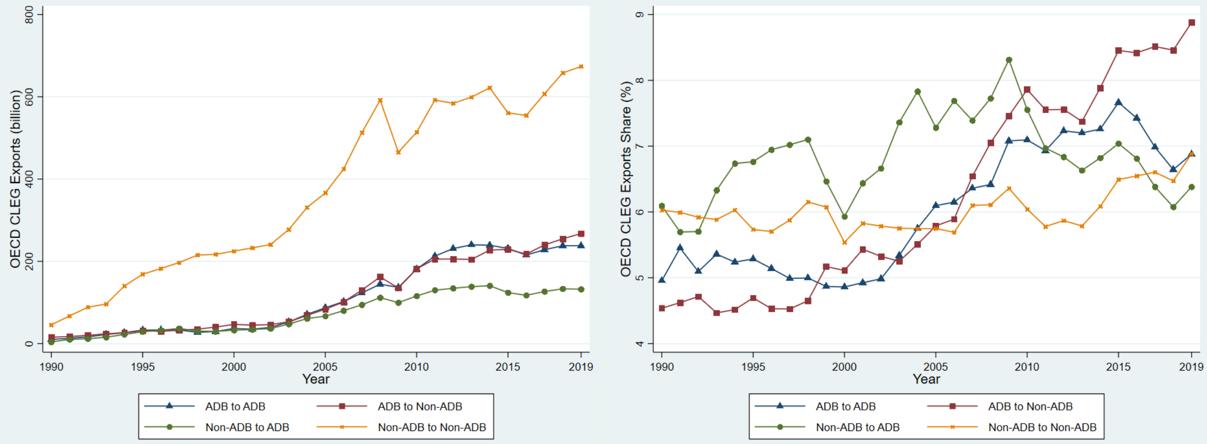
(iii) Non-ADB to ADB: $4.06 billion (6.09%) in 1990, $132.32 billion (6.38%) in 2019; and

(iv) Non-ADB to Non-ADB: \$45.59 billion (6.03%) in 1990, \$637.65 billion (6.89%) in 2019.

Specifically, the exports share from ADB to ADB economies remains stable and show fluctuations until 2002 because, although sectors 85 and 90 increase, sectors 73 (iron or steel articles), 84, and 87 that occupy large proportion fluctuate during the same period. Afterwards, the increase until 2015 is driven by sectors 73 and 90, which increased from 0.36% and 1.02% in 2000 to 0.65% and 2.49% in 2015. Then, the decrease of sectors 73, 85, 90, and 94 (furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, n.e.s.; illuminated signs, illuminated name-plates and the like; prefabricated buildings) contributed to the overall deterioration until 2019.

In terms of exports share from ADB to Non-ADB economies, the main improvement contributors are sectors 73, 84, and 87, which increased from 0.31%, 1.84%, and 0.47% in 1990 to 0.69%, 2.30%, and 1.07% in 2019, respectively. The fluctuations during the sample period are attributed to sectors 85 and 90. Further, the overall exports share from Non-ADB to ADB economies are dominated by that of sectors 84, 85, and 90. As the trend of these sectors demonstrate similar patterns, the overall trend also presents similar pattern to these sectors. In addition, the exports share between the Non-ADB economies remain stable until 2005 because of sectors 84, 85, 90, and 73. Then, the slight increase between 2006 and 2009 are led by sector 85. Afterwards, the decrease until 2013 are attributed to sectors 73, 84, and 85, and the improvement since 2014 are driven by sectors 85, 87, and 90.

Figure 9: Bilateral Export Trend: OECD CLEG



	ADB to ADB		ADB to Non-ADB		Non-ADB to ADB		Non-ADB to Non-ADB	
	Volume	**Share**	**Volume**	**Share**	**Volume**	**Share**	**Volume**	**Share**
1990	10.26	4.96	15.67	4.54	4.06	6.09	45.59	6.03
1995	32.93	5.29	31.15	4.70	29.09	6.76	168.72	5.73
2000	36.86	4.86	46.75	5.11	32.86	5.93	224.94	5.54
2005	87.15	6.10	83.66	5.79	66.82	7.28	366.22	5.75
2010	181.22	7.09	181.81	7.86	115.71	7.55	513.89	6.04
2015	231.32	7.66	229.25	8.45	124.07	7.04	560.96	6.49
2019	237.94	6.88	267.55	8.88	132.32	6.38	673.65	6.89

ADB = Asian Development Bank, CLEG = Combined List of Environmental Goods,
OECD = Organisation for Economic Co-operation and Development.

Source: Authors' calculation using Garsous (2019) and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

Plotting some trends of aggregate and bilateral trade values may not be adequate to identify systemic patterns and draw policy implications. Yet overall, the trends of the three classifications (BLS GGS, OECD ENV-TECH, and OECD CLEG) of aggregate and bilateral green trade indicate that global green trade is growing. Furthermore, the trends show that the green exports share of developing Asian economies has steadily increased. These patterns suggest that low-carbon transition policies and green trade present not only challenges to emerging economies but also opportunities. Therefore, developing Asian economies should consider expanding investment in green technology, innovation, and infrastructure to enhance their industrial competitiveness and achieve comparative advantage.

Specifically, the production of eco-friendly products will contribute to trade expansion and thus economic growth of developing economies. For economies which are able to improve their international competitiveness in green industries, the transition opens up new trade and growth opportunities in the form of global markets for green goods and services. In addition to aggregate and bilateral trade, green trade by industry sectors—i.e., agricultural products, fuels and mining, and manufactures—was analyzed. This analysis is presented in the next section.

4. Green Trade Share by Industry

In terms of imports and exports of ADB economies in industrial level, the average share of manufacturing industry during 1990–2019 are 75.02% and 77.10%, respectively, indicating that the main trade focus area of the ADB economies is the manufacturing sector. On the other hand, agricultural products (exports 9.90%, imports 9.16%) and fuels and mining (exports 8.31%, imports 7.36%) sectors occupy lower portions compared to Manufactures. Therefore, this study derives the green trade trends by industry of the ADB economies to derive relevant implications.[9]

According to the definition of US BLS GGS, OECD ENV-TECH, and OECD CLEG, Table 6 summarizes the proportion of each industry in total imports and exports. In general, as the agricultural products and fuels and mining industries occupy a relatively small proportion of total trade than manufactures in the ADB economies, the green shares of these industries also exhibit significantly lower shares than manufacture using the three classifications. In the agricultural products sector, the OECD CLEG converges to almost zero shares and, also using other classifications, agricultural green exports and imports both decreased since 1990.

In addition, Fuels and Mining sector defined by the US BLS GGS show a deteriorating trend in both exports and imports shares. However, when using the OECD ENV-TECH, it

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[9] The industry is reclassified as follows based on HS1992 2-digits. Agricultural Products include Animal (01–05), Vegetables (05–15), Food Products (16–24), Textiles and Closing (50–53). Fuels and Mining include Minerals (25–26), Fuels (44–49), Stone and Glass (68–71). Moreover, Manufactures except for Agricultural products include Chemicals (27), Plastic or Rubber (28–38), Hides and Skins (39–40), Wood (41–43), Textiles and Clothing (54–63), Footwear (64–67), Metals (72–83), Machinery and Electrical Equipment (84–85), and Transportation (86–89). Miscellaneous (90–99) is excluded from the industrial comparison.

presents U-shape patterns in both exports and imports shares. Moreover, the Fuels and Mining sector green exports and imports according to the OECD CLEG show a gradual increase as time passes.

In the case of Manufactures, which occupy a large proportion of total trade in ADB economies, BLS exports share decreases until 2010, and recovers afterwards. On the other hand, imports share estimated an increasing trend throughout the period. ENV-TECH green exports and imports shares show a U-shape trend. This implies that the green industries should be promoted by enhancing its green technology through feasible assistance and investments. On the other hand, as the absolute volume of green trade is still prominent, it can be seen that ADB economies' green products that are resilient to various NTBs or TBTs have a relative advantage and could increase international competitiveness.

Further, manufacture green trade classified by the CLEG presents an increasing trend in both imports and exports, which exhibit different pattern from the other two categories. This implies that it is necessary to set the scope of green industry well in designing national transition policies and preemptively respond to internationally accepted technologies and trade regulations.

Table 6: Summary Green Trade of ADB Economies by Industry

Agricultural Products												
	Exports						Imports					
	BLS		ENV-TECH		CLEG		BLS		ENV-TECH		CLEG	
	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share
1990	13.625	2.467	4.087	0.740	0.134	0.024	22.841	4.327	3.693	0.700	0.061	0.012
1995	29.101	2.262	10.167	0.790	0.103	0.008	44.783	3.654	9.526	0.777	0.067	0.005
2000	30.812	1.842	7.671	0.459	0.135	0.008	40.134	2.654	8.262	0.546	0.068	0.004
2005	41.804	1.454	13.144	0.457	0.211	0.007	58.715	2.185	15.055	0.560	0.145	0.005
2010	63.394	1.302	28.300	0.581	0.537	0.011	107.281	2.317	29.881	0.645	0.408	0.009
2015	72.815	1.271	32.519	0.567	0.508	0.009	137.507	2.636	39.337	0.754	0.402	0.008
2016	67.336	1.228	32.285	0.589	0.460	0.008	120.668	2.434	34.782	0.702	0.451	0.009
2017	73.364	1.205	37.607	0.618	0.497	0.008	131.543	2.295	37.783	0.659	0.437	0.008
2018	74.222	1.126	36.295	0.550	0.368	0.006	132.513	2.059	38.664	0.601	0.419	0.007
2019	68.972	1.066	33.216	0.513	0.544	0.008	127.006	2.050	38.534	0.622	0.412	0.007

Fuels and Mining												
	Exports						Imports					
	BLS		ENV-TECH		CLEG		BLS		ENV-TECH		CLEG	
	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share
1990	10.628	1.924	6.152	1.114	0.186	0.034	20.623	3.907	11.085	2.100	0.299	0.057
1995	24.517	1.906	12.926	1.005	0.572	0.044	40.359	3.293	16.243	1.325	0.717	0.058
2000	29.626	1.771	15.883	0.949	0.756	0.045	41.145	2.721	18.650	1.233	0.776	0.051
2005	48.520	1.688	25.273	0.879	1.888	0.066	57.106	2.125	36.052	1.342	1.241	0.046
2010	83.580	1.717	48.034	0.987	3.470	0.071	88.193	1.904	89.237	1.927	1.902	0.041
2015	105.464	1.840	59.035	1.030	9.992	0.174	103.191	1.978	98.731	1.892	3.063	0.059
2016	101.056	1.843	54.495	0.994	8.110	0.148	103.670	2.091	96.424	1.945	3.157	0.064
2017	105.356	1.730	61.868	1.016	9.911	0.163	112.864	1.969	119.976	2.093	3.494	0.061
2018	113.847	1.726	69.549	1.055	11.741	0.178	121.166	1.883	133.160	2.069	3.680	0.057
2019	114.315	1.766	70.457	1.088	14.240	0.220	115.489	1.864	133.168	2.149	3.827	0.062

	Manufactures											
	Exports						Imports					
	BLS		ENV-TECH		CLEG		BLS		ENV-TECH		CLEG	
	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share
1990	215.781	39.068	128.133	23.199	21.412	3.877	108.550	20.565	95.197	18.035	17.833	3.378
1995	507.183	39.429	250.690	19.489	52.174	4.056	345.069	28.151	211.542	17.258	51.785	4.225
2000	639.586	38.232	329.685	19.707	62.554	3.739	431.320	28.524	238.970	15.803	55.322	3.659
2005	1026.539	35.711	534.508	18.594	117.393	4.084	737.058	27.432	418.186	15.564	104.114	3.875
2010	1739.783	35.745	815.077	16.746	247.017	5.075	1247.717	26.944	688.407	14.866	189.145	4.084
2015	2115.316	36.914	929.073	16.213	310.592	5.420	1511.955	28.981	762.829	14.622	232.663	4.460
2016	2017.732	36.796	897.197	16.362	297.905	5.433	1501.778	30.290	743.322	14.992	222.150	4.481
2017	2278.620	37.424	1096.390	18.007	326.461	5.362	1727.073	30.136	885.210	15.446	233.188	4.069
2018	2452.106	37.186	1219.432	18.493	352.035	5.339	1878.256	29.188	995.120	15.464	254.732	3.959
2019	2402.572	37.116	1199.765	18.535	372.691	5.758	1817.981	29.337	991.084	15.993	261.032	4.212

BLS = Bureau of Labor Statistics, CLEG = Combined List of Environmental Goods, ENV-TECH = environment-related technologies.

Sources: Authors' calculation using the US BLS (2012), Haščič and Migotto (2015), OECD (2020), Goldschlag et al. (2020), Garsous (2019), and UN Comtrade data. *International Trade Statistics-Import/Export Data*. Retrieved from https://comtrade.un.org/data/ (accessed 8 May 2022).

B. Low-Carbon Transition Policies and Developing Asia

Low-carbon transition policies can present both challenges and opportunities for developing Asian economies. Tax and NTMs which are designed to promote low-carbon goods may slow down global trade in non-green goods. At the same time, production of eco-friendly products will contribute to global trade expansion, and thus economic growth of developing economies. Recent tax measures such as CBAM (EU) and carbon tax (United States) policies should be viewed as legitimate measures rather than green protectionism. Although firms are the main drivers of trade and economic growth, there are areas where government intervention and international cooperation are required to promote green trade. Developing Asian economies could achieve a comparative advantage by being prepared for the stringent environmental policies and taking early mitigation actions. In this context, the following are some specific measures that can improve developing Asia's capacity to capitalize on green trade opportunities.

Above all, harmonization of green industry classification is necessary (Ambroziak et al. 2022). Internationally recognized classification of green industry is needed to define GGS, which, in turn, affects green provisions in trade negotiations and implementation of fiscal measures to reduce carbon emissions. Trade trends based on different classifications such as US BLS GGS, OECD ENV-TECH, and OECD CLEG differ substantially. More specifically, OECD CLEG differs from the two other classifications because no commodities are classified in the animal, vegetable, food products, minerals, fuels, and hide and skin industries. Further, harmonization of NTMs and elimination of unsound NTMs are required to reduce the burden of NTMs on trade. In line with growing global concern about negative externalities, especially those related to public health and the environment, the number of NTMs around the world, including the Asia and Pacific region, rapidly increased since 2000 (ESCAP 2019; Webb et al. 2020). In fact, NTMs can be much more powerful barriers to trade than tariffs (Webb et al. 2020). Lack of adequate technical infrastructure in developing economies often constrains the ability of exporters to access foreign markets (WTO 2021b). Trade and growth can benefit from the harmonization of NTMs and the application of international standards, which precludes unnecessary barriers to trade. Harmonizing NTMs via proactive trade cooperation such as the Regional Comprehensive Economic Partnership as well as investment in digital infrastructure can diversify the supply chain and increase substitutability, making economy more resilient to the low climate transition (IMF 2022).

Third, just transition that supports the losers of the low-carbon transition requires the provision of finance to stranded carbon-intensive industries. For example, in 2022, Spain implemented the “Aid for municipal infrastructure for Just Transition” program which was worth €91 million and covered 184 municipalities. The program finances areas of environmental infrastructures, sustainable mobility, and biomass storage and collection. Creation of new jobs in industries that are more resilient to the low-carbon transition promotes new opportunities and sustains competitiveness (Huxham et al. 2019). Well-designed fiscal systems can provide financial assistance to industries and workers in transition.

Finally, international cooperation benefits developing economies in areas where they lack the technology, infrastructure, and capacity to mitigate climate change. Significantly, a large share of goods produced by developing Asia’s carbon-intensive industries are exported to and consumed by the developed economies. Further, bilateral cooperation can promote the rapid diffusion of new environmental technologies and diversification of supply chains. Examples include Japan–Indonesia cooperation agreement on decarbonization technologies, ROK–Spain green digital partnerships, and Australia–Germany hydrogen supply chain projects.

In addition, developed economies could provide technical cooperation to developing economies in the areas of metrology, testing, certification, and accreditation in order to improve technical infrastructure (WTO 2021b). Green bonds can support carbon taxation by acting as a bridge financing instrument (Semmler et al. 2021). These measures would enable developing economies to become integrated into the global supply chains during the low-carbon transition, and thus provide them with new opportunities. Building a sustainable, inclusive, and resilient global economy requires proactive efforts by all economies and close international cooperation.

V. CONCLUSION

In this paper, we analyzed green trade patterns in developing Asia by using three widely used classifications of green industries, namely US BLS GGS, OECD ENV-TECH, and OECD CLEG. The three classifications yield different patterns of green trade, pointing to a need to achieve international consensus on the definition of green industries, and hence green trade. This would allow us to understand green trade patterns more accurately which, in turn, allows for more meaningful policy recommendations.

Our analysis yields a number of interesting patterns. Global and developing Asia's green trade volume rose throughout the sample period for all three classifications. Developing Asian economies accounted for more than half of the world's green trade volume. In terms of green trade share, when we use the US BLS GGS and the OECD ENV-TECH classifications, both exports and imports shares of global and developing Asian economies decline until 2013 and recover since then. On the other hand, when we use the OECD CLEG classification, exports and imports shares of both global and developing Asian economies gradually rose, with the global green exports share surpassing that of developing Asian economies in 2006. As of 2019, the green imports share of developing Asian economies is higher than the corresponding figure for the world, implying that developing Asia may be losing its competitiveness in green industry relative to the world.

In addition, we examine trends in bilateral exports from developing Asian economies to developing Asian economies, from developing Asian economies to the rest of the world, from the rest of the world to developing Asian economies, and from rest of the world to the rest of the world. When we use the US BLS GGS classification, the green exports share from developing Asian economies to the rest of the world declines while the share of developing Asian economies to developing Asian economies rises. This suggests that the relative importance of developing Asia in global green trade is on the rise. Further, when we use the OECD ENV-TECH classification, the green exports shares of all four origin-destinations show U-shaped trends between 1990 and 2019. When we use the OECD CLEG classification, green exports share from developing Asia to the rest of the world grew the fastest, followed by developing Asia to developing Asia, from the rest of the world to the rest of the world, and from the rest of the world to the rest of the world.

In terms of green trade sectors, manufacturing accounted for the largest share of green trade, dominating the agricultural products and fuels and mining sectors. Green manufacturing exports and imports shares declined until 2010 and recovered afterwards according to the US BLS GGS classification. Green manufacturing exports and imports shares show a U-shape trend when we using OECD ENV-TECH, but show an increasing trend when we use OECD CLEG.

Low-carbon transition is an imperative shift away from the traditional growth paradigm which neglected environmental costs. International trade and global supply chains contribute to economic growth by accelerating technology spillovers and promoting productivity growth and innovation. Because of various climate policy measures, including taxes and NTMs, global trade volume will decline and carbon-intensive industries are at risk of becoming stranded. As the global trade landscape evolves during the low-carbon transition, the losses of the stranded brown industries will grow larger. Therefore, developing Asian economies with sizable carbon-intensive manufacturing sectors stand to suffer major losses. However, these economies could adapt to the more challenging global trade environment by producing more GGS and investing in renewable energy and energy efficiency.

Developing Asian economies, especially those in East Asia and Southeast Asia which collectively formed a regional production network, achieved rapid economic growth on the back of export-oriented manufacturing. But these economies are likely to be seriously affected by the low-carbon transition because many export-oriented manufacturing industries are carbon-intensive. More generally, the low-carbon transition presents challenges to developing Asia by increasing the costs of factors of production and transportation. It also forces them to invest in costly green technologies and innovate to reduce environmental damage. Nevertheless, for economies which are able to improve their international competitiveness in green industries, the transition also opens up new trade and growth opportunities in the form of global markets for GGS. Firms and industries will have to improve their environmental competitiveness in order for an economy to play a major role in green trade. At the same time, a sound national green trade policy and international cooperation can also contribute to an economy’s successful participation in global green trade. Finally, it should be noted that while Asia's low-carbon transition creates new opportunities for the region's international trade, trade itself may have adverse environmental effects.[10] Mitigating such effects must also be a key policy priority.

[10] ADB (2022) examines the potential environmental impact of international trade, along with policy implications, from an Asian perspective.

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Asia's Low-Carbon Transition
Opportunities and Challenges for Trade

This paper finds the green trade pattern of Asian economies is increasing in terms of its export share within the region and in global trade. However, the green imports share showed faster growth than the exports share. In addition, the pattern of green trade differs depending on green industry definitions, pointing to a need for international consensus on defining green trade in order to measure and analyze patterns more accurately.

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