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# IMPACT OF ENVIRONMENTAL REGULATIONS ON POLLUTIVE INDUSTRIAL TRADE: CAREC VS. OECD REGIONS

Saleem Irfan

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# COVID-19 Pandemic and Impact of Environmental Regulations on Pollutive Industrial Trade: CAREC vs. OECD regions

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## Abstract

This study examines the impact of environmental regulations on trade competitiveness for CAREC countries and their bilateral export flows with environmentally stringent OECD countries in the wake of the COVID-19 pandemic. This study is a first attempt to investigate the export competitiveness of most pollutive industries of selected CAREC region countries and whether the CAREC region has become a pollution haven of industrial exports to OECD countries during 2006 to 2020. The literature survey reveals that developing countries, including the CAREC region, have not received due attention to address the impact of environmental regulations on trade competitiveness. Second, the effects of the COVID-19 pandemic on pollution industrial trade flows have not been empirically examined. Third, several earlier studies concluded the competitiveness impact of environmental policy following a single estimation method when the literature surveyed shows that the results are sensitive to the choice of method used. Lastly, the majority of earlier research on the subject focuses on the most pollutive industrial trade when comparative analysis between most pollutive and less pollutive industrial trade flows is vital for developing countries, including the CAREC region.

This study contributes to sustainable development policy goals by filling these gaps and paves the way for a better policy framework for the CAREC region's industrial trade competitiveness and sustainable goals set at the CAREC 2030 regional developmental strategies. Following the neo-classical orthodoxy, the central hypothesis of this research is that environmental regulations negatively affect different categories of pollutive industrial export competitiveness. Using the available UN Comtrade data at the disaggregated SITC level on manufacturing trade during 2006 to 2020, this study has deployed comparative advantage trade models by Balassa (1965) and the geographically controlled bilateral RCA model by Grether and de Melo (2004).

The study finds that the effects of environmental regulations on the pollutive industrial trade of the CAREC region are sensitive to the choice of industry and empirical method used. Most CAREC region countries have enjoyed export competitiveness in the most pollutive industries during the entire study period. The findings for the CAREC region further show that a careful comparative analysis between most pollutive and relatively less pollutive industry is essential for environmental policy impacts on export and trade competitiveness as the impact of the environmental regulations is sensitive to the choice of different pollutive industrial categories and within each pollutive industry group. Therefore, an environmental policy designed to achieve social benefits with industrial trade competitiveness should be carefully weighted to incorporate the impact of more disaggregated level sectors by bringing in the diversity of measurements needed for each pollutive industrial sector rather than framing the policy in the belief that 'one size fits all.'

The study findings also conclude that the COVID-19 pandemic resulted in the volatility of export competitiveness in the most pollutive and less pollutive sectors for the CAREC region. During the pandemic period, some countries of the CAREC region with a narrow base/less diversified and natural resource-based exports have witnessed competitiveness shocks and loss of export competitiveness, while others with a more diversified export base suffered less. Therefore, the study recommends adopting mutually supportive trade and environmental policies that promote and expand diversified, sustainable production and export competitiveness at the sectoral level in the CAREC region. This research finds clear evidence of the CAREC region becoming a pollution haven for the most pollutive exports to OECD countries. Given that the CAREC region has become a pollution haven for environmentally stringent OECD countries, the most environmentally stringent countries' demand for compliance with environmental regulations/agreements will inevitably spread to the CAREC region's traded sectors. Therefore, the study recommends that the CAREC region ensures that the 2030 sustainable development agenda aligns the ambitious and speedy environmental regulations compliance targets with greener industrial production and trade.

*Key words: environmental regulations, trade competitiveness, CAREC region, OECD, pollutive industrial exports, comparative advantage, pollution haven, COVID-19 pandemic and trade competitiveness, China pollutive industrial exports, Azerbaijan pollutive industrial exports, Kazakhstan pollutive industrial exports, Georgia pollutive industrial exports, Pakistan pollutive industrial exports, Kyrgyzstan pollutive industrial exports*

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**Abbreviations and Acronyms**

| | |
|---|---|
| **APEC** | Asia-Pacific Economic Cooperation |
| **ARIMA** | Autoregressive Integrated Moving Average |
| **ASEAN** | Association of Southeast Asian Nations |
| **CAREC** | Central Asia Regional Economic Cooperation Program |
| **CEECs** | Central and Eastern European Countries |
| **CEPII** | Centre d'Études Prospectives et d'Informations Internationales |
| **CIESIN** | Center for International Earth Science Information Network |
| **CPI** | Consumer Price Index |
| **DCs** | developed countries |
| **EEA** | European Economic Area |
| **EEC** | European Economic Community |
| **EKC** | Environmental Kuznets Curve |
| **EPA** | Environmental Protection Agency |
| **EPI** | Environmental Performance Index |
| **ERI** | Environmental Regulations Index |
| **ESG** | Environmentally Sensitive Goods |
| **ESI** | Environmental Sustainability Index |
| **EU** | European Union |
| **FDI** | foreign direct investment |
| **GATT** | General Agreement on Tariffs and Trade |
| **H-O** | Heckscher-Ohlin |
| **H-O-S** | Heckscher-Ohlin-Samuelson |
| **H-O-V** | Heckscher-Ohlin-Vanek |
| **IIT** | intra industry trade |
| **IMF** | International Monetary Fund |
| **ISIC** | International Standard Industrial Classification |
| **LDC** | less developed country |
| **MNC** | multinational corporation |
| **NAFTA** | North American Free Trade Agreement |
| **NGO** | non-governmental organization |
| **OECD** | Organization for Economic Cooperation and Development |
| **OLS** | ordinary least squares |
| **PHH** | pollution haven hypothesis |
| **PPMs** | process and production methods |
| **RCA** | revealed comparative advantage |
| **REM** | Random Effect Model |
| **ROW** | rest of world |
| **RTA** | regional trade agreement |
| **SIC** | Standard Industrial Classification |
| **SITC** | Standard International Trade Classification |
| **UN** | United Nations |
| **UNCED** | United Nations Conference on Environment and Development |
| **UN Comtrade** | United Nations Commodity Trade |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **UNEP** | United Nations Environment Programme |
| **UNIDO** | United Nations Industrial Development Organization |
| **WPI** | Wholesale Price Index |
| **XRCA** | export revealed comparative advantage |
| **XRCDA** | export revealed comparative disadvantage |

## 1. Introduction

### 1.1 Background

Both global growth and trade have witnessed an unprecedented contraction during the COVID-19 outbreak in 2020, seriously disrupting the supply chains of world commodities and increasing economic volatility as well as causing enormous supply and demand shocks in the world economy. These shocks are inevitably causing significant disruptions to global trade. The pace of economic and trade recovery will depend on the pandemic's duration and the speed with which governments worldwide adopt an aggressive monetary stimulus, increase safety nets, and trade policies at local and global levels. WTO predicted that world trade would contract by 13 percent in 2020 and by 32 percent in 2021, and world trade as a proportion of GDP reduced by 3 percent in 2020 (UNEP, 2020). The CAREC countries are not immune to these internal and external shocks, and according to one estimate, the CAREC trade–GDP ratio reduced by 3.3 percent—more than that of world trade—and this had severe implications on industrial trade competitiveness among other things (Feng, Chun, et al., 2021). In the wake of the devastating worldwide effects of the global pandemic, developed countries have increased pressure on the already economically and environmentally fragile developing countries to comply with stringent environmental regulations on pollutive industrial trade. All CAREC countries—as signatories to the 2030 global development agenda, including the sustainable development goals (SDGs)—need to make concerted efforts towards compliance with environmental regulations through innovative approaches to the diffusion of environmental technologies to minimize industrial pollution and shift towards greener production and trade.

Liberalization endeavors worldwide aimed at creating a competitive business environment in the 1990s and onwards have shifted focus from lowering tariff barriers to eliminating non-tariff barriers to trade. And a series of multilateral environmental agreements (MEAs) covering the areas of public health standards, food safety requirements; emission limits; waste management and disposal rules; packaging and recycling regulations, and labeling policies all playing a vital role in, among others, shaping the domestic environmental policies and international trade flows (Esty, 2001). These outcomes have raised serious concerns for developing economies about compliance with environmental policy impacts on manufacturing traded commodities competitiveness at domestic and international levels. At present, issues about the effects of environmental regulations on trade competitiveness are debatable across nations. One of the common concerns is that the differential in environmental standards between countries allows the polluting industries to relocate from those countries where environmental standards are high—generally, advanced OECD countries—to the countries where environmental standards are relatively lower—generally, developing and less developed countries, including the CAREC region. The latter group of countries tends to become a haven for most pollutive industrial exports (Jayawardane and Edirisingh, 2014; Cole and Elliott, 2003; Cole et al., 2005; Low and Yeats, 1992).

The impact of environmental regulations on trade competitiveness has been contested between neo-classical trade theories whose central position premises on competitive market structure and new trade theorists who believe in market imperfection and economies of scale. The literature, especially in a neo-classical orthodoxy, advocates that environmental regulations can have a negative influence on production costs, trade patterns, industry location, and gains from trade and thus competitiveness of the economy and relaxing one or a few assumptions of the model(s) produce quite complex results (Walter, 1975a; Grubel, 1976; Pethig, 1976; McGuire, 1982; Siebert, 1974 and 1980; Copland and Taylor, 1994 and 1995; Merrifield, 1988; Chichilnisky,1994; Palmer, Oates, and Portney, 1995).

New trade theorists such as Porter and Van der Linde (1995) argued that there was no trade-off between environmental related social benefits and private cost as properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them—they therefore advocated a win-win solution. Palmer, Oates, and Portney (1995) argued that there was no free lunch in economics, and pollutive industries would bear some environmental costs. Hence this research is no exception and will follow mainly neo-classical orthodoxy. Furthermore, the theory suggests that environmental costs could be offset through the benefits ascertained through the introduction of new technology. However, the empirical question to investigate is whether the environmental regulation costs can be fully or more than fully offset by the benefits gained after introducing new innovative environmental technology (XU, 2000a).

Two key competing arguments are at work at theoretical, empirical as well as at policy development levels. Firstly, environmental regulations can affect the trade competitiveness of the industry and country. Secondly, since environmental stringency increases with the state of development (Dasgupta et al., 1995), the differences in the degree of stringency in environmental regulations between stringent North and laxer South can allow countries in the South to develop a comparative advantage in pollution-intensive production and trade (Cole, 2004)—later termed pollution haven hypothesis. This pollution haven hypothesis can manifest itself in the form of dirty industries relocating from developed to developing countries and or developed countries' pollutive industries being displaced from the world market by similar industries from developing economies (Cole and Elliott, 2003). The theoretical rationale for the pollution haven hypothesis came from, among others, Baumol and Oates (1988) who concluded that those countries that do not control pollution—rather than others who control pollution emissions—would voluntarily become the repository of the world's dirtiest industries (Baumol and Oates, 1988:265).

The research carried out in the 1970s and 1980s predominantly chose an indirect method of estimation. The focus of attention was on estimating environmental control costs in the most pollutive industrial trade sectors in the United States. Most studies concluded that environmental regulatory costs on the trade patterns of pollutive industries were insignificant as average environmental control costs remained around 2 percent in overall manufacturing costs. Nevertheless, other carefully assessed empirical findings showed that environmental control costs for pollution abatement in manufacturing sectors could have considerable adverse effects on industrial trade flows and the country's balance of trade and payments. The studies, mainly from 1990 onwards, used the direct methods to assess the impact of environmental policy on industrial trade competitiveness and broadly deployed the comparative advantage model developed by Balassa (1965), Heckscher-Ohlin-Vanek (H-O-V) model (in Murrell, 1990), and gravity trade model pioneered by Tinbergen (1962) and Linnemann (1966). Empirical research conducted in the area, which focused mainly on the developed part of the world, has produced mixed results. Some researchers do not find the negative impact of environmental regulations on trade competitiveness, while others do. Similarly, some researchers have explored the possibility of developing countries becoming a haven for world pollutive exports; others tend to reject this phenomenon, thus leaving the issue of the impact of environmental regulations on trade competitiveness unresolved (Walter, 1973; Evans, 1973; Mutti and Richardson, 1977; Robison, 1988; Tobey, 1990; Low and Yeats, 1992; Kalt, 1988; Wilson, 2002; Cole and Elliott, 2003; Mani and Wheeler, 1999; Grether and de Melo, 2004; Jayawardane and Edirisingh, 2014; Cantore and Cheng, 2018).

After critically reviewing empirical literature, the present study has identified some gaps in the existing literature regarding the impact of environmental policies on trade competitiveness. Firstly, the empirical quests on the subject predominantly focused on developed parts of the world, and less attention was given to LDCs, including CAREC countries. Secondly, on the pollution haven hypothesis, earlier literature tended to be biased in countries' coverage choices. It concentrated on only developed world analysis with aggregated trade data (Sorsa, 1994) when the pollution haven hypothesis demands an investigation between developed and developing countries using disaggregated trade data. Thirdly, the results in most of the empirical work this study reviewed are sensitive to the type of methodology chosen and country(s)/period selected, and the nature of pollutive industry/type of environmental regulation chosen. Some studies lacked a theoretical basis regarding the choice of model; others failed to report or perform diagnostic tests/sensitivity analysis. Fourthly, the earlier empirical literature has focused on too narrow a selection of most pollutive industry trade analysis—such as, iron and steel only (Low and Yeats, 1992). The study by XU (1999) provided an in-depth analysis of the trade specialization patterns of most pollutive industries within developed countries but ignored a comparative analysis between trade patterns of most and relatively less pollutive industries. Furthermore, the author of this study could not find any comprehensive research on CAREC countries regarding the impact of environmental regulations on pollutive industrial trade competitiveness and the region's bilateral pollutive industrial trade flows with environmentally stringent OECD countries. This paper contributes to the literature by filling those research gaps.

CAREC countries face the most pressing environmental degradation issues that could impede the efforts of respective governments to address deteriorating health and livelihood and reduce poverty in the region. CAREC countries, as a region, share both domestic and international environmental problems. These include transboundary environmental challenges such as air pollution, industrial waste and management of water resources, and land management. Industrial and agriculture pollution is prevalent among many central Asian and other CAREC countries. Statistics show that China is among the list of the world's largest emitters of greenhouse gases (GHGs) and is projected to witness the most considerable absolute growth in carbon dioxide emission by 2025. The country's long term carbon reduction strategies *inter alia* include raising energy efficiency, industrial strategies towards greener production growth, and substantially reducing its overall dependency on coal in the production process. Some other CAREC countries have also fallen behind in meeting their international environmental agreement obligations of reducing greenhouse gases, as witnessed in the high air pollution levels in Kazakhstan (CAREC, 2006).

Boosting connectivity, especially in landlocked CAREC countries, and increasing international trade are at the heart of CAREC's 2030 sustainable development strategy. CAREC countries, especially Central Asian countries, face challenges including infrastructural bottlenecks, long distances to the major international trade market, numerous tariff and non-tariff regulatory policy challenges including environmental regulations, and increased demand for the stringent compliance of multilateral environmental agreements and domestic environmental regulations by the world's most environmental regulating OECD countries. These challenges can leave discernible negative impacts on the region's trade competitiveness (CAREC, 2030; OECD, 2017). The smooth trade connections of the CAREC countries with OECD countries are vital, especially when some CAREC countries counted for between 40 percent to 60 percent of the most and relative less pollutive exports flows to OECD countries during 2016 to 2020 (Table 1.1).[1]

### 1.2 Exports Directions of Selected CAREC Countries

Being a natural resources/oil rich country and therefore with its production activities largely concentrated on pollutive industries, Azerbaijan's most pollutive exports to OECD during 2006 to 2010 stood at 67 percent of the country's total industrial exports—the highest among the CAREC region

[1] There is a dearth of data on bilateral exports at disaggregated SITC level of all CAREC countries with OECD and the rest of the world during 2006 to 2020. The study, therefore, focuses on six selected CAREC countries for which the data was more complete for the period under review. Also, most pollutive industrial trade group at 2-digit SITC level include: 25, 33, 51, 56, 59, 63, 64, 66, 67, 68, 69 and less pollutive industries are all other industrial groups not included in most pollutive group (UNIDO, 2000; XU, 1999, 2000; Tobey, 1990; Low and Yeats, 1992)

countries. The exports of the same country to the OECD region in the same pollutive category dropped to 59 percent during 2011 to 2015 but rose again to 61 percent during 2016 to 2020. Azerbaijan's most pollutive exports to the rest of world (ROW) is comparatively far below those with OECD, and the country's most pollutive industrial exports were hovering between 25 percent in 2006 to 2010 to 20 percent in 2016 to 2020.

Kazakhstan is the second highest exporter of most pollutive commodities to OECD countries among selected CAREC countries. The country's most pollutive industrial exports to OECD remained 52 percent to 54 percent of total country exports during 2006 to 2020. For those with the rest of the world group, most pollutive industrial exports remained around 23 percent of total exports. China's exports directions in the group of most pollutive industries are more with ROW than OECD countries. The country's most pollutive industrial exports with OECD countries stood at around 6 percent during 2006 to 2010 and reduced to 5 percent in 2016 to 2020. China's exports with ROW rose from about 9 percent in 2006 to 2010 to almost 10 percent of the country's total exports in 2016 to 2020.

Table 1.1 **Pollutive Industrial Exports of Selected CAREC Countries with OECD and Rest of World: 2006-2020**

| | | CAREC Bilateral exports with OECD | | | CAREC Bilateral exports with ROW | | |
|---|---|---|---|---|---|---|---|
| | | 2006-2010 | 2011-2015 | 2016-2020 | 2006-2010 | 2011-2015 | 2016-2020 |
| Industry | Country | % of total country exports | % of total country exports | % of total country exports | % of total country exports | % of total country exports | % of total country exports |
| Most Pollutive Exports | Azerbaijan | 67.51 | 59.11 | 60.95 | 25.16 | 28.51 | 20.37 |
| | China | 6.25 | 4.38 | 5.20 | 8.60 | 7.75 | 9.57 |
| | Georgia | 10.65 | 7.34 | 4.89 | 14.68 | 10.83 | 11.07 |
| | Kazakhstan | 54.13 | 52.66 | 53.05 | 22.83 | 22.99 | 23.84 |
| | Kyrgyzstan | 0.83 | 0.53 | 0.50 | 12.15 | 9.28 | 8.43 |
| | Pakistan | 0.78 | 0.63 | 1.08 | 8.35 | 5.93 | 5.01 |
| Less Pollutive Exports | Azerbaijan | 0.38 | 0.72 | 2.07 | 6.95 | 11.66 | 16.61 |
| | China | 43.13 | 38.51 | 37.89 | 42.02 | 49.36 | 47.33 |
| | Georgia | 19.28 | 18.18 | 13.40 | 55.39 | 63.65 | 70.65 |
| | Kazakhstan | 4.27 | 3.65 | 3.06 | 18.77 | 20.70 | 20.04 |
| | Kyrgyzstan | 30.73 | 32.80 | 40.43 | 56.29 | 57.39 | 50.63 |
| | Pakistan | 42.51 | 37.43 | 45.88 | 48.35 | 56.00 | 48.03 |

Notes:

1. Author's calculation based on UN-Comtrade SITC DATA Revision-2
2. ROW: Rest of world

Similarly, Georgia's exports in the most pollutive industrial group are more with ROW than OECD countries. The other two countries' most pollutive exports in the CAREC region—Pakistan and Kyrgyzstan—are less directed towards OECD countries than ROW.

For less pollutive industrial exports, OECD countries have strong demand for exports from China, Kyrgyzstan, and Pakistan. Within the same pollutive category, the industrial exports to OECD countries range 38 percent from China to 45 percent from Pakistan during 2016 to 2020. Nevertheless, the exports ties of the same three countries in the less pollutive manufacturing commodities group are deemed to be strong even with the rest of the world, as revealed in Table 1.1. The other three countries of the CAREC region's exports among the group of less pollutive industries are more with ROW group countries than the OECD—especially Georgia, which occupies between 55 percent to 70 percent of the less pollutive industrial exports going to ROW countries during 2006 to 2020 (Table 1.1).

**Table 1.2** **Pollutive Industrial Exports Share of CAREC Countries in World Exports 2006-2020**

| Industry | Country/ Year | exports to OECD 2006-2010 % of world exports | exports to OECD 2011-2015 % of world exports | exports to OECD 2016-2020 % of world exports | exports to ROW 2006-2010 % of world exports | exports to ROW 2011-2015 % of world exports | exports to ROW 2016-2020 % of world exports | EPI 2020 | EPI 2020 % Change over 10 Y |
|---|---|---|---|---|---|---|---|---|---|
| **Most Pollutive Exports** | **Azerbaijan** | **0.36** | **0.28** | **0.31** | **0.13** | **0.14** | **0.10** | | |
| | **China** | **2.24** | **2.07** | **4.45** | **3.09** | **3.66** | **8.19** | | |
| | **Georgia** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | | |
| | **Kazakhstan** | **0.79** | **0.90** | **0.89** | **0.33** | **0.39** | **0.40** | | |
| | **Kyrgyzstan** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.01** | | |
| | **Pakistan** | **0.00** | **0.00** | **0.01** | **0.05** | **0.04** | **0.05** | | |
| **Less Pollutive Exports** | **Azerbaijan** | **0.00** | **0.00** | **0.00** | **0.01** | **0.02** | **0.02** | | |
| | **China** | **5.26** | **6.02** | **6.22** | **5.13** | **7.71** | **7.77** | | |
| | **Georgia** | **0.00** | **0.00** | **0.00** | **0.01** | **0.01** | **0.02** | | |
| | **Kazakhstan** | **0.02** | **0.02** | **0.01** | **0.09** | **0.12** | **0.06** | | |
| | **Kyrgyzstan** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | | |
| | **Pakistan** | **0.08** | **0.08** | **0.08** | **0.10** | **0.11** | **0.09** | | |
| **Total Exports** | Azerbaijan | 0.09 | 0.07 | 0.05 | 0.04 | 0.05 | 0.03 | 49.50 | 4.00 |
| | China | 4.50 | 5.03 | 5.94 | 4.61 | 6.70 | 7.84 | 37.30 | 8.40 |
| | Georgia | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 41.30 | -1.30 |
| | Kazakhstan | 0.22 | 0.24 | 0.15 | 0.15 | 0.19 | 0.12 | 44.70 | 9.00 |
| | Kyrgyzstan | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 32.20 | -7.60 |
| | Pakistan | 0.06 | 0.06 | 0.07 | 0.08 | 0.09 | 0.08 | 33.10 | 6.10 |
| **CAREC Region:** | | **4.88** | **7.07** | **7.68** | **4.91** | **9.21** | **9.99** | | |
| **OECD AVG:** | | | | | | | | **75.94** | 4.4 |

Notes:
1. Author's calculation based on UN-Comtrade SITC DATA Revision-2
2. EPI: Environmental Performance Index (CIESIN-2020)
OECD AVG: EPI average data based on high income OECD countries

In Table 1.2, this study shows the pollutive industrial exports share of CAREC countries in the world's total exports during the period 2006 to 2020. The analysis shows that, except for China, most CAREC countries do not enjoy a significant share in total world exports for both most pollutive and less pollutive industries exports supply to OECD and ROW. The export share in world total for both pollutive industrial groups and across regions represents less than 1 percent of total world exports. China depicts a steady increase in its exports share to world total both in most pollutive and relatively less pollutive industrial exports during 2006 to 2020. The country exports share of the world total, in the most pollutive industries category, going to OECD rose from 2.24 percent in 2006 to 2010 and almost doubling to 4.45 percent in 2016 to 2020; for those going to ROW it rose to 8.19 percent in 2016 to 2020 from 3.09 percent in 2006 to 2010 in the world's total of most pollutive industries group. Similar, in the less pollutive industrial exports group, China's share of industrial exports in world total showed a steady increase in exports supply to both OECD and ROW countries. The CAREC region (group of six countries) has increased its export share in total world exports during the last almost 15 years both with OECD—from 4.88 percent in 2006 to 2010 to 7.68 percent in 2016 to 2020—and ROW countries—from 4.91 percent to almost 10 percent during the same period (Table 1.2).

Figures 1.1 and 1.2 further elucidate the direction of different categories of pollutive exports of CAREC countries with OECD and other parts of the world. Figure 1.1 shows that within the group of CAREC countries, China, followed by Kazakhstan, is enjoying an increasing export share in total world exports in the most pollutive industrial group both with OECD and ROW regions during 2006 to 2020. For less pollutive industries group, as Figure 1.2 reveals, China is the leading country in the region that has occupied increasing industrial exports share in the world market directed both to OECD and ROW countries. However, compliance with environmental regulation is equally essential for CAREC regions to access the OECD trade market.

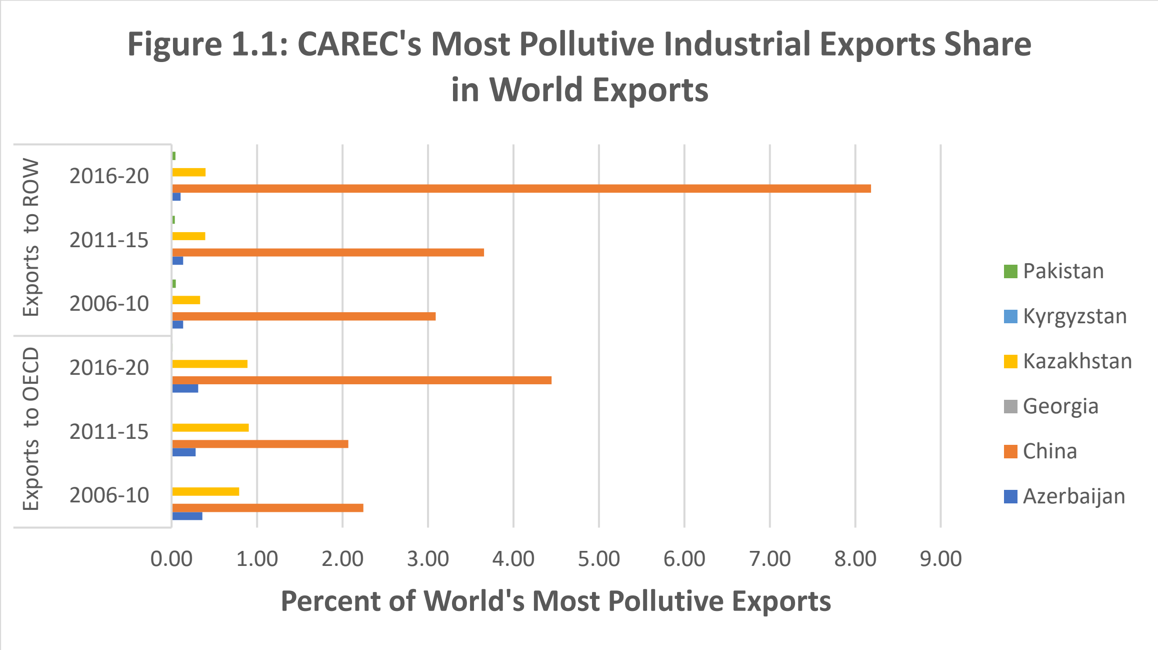
There is a dearth of environmental expenditure data at the industrial level in most developing and low-income countries, including the CAREC countries. Several studies have used an alternate source to measure the effectiveness of environmental performance for cross country analysis. One of the most vital indices, in this context, has been developed by the Center for International Earth Science Information Network (CIESIN, 2020)—the Environmental Performance Index (EPI)—which goes well with environmental regulations and environmental stringency expectations. Table 1.2 shows that most CAREC countries, over the years, are progressing towards increasing environmental compliance. The CAREC region's EPI score hovered between the lowest 32.20 in Kyrgyzstan to the highest 49.50 for Azerbaijan in 2020. However, the CAREC region's environmental performance scores are still far lower than its trade partners of developed OECD countries. The average score in 2020 for OECD countries was around 76 percent, indicating stringent compliance with environmental regulations. The analysis suggests that the demand for harmonization of environmental standards and/or a 'level playing field' by OECD countries would rise in coming years. Therefore, CAREC countries would be required to enact stringent environmental regulations on most pollutive industrial exports to have smooth access to their pollutive industrial export flows, especially environmentally stringent OECD markets.

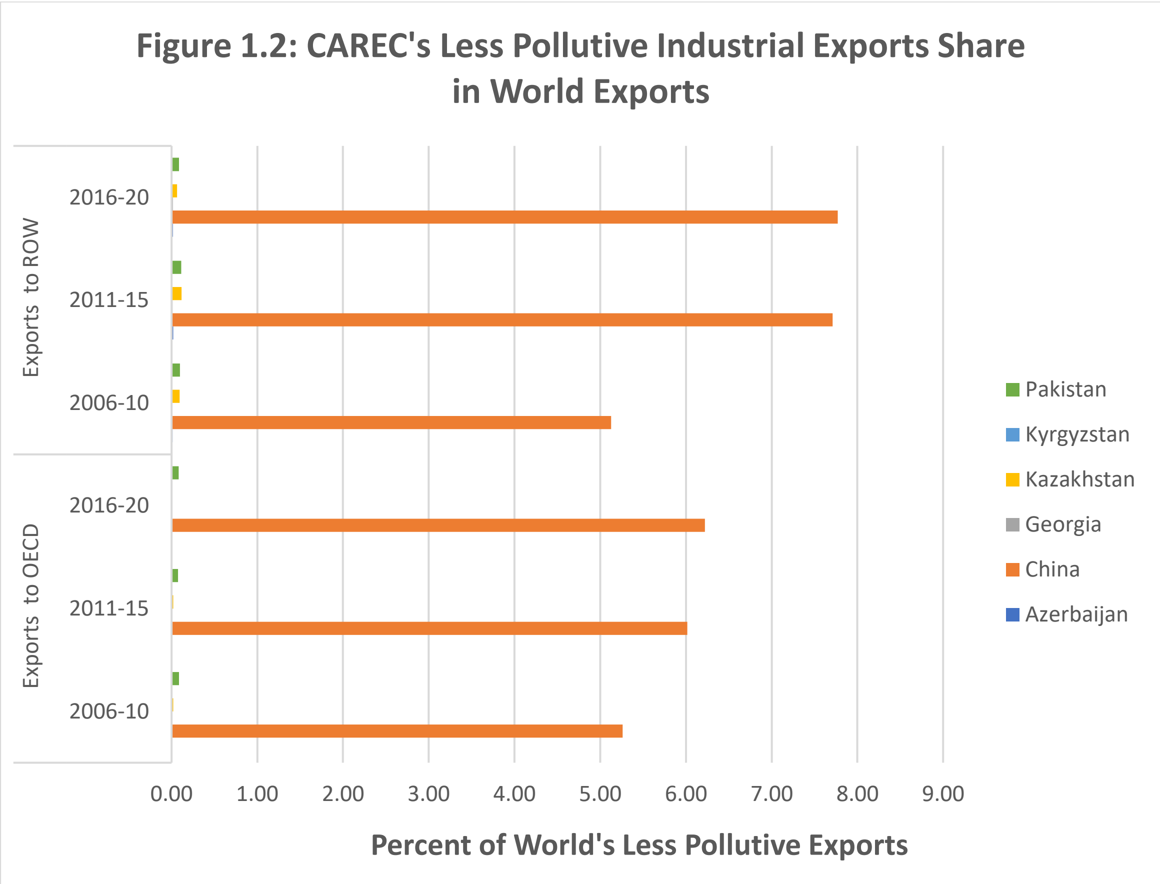
### 1.3 Research Questions

Given the research gaps highlighted in the literature, the study focuses on four research questions. Firstly, owing to internal and external environmental regulations, whether the selected six countries in the CAREC region have lost trade competitiveness in most pollutive industrial trade groups and relative less pollutive industrial trade groups during 2006 to 2020. Secondly, the study examines whether, owing to the difference in environmental regulations compliance between stringent OECD countries and laxer CAREC countries, the CAREC region has become a haven for the most pollutive manufacturing exports to the OECD. Thirdly, in the wake of the pandemic during 2020, the study will examine the impact of the COVID-19 pandemic on the comparatively advantageous position and competitiveness of the most pollutive industrial exports in selected CAREC countries. Fourthly, whether the effects of environmental regulations on the trade competitiveness of the relatively less pollutive industries will be the same as that predicted in the literature for the most pollutive industries.

### 1.4 Methodological Framework

The present research on the methodological choices level firstly employs the comparative trade advantage model offered by Balassa (1965, 1979, 1986) to examine the impact of environmental policy on the competitiveness of pollutive industrial exports. Secondly, keeping in view the significance of this study research question regarding the pollution haven effects, the study uses the model offered by Grether and de Melo (2004) and computes both structural and technique effects for CAREC regions and bilateral RCAs of the CAREC region with OECD and rest of the world (ROW). Following UNIDO (2000) and XU (1999, 2000), and Tobey (1990), this study identifies pollutive industrial groups—namely, most pollutive industries and less pollutive industries at disaggregated SITC trade data. In light of a detailed survey conducted by the present researcher, the term competitiveness is seen mainly through the lens of trade patterns, especially comparative advantage position over time, and via the impact of the environmental policy on various categories of pollutive industrial exports over time.




Source: Author calculations: UN Comtrade SITC 2-digit Rev-2 data: 2006-2020

### 1.5 Sources of Data

The present study will use UN Comtrade trade data covering the period 2006 to 2020 at the 2-digit SITC level. Sources of environmental stringency variables for CAREC and OECD countries is the Center for International Earth Science Information Network (CIESIN, 2020)—a non-governmental organization which collaborates among the World Economic Forum's Global Leaders for Tomorrow Environment Task Force, the Yale Center for Environmental Law and Policy, and the Earth Institute at Columbia University. The most vital indicator the institutions have developed is the Environmental Performance Index (EPI), which measures overall environmental sustainability for 142 countries.

### 1.6 Research Paper Structure

The research paper is spread over seven chapters. Chapter 1 covers the study's highlights, research objectives, fundamental hypotheses, introduction to the methodology, data sources, and study structure. After introducing the notions of environmental externalities and environmental policy instruments, chapter 2 focuses on the dynamics of environmental regulations and international trade. This chapter also highlights the different directions and burning issues surrounding environmental policy and international trade debate. Chapter 3 focuses on theoretical approaches to address environmental policy and international trade linkages. It explores different outcomes of environmental policy and international trade associations. Chapter 4 clarifies the definitional aspects regarding environmental regulations and trade competitiveness. It also emphasizes the empirical quest regarding the likely impacts of environmental policy on international trade to develop the case of appropriate models to be applied in light of this study's research questions. In chapter 5, after a brief introduction to the data sources, the study uses the Balassa model to examine the trade patterns of different pollutive industries over time in the CAREC region and examine the impact of environmental regulation on exports competitiveness. The chapter further provides a comparative statistical analysis on the volatility of export competitiveness in CAREC countries during the pandemic period both in most pollutive and less pollutive industries. The study examines whether the comparative advantage and competitiveness of exports in the most pollutive industries have shifted during the COVID-19 pandemic compared to the average industrial competitiveness of the CAREC region over the last five years. In chapter 6, a geographic based extension of the Balassa model by Grether and de Melo (2004) is deployed to the trade data of the pollutive industries. To trace the evidence of whether the CAREC countries have become a haven for pollutive manufacturing exports, chapter 6 also analyzes compositional and structural effects and the bilateral levels exports comparative advantage between the CAREC region and OECD countries and with the group of ROW countries. The chapter further provides a comparative analysis of the changing bilateral RCA between the most pollutive and less pollutive industries with OECD and the group of ROW countries around the globe. Chapter 7 summarizes the research findings and draws some conclusions. It also offers some policy recommendations and indicates the study's limitations.

## 2. Environmental Economics and Trade Links

### 2.1 Introduction

The relationship between environmental regulations, international trade, environmental quality, and economic growth are multidimensional and complex. In this chapter, the study will reflect on debated issues surrounding those areas, thereby making a case that hardly any general equilibrium model exists that can incorporate all the dynamic links between environmental regulations and trade owing to a series of theoretical modeling approaches required to address complex dynamic links between them. The dynamic links between environment and trade are discussed in section 2.2 to provide a critical review of debated issues/theories/hypotheses. Section 2.3 concludes this chapter by making a case for choosing partial analysis regarding the impact of environmental policies on pollutive trade and competitiveness.

### 2.2 Dynamic Links between Trade and Environment

When market failures prevail, such as unpriced or underpriced resources are unaccounted for, then externalities[2] and/or policy failure exists. To internalize these externalities, economists normally divide policy instruments for achieving environmental objectives into two categories: (1) those that are said to provide firms with little flexibility in achieving goals are normally termed as command and control approaches and (2) those that are deemed to provide firms with better flexibility and incentives to look for more effectual ways of making sustained environmental progress are normally termed as market based incentive based mechanisms (Stavins, 1992).

Before moving to the core issue, some dynamics of the environment and economic activities are presented in Figure 2.2. The dynamics in Figure 2.2 show that the relationship between trade and environment is quite complex. In the forging paragraphs of this chapter, the study has endeavored to elucidate some of these complex dynamic links. However, the core focus of the present research is to examine environmental regulations and trade competitiveness links. These dynamics require due consideration as they leave vital theoretical and empirical links for the core subjects of trade, environmental quality, and environmental regulations.

The theoretical literature on trade has demonstrated that free trade maximizes the efficiency of resource allocation by channelling economic activities to least-cost producers. It thus produces a given level of output at the least cost. If natural and environmental resources are efficiently priced—that is, all relevant social costs are accounted for—the resulting global production is also produced at the least environmental cost. Nevertheless, when market failures are prevailing, such as unpriced or underpriced resources are unaccounted for, then externalities and or policy failure exists. Therefore, the distortions such as environmentally harmful subsidies, if not removed or corrected, then the resources are misallocated to start with, and the removal of trade barriers may exacerbate this misallocation. In these circumstances, the trade will not maximize social welfare although there would still be efficiency gains (positive effects) and welfare losses. Also, owing to the adverse impact resulting from wasteful resource depletion, the net effect would depend on the relative magnitude of the positive and negative effects (Panayotou, 2000). Therefore, policy theory is also vital, and different

[2] Externalities exist whenever an agent has to tolerate part of the cost of another agent's activity without being compensated, and the agent responsible for this externality does take this into account and he or she bears only the private costs of the activities, while neglecting the total cost. The concept of externality was introduced by Sidgwick (1883) in the nineteenth century. Negative externalities are of concern not only in environmental economics but also in consumer theory (envy demand for social status), international trade theory, optimal tariffs and strategic trade policy, public choice (rent-seeking games), industrial organization (oligopolies, patent race) and many other areas (Rauscher, 1997:19).

trade policies such as tariffs, quotas, and export restraints would have different effects on the level and quality of environmental resources (Steininger, 1999).

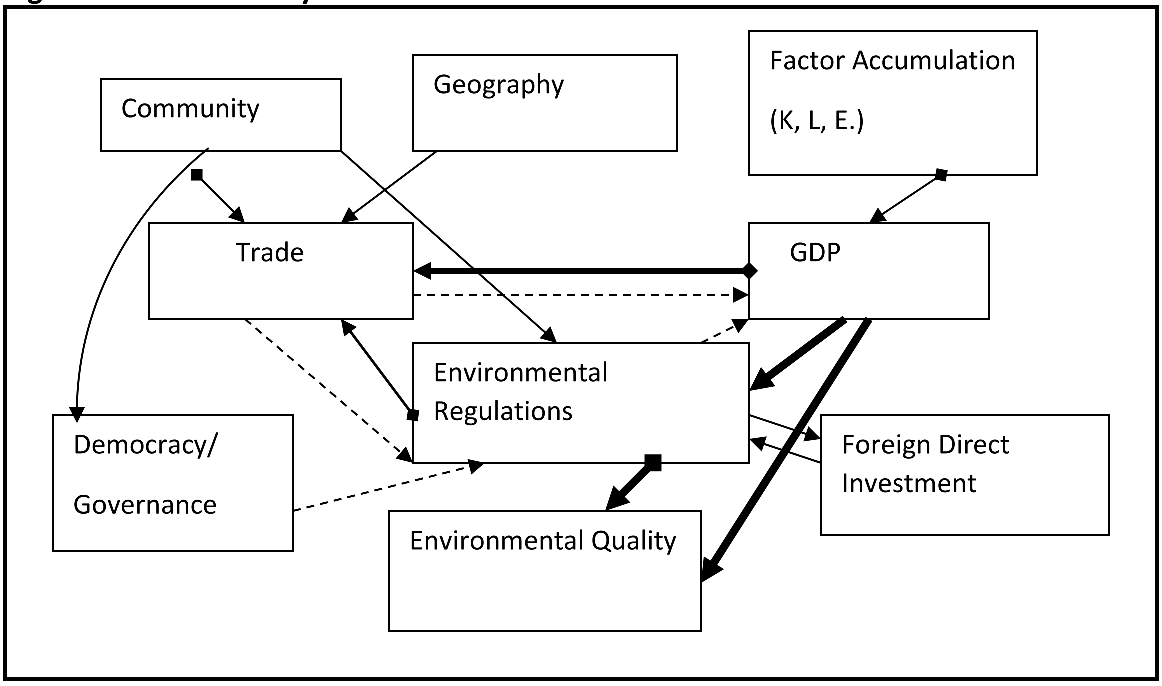
How do geographical factors, as indicated in Figure 2.2, explain the interactions between economic agents? Lipsey's (1960) natural trading partner hypothesis suggests that 'the higher the proportion of trade with the region and the lower the proportion with the rest of the world, the more likely is a regional agreement to raise welfare effects' (Pitigala, 2005). Although the volume of trade based on this hypothesis become popular, it ignored the effect of trade policy, transport logistics, and issues such as competitiveness and trade complementarities (Pitigala, 2005). Wonnacott and Lutz (1989) introduced the modified version of the natural trading partner hypothesis, brought transportation costs and location as vital determinants of trade flows, and found an increasing tendency for countries to trade with other countries in geographic proximity. Deardorff and Stern (1994) on transportation costs opined that geographic proximity between countries tends to reduce trade diversion.

Natural barriers to trade, such as distance, increase transaction costs because of the transportation cost of shipping goods as well as the time cost of acquiring information about remote economies. The gravity model in the literature explains how rapidly distance reduces trade volume between countries (Overman et al., 2001). However, others have argued in the light of traditional trade theories of comparative advantage that countries with different comparative advantage profiles should, in principle, have more opportunities to trade with each other compared with those with similar comparative advantages (Ng and Yeats, 2003 and Pitigala, 2005). The relevance of geography to trade for the present study is to explore the possibility of pollutive industrial relocation or delocalization—the pollution haven effect for CAREC countries—of international trade from rich OECD countries to poor South countries after controlling for geography. Empirical results on the delocalization hypothesis confirmed that the natural barriers to trade, such as transportation cost, in the typically heavy polluting industry is one of the key factors of having a less than expected delocalization of polluting industries from the most stringent environmentally regulated 'North' to the relatively laxer regulated 'South' (Grether and de Melo, 2004).

The relationship between trade, income growth, environmental regulation, and environmental quality is also vital in the trade–environmental debate, as shown in Figure 2.2. The studies that moved from partial equilibrium analysis to the general equilibrium analysis have identified three mechanisms via which income, trade, environmental regulations, and environmental quality are linked. Commencing from Grossman and Krueger's (1991) work on NAFTA regarding trade and environmental quality links, it is customary to decompose the environmental impact of trade into three interacting elements: scale effect, composition effect, and technique effect.

The increase in economic activity following neo-liberal policies may increase economic growth, thereby increasing demand for all inputs, including the stock of the environment—hence increasing emission (the scale effect). Higher income increases the demand for a clean environment. If a clean environment is income elastic, then the consumer will only tolerate a higher pollution level if the effluent charge is higher. Since higher effluent charges encourage firms to shift towards clean production processes, the technique effect reduces emissions. If income growth shifts preferences toward cleaner goods—that is, if clean goods are relatively income elastic—then the share of pollution intensive goods in output will fall (the composition effect). The core point in the trade–environment debate is that if with rising income first composition and then technology effects outweigh the scale effect then trade liberalization should improve environmental quality or reduce environmental degradation and increase the environmental degradation if vice versa is true (Fredriksson, 1999).

**Figure 2.2 Some Dynamics on Trade and Environment Links**




Source: Frankel and Rose (2005) and author extension based on other literature review

For developing countries like those in the CAREC region that possess vital natural resources and face income-constrained demand for environmental quality trade liberalization, environmental quality would largely depend on whether environmental resources are properly valued or priced and whether these values are taken into account by the world market (Panayotou, 2000). Strutt and Anderson (2000) empirically showed that even for a business-as-usual scenario—that is, in the absence of any change in resource pricing or environmental regulation—the implementation of Uruguay Round trade reform would leave a positive impact on environmental quality in LDCs and other parts of the world except for Western Europe, wherein resource policies are well developed. Their sectoral level research for the Indonesian economy during the predicted period 1992 to 2010 depicted that trade liberalization would allow the technique effect to outweigh the composition and income effects, thus reducing Indonesia's emission rate for pollutive industrial waste for textiles pulp and paper.

Recent research has explained the demand-side effects related to environmental regulations through aggregate income in partial instead of the general framework, and the critical argument is that the stringency of environmental regulation increases with the level of development and to be more specific with the level of per capita income (Dasgupta et al., 1995). Figure 2.2 shows the link between GDP, environmental regulation, and environmental quality; empirical models have extended those links with trade. The research has followed the EKC path to develop a relationship between environmental qualities, environmental regulations, and economic growth. The EKC path's primary purpose is to examine whether economic growth eventually brings improved environmental quality.

The EKC drew its theoretical insight from the inverted U-shaped hypothesis introduced by the Kuznets (1955). This hypothesis states that environmental damage rises at a lower level of income and declines after a certain income level (turning point). The proponent of EKC finds no contradiction between economic growth and environmental quality beyond this point (Nordstrom and Vaughan, 1999). The differences of environmental regulations can allow developing countries to possess a comparative advantage in pollutive industries. Either most pollutive industries relocating from developed to developing countries or developed world's pollutive industries being displaced from the world market by a similar industry from developing countries—pollution haven hypothesis; this phenomenon has often been cited as one explanation of the inverted U-shaped relationship between per capital income and emissions of local air pollution (Cole and Elliott, 2003; Cole, 2004).

Multilateral trade rules such as GATT and WTO make a fundamental distinction between product standards and process and production methods (PPMs) as the two are treated very differently and raise a vital concern about environmental regulation impacts on trade competitiveness, especially when environmental rules are used to meet trade objectives—the tuna-dolphin case between the USA and Mexico is the prime example. The national requirements on product standards and product related PPMs are allowed, while non-product related PPMs are not. Product standards apply to both local and international products, while process standards are applied mainly to domestic producers. If the production method affects the characteristics of the imported product, then border tax adjustments are permitted under WTO rules—that is, product related PPMs are treated in the same way as product standards. Charges or standards on non-product related PPMs—on production methods that do not affect the product characteristics—violate the principle that like products should be accorded like treatment and are prohibited under the WTO rules. Therefore, unlike product standards methods, standards are not the prime candidates for harmonization[3] (Panayotou, 2000; Adams, 1997).

In Figure 2.2, the link between foreign direct investment and environmental regulations shows that causality runs in both directions. One theoretical aspect of the pollution haven effect is that introducing stringent environmental regulations in industrialized countries paves the way for capital and investment to transfer to developing countries. And the developing countries may follow the path of what is generally referred to as the regulatory chill where countries refrain from enacting stricter environmental standards in response to fears of losing a competitive edge (Nordström and Vaughan, 1999). The Mabey and McNally (1999) study shows that strictness or laxity of environmental regulation in the host country is not a vital determinant of attracting FDI. Investors, especially MNCs, hardly consider environmental costs in their location decision-making; other determinants—such as availability of cheap labor cost, natural resource endowments of the host country, infrastructure, presence of industrial base, taxes and transport structure, availability of raw material, and market size—are a higher priority for corporations.

The community link with environmental regulations and environmental quality is also vital, as shown in Figure 2.2. In this context, the recent work experiences on industrial pollution in Asia reveal that, in addition to formal regulations, the information regulations—that is, community pressure—have a strong and significant impact on strengthening the regulatory impact and improving environmental performance (Pargal and Wheeler, 1996). Also, Afsah et al. (1996) analyzed environmental performance in China, Brazil, Indonesia, and the United States. They reported that community and market pressure could significantly influence environmental performance, although this outcome would ultimately depend on income, education, and bargaining power.

The environmental regulations leave an impact on economic productivity, as indicated in the arrow from environmental regulations towards GDP and trade variables in Figure 2.2. The famous theoretical debate between Palmer, Oates, and Portney (1995) and Porter and Van der Linde (1995) regarding environmental regulation and competitiveness has been cited in the literature. Porter and Van der Linde (1995) argue that there is no trade-off between environmental regulations and competitiveness as well-designed environmental standards bring efficiencies in the production process that can partially or more than fully offset the cost of complying with them. Palmer, Oates, and Portney (1995) advocate that firms/industries are bound to face some adverse effects of environmental regulations.

[3] Harmonization can be loosely defined as making the regulatory requirements of governmental policies of different jurisdictions identical or at least similar (Leebron, 1996).

Whether environmental regulation cost can be fully or more than fully offset by the benefits gained after introducing new innovative environmental technology is an empirical quest[4] (XU, 2000a).

### 2.3 Conclusion

The issues surrounding trade and environmental relationships are multidimensional and complex, as depicted in chapter 2. Apart from theories pertaining to trade and environmental links, there are hosts of intervening theories/hypotheses influencing trade competitiveness and environmental regulatory associations. Most of the research in this area tended to examine various hypotheses in a partial equilibrium modeling framework. This study, therefore, focuses on just the area related to the impact of environmental regulations on trade—more specifically at pollutive manufacturing exports—competitiveness, which is at the heart of the debate on the association between environmental regulations and trade competitiveness and more relevant to several developing countries like the CAREC region. Chapter 3 sheds light on the different strands of the theoretical debate surrounding the environmental policy and trade competitiveness nexus.

[4] The details on the theoretical debate regarding the possible impact of environmental policy on trade competitiveness between Porter and Van der Linde (1995) and Palmer, Oates, and Portney (1995) are elucidated in the theoretical section of chapter 3.

## 3. Theory to Empirics: Environmental Policies and Trade Links

### 3.1 Introduction to Trade and Environment Theory

The theoretical literature on trade and environmental policy mainly following mainstream neo-classical orthodoxy, especially in comparative advantage framework, wherein factors of productions are immobile internationally and mobile domestically, show that the introduction of environmental policies can generally in a static and both in partial and general equilibrium framework, have clear influence for production costs, trade pattern, industry location, and gains from trade for the economy, and relaxing one or more assumptions produces quite complex outcomes (Walter, 1975a,b; Grubel, 1975; Pethig, 1976; McGuire, 1982; Siebert, 1974 and Siebert et al.,1980; Copland and Taylor, 1994; Merrifield, 1988; Chichilnisky, 1994).

### 3.2 Theory: Environmental Regulations and International Trade

Given the assumptions of neo-classical trade theories, previous studies find a negative impact of environmental regulations on commodity exports (Pethig, 1976). And given two countries, two goods, and two factors of production, the argument between the two countries' trade still holds—that is, an introduction of stringent environmental regulation (say, pollution tax) in the pollution intensive sector by the first country as compared to the regulations being practiced by the second country would lead to a decreased pollutive sector export of the heavily regulated sector(s) of the first country and a shift of resources towards cleaner sectors, other things held constant (Adams, 1997). Given the factor, especially capital immobility and competitive market structure with other assumptions of comparative advantage theories including complete information, the stringency of environmental regulations is observed as internalization of environmental costs that would if introduced on the exported sector reduce home country exports of pollutive goods and increase the imports of those pollutive commodities (Rauscher, 1997).

Between the trade context of advanced and poor nations, one of the key theoretical outcomes is that comparative advantage created through the difference in environmental regulations between developed and developing nations under the free trade era would cause developing countries to become a repository of the world's dirty industries, assuming that developing countries follow environmental standards that are more lax than those of developed ones (Baumol and Oates, 1988). Pethig (1976) and McGuire (1982), in their analytical framework, produce a somewhat similar theoretical outcome. Therefore, the shift in production and trade activities either owing to capital (FDI) or industrial flight—capital flight hypothesis or industrial flight hypothesis—or owing to price diffusion effect (McGuire, 1982), all can allow the developing countries to become a haven for the world pollutive goods production and export, which is termed as pollution haven hypothesis.[5] In the developed part of the world, the fear of losing competitiveness in traded activities owing to stringent environmental regulations created the possibility for a domestic pressure group to put pressure on these countries to lower standards to ensure survival and avert loss of sales and jobs and above all export competitiveness of environmentally sensitive manufacturing commodities, which is termed as 'race towards bottom' hypothesis (Bhagwati and Hudec, 1996; XU, 1999).

One vital piece of research produced by Copland and Taylor (1994) regarding North–South trade is worth elucidation for the present research point of view. Given the assumptions of neo-classical H-O trade theory with the assumption that all else is equal between two regions, except income that is

[5] Another aspect of pollution haven hypothesis has been explained before in our discussion of FDI and production context. The present research following, among others, Pethig (1970), Tobey (1990), Low and Yeats (1992), Mani and Wheeler (1999), and Grether and de Melo (2004) will explain the pollution haven phenomenon in terms of changing trade and especially export specialization patterns of pollutive industries over time.

higher in the North compared to the South and that trade flows are income determined, the introduction of stringent income induced environmental regulations would reduce North pollutive sector exports and increase the pollutive exports from the South. Accordingly, there will be the relocation of pollutive industries and production and specialization activities from the North towards the South. Chichilnisky (1994) has offered a new direction to the North–South theoretical debate on trade, environmental policy, and environmental quality. She proposes that it is the differences of property rights in two regions—North and South—that can provide the basis of trade incentives between them even if they are identical in all other aspects—that is, same taste, technology, endowments, and preferences between two countries—or if the world is presumed to be composed of two regions—namely, North and South. In the general equilibrium modeling framework, she presents two key findings. First, by defining the South as having ill-defined property rights on environmental resources compared to the North, where property rights are well defined, the author depicts that South trade with North aggravates the environmental quality problem as the South overproduces the underpriced environmental resource intensive goods and the North overconsumes the same. Second, on the choice of environmental policy between property rights policies or using taxes to address environmental issues, the study shows that with ill-defined property rights in the South the use of environmental tax policy by the South will exacerbate the environmental problems, as producers in southern countries would over extract the environmental resources to adjust the additional cost. This led her to make a case for depicting the superiority of property rights policies over the tax policy to address the environmental problems.

Most of the literature on environmental regulations and trade competitiveness association has cited the famous theoretical debate between Palmer, Oates, and Portney (1995) and Porter and Van der Linde (1995), which can also be seen as a debate between new versus old trade theorists. Porter and Van der Linde (1995), following the new trade theory, offered the new concept of trade and environmental policy relationship normally termed as the race towards top. The thrust of their argument is that there is no trade-off between environmental related social benefits and private cost as properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them. They argued that the old notion of a trade-off between trade and environment at the theoretical level has resulted from the static and narrowed view of environmental regulation, in that technology, products, processes, and customer needs are all fixed. In this static world, wherein firms have already made their cost minimizing choices, environmental regulation inevitably raises costs. It will tend to reduce the market share of domestic companies in global markets.

For Porter and Van der Linde (1995), dynamic competitiveness at industry level arises from superior productivity in terms of lower costs than rivals or the ability to offer products with a superior value that justifies a premium price. Their detailed research at industry level for the number of economies depicts that internationally competitive companies are not those with the cheapest inputs or the largest scale, but those with the continual capacity to improve and innovate.[6] These innovation offsets[7] can not only reduce the net cost of complying with environmental regulations, they can even lead to absolute advantages over firms in foreign countries that are not subject to similar regulations.

[6] Innovation is defined as including a products or services design, the segments it serves, how it is produced, how it is marketed, and how it is supported (Porter and Van der Linde, 1995).

[7] Innovation offsets cover both product offsets and process offsets. Product offsets occur when environmental regulations lead to reduced pollution but also create better performing or higher quality safe products, and lowering product cost etc. Process offsets occur when environmental regulation not only leads to reduced pollution but also results in higher resource productivity such as higher process yield; material savings owing to substitution, reuse, or recycling; lower energy consumption during the production process; and reduced waste disposal costs (Porter and Van der Linde, 1995).

Palmer, Oates, and Portney (1995) advocate that there is no free lunch in this world, and following the conventional neo-classical approach, they argue that some adverse effects of environmental regulations are out there to be borne by the firm in terms of cost to get benefits that environmental regulation ultimately brings to firm(s). They tend to agree with Porter and Van der Linde (1995) that an incentive based regulatory approach in lieu of command and control do a better job and that regulations have led to the discovery of cost savings and quality improving innovations—that is, firms can never rest vigilantly on their efficiency frontier. They criticized the new trade theorist dynamic argument on regulations and competitiveness links in two areas. First, they advanced that the Porter and Van der Linde (1995) study perceived the private sector as if it systematically overlooks the profitable opportunities for innovations. Second, they foresee the regulatory authority is in a position to correct this market failure. Accordingly, the enlightened regulators are well informed to provide the needed incentives for cost saving and quality improving innovations that competition apparently fails to provide. The regulations thus help firms to overcome organizational inertia and foster creative thinking, thereby increasing profit. Palmer, Oates, and Portney (1995) strongly disagreed with these presumptions. Their analytical model proved that even incentive based environmental regulations result in reduced profit for the regulatory firm, and some loss of competitiveness will be there. This model set the basis of the conventional approach that even additional (or tightening) constraints on a firm set of choices are hardly expected to increase that firm's profit level and thus gain competitiveness.

XU (2000a) tended to synthesize the Palmer, Oates, and Portney (1995) and Porter and Van der Linde (1995) arguments by advancing the point that it is clear that both studies tend to agree that environmental cost is to be offset through the benefits ascertained through the introduction of new technology. The difference of opinion is whether the environmental regulation cost can be fully or more than fully offset by the benefits gained after introducing new innovative environmental technology, which is an empirical question to investigate.

### 3.3 Conclusion

The discussions in this chapter revealed theoretical interconnections between trade and environmental regulations which are complex and produced divergent outcomes. It essentially involved the allocation of productive resources diverted from the output of tradeable goods to the improvement of environmental quality. The magnitude of such reallocation of resources depends on the demand for improved environmental quality against the demand for other goods and services that has to be given up by achieving environmental quality. Depending on theoretical model assumptions, the large literature in neo-classical orthodoxy showed environmental management efforts would leave negative effects on a country's trade comparative advantage and competitiveness when a country uses those productive resources for environmental control in sectors wherein its comparative advantage is based. Hence, there is a trade-off between environmental regulations and trade competitiveness.

New trade theory followers argued that no trade-off exists between compliance with environmental regulations and trade competitiveness owing to the cost savings achieved via innovative environmental technology, which promotes a race to the top. At the same time, the theoretical literature reviewed in this chapter concluded that the differential of environmental standards between the rich North and the relatively poor South and the poor records of property rights in the South had created possibilities for the South to become a haven for world pollutive commodities exports to the North. Neo-classical researchers also challenged the race to the top hypothesis, especially in the wake of poor records of property rights in developing and poor countries. This chapter developed a synthesis that, while neo-classical theories seemed to be more relevant to the quest of current study research endeavors, but in the lights of limitations for the theories to produce conclusive outcomes contends that the impact of environmental regulations on trade could best be examined via empirical quest.

## 4. Environmental Regulation and Trade: Empirical Endeavors

### 4.1 Introduction

This chapter lays the foundation for testable empirical research methods that fit the research questions/hypotheses set out in this study. Accordingly, section 4.2 makes a case for industrial focused analysis for international trade and environmental regulations as *inter alia* the dynamics of competitiveness take place at industrial level as opposed to firm/country level. Section 4.3 examines the channel via which the environmental regulations can affect competitiveness and components of total environmental costs. Furthermore, measurement issues regarding environmental expenditure/costs that research faces at the industry level and shortage of comparable data at both cross country/time series levels on pollution abatement control expenditures are discussed in the same section. In section 4.3, the study examines vital empirical definitions of pollutive industries. It further explains why there was a need to broaden the pollutive industry scope from most pollutive to less pollutive industries. Section 4.3 further defines what constitutes competitiveness and its association with environmental regulations. In section 4.4 this study elucidates a critical survey of empirical literature regarding the association between environmental regulations and trade with a special focus on research methods adopted, regulatory variables chosen, compatibility of research questions and their outcomes, scope of study in terms of countries and pollutive industries, and challenges faced at measurement stages by earlier studies. Section 4.5 concludes the discussion.

### 4.2 Why Industry Focused Analysis?

Several reasons justify the present study's concentration at industry level analysis instead of at firm level in a quest for an empirical investigation about environmental regulations and trade competitiveness links. First, the dynamic of competitiveness takes place at industrial level. The individual firm behavior and its competitiveness strategies, investment decisions, and locational choices need to be understood in terms of the competition the firm faces. The reactions to environmental regulation by firms depend primarily on the competitive characteristics of the industries within which they operate. Secondly, technological development and production processes are industry specific. The response of the industry to environmental regulations over time also very much depends on the technological trajectory of the industry. From a competitiveness point of view, competition at firm level does not provide a good analysis at international level because firms compete with each other. Some of the competitiveness gains that a firm may make through becoming more environmentally sound may be at the expense of other firms. Above all, it is industry trade flow that is a debated issue from an international trade competitiveness perspective. For an international level analysis of environmental stress, it is imperative to take account of how assorted products are produced in different regions and how various stages of the production process are distributed internationally. This phenomenon again guides research focus at industry level (Jenkins et al., 2002).

### 4.3 Defining Environmental Regulations and Competitiveness: Measurement Issues in Empirical Analysis

Owing to the complexity of the relationship between environmental regulations and competitiveness, there are various channels through which regulations could affect competitiveness. First, environmental regulations affect firm/industry production costs directly through increased expenditure incurred on pollution abatement and indirectly through the high price of a certain factor of production affected owing to stringent environmental regulations. Also, innovative environmental technologies have a role in impacting competitiveness (Pethig, 1970; McGuire, 1982; Porter and Van der Linde, 1995; Palmer, Oates, and Portney, 1995).

Given the complexities of measuring pollution abatement costs at both firm/industry levels, the contemporary empirical literature on environmental regulations and pollutive industrial production and trade associations has followed a two-pronged approach to define the pollution intensive industry. The first approach identifies those industries that constitute relatively high abatement costs in total costs or relative to their turnover as pollution intensive (Robison, 1988; Tobey, 1990; Low and Yeats, 1992; Sorsa, 1994). The second approach is to pick those industries that rank high on actual emission intensity—namely, emission per unit of output or value added or per person employed (Mani and Wheeler, 1999). These two approaches lead to identifying the same group of most pollution intensive industries. There seems to be a strong correlation between the ranking of industries by share of pollution abatement costs and the measures of toxic pollution intensity. Based on these two approaches and following an in-depth US industrial data analysis, five most pollutive industries have been identified in most empirical literature: iron and steel, nonferrous metals, industrial chemicals, pulp and paper, and nonmetallic products (Lucas et al., 1992; XU, 1999; Jenkins et al., 2002; Eskeland and Harrison, 2003).

Recently, for pollutive industries, the productivity analysis of Pakistan *vis à vis* South Asia and Southeast Asia and other countries UNIDO (2000) has classified another sector, petroleum refineries, among the most pollutive industries. UNIDO (2000), for South Asia and Southeast Asia analysis, ranked the pollutive industries by their high and low emission intensity per unit of output. For a trade analysis of the CAREC countries and their bilateral trade flows with OECD countries, the study follows the internationally agreed definition for most pollutive and less pollutive industries (Lucas et al., 1992; XU, 1999; Jenkins et al., 2002; Eskeland and Harrison 2003; UNIDO, 2000). Another issue is to define competitiveness for empirical research.

Environmental policy is only one of the many factors that determine the competitiveness of firms. Many other factors—including management ability/capacity to innovate/improve efficiency/product quality continuously, customer service, the pattern of world supply and demand, access to raw material, and market structure—play a vital role in determining the competitiveness of the firm (Panayotou, 2000; Adams, 1997; Pearson, 2000).

At industry level, competitiveness arises from lower costs than those facing international rivals or a higher value to the customer in the form of delivery, services, or quality. Since Ricardo, the term comparative advantage has been coined to explain the international patterns of trade specialization and competitiveness. The notion of comparative advantage describes the relative performance of different industries within a country as a determinant of what gets produced where. A vital assumption of the theory is that factors of production are immobile within the country and mobile within the same country's industry. A move from autarchy to free trade allows the flow of resources from the industries where the country is relatively disadvantaged (generally owing to its factor endowments) to those industries where it enjoys a comparative advantage (Balassa, 1986). In this context, industry competitiveness could be seen as the ability to attract resources from other industries within the same country.

#### 4.4 Empirical Literature Review: Environmental Policy and Trade Competitiveness

Earlier research conducted in the 1970s and 1980s has primarily used indirect ways to analyse the competitiveness impact of environmental regulations. The focus of attention has been on measuring environmental control costs for traded sectors of the economy. The degree to which the production and export shifts take place largely depends on the extent to which environmental regulations raise costs. If the environmental cost differentials at inter-industry level are very high, there would be a significant change in comparative advantage and trade flows. Nonetheless, when the differences in environmental control costs between industries are relatively minute, the change in trade patterns is also likely to be small (Jenkins et al., 2002). Using indirect methods such as input–output/CGE models, these studies determined the abatement costs for most pollutive traded sectors in developed countries. The results produced mixed conclusions. Some studies found a negligible rise in environmental control or pollution abatement costs—on average around 2 percent for most pollutive merchandise sectors—which did not affect pollutive industrial trade competitiveness overall. Nor did environmental regulations affect pollutive industries' trade composition, delocalization, and international trade patterns (Evans, 1973). Nevertheless, other carefully assessed research highlighted the limitations of adopting the correct measurements of environmental costs and modeling choices. It showed that environmental control costs could substantially affect pollutive industrial trade composition, direction, terms of trade and competitiveness, and the country's balance of payments (Walter, 1973, Mutti and Richardson, 1977; Robison, 1988).

For CAREC countries, Khan et al. (2001) have provided some estimates on pollution mitigation costs for Pakistan's textile and leather industries during 1996 to 2004. One of the key study objectives was to estimate a rise in exports of clothing, leather, and footwear based on the Uruguay Round Agreement on textiles and clothing, and measure the cost benefits of pollution mitigation, in addition to a change in pollution levels. Using the ARIMA model the study results showed that pollution abatement costs were rather modest and there were more benefits to be had by manufacturing sectors adopting cleaner production technologies.

From the 1990s onwards, the focus of research shifted from indirect to direct efforts to analyze the environmental policy consequences for trade competitiveness. The empirical studies took theoretical inspiration from one of the most venerated trade models—the Heckscher-Ohlin-Samuelson (H-O-S) model—for the empirical examination of the relationship between environmental regulations and trade competitiveness in multicounty and multicommodity case, first empirically tested by Leamer (1980, 1984) to explain the determinants of net commodity exports in factor abundance framework. The H-O-V model explains that it is relative factor intensities that cause the problem when more than two factors are considered for analysis; Vanek (1968 in Leamer 1980, 1984) introduced the alternative way of elucidating the H-O-S model that is linked with his name and coined the H-O-V model, which in cases of more than two goods, more than two countries, and more than two factors state that a country relatively well endowed with one factor of production will be a net exporter of the services of that factor and a net importer of the services of the other factor, given the standard assumptions of the elegant H-O-S model. Therefore, the H-O-V model is the factor content version of the H-O-S model and helps avert the problem of explaining the factor intensities for more than two factors, thus paving the way for the empirical investigation for more than two goods and more than two factor situation for the multicountry scenario. The environmental resource endowments variable in this framework, in addition to other explanatory variables such as labor and capital, is added in the factor flows model by assigning the price to it, which comes via the environmental stringency variable—the more stringent the environmental control policy of a particular country is, the less that country is endowed with the environment factor (Tobey, 1990).

Tobey (1990) tested the hypothesis of whether stringent environmental policy caused trade patterns to deviate in commodities produced by the world's dirty industries. Pollution intensive commodities are the product of those industries whose direct and indirect abatement costs in the United States are equal to or greater than 1.85 percent of total costs. This 1.85 percent cut-off is selected because it results in a set of industries considered the most polluting industries in the world. Following this criterion, Tobey has identified 34 pollutive industries that are aggregated into five commodity groups encompassing mining, primary nonferrous metals, paper and pulp, primary iron and steel, and chemicals for analysis purposes. He used cross section factors flow-based HOV multifactor, multicommodity model of international trade using the 1975 United Nations trade data for 23 economies—both OECD and non-OECD. The net export variable is regressed on the factors of the production variable including variables of capital accumulated and discounted gross domestic investment; various categories of labor and land; natural resource variable such as coal, mineral, and oil; as well as the environmental stringency variable. The environmental stringency measure is based on the 1976 UNCTAD that ranked the country in 7 categories ranged between 1 (tolerant) to 7 (strict), which served as a proxy for the stock of the environment (Tobey, 1990). Based on empirical findings, the study concluded that the stringent environmental regulations imposed in the 1960s and 1970s by most advanced economies have not measurably affected the patterns of trade and thus competitiveness of most polluting industries (Tobey, 1990).

Tobey's (1990) research approach was based on multilateral trade flows, which means that the differential effects of environmental policy on various trade flows might cancel out owing to the aggregation of bilateral trade flows to multilateral trade flows (Van Beers and Van den Bergh, 1997). These researchers offered disaggregate analysis based on the bilateral trade flow model, composed of the imports and exports gravity model pioneered by Tinbergen (1962) and Linnemann (1966). Second, they believed that the formation of environmental stringency measures might be responsible for ascertaining the Tobey (1990) results being input-oriented environmental stringency measures such as current and investment expenditure in pollution abatement and control activities. These sorts of measure are inappropriate as high abatement control cost could be counterbalanced by the government through export rebates and import surcharges to the most pollutive industries—therefore, failing to represent the real cost incurred by the firms/industries. Therefore, such measures might exaggerate the costs of environmental regulations (Van Beers and Van den Bergh, 1997). The study used three different bilateral trade flows data for both OECD and non-OECD countries. The bilateral trade flows include (1) total bilateral trade flows; (2) dirty bilateral trade flows, which encompass a high degree of resource base (non-footloose) industries; and (3) footloose: trade flows relating to specific dirty sectors covering mining, paper, chemicals, and steel and non-ferrous metals sectors. For regression analysis, the study employed the gravity model of international trade, which considers the relative economic sizes and geographic distances involved in bilateral trade flows. The study used two output-oriented environmental stringent measures, keeping in view the inappropriateness of input-oriented environmental stringency measures. Output-oriented measures encompass the effects of compensating subsidies and facilitate assessing the effective (ex-post) strictness. The study by Van Beers and Van den Bergh (1997) using the same 1975 data as the one used by Tobey (1990) and the same ordinal measures of environmental stringency, did not find a significant association between environmental regulations and pollutive intensive industrial trade. The results showed that stringent environmental regulation places a positive influence on exports and has no significant effect on imports in total bilateral trade flows and non-resource-based pollution intensive trade flows, which is perhaps in line with what the Porter hypothesis envisages.

XU (2000), apart from analyzing the time series effect using the competitiveness indicator, extended the gravity model/OLS approach to examine the impact of environmental stringency on bilateral export flows. Firstly, using statistical modeling framework and covering the industrial trade data of 134 countries at disaggregated SITC levels during 1965 to 1995, he examined whether domestic environmental regulations reduce the international trade competitiveness of environmentally sensitive goods (ESGs). The time series results show no systematic change in the trade pattern of ESGs during this period despite the introduction of stringent environmental regulations around the globe. He then empirically provided a comparative analysis by disaggregating industrial trade flows of 31 developed stringent environmental regulatory North and poor South countries. The trade data was computed at three industrial trade categories—namely, total bilateral export flows, bilateral export flows of ESGs, and bilateral export flows of non-resource based (footloose) industries for 1990.

For the environmental stringency impact on trade flows XU (2000) utilized the Environmental Performance Index for 1990 developed by the team of the World Bank, Dasgupta et al. (1995) for 31 randomly selected countries covering environmentally stringent countries in the North and countries of the South with lax environmental standards. The study found the positive impact of environmental stringency on bilateral export flows, confirming the Porter hypothesis. The study found no evidence that footloose pollutive industry exports were more responsive to the stringency of environmental regulations.

The XU (2000) study faces a few problems. Firstly, his analysis has drawn conclusions based on cross sectional data estimation techniques while ignoring the endogeneity issues in data because results can be sensitive to the choice of modeling technique. Secondly, at the modeling specification level, the study suffered from omitted variable bias as it ignored the use of dummy variables such as common language, colonial links, and contiguity. These paired variables are generally part and parcel of most gravity model specifications in the cross countries analysis.

Cole and Elliott (2003) examined the impact of environmental regulations on international trade using two models. The first was the extension of Tobey's (1990) HOV analysis by increasing the sample size of countries from 23 to 60. They used data set for 1995 instead of mid-1970 to examine whether increased stringency of environmental regulations would have changed the relationship between such regulations and net exports during the intervening period. The study includes two alternative measures of environmental regulations: first, the one based on Dasgupta et al. (1995) and extended by Eliste and Fredriksson (2001). The latter measure of environmental regulations is based on each country's change in energy intensity (energy use/GDP) over the period 1980 to 1995, together with the 1980 level of energy intensity. Second, Cole and Elliott (2003) is the use of a new trade model characterized by monopolistic competition and differentiated products following the development in trade theory owing to the coexistence of inter- and intra-industry trade (Dixit and Stiglitz, 1977; Helpman and Krugman, 1985). The study confirmed Tobey's (1990) results—namely, that environmental regulations did not significantly affect dirty exports. The outcomes of the analysis remained the same regardless of treating environmental regulation as an exogenous and/or endogenous variable, nor did it change when the energy intensity variable was replaced with environmental stringency index (Cole and Elliott, 2003). For the intra-industry trade model, the results suggested that the environmental regulations variable did not significantly impact the pollutive sectors in North–South trade analysis. On the possibility of finding evidence of the pollution haven hypothesis, the authors concluded that, while their research modeling did not focus on the direction of net trade, a finding of an increased share of net trade in total owing to differential environmental regulations was consistent with the pollution haven hypothesis (Cole and Elliott, 2003).

While many studies focused on developed and especially OECD countries for the impact of environmental regulation and trade, the Cantore and Cheng (2018) study has covered both developed and developing countries' trade flows in their analysis covering 2000 to 2014 for 38 developing and 33 developed countries. They, following OECD classification (Steenblik, 2005), chose 151 classification environmental goods. The study used an extended gravity model and estimated both fixed effect and random effect panel estimation techniques. For the gravity model, in addition to standard explanatory variables such as variables of GDP of both exports and importers, distance, and cultural variables, the model is extended using an environmental tax of the importing country and patent ratio export/importers, later shows the impact of environmental innovation on exports.

The study estimates the gravity model for total export and export flows for developed and developing countries. The panel analysis *inter alia* shows that environmental tax on import side coefficients for all bilateral export categories is negative and statistically significant for both developed and developing countries. This means that importing countries tend to import fewer environmental goods owing to environmental policy implementations, especially the developing countries wherein impacts are stronger. Therefore, owing to domestic environmental taxes, the importing country, rather than increasing its imports, diverted resources to enhance domestic production of environmental goods. This finding is in line with a robust version of the Porter hypothesis that advocates the win-win solution for environmental regulations and trade competitiveness (Cantore and Cheng, 2018).

The recent study by Du and Li (2020) examines the effect of environmental regulation on the low carbon transformation of China's export industries. Following Heckman's modeling approach, the study *inter alia* finds that the negative impact of environmental regulations on most pollutive industrial exports could be seen more in enterprises with more pollutive industrial exports compared to the ones who adopted relatively cleaner industrial exports. Therefore, the type of ownership may affect the effectiveness of the environmental policy impact.

Another study by Liu and Xie (2020) examines the application of the Porter hypothesis to the Chinese pollutive industrial sector to find if there is any trade-off between environmental regulations and industrial export competitiveness. They found that environmental regulations promote around 2 percent of the export competitiveness of China's manufacturing sector. Nonetheless, the relationship between environmental regulations and industrial trade competitiveness was non-linear. It displayed a U-shaped effect, indicating that specific prerequisites were imperative for the Porter hypothesis to work for Chinese industrial exports.

One specific aspect missing in most of the regression-based analyses reviewed earlier is that direct analysis of the changing comparative advantage of pollutive industrial exports over time has hardly been the focus of attention. One of the earlier works that drew attention towards that aspect was the one conducted by Low and Yeats (1992). Their research traces the evidence for pollution haven hypotheses and loss of competitiveness owing to the introduction of stringent environmental policies by OECD economies. The study examined the pollution redistribution phenomenon following a two-pronged strategy. Firstly, the study considered the actual trend in pollutive industry exports in developed and developing countries covering 1965 to 1988. Secondly, the study analysed what the Export Reveal Comparative Advantage (XRCA) model explains about the location displacement or pollution haven hypothesis for the same period. The study uses the modified version of the Balassa (1965, 1979) XRCA model and applies it to 109 selected countries. In its simple form, XRCA in an industry is measured by the share of that industry in the country's total exports relative to its share in total world exports of manufacturers. If this ratio (index) turns out to be less than one, then the country is at a comparative disadvantage in goods trade. For selecting the dirty industry's product, the paper focused mainly on five groups—namely, iron and steel, nonferrous metals, refined petroleum, metal manufacturers, and paper manufacturers—which are treated as the most pollutive industries in manufacturing production sectors (Low, and Yeats, 1992).

The empirical level analysis of Low and Yeats (1992) depicts a disproportionately large rise in the average number of developing countries with XRCA greater than unity in dirty industries, and expansion was observed in almost all polluting sectors. While developed countries showed a rise of 14 percent with the comparative advantage of dirty industries, the developing countries' increase in dirty industries was almost three times greater during the sample period. These outcomes suggested that the polluting industry activities were being dispersed internationally, and the dispersion was highest in the direction of developing countries. These results led the authors to conclude that developing economies are strong candidates for pollution haven effects. Nevertheless, in in-depth analysis for both developed and developing countries, iron and steel was the only industry central to their research that might produce an incomplete picture of the changing pattern of the export performance of environmentally sensitive commodities, as indicated by XU (1999).

Sorsa (1994) also examined the trade flow data of environmentally pollutive industries and environmental expenditures in seven OECD high standard countries: Austria, Finland, Germany, Japan, Norway, Sweden, and the United States. He drew a comparative analysis of world trade shares in the environmentally sensitive goods in 1970 with those of 1990 for industrialized and developing countries. He further calculated XRCA following Yeats (1985). His study results on the changing share of environmentally sensitive goods in industrialized countries *vis à vis* developing countries were similar to the results provided earlier by Low and Yeats (1992). Nevertheless, his statistical results showed that the world market share of environmentally sensitive goods did not change dramatically over the decades. XRCA analysis also confirmed his study findings that industrialized countries had maintained their competitiveness in environmentally sensitive industries.

The research by XU (1999) contended that earlier studies have seldom effectively explored the changing patterns of most pollutive industries trade at the highest disaggregated level. He criticized earlier research for either following too narrow an approach in terms of choice of just one specific industry—such as, the iron and steel industry by Low and Yeats (1992)—or looking at the issue at highly aggregated trade data level—such as, Sorsa (1994). He analyzed the impact of stringent environmental regulations on trade competitiveness by covering the period from 1965 to 1995 and using the UN Comtrade database for 34 countries, both OECD and non-OECD. He employed the Balassa index and trade data normalization technique offered by Gagnon and Rose (1995). Firstly, he examined what percentage of the export flows of environmentally sensitive goods (ESGs)[8] changed in 1995 compared with 1965 for each sample country. The expectation was that the environmentally sensitive commodities with a higher export performance at the beginning of the sample period would become less competitive in the end period. Then he used XRCA indexes (Balassa, 1965) to measure the comparative advantages of each commodity and country in two periods, 1965 and 1995, by separating the specialized and non-specialized pollutive industries. Specialized industry is where XRCA for the commodity is greater than one and vice versa is true for non-specialized commodities. He used a weighted version—that is, using normalized trade share of each commodity in 1990 as weight—and expressed this as a percentage. The study concludes that export performance of environmentally sensitive goods in most parts of the world did not change—that is, the comparative advantage of ESG did not change between 1965 to 1995, owing to the introduction of stringent environmental regulations in the advanced part of the world, especially in the 1970s and 1980s (XU, 1999).

XU (1999) offered an innovative and powerful methodology to address research questions regarding the impact of environmental regulations on trade competitiveness. One particular shortcoming in his study was the coverage area—that is, most of the CAREC countries which engaged in pollutive commodities exports were not included in the analysis among the list of non-OECD developing countries. Secondly, his study concluded that developing countries are not a pollution haven for developed countries based on findings of developed countries which could be seen as a violation of the pollution haven hypothesis test. After introducing some control on geography, Grether and de Melo (2004) argued that pollution haven is more of a bilateral trade phenomenon between developed and developing countries.

Whether the South is becoming a haven for the world's pollutive manufacturing production and trade for North consumers is discussed by Grether and de Melo (2004). The study aimed to re-examine the evidence of North–South delocalization of heavily polluting industries—that is, trace evidence of the pollution haven hypothesis by placing some control on geography during 1981 to 1998. Based on the World Bank database on trade (mirror exports) and production at 3-digit ISIC for 52 countries, the

[8] XU (1999) followed the standard literature in terms of identifying the five most pollutive sectors, which earlier studies such as Tobey (1990) and Low and Yeats (1992) did and termed them environmentally sensitive goods (ESGs).

study examined whether owing to the environmental regulatory gap between North and South the production and trade loci of most pollutive industries moved towards the South. The authors described this phenomenon as the delocalization effect. The study, based on earlier work by Hettige et al. (1992) and Mani and Wheeler (1999), has identified the five most pollutive sectors based on US industrial pollution intensity at 3-digit ISIC—namely, paper and products; industrial chemicals; other non-metallic mineral products; iron and steel; and non-ferrous metals. The cleaner industries for the US following Mani and Wheeler (1999) at 3-digit ISIC are textiles, non-electric machinery, electric machinery, transport equipment, and instruments.

At the modeling level, Grether and de Melo (2004) used a new decomposition by extending the Balassa based revealed comparative model that, apart from paving the way for analyzing the composition and technique affect, encompassed the geographic control aspect. The study further employed the gravity model and panel data methods. At the global level, the study found that the export revealed comparative advantage (XRCA) in polluting products fell in advanced countries and increased for the South, which one would expect if the environment were considered a normal good in consumption. Further, after controlling for geography, the study found evidence of a location shift from North to South countries in changing export patterns. The trend remained consistent for all pollutive industries except the non-ferrous metal industry, which reversed delocalization. Furthermore, gravity model based results showed that most polluter industries, on average, incur a high barrier to trade cost, thus rejecting the delocalization hypothesis.

### 4.5 Conclusion and Research Process

This chapter discussed some conceptual and measurement issues regarding the associations of environmental regulations and trade competitiveness. The chapter indicated that the impacts of environmental policy on competitiveness at conceptual levels are multidimensional and complex.

The results in most of the empirical work reviewed are sensitive to the type of model chosen/estimation technique employed, country(s)/period selected, and the nature of pollutive commodities/types of environmental regulation. One notable problem in the existing empirical literature on environmental regulations and trade associations is the lack of attention to drawing a comparative analysis between most pollutive and relatively less pollutive industry export patterns over time. This area is worth examining whether classifying different pollutive categories of environmentally sensitive industries produces somewhat similar or different conclusions. Secondly, there is a dearth of literature regarding the association of environmental regulations and trade that puts the same data to the security of cross methodological analysis, especially when the results are sensitive to the chosen methodology. Furthermore, the author of the present research did not find any comprehensive study for combined CAREC countries that analyzed the possible impact of environmental regulations on industrial trade competitiveness using the most pollutive to less pollutive industry trade at the disaggregated level trade data. Moreover, no efforts have been made to examine how the COVID-19 pandemic has affected the pollutive industrial export competitiveness of CAREC countries. The next two chapters of this study intend to fill these gaps in the literature.

## 5. Environmental Regulations and Trade Competitiveness: Statistical Modeling and Data Analysis

### 5.1 Introduction

The literature reviewed in previous chapters concluded that results regarding the likely impact of environmental regulations on pollutive manufacturing trade are sensitive to the chosen methodology. Accordingly, the research process has guided this study to use cross methodological empirical approaches to examine the impact of environmental policies on pollutive industrial trade competitiveness. Given the study research objectives, chapter five discusses the trade patterns for most pollutive and less pollutive industrial trade groups and their trade specialization patterns for selected CAREC countries. Section 5.2 explains the theoretical basis of the revealed comparative advantage (RCA) model offered by Balassa (1965, 1979, 1986) and sheds light on the strengths and weaknesses of the Balassa index and suitability of the index to measure pollutive industrial trade patterns over time.

In Section 5.3, the results based on RCA models for CAREC countries across pollutive manufacturing categories and individual industries within each category are described for 2006 to 2020. Moreover, in the wake of the COVID-19 pandemic the study examines the volatility in comparative advantage and competitiveness from most pollutive to less pollutive industry exports of selected CAREC region countries. It provides a comparative analysis between both most pollutive and less pollutive industry groups and countries. Section 5.4 concludes this chapter.

### 5.2 Comparative Advantage Modeling

At the modeling level, the starting point of the present research is the H-O-S theory of comparative advantage, which in two countries, two factors and two commodity cases advocates that *other things held constant* the factor in which a country is abundant should produce and export those factor intensive goods. The determinant of comparative advantage nonetheless differed among trade theories. The Ricardian theory explained the comparative advantage from the cost and technological differences, and the H-O-S theory, as mentioned above, relies on the factor price differences. The neo-factor proportion theory looked at factor efficiency, whereas the technological gap and product cycle theory focused on technological innovation as the cause of comparative advantage differences (Bender and Li, 2002). Theoretical literature showed more relevancy of factor abundance H-O-S theory for trade and environmental issues as the environment, when properly priced, is treated as another factor of production and, other things held constant, the more stringent the environmental regulations are the less the country's factor abundance and the more the loss of competitiveness (Pethig, 1976; Walter, 1975; McGuire, 1982; Copland and Taylor, 1994; Merrifield, 1988; Rauscher, 1997).

The theoretical concept of comparative advantage in the famous H-O-S model has usually been specified in terms of pretrade relative prices in a distortion free world wherein the market functions perfectly under complete information, which is difficult to observe in the real world and thus this concept faces a measurement problem. Trade statistics reflect only the post-trade situation. The empirical literature follows the observable data to reveal what would be the pattern of pretrade prices. Numbers of specialization measures based on a country's trade variables are used in the literature to reveal which of the goods a country has a pretrade comparative advantage in. The most popular and widely used for both single and multicountry analysis is the one pioneered by Balassa (Vollrath, 1991; Bender and Li, 2002; Balassa, 1965; Cole and Elliot, 2003).

Balassa (1965, 1979, 1986) coined the concept of RCA to measure the country's relative export performance of product categories, which assumed that the true pattern of comparative advantage could be observed from post-trade data. Although a large body of literature has used the Balassa model recently to analyze the trade competitiveness of manufacturing sectors for single and multicountry trade specialization analysis, this methodology has been applied with some adjustments to examine whether developed and/or developing countries are gaining the comparative advantage or disadvantage in environmentally sensitive goods owing to the introduction of stringent environmental regulations in most parts of the world (XU, 1999; Ratnayake, 1998; Sorsa, 1994; Low and Yeats, 1992; Stavropoulos et al., 2018). One of the key hypotheses examined using the Balassa (1965) model is whether stringent environmental regulations have affected the comparative advantage of pollutive industry trade patterns over time.

The Balassa (1965) index shows the share of the specific industry in the country's total exports as a proportion of that industry's share in total world industrial exports. If this ratio is greater than one, then the country has an export revealed comparative advantage, henceforth XRCA. If this ratio is less than one, the country has an exports revealed comparative disadvantage, henceforth XRCDA. The higher the value of XRCA, the greater the country's comparative advantage in the commodity concerned. The Balassa XRCA index is based on some restrictive assumptions that the trade patterns show the intercountry differences in international competitiveness in terms of relative costs as well as non-price factors. The index assumes the value between zero and infinity.

The index is specified as follows:

$$RCA_i = \left[ \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_j \sum_i X_{ij}} \right]_t \qquad \textbf{(5.1)}$$

Where in equation **(5.1)** $X_{ij}$ are the exports of commodity *i* at country *j*; $\sum_i X_{ij}$ are the total exports of the country *j*; $\sum_j X_{ij}$ are the world exports of commodity *i*(sum of country's commodities *i* exports; and $\sum_j \sum_i X_{ij}$ are the total world exports (Balassa, 1965 in Bender and Li, 2002:10-11).

This index is not free from limitations. Bowen (1983) criticized the Balassa index because it deals with both 'exports and imports separately when comparative advantage is properly a net trade concept.' But, as Balassa himself pointed out, the net export index that he used has the practical disadvantage of being affected by the idiosyncrasies of national import protection; in the case of intermediate products, the net exports are affected by the demand for further transformation in export production. Also, the other indicators offered to measure comparative advantage are not free from limitation either (XU, 1999).

Hillman (1980), using the analytical and mathematical model, has proved the theoretical justification for the use of the Balassa type index for comparative advantage analysis as it provides a pre-trade RCA based on post-trade data. Vollrath (1991), in a comprehensive survey on comparative advantage model indexes, justified the superiority of the Balassa index over other comparative advantage measures/indexes offered during the 1970s and 1980s. He depicted the superiority of the Balassa index over others as *inter alia* the Balassa index drew a clear distinction between a specific commodity and all other commodities and between a specific country and the rest of the world.

This study tends to adopt the Balassa model for the present research analysis. The Balassa index offers analysis closer to the true comparative advantage model because the design on which this index is based—two countries and two commodities—is consistent with what neoclassical trade theory offers. Recent empirical work on Chinese, South Asian and Southeast Asian economic trade structure transformation analysis further endorsed the Balassa index (in Pitigala, 2005; Bender and Li, 2002; Stavropoulos et al., 2018).

It is argued that the availability of data at different levels of aggregation and the data bias caused by government policy distortions (such as, non-trade barriers and export subsidies) caused immeasurable damage to the true pattern of comparative advantage. Therefore, the Balassa index might not reveal the true comparative advantage in the presence of domestic and international distortions. Nonetheless, the Balassa stages of comparative advantage thesis promote a catch-up process that paves the way to move the economies from one area of comparative advantage position to another. (Bender and Li, 2002). Furthermore, Ballance et al. (1987) and Fertö and Hubbard (2003), at commodity level analysis, in terms of producing consistent outcomes, show the superiority of ordinal and dichotomous, especially dichotomous measures over ordinal measures. Since at this stage of analysis for most and less pollutive industrial categories of exports of selected CAREC countries, the objective is to find evidence for a changing pattern of comparative advantage in exports that could be seen as dichotomous measures and the Balassa index performs this job more accurately. The index reflects inflationary effects in data, especially if there is an across the board rise in the price of all manufacturing exports. The export ratio of commodity is ascertained through dividing the particular commodity exports by the total country manufacturing exports; the index by Balassa also considers the macroeconomic trade balance effect. Another characteristic of the Balassa index is that dividing the country's sectoral share of a particular industrial category by the same sectoral share in the world exports of manufactured goods gives a general increase or decrease in world exports of a particular good—that is, the growth effect will not change (XU, 1999).

### 5.3 Export Patterns: Balassa Index Application to Selected CAREC Countries

In this section, using empirical results ascertained through the Balassa index, the study, in a dichotomous framework, concentrates mainly on the competitive position of exports for different pollutive industries from the period 2006 to 2010 to the period 2016 to 2020. The XRCA ratios for six CAREC countries—Azerbaijan, China, Georgia, Kazakhstan, Kyrgyzstan, and Pakistan—have been computed using SITC data at a disaggregated 2-digit level for most pollutive and less pollutive industries. Following the study research questions, increasingly stringent environmental regulations both domestic and international in the CAREC countries will negatively impact the different categories of pollutive industrial trade specialization patterns and competitiveness over time. The coronavirus disease (COVID-19) pandemic has significantly negatively impacted global trade, supply chains, and industrial export competitiveness. Several developing and low income economies with narrow export bases are disproportionately affected by the pandemic. The comparative advantage in exports can be disrupted during the global pandemic period and, depending on the country's economic growth reliance on international trade, volatility in world trade can seriously impact domestic trade competitiveness. The study, therefore, examines the volatility in exports competitiveness, especially in most pollutive industries during the pandemic year 2020, by comparing the results of RCA for the single country with averaged data from the last five years 2016 to 2020.

#### 5.3.1 Environmental Regulations and Industrial Export Competitiveness of Azerbaijan

Azerbaijan is rich in natural resources, and the economy relies on various mineral reserves. Beside oil and gas, the reserves of iron ore, zinc ore, molybdenum ore, alunite, rock salt, boring waters containing iodine and bromine, gypsum, limestone, bitumen, clay, and marble are used in industrial exploitation, including hydroelectric power resources (Almas and Hajiyev, 2014). The reliance on natural resource based industrial production and trade also reflects the country's comparative advantage in the world market. An analysis of the pollutive industrial comparative advantage in Table 5.1 shows that for the world's most pollutive industries group, Azerbaijan has virtually revealed comparative disadvantage (RCA<1), henceforth XRCDA, in all industries during 2006 to 2020, except petroleum products. The country maintains export revealed comparative advantage (RCA>1), henceforth XRCA, in the group of petroleum products in 2006 to 2010. It remained competitive during 2011 to 2020 in the same most pollutive industries group, and comparative advantage in petroleum products further rose in the world market during the end period 2016 to 2020. Following Lall (2001) technological sophistication based classification for manufacturing exports, the petroleum industry comes under primary products. In the same most pollutive industrial group, the results for manufactured fertilizers; iron and steel; non-ferrous metals; manufacturers of metals, nes suggest that even though these industries are not enjoying XRCA they have strengthened their competitiveness position from a very low XRCDA from 2006 to 2010 to an improved XRCDA during 2016 to 2020.

For the less pollutive industrial exports category in Table 5.1, Azerbaijan's results on comparative advantage in exports show generally that the country is less diversified in gaining the comparative export advantage in most of its industrial products during 2006 to 2020. The country exports, except for a few exceptions, remained uncompetitive in less pollutive industries during the same period. For example, the natural and manufactured gas industry faced XRCDA at the beginning of the sample period 2006 to 2010 but increased its export competitiveness in the same industrial category and enjoyed XRCA during 2011 to 2015 and 2016 to 2020. Whereas the less pollutive industries such as, animal and vegetable oil, and leather and leather manufacturing had XRCA from 2006 until 2015 but were faced with XRCDA during the end sample period 2016 to 2020. Explosives and pyrotechnic products was the only industry in Azerbaijan that maintained industrial exports competitiveness with XRCA during the entire sample period.

The country lost its export competitiveness during the pandemic year 2020 in several most pollutive industries—including petroleum sectors, a backbone for its economy—and in some less pollutive industries compared to the averaged 2016 to 2020 period. During the pandemic year, for several most pollutive export industries, XRCA rose, as well as for less pollutive industries. The sectoral exports RCA of Azerbaijan for 2020 indicate significant variations and shifts in comparative advantage/disadvantage in the industry compared to the past five years averaged trade periods in most pollutive and less pollutive industries.

### 5.3.2 Environmental Regulations and Industrial Export Competitiveness of China

China has achieved remarkable economic progress during the past 30 years. Among other factors, industrialization has played a major role in economic growth and increased world trade share. However, the rising growth has been achieved at the expense of deteriorating natural resources, high pollution, and relatively less stringent compliance with environmental regulations than its OECD trading partners. Owing to fears of industrial relocation and the pollution haven effect, the OECD countries demanded a level playing field by extending international pressure through several stringent domestic and international environmental agreements to developing countries' pollutive production and trade sectors. Accordingly, for more than ten years, the Chinese government has embarked on greener industrial production and growth strategies using both market based and non-market based environmental regulatory instruments and made a concerted effort towards industrial structural transformation. All these measures bring implications for China's comparative advantage in manufacturing exports. Compliance with stringent environmental regulations will eventually impact manufacturing production cost, industrial location, and gain from trade for China. As a result, compliance with stringent environmental measures could significantly impact the comparative advantage of industrial exports, especially on most pollutive industrial exports (Stavropoulos et al.; Gong et al., 2020).

The study results in Table 5.2 show that China maintained its export competitiveness and XRCA in several industries in the most pollutive industrial group during 2006 to 2020. These include manufactured fertilizers; cork and wood, cork manufacturers; non-metallic mineral manufacturers; iron and steel; and manufacturers of metals, nes. Owing to environmental regulations, these industries have not seen any loss of trade competitiveness in pollutive manufacturing exports during 2006 to 2020. Other most pollutive industries which had XRCDA in 2006 to 2010 remained non-competitive in industrial exports and witnessed XRCDA in 2016 to 2020. The results for comparative export advantage in most pollutive industries also show that a number of most pollutive industries are heading towards attaining export comparative advantage. Industries such as organic chemicals, paper and paperboard, and non-ferrous metals are close to gaining a comparative export advantage over the rest of the world. These results align with earlier work that suggests that the enhancement of environmental regulation will not impact a country's comparative advantage of trade. Harris et al. (2002) argued that if an industry is heavily dependent on the country's specific factor input, then environmental regulations will have no significant impact on the country's comparative advantage in trade. China, a labor-abundant country combined with relative lax environmental policies, has maintained a comparative advantage in resource based industries such as fertilizers and cork and wood and relatively non-footloose low technology pollutive industries such as iron and steel.

China is indeed the most diversified economy among the CAREC group countries and therefore showed XRCA in a number of industries among the group of less pollutive industrial exports. Apart from a food group, the country enjoys XRCA in several manufacturing industries. These industries include inorganic chemicals; rubber manufacturers, nes; textile yarn, fabrics, made-up articles, nes, and related products; general industrial machinery and equipment, nes, and parts of, nes; office machines and automatic data processing equipment; telecommunications, sound recording and reproducing equipment; electric machinery, apparatus and appliances, nes, and parts, nes; sanitary, plumbing, heating, lighting fixtures and fittings, nes; furniture and parts thereof; travel goods, handbags and similar containers; articles of apparel and clothing accessories; footwear; professional, scientific, controlling instruments, apparatus, nes; photographic equipment and supplies, optical goods, watches, and so on; miscellaneous manufactured articles, nes.

China has maintained its export competitiveness in all these industries during the beginning—2006 to 2010—and end sample periods—2016 to 2020. Following Lall (2000), technological sophistication based classification for manufacturing exports, these industries fall in various categories from primary products such as food groups to high technology products such as office machines, telecommunication, and electric machinery. Another notable feature in industrial trade competitiveness for less pollutive industry groups is that the manufacturing sector such as metalliferous ores and metal scrap, which had XRCDA during beginning periods 2006 to 2015, turned to XRCA in the end sample period 2016 to 2020. China's strong manufacturing export competitiveness and comparative advantage position in various technological classification categories among the group of less pollutive industries tend to reject the assertion and earlier findings by Cole and Elliott (2003) that only developed countries could enjoy the comparative export advantage in capital abundant and capital intensive sectors such as steel and chemical industries. The study results for relatively cleaner industries also confirm the Li et al. (2012) analysis regarding the impact of environmental regulation intensity on the comparative advantage of trade for the Chinese manufacturing industry. Their study concluded that China's abundant labor factor endowment is the main reason the comparative advantage of industry trade is concentrated in clean industries. The comparative analysis between most pollutive and relative less pollutive enterprises for China provides evidence for gaining industrial exports competitiveness for a number of industries in both most pollutive and less pollutive industries during the study period. As industrial trade competitiveness in most pollutive and less pollutive industries seemed to be either maintained or increased over the year, especially in the most pollutive group, this study can confirm that China has not lost its industrial trade competitiveness owing to the introduction of stringent environmental regulations over the years. There is further evidence for China becoming a haven for the world's most pollutive industrial exports. The sectoral shifts in exports comparative advantage/disadvantage during the pandemic (COVID-19) year 2020 *vis à vis* the export competitiveness of the last five years indicate the winners and losers in industrial trade competitiveness during the global pandemic but this study finds less volatility in the shifts of comparative advantage positions of China pollutive industrial sectors during pandemic year 2020 when export competitiveness data of the same industries during last five year was compared with the averaged period 2016 to 2020.

### 5.3.3 Environmental Regulations and Industrial Export Competitiveness of Georgia

Georgia has a locational advantage for being at the cross borders of the two biggest economic markets, namely Europe and Asia. The country has a substantial base to be a competitive export economy in the world trade market. As a newly born market economy, Georgia has made concerted efforts towards economic and trade liberalization and towards joining the integrated global village. The country joined the WTO in 2000 and developed strong trade links with the European Union, granting the country a Generalized System of Preferences (GSP) and a Deep and Comprehensive Free Trade Area (DCFTA). Georgia has among the highest level of compliance with environmental regulations within the CAREC region countries, [9] which, given the country's comparatively advantageous export standing in the world, can affect its trade competitiveness (Belkania, Davit, 2019). This study, like that of the other CAREC countries, applies the Balassa index of RCA to examine the change in export competitiveness of the most pollutive and less pollutive industries reflecting the industrial structural transformation owing to rising demand for the compliance of environmental regulations on industrial production and trade with OECD and other parts of the world (Belkania, Davit, 2019). The Balassa (1965) RCA index also identifies the key export sectors with comparative advantage and correspondingly with higher growth trade potential in those sectors.

In Table 5.3 Georgia, for the most pollutive industries group, has shown an RCA (Balassa index ratios >1) at 2-digit SITC level during 2006 to 2020 for the commodities including fertilizer manufactures and iron and steel throughout the study period; hence, the country maintained its export competitiveness. Following Lall (2000), these most pollutive industries are medium technology manufacturing and low technology manufacturing industries, respectively. The RCA index results for the same most pollutive group show that both cork and wood (resource based manufacturing) and paper and paper board (low technology) industries had an XRCDA both in 2006 to 2010 and 2011 to 2015 whereas, the country enjoyed XRCA in the end sample period and gained trade competitiveness. However, non-metallic mineral manufacturers nes in the most pollutive industries group, which were in a state of XRCA in 2006 to 2010, lost export competitiveness in the world market during the end sample period. Therefore, Georgia showed a mixed result on changing the comparative advantage position of most pollutive industrial exports.

In the less pollutive industries group, Georgia's XRCA remained intact from beginning to end of the sample periods between 2006 and 2020 for the industries including: live animals chiefly for food; beverages; metalliferous ores and metal scrap; electric current; animal oils and fats; inorganic chemicals; explosives and pyrotechnic products; and road vehicles. Regarding technological sophistication based classification for manufacturing exports, these industries cover primary products such as food to resource based products like beverages to medium technology industries such as road

[9] See Table 2.1, the Environmental Performance Index score of Georgia.

vehicles to high technology manufacturing inorganic chemicals of less pollutive industries. Therefore, Georgia has maintained its export competitiveness in diversified industrial traded goods, some of which are the world's fastest growing industrial exports. On the other hand, within the less pollutive industries group, the country has had an XRCA in some industries during the beginning period 2006 to 2010. However, it lost export competitiveness in the end sample periods. These industries include cork and wood; crude fertilizer and crude minerals; leather, leather manufacturers; other transport equipment; and gold, non-monetary (excluding gold ores and concentrates). The study also finds that some industries have had an XRCDA in 2006 to 2010 and moved to the competitive export category with XRCA during the end sample period 2016 to 2020. The sectors that exhibited a loss in export competitiveness during the end sample study period encompass tobacco, natural and manufactured; medicinal and pharmaceutical products; rubber manufacturing; and articles of apparel and clothing accessories. Again these industries range from primary products such as tobacco to high technological manufacturing goods like pharmaceutical products. The study finds mixed results regarding industrial trade competitiveness in a comparative static framework for most pollutive and less pollutive industries. Furthermore, less evidence supports the hypothesis that Georgia has lost industrial export competitiveness in most pollutive sectors owing to the rise in environmental regulations in production and traded sectors over the years. However, the RCA results for the COVID-19 period, 2020, show that the country increased its competitiveness most in the group of most pollutive industries compared to less pollutive industries, *vis-à-vis* sectoral exports competitiveness during the last five years of the averaged period 2016 to 2020.

### 5.3.4 Environmental Regulations and Industrial Export Competitiveness of Kazakhstan

Central Asian countries such as Kazakhstan and Kyrgyzstan face two daunting challenges: being landlocked and their production base being biased toward natural resources. Their landlocked geography significantly reduces their market accessibility, which limits their prospects for offshore export diversification strategies. Their heavy reliance on natural resources also substantially reduces their export competitiveness. The story of Kazakhstan's economic success is primarily thanks to its rich energy resources and the government's efforts in restructuring its centrally planned economy towards a more accessible market based economy (Khatibi, Arastou, 2008). More than 50 percent of its total exports were directed to OECD countries during 2006 to 2020 (Table 1.1).

Export diversification is among the most significant challenges the country faces. The Kazakhstan economy is currently heavily dependent on its energy resources, with its most pollutive industrial exports—including petroleum products, iron and steel, non-ferrous metals, and manufacturing of metals—accounting for more than 50 percent of the country's total manufacturing exports to OECD countries during 2006 to 2020 while those of less pollutive industries were just around 4 percent during 2006 to 2020 to OECD countries. This is reflected in Kazakhstan's trade comparative advantage/export competitiveness position *vis-à-vis* world exports in most pollutive and less pollutive industries.

Among the most pollutive industries, Kazakhstan has kept its XRCA and competitiveness on a small selection of industries—petroleum and petroleum products; iron and steel; and non-ferrous metals—both at the beginning of the analysis period 2006 to 2010 and at the end 2016 to 2020. Nevertheless, the country has not had a comparative advantage in exports in any other industries within the group of the most pollutive sectors during 2006 to 2020, except the industry XRCDA has reduced in chemical materials and products from the beginning to the end of the period studied. In the less pollutive industry group, the sources of country export comparative advantage, following Lall (2000) technological sophistication based classification for manufacturing exports, emanates primarily from primary products and resource based industries. These industries include crude fertilizer and crude minerals; metalliferous ores and metal scrap; coal, coke, and briquettes; gas, natural and manufactured; animal and vegetable oils and fats. All these industries had XRCA in 2006 to 2010 and maintained the XRCA until 2016 to 2020. Kazakhstan achieved export competitiveness in world exports in the high technology industry, but it was limited to one sector only—inorganic chemicals—wherein the country's XRCA remained consistent during the whole sample period. Furthermore, within the less pollutive industries, it had XRCA in leather and leather manufacturing; textile fibers; as well as in gold, non-monetary industries during 2006 to 2010; the country lost export competitiveness during 2011 to 2015 and 2016 to 2020, indicating the reversal of export specialization and competitiveness in those industries. However, the oil seed industry and coin (other than gold) sectors, which had XRCDA in 2006 to 2010, moved to export specialization and observed XRCA in the end period 2016 to 2020.

**5.3.5 Environmental Regulations and Industrial Export Competitiveness of Kyrgyzstan**

Kyrgyzstan, being landlocked like other Central Asian countries, lacks infrastructure and connection to the cross-border markets. These problems combined with rising transborder transportation costs have *inter alia* added to the slow economic growth and process of export diversification to non-natural resource base exports. The country's exports direction in most pollutive and less pollutive industries are less with OECD countries and more with other global regions (see Table 1.1). In the most pollutive industry categories, the non-metallic mineral manufacturing shows a consistent XRCA in the beginning and end study periods. The country maintained its export competitiveness position in that industry in the world export market. This study would expect the impact of environmental policies that have arisen over the years to reduce export competitiveness, especially in the most pollutive industries. The analysis for Kyrgyzstan, on the contrary, finds that a few most pollutive manufacturing sectors—such as, fertilizers, and iron and steel—have gained export competitiveness (RCA>1) during 2016 to 2020 from being XRCDA in 2006 to 2010. The results seem to suggest a pollution haven effect for Kyrgyzstan's most pollutive industry exports. All other sectors within the group of most pollutive industries remained uncompetitive in exports both during the beginning and end periods.

In the less pollutive industries, the industries that had XRCA during the entire study period included live animals chiefly for food; tobacco and tobacco manufactures; hides, skins and fur skins, raw; textile fibers; crude fertilizer; electric current; medicinal and pharmaceutical products; explosives and pyrotechnics products; articles of apparel and clothing accessories; and gold, non-monetary (excluding gold ores and concentrates). Some industries facing XRCDA during 2006 to 2010 moved to the XRCA group and gained competitiveness in world export markets during the end study period 2016 to 2020. Those industries included crude rubber; metalliferous ores and metal scrap; coal, coke, and briquettes; textile yarn, fabrics, made-up articles, nes, and related products; and footwear. There were fewer cases where industries faced XRCA during 2006 to 2010 or 2011 to 2015 and moved to XRCDA, except the beverage industry. Therefore, overall, Kyrgyzstan's industrial exports gained more competitiveness both in most pollutive and less pollutive industries and seemed to be less affected by the compliance of stringency of environmental regulation emanating from both national and international levels.

During the COVID-19 pandemic period, Kyrgyzstan's comparative advantage position in both the most pollutive industry and the less pollutive industry exports has shown volatility in export competitiveness compared to the country's last five years averaged exports competitiveness position in the world market. Especially in the most pollutive industrial group, the industries including petroleum and petroleum products, cork and wood, paper and pulp, and manufacturing metals moved to XRCA in the volatile economic period 2020 as from XRCDA during 2016 to 2020. Therefore, the study finds sharp structural shifts in export competitiveness in the most pollutive industries. The study finds similar trends for several of the less pollutive industries of Kyrgyzstan.

### 5.3.6 Environmental Regulations and Industrial Exports Competitiveness of Pakistan

Pakistan, a member of the CAREC club, is also part of the South Asian region, which is home to 22 percent of the world population. The country has not received much attention in the literature to examine the association between environmental regulations and trade competitiveness. South Asia is one of the fastest growing regions globally and depicted a rapid expansion of trade during the liberalization periods of the 1980s and 1990s (Kemal et al., 2000). Confronted with environmental pollution issues, Pakistan has made progress during the 1990s and onwards in creating environmental institutions, strengthening environmental protection activities, and improving environmental governance through *inter alia* creating environmental ministries, environmental protection agencies, and emerging independent bodies such as NGOs. These efforts are focused on creating an environment of internalizing the environmental externalities using environmental regulatory tools and promoting and encouraging property rights that foster new institutions at grassroots level for environmental management. South Asian economies still rely on regulatory—command and control—mechanisms for accomplishing environmental control objectives than those of market based economic instruments. Pakistan is gradually moving towards market based instruments like assigning the proper pricing to environmental resources such as water at industrial level (UNIDO, 2000).

In Table 5.6, the most pollutive industrial group results show that Pakistan faced XRCDA in the beginning period 2006 to 2010 in most commodities, except for non-metallic mineral manufacturers. In later industries it had an XRCA in 2011 to 2015, but for the end period, 2016 to 2020, XRCDA in all the most pollutive, except for organic chemicals. The country gained export competitiveness in organic chemical exports in world pollutive industrial exports during 2016 to 2020. The results of RCA for most pollutive industries category revealed that XRCDA for most industries receded over time. The computed RCA values for those industries were near the XRCA region—such as, fertilizer manufacturing (0.98) and petroleum products (0.72)—during 2016 to 2020 compared to shallow RCA values of the same industries during 2006 to 2010. Despite liberalization efforts since the 1980s, the country's exports are not much diversified. Its comparative advantage in exports *vis-à-vis* world industrial exports concentrates mainly on selected primary and resource based manufacturing products. Therefore, the introduction of environmental regulations in manufacturing sectors has not had a discernable impact on industrial export competitiveness. Instead, there are more signs of gaining competitiveness in some of the world's most pollutive industries.

For the less pollutive industrial exports category, the industries that maintained the comparative export advantage throughout 2006 to 2020 included live animals chiefly for food; textile fibers (not wool tops) and their wastes (not in yarn); fixed vegetable oils and fats; explosives and pyrotechnic products; leather and leather manufacturers' products; textile yarn, fabrics, made-up articles, nes, and related products; and articles of apparel and clothing accessories. Other industrial sectors in a state of XRCDA in 2006 to 2010 but which moved to XRCA in 2016 to 2020 included oil seeds and oleaginous fruit; crude fertilizer and crude minerals; coal, coke and briquettes; gas, natural and manufactured; animal oils and fats; dyeing, tanning and coloring materials; and artificial resins and plastic materials, and cellulose esters. However, the footwear industry in a state of XRCA in 2006 to 2010 became XRCDA and lost export competitiveness in 2016 to 2020. As a whole, based on comparative advantage in exports for Pakistan, the study did not find the less pollutive industries lost trade competitiveness owing to the introduction of both internal and external environmental regulations.

The RCA results for the pandemic year 2020 suggest that Pakistan improved its comparative advantage in several industries among the group of most pollutive industries. Comparing the XRCA results of the COVID-19 year 2020 with the last five year average of 2016 to 2020, this study finds mixed outcomes for the less pollutive industries. The sectors that showed improvement in export competitiveness include hides, skins, and furskins; crude rubber (including synthetic and reclaimed); metalliferous ores and metal scrap; crude animal and vegetable materials, nes; inorganic chemicals; rubber manufacturers, nes; power generating machinery and equipment; machinery specialized for particular industries; and telecommunications, sound recording and reproducing equipment. However, industries showing lost export competitiveness in 2020 include live animals chiefly for food; animal oils and fats; explosives and pyrotechnic products; leather, leather manufacturers, nes, and dressed furskins; and footwear. Lastly, in the wake of global trade volatility from COVID-19 in 2000, the study found sharp variation and shifts in sectoral comparative advantage/disadvantage in industrial exports in both pollutive industry groups compared to the average industrial export competitiveness in the last five years, hence indicating volatility in pollutive manufacturing exports during 2020.

The graphical analysis of XRCDA for the CAREC countries in the world's most pollutive industrial exports provides further insight into the changing trends in industrial trade competitiveness during 2006 to 2020. The analysis also highlights how the COVID-19 pandemic has impacted pollutive industrial export competitiveness in terms of both gains and losses of comparative advantage.

First, Figures 5.1 and 5.2 show the trends in changing RCAs and export competitiveness scenarios during 2006 to 2020 for the six selected CAREC countries incorporating the global trade shock witnessed during the pandemic year 2020. Figure 5.1 shows the steady change in RCA in several industries of the most pollutive industry group in Azerbaijan, China, and Georgia over the years. However, the study finds relatively more variation in changing RCAs for Georgia during 2016 to 2020 for some pollutive sectors than the other two countries. The trends seemed to be continued for the rest of the three CAREC countries as shown in Figure 5.2.

This study finds significant volatility in the group of most pollutive industrial export competitiveness positions for all selected CAREC countries when RCAs of pandemic year 2020 are compared to the last five years' averaged RCAs from 2016 to 2020, as Figures 5.3 and 5.4 reveal. The graphic illustration in Figure 5.3 *inter alia* shows that Azerbaijan lost trade competitiveness during the pandemic year 2020 in its most vital industrial sector exports of petroleum products but had XRCA and thus export competitiveness in many other most pollutive sectors such as fertilizers, chemical materials and products, and iron and steel. The study findings for China and Georgia indicate the winners and losers in maintaining export competitiveness through changes in sectoral RCA in the most pollutive industries. However, China seemed to have experienced less volatility regarding the loss of most pollutive industrial export competitiveness during the pandemic year 2020 as compared to other CAREC countries.

The analysis depicted in Figure 5.4 shows that, compared to the average export comparative advantage position of the last five years, Kyrgyzstan and Pakistan also saw volatility in RCA trends during the pandemic period. However, unlike other CAREC countries, these two countries increased their export competitiveness in most sectors of pollutive industry during the COVID-19 pandemic year 2020 as compared with the last five-year averaged period 2016 to 2020. Therefore, drawing any conclusions and setting long term trade and sustainable environmental development policy objectives based on just COVID-19 period results and without studying the trade competitiveness performances of past years on pollutive industrial export competitiveness for CAREC regions could be erroneous and less effective.

### 5.4 Conclusion

This study results based on the Balassa comparative model show that the impact of environmental regulations on industrial trade is sensitive to industry groups and individual industries; results vary for different pollutive industrial groups from most pollutive to least pollutive. There is an increasing tendency to gain export competitiveness in the most pollutive industries among a number of CAREC countries, signaling the presence of the pollution haven effect. For some other CAREC countries, there are changes in the location of production and trade specialization. Overall, over time, based on a comparative analysis between the most pollutive and less pollutive industries, fewer systematic trends emerged regarding the impact of environmental regulations on the trade specialization patterns of pollutive industries in the CAREC countries. Most CAREC countries still face diversity challenges and rely on primary and resource based exports and are still some way off trade competitiveness in high technology manufacturing production and exports. The study findings for the CAREC region show that the COVID-19 pandemic has negatively affected export competitiveness mostly for countries that rely on primarily natural resource based and less diversified industrial trade.

Table 5.1 **Revealed Comparative Advantage of Azerbaijan Pollutive Manufacturing Exports: 2006-2020**

| Industry category | Ind. code | Commodity Name/Year | 2006-2010 RCA | 2011-2015 RCA | 2016-2020 RCA | 2020* RCA |
|---|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.00 | 0.00 | 0.02 | 0.01 |
| | 33 | Petroleum, petroleum products and related materials | **8.14** | **7.31** | **9.56** | 0.41 |
| | 51 | Organic chemicals | 0.07 | 0.11 | 0.18 | 0.19 |
| | 56 | Fertilizers, manufactured | 0.02 | 0.03 | 0.46 | **2.96** |
| | 59 | Chemical materials and products, nes | 0.03 | 0.03 | 0.21 | **1.33** |
| | 63 | Cork and wood, cork manufactures | 0.01 | 0.01 | 0.39 | **3.01** |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.01 | 0.04 | 0.25 | **2.01** |
| | 66 | Non-metallic mineral manufactures, nes | 0.01 | 0.01 | 0.20 | **1.48** |
| | 67 | Iron and steel | 0.08 | 0.09 | 0.48 | **3.05** |
| | 68 | Non-ferrous metals | 0.17 | 0.20 | 0.43 | 0.25 |
| | 69 | Manufactures of metals, nes | 0.13 | 0.01 | 0.30 | **2.06** |
| Less Pollutive Industries | 0 | Live animals chiefly for food | 0.36 | 0.48 | 0.61 | **5.88** |
| | 11 | Beverages | 0.08 | 0.10 | 0.16 | 0.96 |
| | 12 | Tobacco and tobacco manufactures | 0.18 | 0.19 | 0.74 | **4.02** |
| | 21 | Hides, skins and furskins, raw | 0.26 | 0.34 | 0.97 | 0.00 |
| | 22 | Oil seeds and oleaginous fruit | 0.01 | 0.01 | 0.08 | 0.48 |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.00 | 0.00 | 0.10 | 0.07 |
| | 24 | Cork and wood | 0.01 | 0.01 | 0.34 | **2.88** |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | 0.56 | 0.11 | **1.64** | 0.49 |
| | 27 | Crude fertilizer and crude minerals | 0.12 | 0.23 | 0.55 | **1.62** |
| | 28 | Metalliferous ores and metal scrap | 0.19 | 0.05 | 0.08 | 0.15 |
| | 29 | Crude animal and vegetable materials, nes | 0.03 | 0.10 | 0.28 | **1.50** |
| | 32 | Coal, coke and briquettes | 0.00 | 0.00 | 0.02 | 0.08 |
| | 34 | Gas, natural and manufactured | 0.28 | **1.47** | **5.17** | 0.04 |
| | 35 | Electric current | 0.38 | 0.57 | **1.47** | 0.31 |
| | 41 | Animal oils and fats | 0.02 | 0.00 | 0.06 | **3.60** |
| | 42 | Fixed vegetable oils and fats | 0.45 | 0.67 | 0.40 | **2.85** |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | **2.75** | **2.71** | 0.41 | 0.86 |
| | 52 | Inorganic chemicals | 0.04 | 0.06 | 0.21 | **1.26** |
| | 53 | Dyeing, tanning and colouring materials | 0.01 | 0.01 | 0.21 | **1.46** |
| | 54 | Medicinal and pharmaceutical products | 0.08 | 0.17 | 0.42 | 0.90 |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | 0.00 | 0.00 | 0.32 | **2.37** |
| | 57 | Explosives and pyrotechnic products | **1.46** | **1.70** | **2.93** | 0.11 |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.24 | 0.28 | 0.43 | **1.01** |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | **1.34** | **2.48** | 0.81 | 0.07 |
| | 62 | Rubber manufactures, nes | 0.00 | 0.00 | 0.16 | **1.36** |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | 0.08 | 0.11 | 0.28 | **1.16** |
| | 71 | Power generating machinery and equipment | 0.01 | 0.01 | 0.10 | 0.78 |
| | 72 | Machinery specialized for particular industries | 0.07 | 0.11 | 0.30 | **1.87** |
| | 73 | Metalworking machinery | 0.02 | 0.09 | 0.14 | **1.21** |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | 0.05 | 0.06 | 0.29 | **2.12** |
| | 75 | Office machines and automatic data processing equipment | 0.00 | 0.00 | 0.06 | 0.41 |
| | 76 | Telecommunications, sound recording and reproducing equipment | 0.00 | 0.00 | 0.14 | **1.13** |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | 0.00 | 0.01 | 0.08 | 0.47 |
| | 78 | Road vehicles | 0.00 | 0.00 | 0.14 | **1.12** |
| | 79 | Other transport equipment | 0.30 | 0.07 | 0.19 | **1.67** |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | 0.08 | 0.04 | 0.18 | **3.84** |
| | 82 | Furniture and parts thereof | 0.04 | 0.01 | 0.11 | 0.81 |
| | 83 | Travel goods, handbags and similar containers | 0.00 | 0.00 | 0.05 | 0.49 |
| | 84 | Articles of apparel and clothing accessories | 0.00 | 0.00 | 0.12 | 0.93 |
| | 85 | Footwear | 0.00 | 0.00 | 0.13 | **1.06** |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | 0.02 | 0.02 | 0.14 | 0.84 |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | 0.00 | 0.00 | 0.09 | 0.78 |
| | 89 | Miscellaneous manufactured articles, nes | 0.01 | 0.01 | 0.13 | 0.89 |
| | 96 | Coin (other than gold coin), not being legal tender | 0.00 | 0.00 | 0.00 | 0.00 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | 0.00 | 0.00 | 0.31 | 0.00 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in Bold

Author's calculations based on UNComtrade SITC revision-2 data

*: Owing to world pandemic in 2020 (COVID-19) RCA 2020 results are subject to the volatility in world exports

Table 5.2 **Revealed Comparative Advantage of China Pollutive Manufacturing Exports: 2006-2020**

| Industry Category | Ind. code | Commodity Name/Year | 2006-2010 RCA | 2011-2015 RCA | 2016-2020 RCA | 2020* RCA |
|---|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.06 | 0.05 | 0.56 | **2.94** |
| | 33 | Petroleum, petroleum products and related materials | 0.11 | 0.10 | 0.40 | **1.46** |
| | 51 | Organic chemicals | 0.72 | 0.82 | 0.96 | 0.93 |
| | 56 | Fertilizers, manufactured | **1.21** | **1.37** | **1.25** | 0.39 |
| | 59 | Chemical materials and products, nes | 0.62 | 0.64 | 0.71 | 0.76 |
| | 63 | Cork and wood, cork manufactures | **1.57** | **1.60** | **1.28** | 0.20 |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.54 | 0.82 | 0.81 | 0.40 |
| | 66 | Non-metallic mineral manufactures, nes | **1.03** | **1.20** | **1.04** | 0.64 |
| | 67 | Iron and steel | **1.09** | **1.11** | **1.08** | 0.99 |
| | 68 | Non-ferrous metals | 0.62 | 0.57 | 0.76 | **1.45** |
| | 69 | Manufactures of metals, nes | **1.74** | **1.82** | **1.52** | 0.33 |
| Less Pollutive Industries | 0 | Live animals chiefly for food | 0.48 | 0.44 | 0.43 | 0.25 |
| | 11 | Beverages | 0.11 | 0.10 | 0.13 | 0.39 |
| | 12 | Tobacco and tobacco manufactures | 0.24 | 0.25 | 0.24 | 0.26 |
| | 21 | Hides, skins and furskins, raw | 0.02 | 0.01 | 0.16 | **1.56** |
| | 22 | Oil seeds and oleaginous fruit | 0.14 | 0.08 | 0.70 | **3.89** |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.10 | 0.12 | 0.24 | **1.66** |
| | 24 | Cork and wood | 0.17 | 0.10 | 0.38 | **2.14** |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | 0.60 | 0.58 | 0.86 | **1.90** |
| | 27 | Crude fertilizer and crude minerals | 0.81 | 0.71 | 0.82 | **1.26** |
| | 28 | Metalliferous ores and metal scrap | 0.04 | 0.01 | **1.01** | **3.85** |
| | 29 | Crude animal and vegetable materials, nes | 0.75 | 0.84 | 0.68 | 0.39 |
| | 32 | Coal, coke and briquettes | 0.76 | 0.18 | 0.45 | **1.56** |
| | 34 | Gas, natural and manufactured | 0.19 | 0.19 | 0.46 | **1.35** |
| | 35 | Electric current | 0.36 | 0.37 | 0.36 | 0.05 |
| | 41 | Animal oils and fats | 0.06 | 0.03 | 0.02 | 0.72 |
| | 42 | Fixed vegetable oils and fats | 0.11 | 0.05 | 0.24 | **1.03** |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | 0.08 | 0.07 | 0.27 | 0.99 |
| | 52 | Inorganic chemicals | **1.36** | **1.22** | **1.14** | 0.69 |
| | 53 | Dyeing, tanning and colouring materials | 0.64 | 0.70 | 0.71 | 0.56 |
| | 54 | Medicinal and pharmaceutical products | 0.30 | 0.30 | 0.30 | 0.40 |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | 0.28 | 0.34 | 0.48 | **1.04** |
| | 57 | Explosives and pyrotechnic products | 0.41 | 0.42 | 0.41 | 0.22 |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.43 | 0.51 | 0.68 | **1.40** |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | 0.67 | 0.59 | 0.49 | **1.31** |
| | 62 | Rubber manufactures, nes | **1.06** | **1.19** | **1.00** | 0.71 |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | **2.81** | **2.92** | **2.46** | 0.41 |
| | 71 | Power generating machinery and equipment | 0.59 | 0.68 | 0.64 | 0.48 |
| | 72 | Machinery specialized for particular industries | 0.62 | 0.73 | 0.91 | **1.02** |
| | 73 | Metalworking machinery | 0.51 | 0.54 | 0.56 | **1.17** |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | **1.07** | **1.19** | **1.17** | 0.63 |
| | 75 | Office machines and automatic data processing equipment | **3.40** | **3.16** | **2.39** | **1.05** |
| | 76 | Telecommunications, sound recording and reproducing equipment | **2.81** | **2.93** | **2.40** | 0.20 |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | **1.46** | **1.60** | **1.52** | 1.86 |
| | 78 | Road vehicles | 0.39 | 0.43 | 0.51 | 0.49 |
| | 79 | Other transport equipment | 0.85 | 0.90 | 0.63 | 0.46 |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | **1.36** | **1.88** | **1.31** | 0.18 |
| | 82 | Furniture and parts thereof | **2.62** | **2.93** | **2.11** | 0.11 |
| | 83 | Travel goods, handbags and similar containers | **4.18** | **3.89** | **2.91** | 0.95 |
| | 84 | Articles of apparel and clothing accessories | **3.53** | **3.23** | **2.28** | 0.19 |
| | 85 | Footwear | **3.77** | **3.55** | **2.40** | 0.41 |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | **1.20** | **1.22** | **1.31** | **1.42** |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | **1.01** | **1.10** | **1.05** | 0.99 |
| | 89 | Miscellaneous manufactured articles, nes | **1.71** | **2.02** | **1.43** | 0.38 |
| | 96 | Coin (other than gold coin), not being legal tender | 0.06 | 0.01 | 0.05 | 0.00 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | 0.00 | 0.01 | 0.07 | 0.23 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in Bold
Author's calculations based on UNComtrade SITC revision-2 data
*: Owing to world pandemic in 2020 (COVID-19) RCA 2020 results are subject to the volatility in world exports

Table 5.3 **Revealed Comparative Advantage of Georgia Pollutive Manufacturing Exports: 2006-2020**

| Industry Category | Ind. code | Commodity Name/Year | 2006-2010 RCA | 2011-2015 RCA | 2016-2020 RCA | 2020* RCA |
|---|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.11 | 0.16 | 0.16 | 0.01 |
| | 33 | Petroleum, petroleum products and related materials | 0.17 | 0.16 | 0.49 | **1.07** |
| | 51 | Organic chemicals | 0.01 | 0.03 | 0.12 | 0.24 |
| | 56 | Fertilizers, manufactured | **12.04** | **10.53** | **5.01** | 0.69 |
| | 59 | Chemical materials and products, nes | 0.14 | 0.15 | 0.57 | **1.09** |
| | 63 | Cork and wood, cork manufactures | 0.83 | 0.93 | **2.44** | **3.07** |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.11 | 0.30 | **1.07** | **2.44** |
| | 66 | Non-metallic mineral manufactures, nes | **1.94** | 0.63 | 0.87 | **2.16** |
| | 67 | Iron and steel | **4.67** | **5.01** | **3.71** | **1.78** |
| | 68 | Non-ferrous metals | 0.14 | 0.16 | 0.33 | 0.26 |
| | 69 | Manufactures of metals, nes | 0.18 | 0.21 | 0.74 | **1.56** |
| Less Pollutive Industries | 0 | Live animals chiefly for food | **1.85** | **2.20** | **1.36** | **1.83** |
| | 11 | Beverages | **8.80** | **9.39** | **8.25** | **1.16** |
| | 12 | Tobacco and tobacco manufactures | 0.02 | 0.28 | **8.03** | **6.15** |
| | 21 | Hides, skins and furskins, raw | **2.36** | 0.14 | **1.14** | 0.01 |
| | 22 | Oil seeds and oleaginous fruit | 0.85 | 0.11 | 0.13 | 0.20 |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.11 | 0.11 | 0.43 | 0.62 |
| | 24 | Cork and wood | **2.24** | 0.85 | 0.77 | 0.43 |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | 0.16 | 0.11 | 0.61 | **1.44** |
| | 27 | Crude fertilizer and crude minerals | **1.27** | 0.46 | 0.98 | **1.46** |
| | 28 | Metalliferous ores and metal scrap | **10.26** | **5.40** | **8.03** | **3.47** |
| | 29 | Crude animal and vegetable materials, nes | 0.85 | 0.61 | 0.92 | **1.29** |
| | 32 | Coal, coke and briquettes | 0.05 | 0.02 | 0.28 | 0.71 |
| | 34 | Gas, natural and manufactured | 0.05 | 0.11 | **1.01** | **2.61** |
| | 35 | Electric current | **5.05** | **3.95** | **3.47** | **5.19** |
| | 41 | Animal oils and fats | **1.06** | **3.37** | **1.09** | **2.16** |
| | 42 | Fixed vegetable oils and fats | 0.11 | 0.21 | 0.64 | **1.57** |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | 0.24 | 0.11 | 0.41 | 0.36 |
| | 52 | Inorganic chemicals | **1.13** | **1.68** | **1.06** | 0.48 |
| | 53 | Dyeing, tanning and colouring materials | 0.12 | 0.16 | 0.84 | **1.79** |
| | 54 | Medicinal and pharmaceutical products | 0.60 | **1.12** | **1.49** | **1.25** |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | **1.01** | 0.88 | **1.45** | **2.50** |
| | 57 | Explosives and pyrotechnic products | **11.50** | **12.02** | **5.04** | **3.75** |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.27 | 0.30 | 0.61 | 0.93 |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | **1.99** | 0.39 | 0.28 | 0.45 |
| | 62 | Rubber manufactures, nes | 0.12 | 0.51 | **1.55** | **1.98** |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | 0.03 | 0.04 | 0.61 | **1.23** |
| | 71 | Power generating machinery and equipment | 0.14 | 0.10 | 0.17 | 0.27 |
| | 72 | Machinery specialized for particular industries | 0.38 | 0.20 | 0.53 | **1.04** |
| | 73 | Metalworking machinery | 0.21 | 0.32 | 0.34 | 0.78 |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | 0.15 | 0.14 | 0.57 | 0.98 |
| | 75 | Office machines and automatic data processing equipment | 0.07 | 0.12 | 0.17 | 0.26 |
| | 76 | Telecommunications, sound recording and reproducing equipment | 0.04 | 0.11 | 0.36 | 0.85 |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | 0.05 | 0.08 | 0.19 | 0.29 |
| | 78 | Road vehicles | **1.12** | **2.74** | **1.71** | **1.82** |
| | 79 | Other transport equipment | **1.49** | 0.66 | 0.15 | 0.17 |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | 0.97 | 0.92 | 1.48 | **6.21** |
| | 82 | Furniture and parts thereof | 0.28 | 0.36 | 0.46 | **1.04** |
| | 83 | Travel goods, handbags and similar containers | 0.14 | 0.13 | 0.25 | 0.77 |
| | 84 | Articles of apparel and clothing accessories | 0.56 | 0.93 | **1.03** | 0.83 |
| | 85 | Footwear | 0.08 | 0.11 | 0.46 | **1.06** |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | 0.09 | 0.14 | 0.31 | 0.37 |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | 0.03 | 0.11 | 0.36 | 0.40 |
| | 89 | Miscellaneous manufactured articles, nes | 0.16 | 0.14 | 0.46 | 0.84 |
| | 96 | Coin (other than gold coin), not being legal tender | 0.12 | 0.12 | 0.04 | 0.00 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | **8.72** | **1.43** | 0.80 | 0.00 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in Bold

Author's calculations based on UNComtrade SITC revision-2 data

*: Owing to world pandemic in 2020 (COVID-19) RCA 2020 results are subject to the volatility in world exports

Table 5.4 **Revealed Comparative Advantage of Kazakhstan Pollutive Manufacturing Exports: 2006-2020**

| Industry Category | Ind. code | Commodity Name/Year | 2006-2020 RCA | 2011-2015 RCA | 2016-2020 RCA |
|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.00 | 0.02 | 0.14 |
| | 33 | Petroleum, petroleum products and related materials | 5.56 | 5.52 | 7.84 |
| | 51 | Organic chemicals | 0.01 | 0.02 | 0.04 |
| | 56 | Fertilizers, manufactured | 0.15 | 0.17 | 0.48 |
| | 59 | Chemical materials and products, nes | 0.10 | 0.01 | 0.05 |
| | 63 | Cork and wood, cork manufactures | 0.01 | 0.05 | 0.03 |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.04 | 0.04 | 0.03 |
| | 66 | Non-metallic mineral manufactures, nes | 0.03 | 0.04 | 0.11 |
| | 67 | Iron and steel | 2.25 | 2.15 | 4.02 |
| | 68 | Non-ferrous metals | 3.39 | 3.36 | 4.31 |
| | 69 | Manufactures of metals, nes | 0.06 | 0.06 | 0.06 |
| Less Pollutive Industries | 0 | Live animals chiefly for food | 0.65 | 0.45 | 0.80 |
| | 11 | Beverages | 0.03 | 0.06 | 0.14 |
| | 12 | Tobacco and tobacco manufactures | 0.33 | 0.46 | 0.78 |
| | 21 | Hides, skins and furskins, raw | 0.11 | 0.05 | 0.02 |
| | 22 | Oil seeds and oleaginous fruit | 0.10 | 0.41 | 1.01 |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.01 | 0.02 | 0.08 |
| | 24 | Cork and wood | 0.01 | 0.01 | 0.14 |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | 1.31 | 0.53 | 0.87 |
| | 27 | Crude fertilizer and crude minerals | 2.73 | 3.88 | 4.44 |
| | 28 | Metalliferous ores and metal scrap | 3.12 | 2.61 | 2.93 |
| | 29 | Crude animal and vegetable materials, nes | 0.03 | 0.14 | 0.15 |
| | 32 | Coal, coke and briquettes | 1.91 | 1.85 | 1.33 |
| | 34 | Gas, natural and manufactured | 1.45 | 1.81 | 3.30 |
| | 35 | Electric current | 0.28 | 0.48 | 0.68 |
| | 41 | Animal oils and fats | 7.12 | 4.69 | 8.21 |
| | 42 | Fixed vegetable oils and fats | 0.12 | 0.15 | 0.44 |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | 1.57 | 1.15 | 3.51 |
| | 52 | Inorganic chemicals | 5.31 | 6.49 | 3.11 |
| | 53 | Dyeing, tanning and colouring materials | 0.04 | 0.04 | 0.07 |
| | 54 | Medicinal and pharmaceutical products | 0.04 | 0.02 | 0.08 |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | 0.05 | 0.08 | 0.06 |
| | 57 | Explosives and pyrotechnic products | 0.16 | 0.04 | 0.15 |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.02 | 0.04 | 0.06 |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | 1.36 | 0.09 | 0.18 |
| | 62 | Rubber manufactures, nes | 0.07 | 0.06 | 0.10 |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | 0.07 | 0.02 | 0.08 |
| | 71 | Power generating machinery and equipment | 0.02 | 0.03 | 0.03 |
| | 72 | Machinery specialized for particular industries | 0.05 | 0.07 | 0.12 |
| | 73 | Metalworking machinery | 0.03 | 0.10 | 0.20 |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | 0.07 | 0.07 | 0.08 |
| | 75 | Office machines and automatic data processing equipment | 0.00 | 0.08 | 0.01 |
| | 76 | Telecommunications, sound recording and reproducing equipment | 0.01 | 0.04 | 0.02 |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | 0.02 | 0.02 | 0.03 |
| | 78 | Road vehicles | 0.01 | 0.01 | 0.02 |
| | 79 | Other transport equipment | 0.32 | 0.21 | 0.21 |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | 0.13 | 0.10 | 0.28 |
| | 82 | Furniture and parts thereof | 0.00 | 0.00 | 0.01 |
| | 83 | Travel goods, handbags and similar containers | 0.00 | 0.02 | 0.06 |
| | 84 | Articles of apparel and clothing accessories | 0.00 | 0.01 | 0.02 |
| | 85 | Footwear | 0.01 | 0.10 | 0.08 |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | 0.02 | 0.02 | 0.02 |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | 0.00 | 0.00 | 0.01 |
| | 89 | Miscellaneous manufactured articles, nes | 0.02 | 0.07 | 0.09 |
| | 96 | Coin (other than gold coin), not being legal tender | 0.00 | 0.05 | 1.23 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | 1.49 | 0.37 | 0.01 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depiced in Bold

Author's calculations based on UNComtrade SITC revision-2 data

UN Comtrade SITC Trade data was not available for 2020.

Table 5.5 **Revealed Comparative Advantage of Kyrgystan Pollutive Manufacturing Exports: 2006-2020**

| Industry Category | Ind. code | Commodity Name/Year | 2006-2010 RCA | 2011-2015 RCA | 2016-2020 RCA | 2020* RCA |
|---|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.05 | 0.00 | 0.02 | 0.05 |
| | 33 | Petroleum, petroleum products and related materials | 0.61 | 0.47 | 0.89 | **1.91** |
| | 51 | Organic chemicals | 0.02 | 0.01 | 0.06 | 0.10 |
| | 56 | Fertilizers, manufactured | 0.31 | 0.45 | **1.34** | **3.06** |
| | 59 | Chemical materials and products, nes | 0.31 | 0.14 | 0.44 | 0.97 |
| | 63 | Cork and wood, cork manufactures | 0.13 | 0.06 | 0.84 | **2.65** |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.34 | 0.41 | 0.57 | **1.60** |
| | 66 | Non-metallic mineral manufactures, nes | **2.35** | **1.17** | **1.70** | **1.51** |
| | 67 | Iron and steel | 0.07 | 0.42 | **1.10** | **3.02** |
| | 68 | Non-ferrous metals | 0.30 | 0.18 | 0.29 | 0.27 |
| | 69 | Manufactures of metals, nes | 0.24 | 0.32 | 0.66 | **1.76** |
| Less Pollutive Industries | 0 | Live animals chiefly for food | **1.93** | **2.07** | **1.32** | **1.94** |
| | 11 | Beverages | 0.32 | **1.71** | 0.63 | **2.24** |
| | 12 | Tobacco and tobacco manufactures | **4.87** | **4.93** | **5.03** | **7.71** |
| | 21 | Hides, skins and furskins, raw | **9.62** | **4.25** | **2.22** | 0.17 |
| | 22 | Oil seeds and oleaginous fruit | **2.56** | **1.73** | 0.76 | 0.09 |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.57 | 0.46 | **2.80** | 0.03 |
| | 24 | Cork and wood | 0.99 | 0.34 | 0.84 | 0.75 |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | **10.65** | **5.97** | **6.15** | **1.10** |
| | 27 | Crude fertilizer and crude minerals | **2.15** | **1.52** | **1.60** | **2.78** |
| | 28 | Metalliferous ores and metal scrap | 0.90 | **1.46** | **4.60** | 0.03 |
| | 29 | Crude animal and vegetable materials, nes | 0.58 | 0.49 | 0.87 | **1.09** |
| | 32 | Coal, coke and briquettes | 0.14 | 0.41 | **1.14** | 0.57 |
| | 34 | Gas, natural and manufactured | 0.00 | 0.00 | 0.42 | **1.28** |
| | 35 | Electric current | **9.32** | **7.29** | **2.04** | 0.24 |
| | 41 | Animal oils and fats | 0.09 | 0.00 | 0.01 | 0.25 |
| | 42 | Fixed vegetable oils and fats | 0.14 | 0.02 | 0.62 | **2.29** |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | 0.01 | 0.06 | 0.18 | 0.42 |
| | 52 | Inorganic chemicals | 0.43 | 0.18 | 0.50 | **1.35** |
| | 53 | Dyeing, tanning and colouring materials | 0.14 | 0.27 | 0.83 | **2.21** |
| | 54 | Medicinal and pharmaceutical products | **1.10** | **1.71** | **1.25** | **1.44** |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | 0.06 | 0.05 | 0.77 | **1.82** |
| | 57 | Explosives and pyrotechnic products | **4.81** | **4.05** | **2.40** | **5.17** |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.15 | 0.16 | 0.36 | **1.02** |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | **1.39** | **0.74** | **1.50** | 0.08 |
| | 62 | Rubber manufactures, nes | 0.34 | **1.00** | 0.81 | **2.40** |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | 0.42 | 0.39 | **1.30** | **3.93** |
| | 71 | Power generating machinery and equipment | 0.11 | 0.28 | 0.39 | **0.54** |
| | 72 | Machinery specialized for particular industries | 0.33 | 0.36 | 0.82 | **2.19** |
| | 73 | Metalworking machinery | 0.40 | 0.17 | 0.22 | 0.62 |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | 0.21 | 0.19 | 0.35 | 0.84 |
| | 75 | Office machines and automatic data processing equipment | 0.02 | 0.01 | 0.11 | 0.25 |
| | 76 | Telecommunications, sound recording and reproducing equipment | 0.06 | 0.02 | 0.36 | **1.19** |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | 0.24 | 0.19 | 0.16 | 0.23 |
| | 78 | Road vehicles | 0.29 | 0.57 | 0.46 | 0.76 |
| | 79 | Other transport equipment | 0.14 | 0.49 | 0.94 | 0.28 |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | 0.07 | 0.05 | 0.13 | 0.95 |
| | 82 | Furniture and parts thereof | 0.30 | 0.22 | 0.18 | 0.32 |
| | 83 | Travel goods, handbags and similar containers | 0.03 | 0.02 | 0.45 | 0.40 |
| | 84 | Articles of apparel and clothing accessories | **2.51** | **2.31** | **2.09** | **1.25** |
| | 85 | Footwear | 0.30 | 0.66 | **1.82** | **2.58** |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | 0.07 | 0.16 | 0.24 | 0.42 |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | 0.01 | 0.01 | 0.10 | 0.26 |
| | 89 | Miscellaneous manufactured articles, nes | 0.37 | 0.24 | 0.62 | **1.15** |
| | 96 | Coin (other than gold coin), not being legal tender | 0.24 | 0.02 | 0.00 | 0.00 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | **41.82** | **19.88** | **15.05** | 0.00 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in Bold

Author's calculations based on UNComtrade SITC revision-2 data

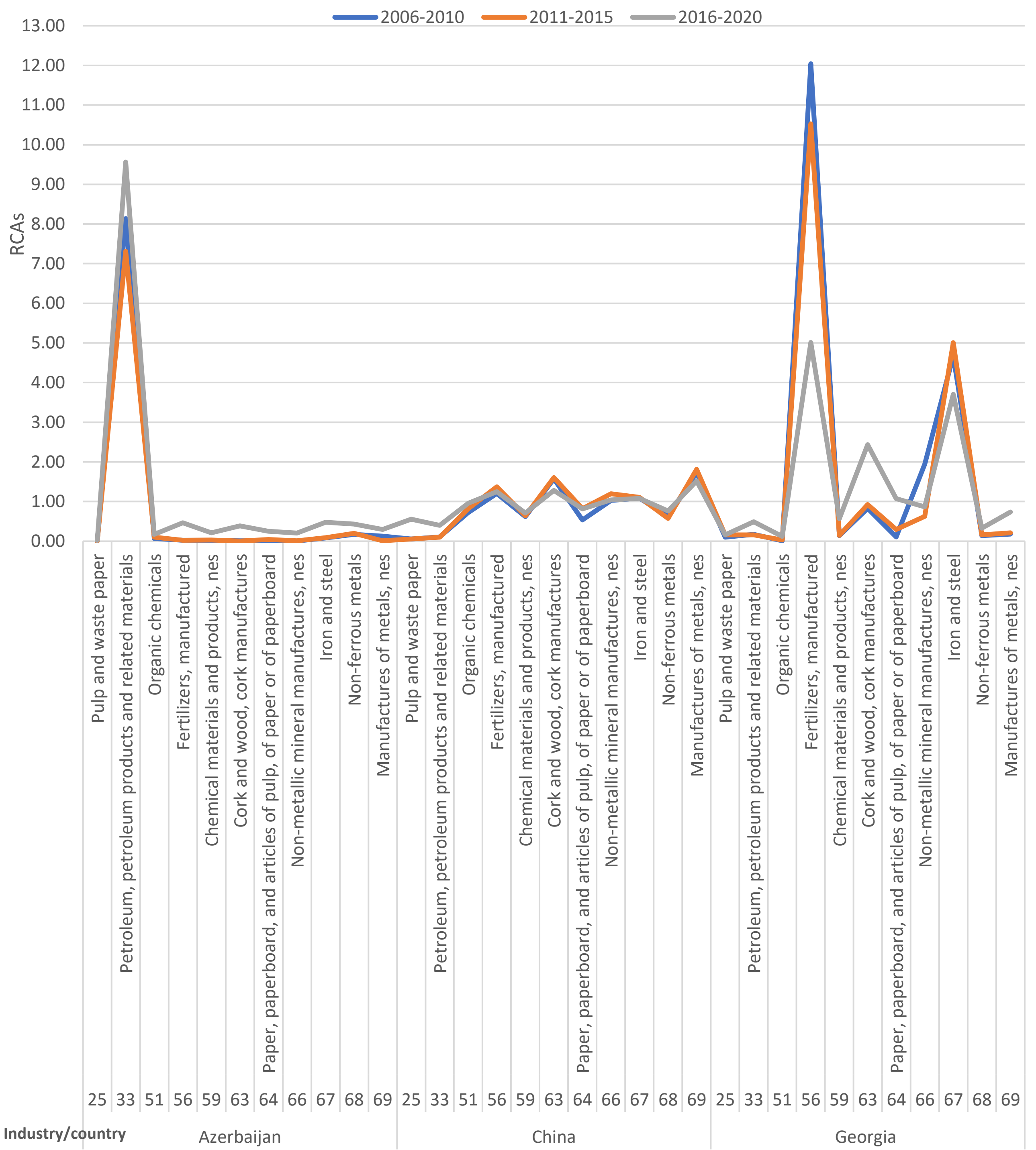
*: Owing to world pandemic in 2020 (COVID-19) RCA 2020 results are subject to the volatility in world exports

Table 5.6 **Revealed Comparative Advantage of Pakistan Pollutive Manufacturing Exports: 2006-2020**

| Industry Category | Ind. code | Commodity Name/Year | 2006-2010 RCA | 2011-2015 RCA | 2016-2020 RCA | 2020* RCA |
|---|---|---|---|---|---|---|
| Most Pollutive Industries | 25 | Pulp and waste paper | 0.04 | 0.12 | 0.58 | **1.47** |
| | 33 | Petroleum, petroleum products and related materials | 0.41 | 0.18 | 0.72 | **2.17** |
| | 51 | Organic chemicals | 0.41 | 0.57 | **1.10** | **1.82** |
| | 56 | Fertilizers, manufactured | 0.12 | 0.21 | 0.98 | **2.80** |
| | 59 | Chemical materials and products, nes | 0.12 | 0.12 | 0.58 | **1.34** |
| | 63 | Cork and wood, cork manufactures | 0.16 | 0.15 | 0.08 | 0.11 |
| | 64 | Paper, paperboard, and articles of pulp, of paper or of paperboard | 0.12 | 0.31 | 0.67 | **1.14** |
| | 66 | Non-metallic mineral manufactures, nes | **1.22** | **1.10** | 0.59 | 0.42 |
| | 67 | Iron and steel | 0.13 | 0.21 | 0.61 | **1.80** |
| | 68 | Non-ferrous metals | 0.08 | 0.08 | 0.31 | 0.34 |
| | 69 | Manufactures of metals, nes | 0.35 | 0.38 | 0.41 | 0.59 |
| Less Pollutive Industries | 0 | Live animals chiefly for food | **2.38** | **2.66** | **2.21** | 0.22 |
| | 11 | Beverages | 0.35 | 0.69 | 0.58 | 0.02 |
| | 12 | Tobacco and tobacco manufactures | 0.22 | 0.35 | 0.32 | 0.12 |
| | 21 | Hides, skins and furskins, raw | 0.05 | 0.03 | 0.69 | 4.34 |
| | 22 | Oil seeds and oleaginous fruit | 0.59 | 0.67 | **1.72** | 4.99 |
| | 23 | Crude rubber (including synthetic and reclaimed) | 0.06 | 0.07 | 0.52 | 2.09 |
| | 24 | Cork and wood | 0.00 | 0.00 | 0.16 | 0.62 |
| | 26 | Textile fibres (not wool tops) and their wastes (not in yarn) | **4.89** | **5.90** | **8.81** | **24.64** |
| | 27 | Crude fertilizer and crude minerals | 0.81 | **2.92** | **2.90** | **1.17** |
| | 28 | Metalliferous ores and metal scrap | 0.42 | 0.47 | 0.99 | **1.71** |
| | 29 | Crude animal and vegetable materials, nes | 0.99 | **1.15** | 0.83 | **1.01** |
| | 32 | Coal, coke and briquettes | 0.00 | 0.00 | **1.33** | **4.35** |
| | 34 | Gas, natural and manufactured | 0.30 | 0.31 | **1.61** | **3.63** |
| | 35 | Electric current | 0.23 | 0.19 | 0.32 | 0.47 |
| | 41 | Animal oils and fats | 0.55 | **1.97** | **1.39** | 0.35 |
| | 42 | Fixed vegetable oils and fats | **16.62** | **12.74** | **12.94** | **11.03** |
| | 43 | Animal and vegetable oils and fats, processed, and waxes | **5.37** | **4.64** | 0.57 | 0.86 |
| | 52 | Inorganic chemicals | 0.14 | 0.20 | 0.71 | **1.85** |
| | 53 | Dyeing, tanning and colouring materials | 0.24 | 0.37 | **1.04** | **2.49** |
| | 54 | Medicinal and pharmaceutical products | 0.29 | 0.46 | 0.49 | 0.53 |
| | 55 | Oils and perfume materials; toilet and cleansing preparations | 0.14 | 0.19 | 0.32 | 0.59 |
| | 57 | Explosives and pyrotechnic products | **1.78** | **2.68** | **2.06** | 0.28 |
| | 58 | Artificial resins and plastic materials, and cellulose esters etc | 0.50 | 0.75 | **1.01** | **2.08** |
| | 61 | Leather, leather manufactures, nes, and dressed furskins | **5.26** | **6.66** | **5.82** | 0.38 |
| | 62 | Rubber manufactures, nes | 0.25 | 0.33 | 0.69 | **1.29** |
| | 65 | Textile yarn, fabrics, made-up articles, nes, and related products | **20.14** | **19.12** | **13.16** | **1.51** |
| | 71 | Power generating machinery and equipment | 0.12 | 0.08 | 0.50 | **1.43** |
| | 72 | Machinery specialized for particular industries | 0.21 | 0.11 | 0.41 | **1.10** |
| | 73 | Metalworking machinery | 0.03 | 0.04 | 0.20 | 0.68 |
| | 74 | General industrial machinery and equipment, nes, and parts of, nes | 0.04 | 0.05 | 0.33 | 0.90 |
| | 75 | Office machines and automatic data processing equipment | 0.05 | 0.08 | 0.15 | 0.23 |
| | 76 | Telecommunications, sound recording and reproducing equipment | 0.07 | 0.04 | 0.41 | **1.31** |
| | 77 | Electric machinery, apparatus and appliances, nes, and parts, nes | 0.04 | 0.05 | 0.13 | 0.30 |
| | 78 | Road vehicles | 0.04 | 0.02 | 0.14 | 0.44 |
| | 79 | Other transport equipment | 0.27 | 0.04 | 0.20 | 0.52 |
| | 81 | Sanitary, plumbing, heating, lighting fixtures and fittings, nes | 0.20 | 0.40 | 0.49 | 0.83 |
| | 82 | Furniture and parts thereof | 0.36 | 0.38 | 0.26 | 0.08 |
| | 83 | Travel goods, handbags and similar containers | 0.24 | 0.30 | 0.21 | 0.17 |
| | 84 | Articles of apparel and clothing accessories | **7.31** | **6.95** | **6.49** | 0.10 |
| | 85 | Footwear | **1.00** | 0.65 | 0.49 | 0.11 |
| | 87 | Professional, scientific, controlling instruments, apparatus, nes | 0.55 | 0.57 | 0.57 | 0.41 |
| | 88 | Photographic equipment and supplies, optical goods; watches, etc | 0.01 | 0.03 | 0.08 | 0.20 |
| | 89 | Miscellaneous manufactured articles, nes | 0.93 | 0.94 | 0.37 | 0.31 |
| | 96 | Coin (other than gold coin), not being legal tender | 0.00 | 0.00 | 0.00 | 0.00 |
| | 97 | Gold, non-monetary (excluding gold ores and concentrates) | 0.00 | 0.00 | 0.01 | 0.01 |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in Bold
Author's calculations based on UNComtrade SITC revision-2 data
*: Owing to world pandemic in 2020 (COVID-19) RCA 2020 results are subject to the volatility in world exports

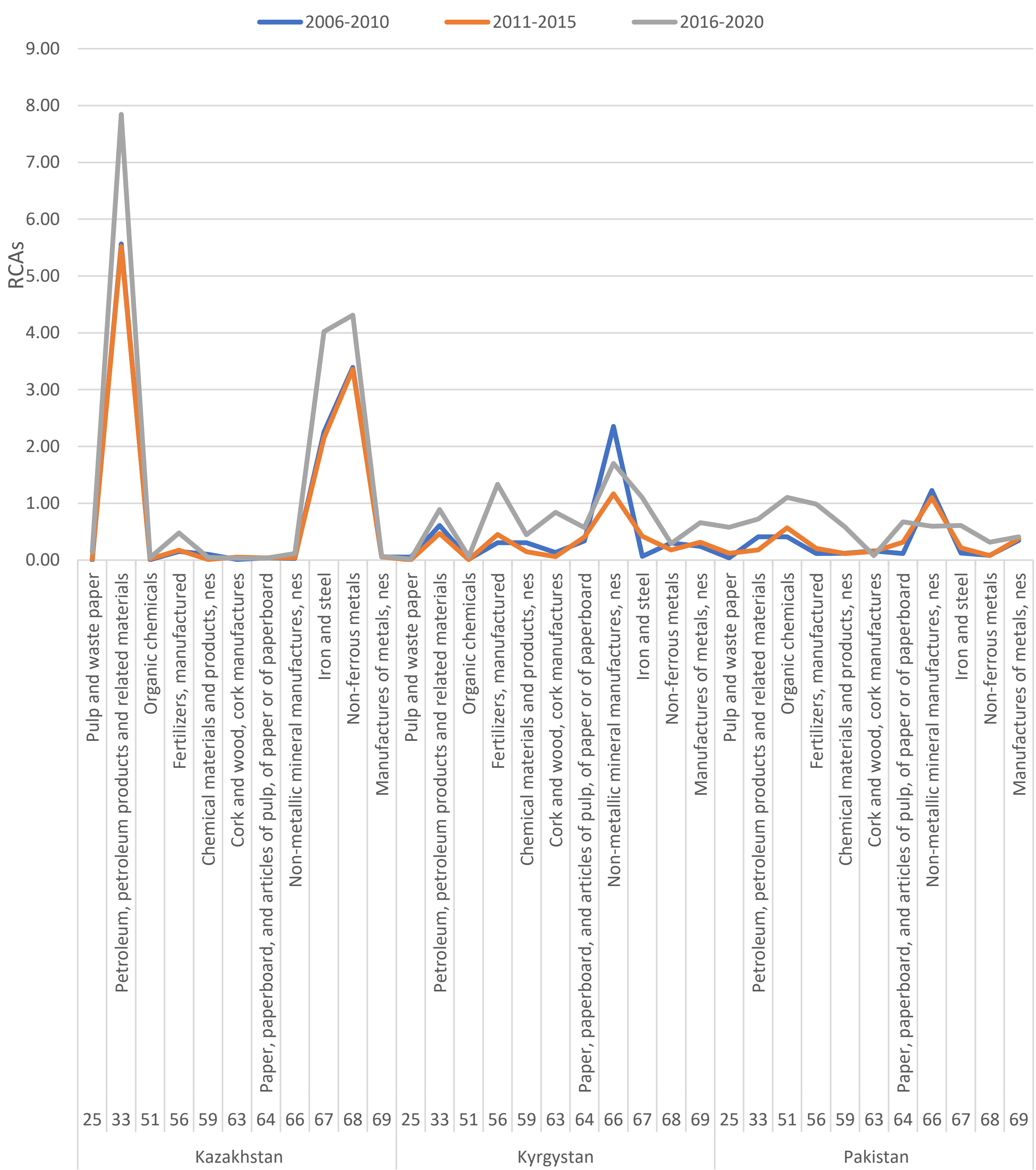
Figure 5.1 **Most Pollutive Industries RCA Trends in CAREC Countries: 2006-2020**




Author calculation based on UN Comtrade 2-digit SITC rev-2 Data

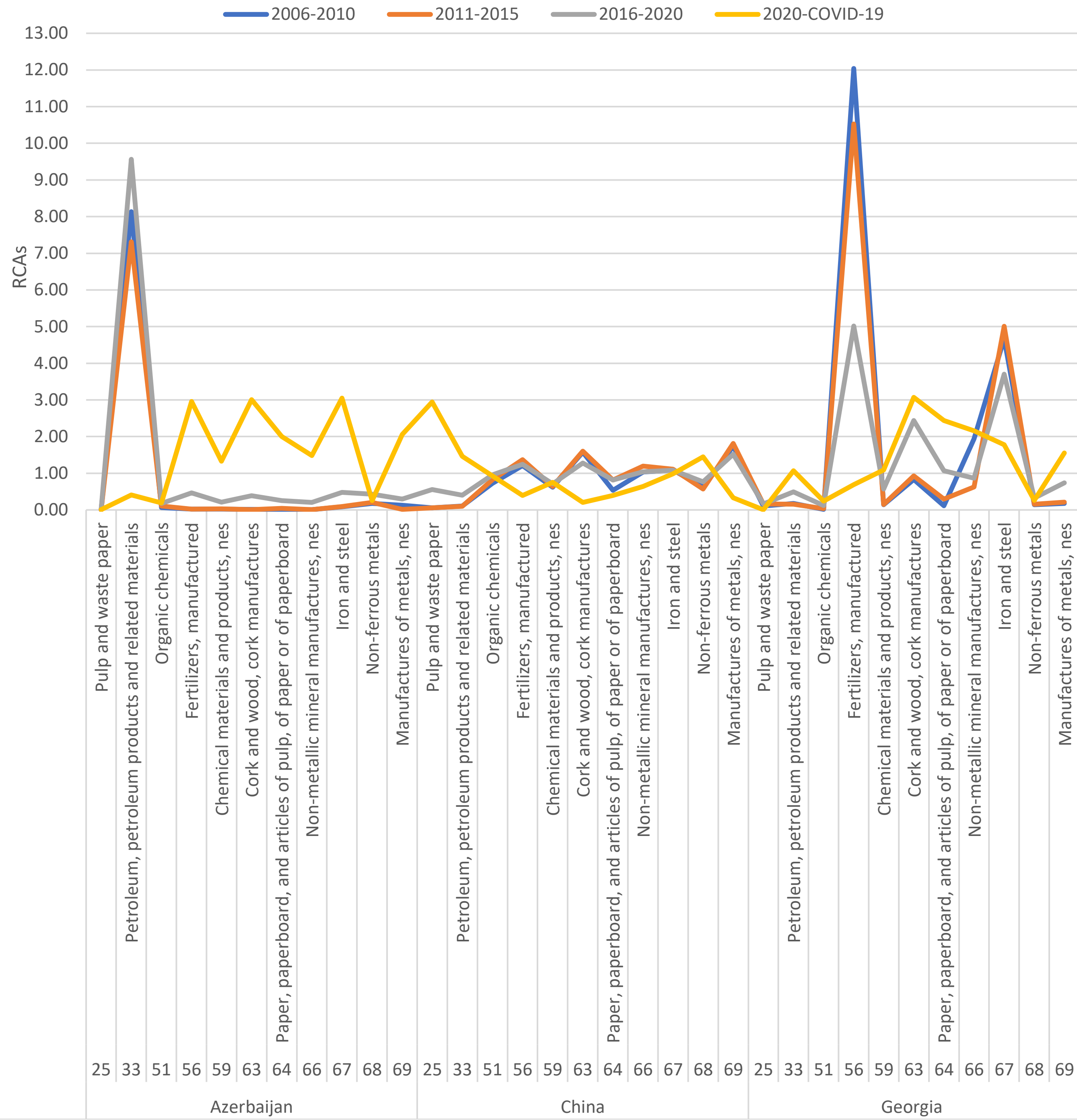
Figure continued:

Figure 5.2 **Most Pollutive Industries RCA Trends in CAREC Countries: 2006-2020**



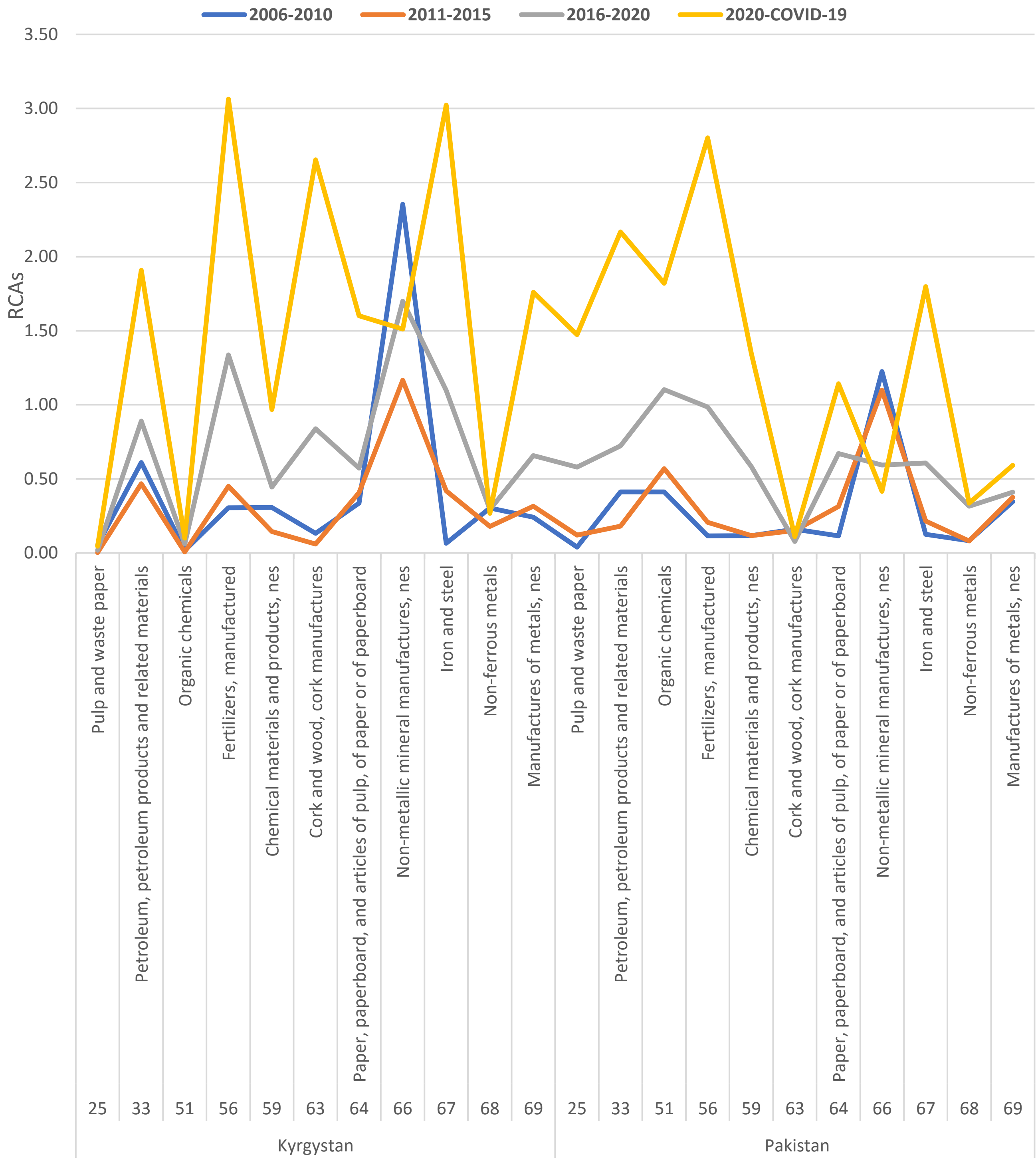

Author calculation based on UN Comtrade 2-digit SITC rev-2 Data

Figure 5.3 **Covid-19 and most Pollutive Industries RCA Trends in CAREC Countries: 2006-2020**




Author calculation based on UN Comtrade 2-digit SITC rev-2 Data

Figure 5.4 **Covid-19 and Most Pollutive Industries RCA Trends in CAREC Countries: 2006-2020**




Author calculation based on UN Comtrade 2-digit SITC rev-2 Data

# 6. Searching for the Pollution Haven Effect: Evidence from the CAREC Region

## 6.1 Introduction

One of the main research objectives of this study is to examine whether, owing to differences in environmental regulations between the stringent North OECD countries and the laxer CAREC region, the CAREC countries have become a haven for pollutive industrial trade flows to the North. The literature surveyed indicates that the gap in environmental regulations between rich North and poor South will lead to pollutive industrial relocation towards developing countries. Accordingly, the developing and less developed countries can develop a comparative advantage in most pollutive industries and become a repository for pollutive industrial production and trade (McGuire, 1982; Baumol and Oates, 1988; Copland and Taylor, 1994). Earlier empirical literature focusing on trade data has traced the evidence of the pollutive haven effect (Tobey, 1990; Low and Yeats, 1992; Sorsa, 1994; Van Beers and Van den Bergh, 1997 and 2000; XU, 1999; Grether and de Melo, 2004; Cole and Elliott, 2003).

Chapter 5 provides an in-depth analysis of competitive position and trade specialization patterns of pollutive industrial trade for CAREC countries and sheds light on the pollution haven hypothesis. The research on the pollution haven hypothesis further demands whether the difference in environmental regulations between stringent OECD and laxer CAREC countries has allowed the latter to become a haven for pollutive industrial exports to the OECD. Such an analysis requires the adoption of a methodology that incorporates bilateral level pollutive industrial trade data while keeping some control on geography. Grether and de Melo (2004) offered that methodology. The present study tends to adopt it to examine whether the CAREC region has become a haven for pollutive industrial exports to OECD countries. This study for new methodological analysis uses bilateral industrial trade SITC 2-digit export flow data. Furthermore, no efforts have been made before to examine whether the CAREC region (trade data from six selected countries) region has become a pollution haven for industrial exports to OECD and other countries. This study fills the gap in the literature by first computing the composition and structural effects of different pollutive industry groups and later estimating bilateral level RCA exports of CAREC countries with OECD and the rest of the world (ROW). The chapter further examines whether a comparative analysis between most pollutive with less pollutive industrial trade provides further insights into the pollution haven effects in the CAREC region.

Section 6.2 outlines first the choices of countries and data to examine the pollution haven hypotheses in the North–South framework. Then it explains in detail the Grether and de Melo (2004) model that would allow a time series analysis on bilateral export flows between CAREC and OECD and the ROW countries. The bilateral RCA model paves the way for computing both technique and composition effects and total effects for pollutive industries. Section 6.3 explains the effectiveness of the composition effect, and structural and total effects for pollutive industry trade in selected CAREC countries over time. After that, bilateral export RCAs between CAREC countries with OECD and ROW countries are analyzed, and the results examined for the pollution haven effect. Section 6.4 concludes this chapter.

## 6.2 Data and Modeling Choices to the Pollution Haven Hypothesis: CAREC *vis-à-vis* OECD

This study has identified the 28 OECD countries to examine the hypothesis of whether the CAREC economies over time have become a haven for pollutive industrial exports to OECD countries. These countries include Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The six CAREC countries are Azerbaijan, China, Georgia, Kazakhstan, Kyrgyzstan, and Pakistan.

For a comparative analysis of bilateral pollutive industrial exports of the six selected CAREC countries with OECD and ROW countries, the study uses UN Comtrade SITC rev-2 2-digit bilateral trade data of world countries and splits that data for bilateral exports of CAREC countries with 28 OECD and ROW countries. The study used the same periods it chose for trade data analysis in chapter 5. The sample periods are 2006 to 2010, 2011 to 2015, and 2016 to 2020 and there are two pollutive industrial groups: most pollutive and less pollutive industrial exports. Therefore, again, to avert or minimize any random factors that might influence the results of a single year, five years of averaged pollutive industrial trade data were chosen at the analysis stage.

It is worth indicating here that it is difficult to distinguish between the literature on the impact of environmental regulations and trade competitiveness and on pollution haven hypothesis, as both notions are to some extent interconnected in a developing country context. For example, if the number of CAREC country shares in most pollutive industry exports going towards OECD countries increases over the years, this would imply that, on the one hand, CAREC countries are becoming a haven for the most pollutive industrial exports to OECD owing to differential environmental regulations between the two regions and that, on the other hand, OECD countries are gaining competitiveness in those industries too. Grether and de Melo (2004) have argued that controlling for geography is imperative to elucidate the pollution haven effect and offered the following new research methodology to address the pollution haven hypothesis.

Keeping in view the RCA weighting issues of high and low income countries around the globe, the importance of composition, technique effects as well as geographical controlled bilateral RCAs, this study adopted a model offered by Grether and de Melo (2004). It provided a process of extensions to the Balassa (1965) model via equations 6.1 to 6.7, as follows:

$$RCA_i^P = \frac{S_{wp}^{ip}}{S_{wa}^{ia}} \div \frac{S_{ia}^{ip}}{S_{wa}^{wp}} \tag{6.1}$$

Where $\frac{S_{wp}^{ip}}{S_{wa}^{ia}}$ is country *i*'s share in world exports of polluting products (of all products) and $\frac{S_{ia}^{ip}}{S_{wa}^{wp}}$ is the share of polluting products in total exports of county *i* (of the world).

Based on equation (6.1) and using the World Production and Trade Data (2001) at 3-digit ISIC level for the five most pollutive industries and dividing sample countries into low and high income groups based on per capita GNP, Grether and de Melo (2004) found puzzling outcomes. Firstly, global trends towards the higher RCA values were observed for both high and low income groups whereas, more intuitively, an increase in one group of RCAs should be accompanied by a decrease of other groups at a particular point in time. The answer to this query is provided through the weighted sum, which although totaled to one can vary—that is, if from equation (6.1) the world consists of two countries *n* and *s*, the result is as follows:

$$S_{sw}^{sa} RCA_s^P + S_{wa}^{na} RCA_n^P = 1 \tag{6.2}$$

Therefore, following equation (6.2), the simultaneous increase in both RCA indices can happen when a large weight is placed on smaller values. Their empirical results also supported that argument as

developed countries depicted low RCA but their share in world exports increased. That was one of the reasons that, unlike earlier work such as Low and Yeats (1992), Sorsa (1994), and XU (1999), this study has not relied on the Balassa index alone to witness pollution haven effects in CAREC countries.
The second contradiction in the results was that in a group (LDCs) most RCA (Balassa index) is increasing while the aggregate RCA of the group is declining. The answer to this contradictory outcome was sought again through the shares—that is, the composition effect, with the share of lowest RCA countries rising at the cost of the highest RCA countries. By elaborating the equation (6.1), this notion can be easily verified, and this study, in what follows, attempts to make use of this methodology for CAREC regional analysis to compute composition and structural effect based on the beginning and end data sample periods.

$$RCA_S^P = \sum_{I=1}^{ns} S_{sa}^{ia} RCA_i^p \quad (6.3)$$

Where the group for the CAREC region is assumed to be composed of $n_s$ countries (six selected CAREC countries) and $S_{sa}^{ia}$ is the share of country *i* in total exports of the group.

Following equation (6.3) the change in the aggregate RCA index (Balassa index) can be decomposed in the following terms. For the current analysis, a bar over a variable implies the average over both periods—that is, beginning period 2006 to 2010 and end period 2016 to 2020.

$$\Delta RCA_S^P = \sum_{i=1}^{ns} \Delta S_{sa}^{ia} \overline{RCA_i^p} + \sum_{i}^{ns} \overline{S}_{sa}^{ia} \Delta RCA_i^p \quad (6.4)$$

The first term in equation (6.4) is the composition effect: it is the part of the aggregate RCA change that is attributable to the changes in export share of countries—that is, the share of one country in a specific industry of the country—say, Pakistan—is falling and that of—say, China—is increasing. The second part of equation (6.4) reveals the pure structural effect that reflects the opposite of the composition effect. It provides information on a structure shift in pollutive industrial exports at the disaggregated SITC level export data of the CAREC region through the impact of change in export RCAs while keeping the industrial export share of the six selected CAREC countries constant at their average value.

Next, after controlling for geography, the study computes the bilateral export RCA of the CAREC region with environmentally stringent OECD and ROW, which is what the pollution haven effect has called for. To accomplish this task, again following mainly Grether and de Melo (2004), with a slight change, a new decomposition is introduced in what follows that isolates the impact of geography on the RCA index. From equation (6.1), again, the RCA of country *i* in product *p* ($RCA_p^i$) can be decomposed as follows:

$$RCA_i^P = \sum_{j=1}^{N} RCA_{ij}^p S_{iwa}^{ija} \quad (6.5)$$

Where bilateral RCA ($RCA_{ij}^p$) is defined as the ratio between the share of product *p* in total exports of country *i* to country *j* ($S_{ija}^{ijp}$) and the share of product *p* in total world exports ($S_{wa}^{wp}$). This share is weighted by the share of country *j* in total exports country *i* to world ($S_{iwa}^{ija}$). For analysis purposes, this study divides trade data into two groups of countries: $n_S$ is the CAREC region group of six countries' bilateral exports going to high income OECD countries, and $n_N$ is the CAREC region group of six countries' bilateral exports link with ROW countries during the sample period and that $n_{S} + n_{N} = N$. The equation (6.5) can be rewritten as follows:

$$RCA_i^P = S_i^p + N_i^p \equiv \sum_{j=1}^{n_s} RCA_{ij}^p S_{iwa}^{ija} + \sum_{j=1}^{n_N} RCA_{ij}^p S_{iwa}^{ija} \quad (6.6)$$

Where $S_i^p$ is the OECD contribution in changing selected CAREC countries bilateral $RCA_i^P$ and $N_i^p$ is the ROW contribution regarding changing bilateral $RCA_i^P$ patterns of the region. Therefore, in terms of variation between analysis periods—that is, ending periods (2011 to 2015) and (2016 to 2020) and the beginning period (2006 to 2010)—equation (6.6) will be changed as follows:

$$\Delta RCA_i^p = \Delta S_i^p + \Delta N_i^p \quad (6.7)$$

Where Δ indicates a change between periods, the study has accordingly computed equations (6.4), (6.6), and (6.7), and the results are discussed in section 6.3.

### 6.3 Results: Pollution Haven Effects for the CAREC Region: Statistical Analysis

In this section, the study based on the methodological approach described in section 6.2 presents results ascertained by applying the equations (6.4), (6.6), and (6.7) to two pollutive industrial export categories using SITC 2-digit export data.

Table 6.1 shows the unweighted bilateral XRCA of the six CAREC countries with OECD and ROW economies. The export comparative advantage results for combined most pollutive industries show that Azerbaijan and Kazakhstan maintained their competitiveness in the world's most pollutive exports group from 2006 to 2020. The comparative advantage in exports of most pollutive industries for these countries also remained intact with ROW countries during the same period. Georgia enjoyed bilateral XRCA with OECD countries for the same pollutive industry group but had an XRCDA with other countries. All other countries within the combined group of most pollutive industries faced XRCDA both with OECD and ROW, except China, whose export competitiveness rose with ROW during 2016 to 2020. In the less pollutive industrial group, China, Kyrgyzstan, and Pakistan enjoyed XRCA both with the OECD and ROW countries. Whereas, Georgia's export comparative advantages within the combined group of less pollutive industries was more with the ROW countries rather than OECD.

**Table 6.1** **Bilateral RCA of CAREC Countries with OECD and Rest of World: 2006-2020**

| Commodities | Counntry | RCA with OECD | | | CAREC to ROW RCA | | |
|---|---|---|---|---|---|---|---|
| | | 2006-2010 | 2011-2015 | 2016-2020 | 2006-2010 | 2011-2015 | 2016-2020 |
| **Most Pollutive Industries (MPE)** | **Azerbaijan** | **3.9** | **4.0** | **6.0** | **3.1** | **2.9** | **3.4** |
| | **China** | 0.5 | 0.4 | 0.7 | 0.7 | 0.5 | 1.0 |
| | **Georgia** | **1.4** | **1.2** | **1.7** | 0.8 | 0.6 | 0.8 |
| | **Kazakhstan** | **3.7** | **3.8** | **5.9** | **2.2** | **2.1** | **3.4** |
| | **Kyrgyzstan** | 0.1 | 0.1 | 0.1 | 0.7 | 0.6 | 0.9 |
| | **Pakistan** | 0.1 | 0.1 | 0.1 | 0.6 | 0.4 | 0.6 |
| **Less Pollutive Industries (LPE)** | **Azerbaijan** | 0.0 | 0.0 | 0.0 | 0.3 | 0.4 | 0.5 |
| | **China** | **1.2** | **1.2** | **1.0** | **1.1** | **1.2** | **1.0** |
| | **Georgia** | 0.9 | 0.9 | 0.9 | **1.1** | **1.1** | 1.0 |
| | **Kazakhstan** | 0.1 | 0.1 | 0.1 | 0.6 | 0.6 | 0.5 |
| | **Kyrgyzstan** | **1.3** | **1.3** | **1.2** | **1.1** | **1.1** | **1.0** |
| | **Pakistan** | **1.3** | **1.3** | **1.2** | **1.1** | **1.2** | **1.1** |

Notes: RCA: Revealed Comparative Advantage Index values >1 depicted in bold

Author calculations based on UNComtrade SITC revision-2 data

ROW: Based on Bilateral exports with 167 Rest of World Countries (UNComtrade SITC-rev-2 2-digits data)

MPE: Including group of all 11 industries defined as most pollutive industries

LPE: Including group of all industries defined as less pollutive industries

The results based on equation 6.4 are reported in Table 6.2. It shows how composition and structural effects (technique effects) have changed in the selected CAREC countries and at combined regional levels during 2006 to 2020. Table 6.2 shows that the export composition within the category of most pollutive industries of the CAREC countries has moved in both positive and negative directions during the beginning and end sample periods. For a region as a whole, the change in structural effect, within the most pollutive industry exports group, showed positive outcomes for all selected CAREC countries. The results also show that the structural effect for the majority in the most pollutive industry group is stronger than the composition effect, making the total effect for the combined region positive during the period under study. This implies that the impact of change in XRCA, keeping the share of the respective commodities constant around the mean value during the two sample periods, is stronger than the change in export share of these countries (keeping RCA constant around an average of two periods). Therefore, the composition effect has reinforced the structural effect in the most pollutive industrial exports for the CAREC countries—for this reason the total effect is positive. By definition, the total effect is the sum of composition and structural effects. The study finds positive effects for the most pollutive industrial exports for the CAREC region as a whole; therefore, the role of technology has been of paramount importance in the most pollutive industrial development and competitiveness in the CAREC countries. For the less pollutive industrial exports group, the total effect was negative for the CAREC region, primarily owing to the strong negative structural effect on China's manufacturing sectors within the combined group of less pollutive industries. Recent research by the OECD (2017) on China's industrial upgradation shows that the industrial structural transformation and compliance with environmental regulatory measures taken by China have had implications for industrial pollution abatement costs. However, the OECD (2017) study acknowledges that during the last decade China's pursuit towards compliance with environmental regulations was moving rapidly to meet OECD environmental standards compared with the other emerging economies. The negative structural effect reported in Table 6.2 for the less pollutive industry group indicates that the change in weighted RCA in the end period 2016 to 2020 compared to the beginning period 2006 to 2010 could reflect China's industrial upgradation/structural transformation endeavors towards greener and sustainable industrial growth.

Overall, the study finds that the most pollutive industries group provides more consistent outcomes throughout the sample period. Within the same group, in most industries, both composition and structural effects moved in the same positive direction for several countries, paving the way for confirming the pollution haven hypothesis (PHH) for the CAREC region. The analysis provides valued insight into the characteristics of pollutive categories of industrial export patterns for the CAREC region. Nonetheless, the results need to be supported by additional analysis on bilateral trade flows between CAREC, OECD, and ROW countries before concluding PHH for the CAREC region.

The research conducted by computing equations (6.6) and (6.7) explains these results in Table 6.3. For bilateral RCA analysis, the sample of world exporting countries has been divided into two groups: first, the environmentally stringent North 28 OECD countries and a second group including ROW countries covering 2006 to 2020. In addition to the change in export shares at bilateral level, the study also reports the average annual percentage growth rates of these shares based on the beginning and end sample periods.

In Table 6.3, in the combined most pollutive industry group, the bilateral change in export RCAs and its growth rates of CAREC with environmentally stringent OECD countries are positive during 2006 to 2020. The positive shift in shares at bilateral level of the CAREC countries with the OECD and conspicuously high average annual growth rates for most pollutive industries provide convincing evidence to confirm the hypothesis that the CAREC countries have become a haven for most pollutive industry exports to the environmentally stringent OECD. The results remained consistent for the ROW economies and the same pollutive industry group and are also in line with earlier research conducted in the area. For example, Mani and Wheeler (1999) and Low and Yeats (1992) find evidence consistent with the pollution haven hypothesis based on trade data. Lucas et al. (1992), based on production data for the most pollutive industries, found that growth in pollution intensive industry was highest in the South when OECD economies were pursuing stringent environmental regulations. For a sample group of developing countries, Grether and de Melo (2004) find some evidence consistent with pollution haven hypothesis—that is, the South as a whole is becoming a haven for the dirtiest industrial exports from the North.

Table 6.2 **Decomposition of Aggregate RCA for the CAREC Region, 2006-20**

| | 2006-2020 | Composition effect | Structural effect | Total effect | Signs of Total Effect |
|---|---|---|---|---|---|
| | Country/Industry | 1 | 2 | 1+2 | |
| **Most** | **Azerbaijan** | **-0.035** | **0.011** | **-0.024** | - |
| **Pollutive** | **China** | **0.003** | **0.047** | **0.050** | + |
| **Exports** | **Georgia** | **0.000** | **0.000** | **0.000** | + |
| | **Kazakhstan** | **-0.056** | **0.035** | **-0.021** | - |
| | **Kyrgyzstan** | **0.000** | **0.000** | **0.000** | + |
| | **Pakistan** | **0.000** | **0.000** | **0.000** | + |
| **MPE: CAREC Region** | | **-0.089** | **0.092** | **0.004** | + |
| **LESS** | **Azerbaijan** | **0.000** | **0.000** | **0.000** | + |
| **Pollutive** | **China** | **0.030** | **-0.101** | **-0.071** | - |
| **Exports** | **Georgia** | **0.000** | **0.000** | **0.000** | + |
| | **Kazakhstan** | **-0.001** | **0.000** | **-0.001** | - |
| | **Kyrgyzstan** | **0.000** | **0.000** | **0.000** | + |
| | **Pakistan** | **-0.005** | **-0.001** | **-0.006** | - |
| **LPE: CAREC Region** | | **0.024** | **-0.102** | **-0.078** | - |

Author calculations based on UNComtrade SITC revision-2 data
MPE: Most Pollutive Exports
LPE: Less Pollutive Exports
CAREC Region: Based on data from countries

However, the earlier studies on the impact of environmental regulations and trade competitiveness for China produced mixed results. The empirical work regarding environmental regulations, technological innovation, and trade competitiveness for China show that China's environmental policies validate Porter's hypothesis—that environmental regulations are good for industrial trade competitiveness (Li and Zhu, 2019). Whereas the study by Ren and Huang (2015), using bilateral trade data between China and 37 trading partners, found a statistically significant negative association between the stringency of environmental regulations and China's industrial export comparative advantage.

For the most pollutive industrial category, this study also found positive bilateral export RCA shares and growth rates of CAREC trade with the ROW from 2006 to 2020. This phenomenon highlights that pollutive industries in CAREC countries as a region are gaining a bilateral comparative advantage in exports with the relatively environmentally stringent OECD countries and the rest of the world. Therefore, in addition to the differential of environmental regulation compliance between CAREC countries and the OECD, other comparative advantage sources—natural resources and traditional comparative advantage resources such as labor and land—might be valuable for the CAREC region to explain bilateral trade pattern, trade competitiveness, and pollution haven effects.

This research aims to examine whether a somewhat different scenario could emerge for the relatively less pollutive industries than the study findings for the most pollutive industries in the North–South bilateral RCA framework. In Table 6.3, the results for the less pollutive industry category shed further light on bilateral RCAs of the less pollutive industries with OECD as estimated results for the CAREC countries for both changes in RCA shares and their growth rates are positive with OECD and ROW countries.

Table 6.3 Bilateral RCAs of Selected CAREC Countries with OECD and Rest of World : Pollution Haven Effect

| Industry/Region | CAREC's Change in RCA with OECD | | CAREC's Change in RCA with Rest of World | | Total |
|---|---|---|---|---|---|
| | Change in RCA shares | Change in RCA Growth Rates | Change in RCA shares | Change in RCA Growth Rates | Change in RCA Shares |
| | 2006-20 | 2006-20 | 2006-20 | 2006-20 | |
| | 1 | 2 | 3 | 4 | 5=( 1+3) |
| Most Pollutive Industries | 0.060 | 4.805 | 0.003 | 5.489 | 0.063 |
| Less Pollutive Industries | 0.037 | 2.132 | 0.035 | 2.040 | 0.072 |

1. Author's Calcuation based on UN-Comtrade SITC DATA Revision-2

The analysis between the comparative pollutive industry group and between regional groups has produced somewhat puzzling results. Because, if the difference of environmental policy was a key factor in bilateral export flows between CAREC and OECD, the study would have seen improved bilateral RCA of CAREC with OECD in the most pollutive industries only and not in other pollutive industry groups, nor a consistent rise of CAREC bilateral exports with ROW and OECD in relatively cleaner industries. A few plausible reasons can explain this phenomenon. Firstly, based on competitiveness indicators, the results produced in chapter 5 *inter alia* concluded that the CAREC region, in general, gained competitiveness both in most pollutive and less pollutive industries. Secondly, results produced for compositional and structural effects for industrial exports suggest that the structural and composition effects reinforced each other across pollutive groups, not for all but for most industries. Thirdly, which is appealing in the light of comparative advantage theory, that in addition to the theoretical difference in environmental regulations between the rich North and the relatively poor South, other traditional sources of comparative advantage—such as, labor cost differential, access to natural resources, and trade and industrial policies—are contributing factors in industrial trade competitiveness, increasing the bilateral trade flows with the OECD and ROW countries. While confirming pollution haven effects for trade of the most pollutive industries between the CAREC region and OECD countries, these results highlight the importance of the traditional sources of comparative advantage predicted by trade theories.

**6.4 Conclusion**

This chapter examined the key research question of tracing evidence of the pollution haven effect in the CAREC region. The study deployed a bilateral level trade methodology to different pollutive industry groups of the CAREC region's trade flows with OECD and ROW countries from 2006 to 2020. To achieve this task, the study first computed bilateral RCAs of the CAREC region with OECD and ROW countries followed by technique and composition effects for pollutive industrial trade groups. An in-depth analysis was conducted to determine whether the change in comparative advantage over time can be attributed more to productivity/technology improvement via technique effects or to change in industrial composition. Second, to comply with the demand of the pollution haven hypothesis, the study examined the bilateral RCA changes with the OECD and ROW country groups for two pollutive industry categories by controlling for geography. This comparative analysis aimed to find evidence of the pollution haven effect between the environmentally stringent North OECD countries and the relatively lax CAREC countries.

The study finds that the structural effects among the most pollutive industrial sectors are generally more substantial than the compositional effect for the CAREC region. The compositional effects of pollutive industrial trade reinforce the technique effects, making the total effects for pollutive industrial exports move in a positive direction. The results further reveal that the structural transformation mechanism worked for pollutive industrial trade competitiveness. The impact is more visible among the most pollutive industries where, except for a few exceptions, the total effects for the combined region are positive for all the most pollutive industrial exports. The results for the less pollutive industry group confirmed the opposite of this study's findings for the most pollutive industries. The total effect for the CAREC region is negative for the less pollutive industry group, primarily owing to China's negative structural change in combined industrial comparative advantage in the less pollutive industries. This study has clarified many reasons for the negative change in comparative industrial advantage, including China's recent rigorous drive towards industrial upgradations for greener growth. That is one of the vital contributions of the study towards the pollution haven effect. The findings reveal that confining the research analysis to just the most pollutive industry trade could provide incomplete information on the real impact of environmental policy on trade flows. This was especially true for some CAREC countries where environmental regulations were equally or perhaps more important for industries other than the most pollutive industries, as a large volume of bilateral industrial trade flows of the CAREC region with OECD and ROW countries falls in the less pollutive industry group.

In this chapter, the study finds positive bilateral RCA exports, their shares, and share growth rates of the CAREC countries with OECD countries combined in most pollutive and less pollutive industries. These findings confirm that the selected CAREC countries as a group have become a haven for pollutive exports to the environmentally stringent OECD. Nonetheless, the CAREC region's bilateral export share and RCA growth rates in the same pollutive groups have also risen over time with the ROW countries, which are relatively environmentally laxer. The strongest trend was witnessed for the most pollutive industries compared to the other groups. For the less pollutive or relatively cleaner industry group, the study results found that bilateral RCA of the CAREC, OECD, and ROW countries was positive. The current research further revealed that in addition to the difference of environmental regulations between North and South as predicted by theory, other traditional sources of comparative advantage—such as, provision of natural resources, the labor cost differential between CAREC and OECD, and industrial and trade policies facilitating competitiveness—could be contributing factors in determining bilateral trade flows.

## 7. Concluding Discussions and Policy Recommendations

### 7.1 Introduction

In an era of economic liberalization, the association between environmental regulations and trade competitiveness has received considerable attention within developed countries and between developed and developing countries. The world economies have seen rapid reductions in trade and tariff barriers in the liberalization era, combined with increased demand for compliance with environmental regulations by the rich North for the developing South in the wake of the fear of losing trade competitiveness and industrial delocalization. On the other hand, developing and less developed countries have major concerns about the challenges that the environmental regulations would inflict on the production and international trade of their pollutive industries. In the wake of the COVID-19 pandemic, the global economies—including the economies of the CAREC countries—experienced unprecedented contractions in growth and trade during 2020, which disrupted global commodity supply chains, causing severe supply and demand shocks and volatility in industry production and trade competitiveness.

The CAREC countries' smooth trade connections with OECD countries are vital, especially when some of the CAREC countries accounted for 40 percent to 60 percent of their most and relatively less pollutive export flows to OECD countries between 2016 and 2020. However, the CAREC region's environmental stringency records still lag far behind those of the OECD countries. Accordingly, the demand for a level playing field and/or harmonization of environmental standards from the stringent environmental compliance countries is rising. All the CAREC countries are signatories to the 2030 global development agenda, including the sustainable development goals (SDGs); this will require concerted efforts towards compliance with environmental regulations through innovative approaches to the diffusion of environmental technologies to minimize industrial pollution and shifting towards greener production and trade.

Given this background, the study first examined whether the CAREC countries, owing to internal and external environmental regulations, lost trade competitiveness in most pollutive and less pollutive industrial trade from 2006 to 2020. Second, the study examined whether—owing to the difference in environmental regulations compliance between stringent OECD countries and lax CAREC countries—the CAREC countries have become a haven for the most pollutive manufacturing exports to OECD countries. Third, which is linked with the first two research questions, whether the impact of environmental regulations on the competitiveness of the relatively less pollutive industrial trade was the same as that predicted by the literature for the most pollutive industrial trade. And last, whether the COVID-19 pandemic negatively affected the CAREC region's pollutive industrial export patterns and competitiveness during 2006 to 2020.

The present study deploys a cross methodological approach to find how environmental regulations affect pollutive industrial trade flows and export competitiveness by using UN Comtrade SITC 2-digit level data during 2006 to 2020. One of the key study findings is that the impact of the environmental regulations on pollutive industrial trade in the CAREC region depends on whether it is most pollutive or less pollutive. Most CAREC region countries have enjoyed export competitiveness in the most pollutive industry and maintained that competitiveness during the entire study period. This study also found that the COVID-19 pandemic affected the pollutive industrial export competitiveness and increased volatility in comparative advantage mostly in the CAREC region countries, which rely on natural resources and lack export diversification. There was further evidence of pollution haven effects for pollutive industrial export flows of the CAREC countries with OECD and ROW countries. By broadening the research definition of pollutive industries to most pollutive and less pollutive industry groups, the current study provides a better insight into the dynamics of environmental policy impacts on trade competitiveness for the CAREC countries and their trade flows with environmentally stringent OECD countries. There is clear evidence regarding the CAREC countries becoming a pollution haven for industrial exports to environmentally stringent OECD countries.

Therefore, this chapter concludes the study in the following paragraphs by summarizing the conceptual frameworks and research process—from theory to empirics, methodological choices to data sources, and examination of the study research questions—reporting key study findings and accordingly offering some policy recommendations and sharing the study limitations.

### 7.2 Summary and Conclusions

Chapter two explained that the association between environmental quality, environmental regulations, and trade is multidimensional and complex. Therefore, the current study attempted to provide a cursory look at overall debated research endeavors/hypotheses surrounding trade and environmental policy dynamics. The dynamic links cover a variety of areas from economic growth to environmental regulations and trade, and those of an environmental quality aspect to FDI, geographic aspects, and the trade competitiveness effects of environmental regulations. There are further competing theories that this study critically reviewed on the association between environmental regulations and trade, such as industrial delocalization/pollution displacements, pollution haven hypothesis, and the Porter hypothesis. The discussions in chapter two concluded that research areas and issues surrounding trade and environmental relationships are multidimensional, which involved links of pollutive industrial trade flow with economic growth, FDI, product structure, ecological governance and stringency/community pressure/geographic factors, and a host of other factors that led to the emergence of competing theories/hypotheses about trade and environmental policy links. Therefore, there was no general equilibrium model that could capture all those theories under one umbrella. And the present research is no exception either. Consequently, the research focus was on environmental regulations and pollutive industrial trade associations.

Theoretical literature reviewed in chapter 3, especially under neo-classical assumptions, advocated that environmental regulations could influence production costs, trade patterns, industry comparative advantage and location, gains from trade, and thus the competitiveness of the economy. The literature reviewed in the light of neo-classical comparative advantage theory for environmental regulations and trade competitiveness perspective produced various possibilities depending on theoretical model assumptions and policies levied, but maintained the belief that environmental management efforts will negatively affect the country's trade comparative advantage and industrial competitiveness. Therefore, given the limited economic productive resources, there was a trade-off between environmental regulations and trade competitiveness.

The competing new trade theory followers that *inter alia* believed in economies of scale/product innovation/market imperfections, on the other hand, argued that there was no trade-off between compliance of environmental regulations and trade competitiveness owing to cost savings achieved via innovative environmental technology, which promotes a race to the top. The study further reviewed literature wherein neo-classical orthodoxy challenged the race to the top hypothesis, especially in the wake of poor records of property rights and lax environmental regulations in developed and developing countries and argued that the race to the top hypothesis could not exist, especially in developing countries' economies. Theoretical debate conducted in chapter 3 also reflected on one of these study's hypotheses: PHH, and concluded that the differential of environmental standards between the rich North and the relatively poor South as well as poor records of property rights in the South had created the situation where the South has become a haven for world pollutive commodity exports to the North. Accordingly, this study developed a synthesis in chapter 3 that, while neo-classical theories seemed to be more relevant to the quest of the current study research endeavors and for setting study research hypotheses, in the light of limitations among competing theories to produce conclusive outcomes, the impact of environmental regulations on pollutive industrial trade could best be examined via empirical quest.

The study clarified the definitional aspects of environmental regulation and trade competitiveness and surveyed the relevant literature in chapter 4. Since the study focuses on pollutive industrial trade, for statistical/empirical research analysis, the concept of pollutive industrial trade competitiveness had been seen through the lense of trade specialization patterns and, to be more specific, industrial export comparative advantage/specialization of pollutive industrial trade over time. In a cross methodological analysis framework, the competitiveness in pollutive industrial trade for the CAREC countries and overall sample countries, including OECD, would be judged based on environmental policy impact—positive and or negative—on different categories of pollutive industrial trade flow. Contemporary empirical literature regarding the effects of environmental regulations on pollutive industrial trade competitiveness followed a two-pronged definition of pollution intensive industry. The first approach identifies those industries that constitute relatively high pollution abatement costs in total costs or relative to their turnover as pollution intensive. The second approach is to pick those industries that rank high on actual emission intensity—that is, emission per unit of output or value added or per person employed. Both methods identified the same most pollutive manufacturing industries. This study embraced the definition offered by UNIDO (2000), XU (1999), and Tobey (1990) of pollutive industries that ranked those industries by their high and low emission intensity per unit of output and identified two pollutive industrial groups at disaggregated SITC level—namely, the most pollutive industries and the less pollutive industries.

The present study has critically reviewed both direct and indirect methods in chapter 4 deployed to study trade and environment regulations data to find a measurable impact of environmental regulation policies on pollutive industrial trade and competitiveness for the appropriate methodology choices. Most of the research conducted in the 1970s and 1980s tended to choose an indirect method of estimation. The focus of attention was on measuring environmental control costs for the most pollutive industrial trade sectors. The research was predominantly focused on US pollutive industrial trade sectors. Several studies found an insignificant impact of environmental regulatory costs on the trade patterns of pollutive industries, as environmental control costs on average remained around 2 percent of overall manufacturing costs. Nevertheless, other carefully assessed empirical findings showed that environmental control cost for pollution abatement in manufacturing sectors could have considerable negative effects on industrial trade flow and on the country's balance of trade and payments.

Among the direct empirical methods, the mainstream empirical research in this area has been broadly dominated by three trade modeling approaches, including: the industrial comparative advantage model developed by Balassa (1965); the H-O-V model (Murrell, 1990, 237-239) that allows the regression of net trade on factor abundance variables, including environment; and the gravity trade modeling approach pioneered by Tinbergen (1962) and Linnemann (1966), which is a bilateral trade flow model wherein industrial flows are determined by the income of home and partner countries, the distance between countries, and a host of geographic dummy and policy variables. This study reviewed a good number of studies covering all three trade models (see chapter 4). Most of the empirical work on the impact of environmental policy on pollutive industrial competitiveness focused on the developed part of the world, and less attention was given to LDCs. The empirical outcomes based on both bilateral trade flows—such as, gravity models—and multilateral trade flows—like H-O-V models—depicted that the impact of environmental regulations on trade competitiveness was both positive and negative, and the results were sensitive to the choice of methodology, estimation techniques, pollutive industries, geographic coverage, and period selected. Moreover, regarding tracing the effects of PHH, some studies indicated the possibility that developing countries might become a haven for world dirty production and trade.

Studies that adopted comparative advantage, Balassa based indexes have analyzed the impact of environmental regulations on trade via changing trade patterns and the comparative advantage of most pollutive industries over time. These studies conducted a comparative static analysis of pollutive industry trade between the beginning and end of the study period. The expectation was that an increase in stringency of environmental regulations faced by the country's industrial trade sectors over time would lead to loss of comparative trade and export competitiveness for that country. The underlying assumption in choosing this methodology was that environmental stringency on pollutive manufacturing production and trade sectors had risen over time in the country. Some studies found that trade shares and comparative export advantages in the most pollutive industries of environmentally stringent developed countries reduced over time. Whereas developing countries with lax environmental standards were gaining export share of the world total in the most pollutive industries and export comparative advantages in the most pollutive manufacturing sectors over the years. Based on these results, the researchers concluded with pollutive industry displacement/delocalization hypotheses and developing countries becoming a pollution haven for industrial production and trade for environmentally stringent developed countries (chapter 4).

The critical examination of literature reviewed in chapters 2 to 4 enabled this study to point out other notable issues/research gaps. Firstly, the large body of literature ignored the significance of drawing a comparative analysis between most pollutive and relatively less pollutive industry export patterns over time. It was worth examining whether somewhat similar or different conclusions could be drawn for most pollutive to less pollutive industrial trade owing to the introduction of stringent environmental regulations. Secondly, there was a dearth of literature regarding the impact of environmental regulations on trade wherein the same data set was placed to scrutinize cross methodological analysis, especially when the results were sensitive to the choice of method deployed. Furthermore, the author of the present research could not find any comprehensive study for the CAREC countries that analyzed the possible impact of environmental regulations on industrial trade competitiveness covering the most pollutive to less pollutive industry trade using SITC data. Nor did any study exist that examined pollutive industrial bilateral trade flows of CAREC countries with OECD and ROW. The present research filled these gaps in the literature.

Accordingly, in the light of this study's research questions and the paucity of environmental expenditure data at industrial levels in the CAREC region, this study employed the comparative advantage model offered by Balassa (1965, 1979, 1986) to examine the time series trend in the pollutive industry export comparative advantage for the CAREC countries. Secondly, the study deployed the Grether and de Melo (2004) model to examine the pollution haven hypothesis for the CAREC region. This study used and transformed available UN Comtrade SITC 2-digit revision-2 data for 2006 to 2020 for six CAREC, 28 OECD, and ROW countries.

The expectation in using the Balassa model in chapter 5 was that owing to relatively stringent environmental regulation in the end period 2016 to 2020 compared to 2006 to 2010, environmental pollutive industries with a higher export performance at the beginning period would become less competitive in the end sample period. The Balassa XRCA measured the competitiveness of each pollutive industry of the selected CAREC countries in three different periods—2006 to 2010, 2011 to 2015, and 2016 to 2020—by separating the specialized and non-specialized pollutive industries. A specialized industry is where XRCA for the sector is one or greater than one, and vice versa is true for a non-specialized industry, XRCDA.

For Azerbaijan, analysis shows that the country has virtually revealed comparative disadvantage for the world's most pollutive industries group (RCA<1)—XRCDA—in all industries during the period 2006 to 2020, except petroleum products. The country maintains export revealed comparative advantage (RCA>1)—XRCA—in the group of petroleum products in 2006 to 2010. It remained competitive during 2011 to 2020 in the same most pollutive industry group, and its comparative advantage in petroleum products further rose in the world market during the end period 2016 to 2020. Following Lall's (2001) technological sophistication based classification for manufacturing exports, the petroleum industries come under primary products. In the same most pollutive industrial group, the results for manufactured fertilizers, iron and steel, non-ferrous metals, and manufacturers of metals suggest that, even though these industries are not enjoying XRCA, they have strengthened their competitiveness position from a very low XRCDA in 2006 to 2010 to improved XRCDA during 2016 to 2020 (chapter 5).

For the less pollutive industrial exports category, Azerbaijan's results on comparative advantage in exports generally show that the country is less diversified in gaining the comparative export advantage in most of its industrial products during 2006 to 2020. The country exports, except for a few exceptions, remained uncompetitive in less pollutive industries during the same period. The country lost its export competitiveness during the pandemic year 2020 in several most pollutive industries, including the petroleum sector—a backbone to the country's economy. The trend continued in less pollutive industries when the export competitiveness results of these industries for the pandemic period 2020 were compared with the normalized averaged period 2016 to 2020. The sectoral level export RCA for 2020 indicate significant variations/volatility and shifts in comparative advantage/disadvantage position in the industries compared to the competitiveness performance of the country in both most pollutive and less pollutive industries during the normalized period 2016 to 2020.

China has achieved remarkable economic progress during the past 30 years. Among other factors, industrialization has played a major role in the economic growth of China and increased its world trade share. However, the rising growth has been achieved at the expense of deteriorating natural resources, high pollution, and relatively less stringent compliance with environmental regulations compared with its OECD trading partners. The study results show that China maintained its export competitiveness and XRCA in several industries in the most pollutive industrial group during 2006 to 2020. These include manufactured fertilizers; cork and wood, cork manufacturers; non-metallic mineral manufacturers; iron and steel; and manufacturers of metals. Owing to environmental regulations, these industries have not seen any loss of trade competitiveness in pollutive manufacturing exports during 2006 to 2020. The other most pollutive industries which had XRCDA in 2006 to 2010 remained non-competitive in industrial exports and witnessed XRCDA in 2016 to 2020. The results for comparative export advantage in most pollutive industries also show that a number of most pollutive industries are heading towards attaining export comparative advantage. Industries such as organic chemicals, paper and paperboard, and non-ferrous metals are close to gaining a comparative export advantage over the rest of the world. Therefore, an increase in stringency in environmental regulations has not negatively impacted China's pollutive industrial comparative advantage and export competitiveness during the study period. China, a labor-abundant country combined with lax environmental policies, has maintained a comparative advantage in resource based industries such as fertilizers and cork and wood and relatively non-footloose low technology pollutive industries such as iron and steel.

China is indeed the most diversified economy among the CAREC group countries; hence it showed XRCA in a number of industries among the group of less pollutive industrial exports. Following Lall's (2000) technological sophistication based classification for manufacturing exports, these industries fall into various categories from primary products such as food groups to high technology products such as office machines, telecommunication, and electric machinery. Another notable feature in industrial trade competitiveness for less pollutive industries group is that the manufacturing sector—such as metalliferous ores and metal scrap—which showed XRCDA during the beginning periods 2006 to 2015, then turned to XRCA in the end sample period 2016 to 2020. China's strong manufacturing export competitiveness and comparative advantage position in various technological classification categories among the group of less pollutive industries tend to reject the assertion and earlier findings by Cole and Elliott (2003) that only developed countries can enjoy the comparative export advantage in capital abundant and capital intensive sectors such as steel and chemical industries. The study results for relatively cleaner industries also confirm the Li et al. (2012) analysis that China's abundant labor factor endowment is the main reason the comparative advantage of industry trade is concentrated in cleaner industries. The comparative analysis between China's most pollutive and relatively less pollutive enterprises provides evidence of gaining industrial export competitiveness for several industries in both most pollutive and less pollutive industries during the study period. As industrial trade competitiveness in most pollutive and less pollutive industries seemed to be either maintained or increased over the year, especially in the most pollutive group, the study can confirm that China has not lost its industrial trade competitiveness owing to the introduction of stringent environmental regulations over the years in both most pollutive and less pollutive industries. There is further evidence for China to become a pollution haven for the world's most pollutive industrial exports.

The sectoral shifts in export comparative advantage/disadvantage during the pandemic (COVID-19) year 2020 *vis-à-vis* the averaged export competitiveness of the last five years indicate the winners and losers in industrial trade competitiveness for China's industrial exports to the world. However, owing to the diverse export base, the study findings showed far less volatility and shifts in exports competitiveness both in most and less pollutive industries of China compared to other CAREC countries.

Georgia has a locational advantage for being at the cross borders of the two biggest economic markets, namely Europe and Asia. The country has a substantial base to be a competitive export economy in the world trade market. For the most pollutive industry group, Georgia has shown an RCA during 2006 to 2020 for the commodities including manufactured fertilizers and iron and steel throughout the sample period; hence, the country maintained its export competitiveness. These pollutive industries fall in the category of medium technology manufacturing and low technology manufacturing industries, respectively. The RCA index results for the same most pollutive group show that both cork and wood (resource based manufacturing) and paper and paper board (low technology) industries had XRCDA both in 2006 to 2010 and 2011 to 2015, whereas the country enjoyed XRCA in the same industries during the end period and gained trade competitiveness. However, non-metallic mineral manufacturers in the most pollutive industries group, which were in a state of XRCA in 2006 to 2010 lost export competitiveness in the world market during the end sample period. Therefore, Georgia showed a mixed result in changing the comparative advantage position of most pollutive industrial exports. As a whole, over time, the country's export competitiveness in most pollutive industries has been less affected by environmental regulation.

In the less pollutive industry group, Georgia's XRCA remained intact from beginning to end sample periods between 2006 and 2020 for the industries including live animals chiefly for food; beverages; metalliferous ores and metal scrap; electric current; animal oils and fats; inorganic chemicals; explosives and pyrotechnic products; and road vehicles. Regarding technological sophistication based classification for manufacturing exports, these industries cover primary products—such as food—to resource based—like beverages—to medium technology industries—such as road vehicles—to high technology manufacturing less pollutive industries of inorganic chemicals. Therefore, Georgia has maintained its export competitiveness in diversified industrial traded goods, some of which are the world's fastest growing industrial exports. On the other hand, within the less pollutive industry group, the country has had an XRCA in some industries during the beginning period 2006 to 2010. However, it lost export competitiveness in the end sample periods. These industries include cork and wood; crude fertilizer and crude minerals; leather, leather manufacturers; other transport equipment; and gold, non-monetary (excluding gold ores and concentrates). The study also finds that some industries have had XRCDA in 2006 to 2010 and moved to competitive export category with XRCA during the end sample period 2016 to 2020. The study finds mixed results regarding environmental regulations affecting industrial trade competitiveness in the two pollutive industry groups. Furthermore, less evidence supports the hypothesis that Georgia has lost industrial export competitiveness in most pollutive sectors owing to the rise in environmental regulations in production and traded sectors over the years. The results for the COVID-19 period—2020—show that the country increased its export comparative advantage more in the group of most pollutive industries compared to less pollutive industries *vis-à-vis* sectoral export competitiveness observed for the same industries during the period 2016 to 2020.

Kazakhstan maintained its XRCA and competitiveness in a small selection of industries, including petroleum and petroleum products, iron and steel, and non-ferrous metals in the beginning period 2006 to 2010 and the end period 2016 to 2020. Nevertheless, the country has not been able to have a comparative advantage in exports in any other industry within the group of most pollutive sectors during 2006 to 2020, except the industries XRCDA has reduced in chemical and material products industries from the beginning to the end period. In the less pollutive industry group, the sources of country export comparative advantage, following Lall's (2000) technological sophistication based classification for manufacturing exports, emanates primarily from primary products and resource based industries. These industries include crude fertilizer and crude minerals; metalliferous ores and metal scrap; coals, coke, and briquettes; gas, natural and manufactured; animal and vegetable oils and fats. All these industries had XRCA in the beginning period 2006 to 2010 and maintained the XRCA until 2016 to 2020. There is some evidence that Kazakhstan enjoyed export competitiveness over the world exports in the high technology industry, but that was limited to one sector only—inorganic chemicals, wherein the country's XRCA remained consistent during the whole sample period. Furthermore, within the less pollutive industries, it had XRCA in leather and leather manufacturing; textile fibers; and gold, non-monetary industries during 2006 to 2010. The country lost export competitiveness in 2011 to 2015 and 2016 to 2020, indicating the reversal of export specialization and competitiveness in those industries. However, the oil seeds and coin (other than gold) sectors which had XRCDA in 2006 to 2010 moved to export specialization and observed XRCA in the end period 2016 to 2020. Overall, the study did not find the negative impact of environmental policy on most pollutive industry exports. For less pollutive industries, the impact of an increase in environmental stringency on comparative trade advantage depended on the industry.

For Kyrgyzstan, in most pollutive industry categories, the non-metallic mineral manufacturing area displayed a consistent XRCA in the beginning and end study periods. The country maintained its export competitiveness position in that industry in the world export market. The study would expect the impact of environmental policies that have risen over the year to reduce export competitiveness, especially to the most pollutive industries. This study for Kyrgyzstan, on the contrary, finds a few most pollutive manufacturing sectors—such as fertilizers, and iron and steel—gained export competitiveness (RCA>1) during 2016 to 2020 from the beginning of period 2006 to 2010 when those industries had comparative trade disadvantage (RCA<1). All other sectors within the group of most pollutive industries remained uncompetitive in exports both during the beginning and end periods. The results seemed to point towards the pollution haven effect for Kyrgyzstan's most pollutive export industries as less evidence was found regarding loss of export competitiveness in most pollutive industries owing to increased environmental regulations over time.

In the less pollutive industries of Kyrgyzstan, the industries that had XRCA during the entire study period included live animals chiefly for food; tobacco and tobacco manufacturers; hides, skins and fur skins, raw; textile fibers; crude fertilizer; electric current; medicinal and pharmaceutical products; explosives and pyrotechnic products; articles of apparel and clothing accessories; and gold, non-monetary (excluding gold ores and concentrates). Some industries facing export revealed comparative disadvantage during 2006 to 2010 moved to the export comparative advantage group and gained competitiveness in world export markets during the end of the study period 2016 to 2020. Those industries included crude rubber; metalliferous ores and metal scrap; coal, coke, and briquettes; textile yarn, fabrics, made-up articles, and related products; and footwear. There were fewer cases where industries faced XRCA during 2006 to 2010 or 2011 to 2015 and moved to XRCDA, except the beverage industry. Therefore, Kyrgyzstan's industrial exports as a whole gained more competitiveness both in most pollutive and less pollutive industries during the study period.

For the most pollutive industrial group, the results show that Pakistan faced XRCDA in the beginning period 2006 to 2010 in most commodities, except non-metallic mineral manufacturers. In later industries, it had an XRCA until 2011 to 2015, but for the end period, 2016 to 2020, the country witnessed XRCDA in all the most pollutive industries, except organic chemicals. The country gained export competitiveness in organic chemical exports in world pollutive industrial exports during 2016 to 2020. The results of RCA for most pollutive industries category revealed that XRCDA for most industries receded over time. Despite liberalization efforts since the 1980s, the country's exports are not much diversified. Its comparative advantage in exports *vis-a-vis* the world's industrial exports concentrates mainly on selected primary and resource based manufacturing products. Therefore, the introduction of environmental regulations in manufacturing sectors has not had a discernable impact on industrial export competitiveness. Instead, there are more signs of gaining competitiveness in some of the world's most pollutive industries.

For the less pollutive industrial category of Pakistan's exports, the industries that maintained comparative export advantage throughout 2006 to 2020 included live animals chiefly for food; textile fibers (not wool tops) and their wastes (not in yarn); fixed vegetable oils and fats, processed, and waxes; explosive and pyrotechnic products; leather and leather manufacturer products; textile yarn, fabrics, made-up articles, and related products; articles of apparel and clothing accessories. Other industrial sectors that were in a state of XRCDA in 2006 to 2010 but moved to XRCA in 2016 to 2020 included: oil seeds and oleaginous fruit; crude fertilizer and crude minerals; coal, coke, and briquettes; gas, natural and manufactured; animal oils and fats; dyeing, tanning, and coloring materials; and artificial resins and plastic materials, and cellulose esters. However, the footwear industry in a state of XRCA in 2006 to 2010 became XRCDA and lost export competitiveness in 2011 to 2020. Overall, based on XRCA results for Pakistan's economy, the study did not find that the less pollutive industries lost trade competitiveness owing to the introduction of both internal and external environmental regulations.

The coronavirus disease (COVID-19) pandemic has significantly negatively impacted global trade, supply chains, and industrial export competitiveness. The RCA results for the pandemic year 2020 suggest that Pakistan improved its export comparative advantage in several industries among the group of most pollutive industries when compared with the preceding five year averaged period 2016 to 2020. Compared to the XRCA results of COVID-19 during 2020 with the last five year average of 2016 to 2020, this study finds mixed outcomes for less pollutive industries. Lastly, in the wake of global trade volatility from COVID-19 in 2000, the study found shifts in sectoral comparative advantage/disadvantage in industrial exports in both pollutive industry groups when compared with the export comparative advantage position during the averaged period 2016 to 2020.

This study results based on the Balassa comparative model for the CAREC region show that the impact of environmental stringency on industrial export competitiveness is sensitive to industry group and individual industry, and results vary for different pollutive industrial groups from most pollutive to least pollutive. There is an increasing tendency for gaining export competitiveness in most pollutive industries among most CAREC countries chosen for the study analysis, signaling the presence of the pollution haven effect. For some other CAREC countries, there are shifts of production locations and trade specialization patterns. Overall, over time, based on comparative analysis between most pollutive and less pollutive industries, fewer systematic trends emerged regarding the impact of environmental regulations on pollutive industry trade specialization patterns for CAREC countries. Most CAREC countries still face production and trade diversity challenges and rely on primary and resource based exports and are a long way off trade competitiveness in high technology manufacturing production and exports.

One of the study objectives was to examine whether differences in environmental regulations between the stringent North OECD and laxer CAREC countries have caused the CAREC region to become a haven for pollutive industrial trade flows to the OECD countries. The theoretical literature reviewed in chapter 3 indicated that a gap in environmental regulations between the rich North and the poor South could lead to the relocation of pollutive industry towards developing countries, assuming all other things are constant and/or developing countries developing a comparative advantage in most pollutive industries and becoming a repository for pollutive industrial production and trade.

This study reviewed some of the earlier literature on PHH and the number of studies that drew conclusions for developing countries to become PHH by finding the reduced pollutive industry export share of developed countries over time, which seemed to violate PHH. The competitiveness indicator computed in chapter 5 for both pollutive industry groups and for each CAREC country has provided an in-depth understanding of pollutive industrial competitiveness and trade specialization patterns over time and reflected the pollution haven effect. Nevertheless, as this study argued in chapter 6, the examination of PHH demanded further control on geography so that the bilateral trade flows of pollutive industry over time could be analyzed between the environmentally stringent OECD and the environmental laxer CAREC region. Such analysis requires the adoption of a methodology that enables the measurement of bilateral RCAs in the North-South framework. Grether and de Melo (2004) offered that methodology and deployed it to trace evidence of PHH in the CAREC region. Furthermore, no efforts were made in the earlier literature to examine whether the CAREC region had become a pollution haven for different groups of industrial export to OECD countries. The study further examined whether a comparative analysis between most pollutive and relatively cleaner industrial trade groups provided further insight into the pollution haven effects for the CAREC region.

Following Grether and de Melo's (2004) methodology, the study first computed composition effect: it is the part of the aggregate RCA change that is attributable to the changes in a country's export share—that is, the share of one country in a specific industry of the country—say, Pakistan—is falling and that of—say, China—is increasing. Then it focused on computing the structural effect that provides information on structure shift in industrial exports measured through bilateral RCAs by keeping the composition effect constant around its average. The estimation of composition and technique effects during the period 2006 to 2020 reflected whether the change in comparative advantage over time attributed more to productivity/technology improvement via technique effect or owing to change in industrial composition. Then based on world countries' (UN Comtrade, SITC 2-digit) export data, it computed CAREC countries' bilateral weighted export RCAs for most and less pollutive industry categories with 28 environmentally stringent high income OECD countries and with ROW for the beginning (2006 to 2010) and end (2016 to 2020) sample periods. These new geographically controlled bilateral export analyses provided a better understanding of whether CAREC countries had become a pollution haven of dirty exports for the most environmentally stringent OECD countries. Also, for comparative analysis, the study examined whether somewhat different results could be drawn from the analysis of the same region's bilateral pollutive industry exports with the ROW country group. Later groups of countries were not necessarily environmentally stringent.

The study finds that structural effects among the most pollutive industrial sectors are generally more substantial than the compositional effect for the CAREC region. The compositional effects of pollutive industrial trade reinforce technique effects, making total effects for pollutive industrial exports move in a positive direction. The results further revealed that the structural transformation mechanism worked for pollutive industrial trade competitiveness. The impacts are more visible among the most pollutive industries where, except for a few exceptions, the total effects for the combined regions are positive for all the most pollutive industrial exports. The results for the less pollutive industry group confirmed the opposite of the study's findings for the most pollutive industries. The total effect for the CAREC region is negative for the less pollutive industry group, primarily owing to China's negative change in combined industrial comparative advantage in the less pollutive industries. This study has clarified many reasons for the negative change in comparative industrial advantage, including China's recent rigorous drive towards industrial upgradations for greener growth. That is one of the vital contributions of the study towards the pollution haven effect. The findings revealed that confining the research analysis to just the most pollutive industry trade could provide incomplete information on the impact of environmental policy on trade flows. That was especially true for the CAREC countries where environmental regulations were equally or perhaps more important for industries other than the most pollutive industries, as the large volume of bilateral industrial export flows from the CAREC region to OECD and ROW countries fall in the less pollutive industry group.

The study, in chapter 6, finds positive export bilateral RCAs, a change in bilateral RCA shares, and share growth rates of CAREC with OECD in combined most pollutive and less pollutive industries. The results confirm that CAREC countries have become a haven for most pollutive industrial exports to stringent environmental OECD over time. Nonetheless, the CAREC region's bilateral export share and RCA growth rates in the same pollutive groups have also risen over time with the ROW group, which is made up of relatively environmentally laxer countries. The strongest trend witnessed was for the most pollutive industries compared to other groups. For the less pollutive or relatively cleaner industry group, the study found that bilateral RCA of CAREC, OECD and ROW countries are positive.

The comparative analysis between different pollutive industry groups and the two regional groups—OECD and CAREC—has depicted somewhat puzzling results. The theory behind this is if the difference in environmental policy was a crucial factor in bilateral export flows between CAREC and OECD then the study would have seen improved bilateral RCA of CAREC with OECD in the most pollutive industries only and not in other pollutive industry groups, nor would there be a consistent rise of CAREC bilateral exports with ROW and OECD in relatively cleaner industries. A few plausible reasons explain this phenomenon. Firstly, based on the RCA index, the results produced in chapter 5 *inter alia* concluded that the CAREC region, in general, gained competitiveness in both most pollutive and less pollutive industries. Secondly, the results produced for compositional and structural effects for industrial exports suggest that these effects reinforced each other across the pollutive groups, not for all industries but in most. Thirdly, which is appealing in the light of comparative advantage theory, that in addition to the theoretical difference of environmental regulations between North and South, other traditional sources of comparative advantage—such as, provision of natural resources, the labor cost differential between CAREC and OECD, industrial and trade policies, and other sources of comparative advantage facilitating competitiveness—could be contributing factors to determine bilateral trade flows.

Overall, the study concludes that rising environmental regulations over time could not alter the export competitiveness position of most pollutive industries in the CAREC region. However, the results were sensitive to the choice of industry within the most pollutive industries, wherein some most pollutive sectors lost trade competitiveness owing to the introduction of stringent environmental regulations over the years in those countries. For the less pollutive industries, there were again mixed outcomes, and the impact of environmental policy was sensitive to the choice of a particular industry and its competitive position in world trade. The bilateral RCA model provides clear evidence that the combined CAREC countries have become a pollution haven for OECD countries in most pollutive and less pollutive industries. This study further cautioned on the robustness on this conclusion in the wake of puzzling outcomes observed in the export flows of the CAREC region with OECD and ROW and across pollutive industry categories. Accordingly, there seemed to be fewer systemic results/conclusions drawn about the impact of environmental regulations on different categories of pollutive manufacturing trade in the CAREC countries and their bilateral trade flows with the OECD countries and ROW. Also, as trade theory predicted, other sources of comparative advantage—including land, labor and natural resources—could be vital contributing factors in the industrial trade competitiveness of the CAREC countries. Also, the COVID-19 pandemic has created volatility in comparative advantage and thus export competitiveness in both the most pollutive and less pollutive industries of the CAREC region.

### 7.3 Policy Recommendations

The study findings for the CAREC region show that a careful comparative analysis between most pollutive and relatively less pollutive industries is essential in determining the environmental policy impacts on export and trade competitiveness, as the impact of the policies is sensitive to the choice of different pollutive industrial category and within each pollutive industry group. Therefore, an environmental policy designed to achieve social benefits with industrial trade competitiveness should be carefully weighted to incorporate the impact of more disaggregated level sectors by bringing in the diversity of measurements needed for each pollutive industrial sector rather than framing the policy in the belief that 'one size fits all.' The study findings also show that the impact of environmental regulations on pollutive industrial exports is sensitive to the methodology adopted. Therefore, any policy making endeavors to achieve industrial competitiveness and environmental management should be based on rigorous cross methodological research analysis.

The study concluded that the COVID-19 pandemic resulted in the volatility of export competitiveness in most pollutive and less pollutive sectors for the CAREC region. The countries with a narrow base/less diversified and natural resource based exports have witnessed competitiveness shocks, and loss of export competitiveness; others with more diversified export base economies suffered less. Therefore, the study recommends adopting a mutually supportive trade and environmental policy design that promotes and expands the diversified, sustainable production and export competitiveness at sectoral level in the CAREC region.

The study findings of composition, technique, and pollution haven effects for the CAREC region have provided insights into whether the change in the comparative advantage of pollutive industries attributed more to productivity/technology improvement via technique effect or change in industrial composition. The study outcomes send a clear signal to the policymakers of the individual CAREC countries to make concerted efforts to improve both productivity and innovative techniques to enhance industrial export competitiveness both within and between the regions.

Given that the CAREC region has become a pollution haven for environmentally stringent OECD countries, the most environmentally stringent countries' demand for compliance with domestic and international environmental regulations/agreements will inevitably spread to the CAREC region's trade sectors. Therefore, the study recommends the CAREC region to ensure that the 2030 agenda of sustainable developments aligns the ambitious and speedy environmental regulation compliance targets with greener industrial production and trade.

This study, deemed to be the first of its kind to examine the impact of environmental policy on pollutive industrial trade competitiveness for the CAREC region in the wake of the COVID-19 pandemic. The study findings contribute to the CAREC countries' industrial trade competitiveness and sustainable environmental strategies. It has contributed to research and policy that analysis on the most pollutive industry trade alone could give incomplete information on trade flows when the impacts of environmental regulations are equally or perhaps more important for other industries rather than just the most pollutive industries in the CAREC region. The comparative analysis between different categories of pollutive industrial trade is vital when a large volume of pollutive industrial trade flow from the CAREC region to OECD and ROW countries could fall in an industry group other than the most pollutive industries.

The study findings showed both positive and negative impacts of the policy for individual pollutive export sectors for a number of CAREC countries. There is thus a trade-off between environmental and industrial competitiveness objectives. Trade-offs are the most challenging situations for policymaking. Therefore, this research conveys that sustainable production and trade policies, combined with innovative and cost-effective environmental policies, need to be designed to achieve both the economic gains in terms of industrial competitiveness and environmental benefits for society.

### 7.4 Study Limitations

There is a dearth of data on environmental regulations. Therefore, empirical literature in the past aimed at analyzing the environmental regulations on trade competitiveness has suffered from a lack of adequate and comprehensive comparative data on environmental stringency across countries. While some efforts have been made in the advanced part of the world to measure the abatement costs of environmental regulations in terms of environmental expenditure at industry level, these are not free from error. One of the significant problems the countries face is measuring the exact abatement cost that regulation imposes on manufacturers, which is not straightforward.

Given these data deficiencies, the current study focused on the widely accepted comparative trade advantage modeling approach applying to pollutive industrial trade data over time. There is a dire need for a time series analysis of cross country comparable environmental controlled cost data at individual industry/firm level from the most pollutive to the least pollutive industries for developing countries including CAREC and other regions. Moreover, there should be a uniformity in data collection methodology for both developed and developing countries, allowing the researcher to have better insights into the environmental regulation and trade competitiveness links within developing countries and between developed and developing countries.

This study has not focused on aspects of political economy nor strategic issues of environmental policies and trade. The main purview of the research did not include the debate on the role of non-tariff measures to protect public health and the environment, or their impact on trade and issues relating to the association between transboundary pollutions and international trade.

## Bibliography


ADB (2006), Central Asia Increasing Gains from Trade Through Regional Cooperation in Trade Policy, Transport, and Customs Transit, **ADB, Philippine**.

ADBI (2017), CAREC 2030**:** Connecting the Region For Shared and Sustainable Development, ADBI: Philippine.

Adams, J. (1997), Environmental policy and competitiveness in a globalised economy: Conceptual issues and a review of the empirical evidence, In: **Globalisation and environment: Preliminary perspectives**. Paris: OECD.

Afsah, S. et al. (1996), Controlling Industrial Pollution: A New Paradigm, **Policy Research Working Paper 1672,** Washington, DC: World Bank.

Alanen, Leena (1996), The impact of environmental cost internalization on sectoral competitiveness: a new conceptual framework, **Discussion Papers Number 119: UNCTAD.**

Almas, L. K. and Hajiyev, N.U. (2013), Azerbaijan’s Current and Potential Comparative Advantage: An Exploratory Study**, International Conference on Policy Modeling**.

Álvarez, Inmaculada C. et al. (2018), Does institutional quality matter for trade? Institutional conditions in a sectoral trade framework, **World Development,** 103, pp. 72-87.

Balassa, B. (1965), Trade Liberalization and “Revealed” Comparative Advantage, **The Manchester School of Economic and Social Studies**, Vol.33. pp.92-123.

Balassa, B. (1979), The Changing Pattern of Comparative Advantage in Manufactured Goods, **Review of Economics and Statistics**, Vol.61, pp. 259-266.

Balassa, B. (1986), Comparative Advantage in Manufactured Goods: A Reappraisal, **Review of Economics and Statistics**, Vol.68, pp. 315-319.

Ballance, R. H., Forstner, H. and Murray, T. (1987), Consistency tests of alternative measures of comparative advantage, **Review of Economics and Statistics** 69 (1), pp. 157-161.

Baumol, W.J. and Oates, W. (1988), **The Theory of Environmental Policy**. Cambridge University Press, Cambridge.

Belkania, Davit (2019), Dissecting Export Trade Patterns of Georgian Economy and the Growing Importance of the European Union Market, **European Journal of Interdisciplinary Studies**, vol (5), 18-26.

Bender, S. and Li, Kui-Wai (2002), The Changing Trade and Revealed Comparative Advantage of Asian and Latin American Manufacture Exports, **Economic Growth Centre, Yale University**, Discussion paper No.843.

Bhagwati, J. and Robert E. Hudec (1996), **Fair Trade and Harmonization: Prerequisites for Free Trade?** Cambridge: MIT Press.

Bhagwati, J. and Srinivasan, T. N. (1996), Trade and the Environment: Does Environmental Diversity Detract from the Case for Free Trade? in Jagdish Bhagwati and Robert E. Hudec (eds.), **Fair Trade and Harmonization: Prerequisites for Free Trade?** vol.1. Cambridge: MIT Press.

Birdsall, N., Wheeler, D., (1992), Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens? In Low, P.(ed.), International Trade and the Environment. **World Bank Discussion Paper, vol. 159.** World Bank, Washington, DC.

Boumal and Oates (1988), **The Theory of Environmental Policy, 2nd ed**. Cambridge University press, Cambridge.

Bowen, H.P. (1983), On the theoretical interpretation of indices of trade intensity and revealed comparative advantage, **Weltwirtschaftliches Archiv**, vol.119, pp. 464–472.

CAREC (2006**), Regional Cooperation on Environment**, CAREC, Urumqi, China.

CAREC (2020), https://**www.carecprogram.org**/

Cantore, N. and Cheng, C.F.C. (2018), International trade of environmental goods in gravity models, **Journal of Environmental Management** 223, pp.1047-1060.

Chichilnisky, G. (1994), North-South Trade and the Global Environment, **American Economic Review**, 84(4), pp. 851-74.

Chichilnisky, G. (1993), North-South Trade and the Dynamics of Renewable Resources, **Structural Change and Economic Dynamics** 4(2), pp. 219-48.

CIESIN (2020), Environmental Performance Index(2006-20), [online]. CIESIN, [viewed on July 2021]. **https://sedac.ciesin.columbia.edu/data/set/epi-environmental performance-index.**

Coase, R. H. (1960), The Problem of Social Cost, **Journal of Law and Economics**, vol.3, pp. 1-44.

Cole, M. et al. (2003a), US Specialization in Pollution-Intensive Industries: Factor Intensities versus Environmental Regulations, **The School of Economics Discussion Paper Series**, The University of Manchester.

Cole, M. A. (2004), Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages, **Ecological Economics**, vol 48(1), pp. 71-81.

Cole, M. A. et al. ( 2005), Why the grass is not always greener: the competing effects of environmental regulations and factor intensities on US specialization, **Ecological Economics,** vol 54(1), pp. 95-109.

Cole, M.A. and Elliott, R. J. R. (2003), Do Environmental Regulations Influence Trade Patterns? Testing Old and New Trade Theories. **World Economy**. vol 26(8), pp.1163-1186.

Cole, M. A. and Rayner, A. J. (2000), The Uruguay Round and Air Pollution: Estimating the Composition, Scale and Technique Effects of Trade Liberalization, **Journal of International Trade and Economic Development,** vol 9(3), pp.339-54.

Copeland and Taylor (1994), North-South Trade and the Environment, **Quarterly Journal of Economics**,109(3), pp.755-87.

Dasgupta, S., A. Mody, S. Roy and D. Wheeler (1995), Environmental Regulation and Development: A Cross-Country Empirical Analysis, **World Bank Policy Research working paper** No. 1448, pp.1–24.

Dean, J. M. (1992), Trade and Environment- A Survey of the Literature, In Low, P.(ed.), International Trade and the Environment, **World Bank Discussion Paper,** vol. 159, pp. 15-28, World Bank: Washington DC.

Dean, Judith M. (2000), Does Trade Liberalization Harm the Environment? A New Test, **CIES Policy Discussion Paper #0015**, http://www.adelaide.edu.au/cies.

Dean, Judith M. (2002), International Trade and the Environment**, International Library of Environmental Economics and Policy Series**, Ashgate, UK.

Deardorff, A.V. and R.M. Stern. (1994), Multilateral Trade Negotiations and Preferential Trading Arrangements, Chapter 2 in Deardorff and Stern (eds.), **Analytical and Negotiating Issues in the Global Trading System**. Ann Arbor: Univ. of Mich. Press.

Dixit, Avinash K.; Stiglitz, Joseph E. (1977), Monopolistic Competition and Optimum Product Diversity, **American Economic Review,** 67(3), pp. 297-308.

Du, W. and Li, M. (2020), Influence of environmental regulation on promoting the low-carbon transformation of China's foreign trade: Based on the dual margin of export enterprise. **Journal of Cleaner Production,** 244, 118687.

Eliste, P. and P.G. Fredriksson (2001), Does Trade Liberalisation Cause a Race to the Bottom in Environmental Policies? A Spatial Econometric Analysis. Forthcoming in Anselin, L. and R. Florax (eds.) (2001), **New Advances in Spatial Econometrics**, Springer-Verlag, Berlin.

Eskeland, G.S. and Harrison, A. E. (2003), Moving to Green Pastures? Multinationals and the Pollution Haven Hypothesis, **Journal of Development Economics,** 70(1), pp.1-23.

Esty, Daniel, C. (2001), Bridging the Trade-Environment Divide, **Journal of Economic Perspectives,** vol 15, pp. 113–130.

Evans, M. K. (1973), A Forecasting Model Applied to Pollution Control Costs, **American Economic Review**, **A Supplement**, vol 63, pp-244-256.

Feng, Chun, et al. (2021), An Empirical Analysis of the Industrial Trade Relationship between China and Central Asia from the Perspective of the Belt and Road Economic Belt, **E3S Web of Conferences vol 235**.

Fertö, I. and Hubbard, L.J. (2003), Revealed Comparative Advantage and Competitiveness in Hungarian Agri–Food Sectors, **https://doi.org/10.1111/1467-9701.00520.**

Frankel, Jeffrey, A. and Romer, David, H. (1999), Does Trade Cause Growth? **American Economic Review**, 89 (3), pp. 379-399.

Frankel, Jeffrey, A. and Rose, A.K. (2005), Is Trade Good Or Bad for the Environment? Sorting Out the Causality**, Review of Economics and Statistics**, 87(1), pp.85-91

Fredriksson, P.G.(Ed.) (1999), Trade, Global Policy, and the Environment. **World Bank Discussion Paper no 402.** World Bank. Washington, D.C.

Gagnon, J. E. and Rose, A. K. (1995), Dynamic Persistence of Industry Trade Balance: How Pervasive is the Product Cycle? **Oxford Economic Papers**, vol.47, pp. 229-248.

Gong, M. et al. (2020), Environmental Regulation, Trade Comparative Advantage, and the Manufacturing Industry's Green Transformation and Upgrading, **International Journal of Environmental Research and Public Health**, 17(8): 2823.

Grether, J.M. and J. de Melo, (2004), Globalisation and dirty industries: Do pollution havens matter?, in R.E. Baldwin and A. Winters (eds), **Challenges to Globalisation: Analyzing the Economics**, Chicago: University of Chicago Press, pp. 167-208.

Grossman, G.M. and Krueger, A.B. (1991), Economic Growth and the Environment, **Quarterly Journal of Economics**, CX (2), pp. 353-379.

Grubel, H.G. (1975a), Some Effects on Environmental Control on International Trade: The H-O model. In Walter, Ingo(ed.), **Studies in International Environmental Economics.** Wiley-Interscience, New York.

Grubel, H. G. and Lloyd, P. (1975), **Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products**. Macmillan, London.

Harris, M.N. et al. (2002), Modelling the Impact of Environmental Regulation on Bilateral Trade Flows: OECD, 1990-96, **World Economy**, 25(3), pp.387-405.

Helpman, E. and Krugman, P.R. (1985)**, Market Structure and Foreign Trade: Increasing Return, Imperfect Competition, and International Economy**, Cambridge, USA.

Hettige, H. et al. (1999), Industrial Pollution in Economic Development: Kuznets Revisited, in Fredriksson, Per G. (ed.), Trade, global policy, and the environment, **Discussion Paper, no. 402, World Bank,** Washington, D.C., 1999, 65-82.

Hillman, Rye (1980), Observations on the relation between "revealed comparative advantage" and comparative advantage as indicated by pre-trade relative prices, **Review of World Economics (Weltwirtschaftliches Archiv**), Springer;Institut für Weltwirtschaft (Kiel Institute for the World Economy), vol. 116(2), pages 315-321.

IMF (2021), Direction of Trade Statistics, **https://data.imf.org/?sk=9D6028D4-F14A-464C-A2F2-59B2CD424B85**

Jaffe, B.A. et al. (1995), Environmental Regulation and the Competitiveness of US Manufacturing: What Does the Evidence tell us? **Journal of Economic Literature.** 33(1),132-64.

Jayawardane, C. and Edirisinghe, J.C. (2014), Environmental Stringency and Dirty Exports: An Empirical Analysis, **International Journal of Economic Practices and Theories**, Vol. 4(6), pp.1018-1023.

Jenkins, Rhys, et al. (2002), **Environmental Regulation in the New Global Economy**, Edward Elgar: UK.

Kalt, J. (1988), The Impact of Domestic Environmental Regulatory Policies on US International Competitiveness, in M. Spence and H. Hazard (eds**), International Competitiveness,** Cambridge, MA: Ballinger Publishing, pp. 221-261.

Kemal, A.R., M. Din, K. Abbas and U. Qadir (2000), A Plan to Strengthen Regional Trade Cooperation in South Asia , **Paper presented at the Second Conference of the South Asia Network of Economic Research Institute (SANEI)**, 28–29 August, Kathmandu.

Khatibi, Arastou (2008), Kazakhstan's Revealed Comparative Advantage Vis-À-Vis the EU-27, **ECIPE Working Paper No.03/2008.**

Khan, Shahrukh Rafi et al. (2001), Environmental impacts and mitigation costs associated with cloth and leather exports from Pakistan, **Environment and Development Economics**, Cambridge University Press, vol. 6(3), pages 383-403, July.

Kruger, A.O. (1997), Trade Policy and Economic Development: How we Learn, **American Economic Review**, 87(1), pp.1-22.

Lall, S. (2001), Competitiveness Indices and Developing Countries: An Economic Evaluation of the Global Competitiveness Report, **World Development**, 29 (9), pp.1457-1621.

Leamer, E. (1980), The Leontief Paradox, Reconsidered, **Journal of Political Economy**, vol 88, pp. 495-503

Leamer, E. (1984), **Sources of International Comparative Advantage: Theory and Evidence**. Cambridge: MIT Press.

Leebron, David W. (1996), Claims for Harmonization: A Theoretical Framework, **Canadian Business Law Journal**, vol 27.

Levinson, A. and Taylor, S. (2004), Unmasking the Pollution Haven Effect, **NBER Working Paper 10629**, Massachusetts: Cambridge, MA.

Li, X. et al. (2012), Does the Intensity of Environmental Regulation Affects the Trade Comparative Advantage of China's Industrial Industry, **Journal of World Economy**, vol (35), 62-78.

Li, D. and Zhu, J. (2019), The role of environmental regulation and technological innovation in the employment of manufacturing enterprises: Evidence from China. **Sustainability**, 11, 2982.

Lin, B. and Xu, M. (2019), Exploring the green total factor productivity of China's metallurgical industry under carbon tax: A perspective on factor substitution, **Journal of Cleaner Production**, vol (233) pp: 1322–1333.

Linnemann, H. (1966), **An Econometric Study of International Trade Flows**, Netherlands: North Holland Publishing Company.

Lipsey, Richard (1960), The Theory of Customs Unions: A General Survey, **Economic Journal**, 70, pp. 498-513.

Liu, J. and Xie, J. (2020), Environmental Regulation, Technological Innovation, and Export Competitiveness: An Empirical Study Based on China's Manufacturing Industry. **International Journal of Environmental Research and Public Health**, 17, 1427.

Low, P. (1992), Trade Measurement and Environmental Quality: The Implications for Mexico Exports? In Low, P.(ed.), International Trade and the Environment. **World Bank Discussion Paper,** vol. 159**.** World Bank, Washington, DC.

Low, P. and Safadi, R. (1992), Trade Policy and Pollution. In Low, P.(ed.), International Trade and the Environment. **World Bank Discussion Paper, vol. 159**. World Bank, Washington, DC.

Low, P. and Yeats, A. (1992), Do Dirty Industries Migrate?, In Low, P.(ed.), International Trade and the Environment, **World Bank Discussion Paper,** vol. 159, pp.89-103. World Bank, Washington, DC.

Lucas, E.B.R., Wheeler, D., Hettige, H. (1992), Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution:1960-88, In Low, P.(ed.), International Trade and the Environment. **World Bank Discussion Paper no 159**, pp.67-86, Washington, DC: World Bank,

Mabey, Nick and McNally, Richard (1999), Foreign Direct Investment and the Environment: From Pollution Havens to Sustainable Development, **WWF UK Report**, UK.

Mani, M. and Wheeler, D. (1999), In Search of Pollution Havens? Dirty Industry in the World Economy, 1960-1995, in Fredriksson, Per G., ed., Trade, global policy, and the environment, **World Bank Discussion Paper**, no. 402, Washington, D.C.: World Bank, pp. 115-28.

McGuire, M. (1982), Regulation, Factor Rewards, and International Trade, **Journal of Public Economics,** vol 17(3), pp. 335-354.

Merrifield, J. (1988), The Impact of Selected Abatement Strategies on Transnational Pollution, the Terms of Trade, and Factor Rewards: A General Equilibrium Approach, **Journal of Environmental Economics and Management**, vol 15(3), pp. 259-284.

Murrell, P. (1990), **The Nature of Socialist Economies: Lessons from East European Foreign Trade,** Princeton University Press.

Mutti, John H. and Richardson, J. David, (1977), International competitive displacement from environmental control The quantitative gains from methodological refinement**, Journal of Environmental Economics and Management,** vol. 4(2), pp.135-152.

Nordstrom, H. and Vaughan, S. (1999), Trade and Environment, Geneva, Switzerland: **World Trade Organization**. Geneva.

OECD (1993), **Environmental Polices and Industrial Competitiveness, Paris**: OECD,

OECD (1994), **Trade and Environment: Process and Production Methods, Paris**: OECD,

OECD (2017), Industrial upgrading for green growth in China, **Development Research Centre of State Council: OECD. Thematic focus on environment**

Overman, H. G. et al., (2001), The Economic Geography of Trade Production and Income: A Survey of Empirics, **CEPR Discussion Papers 2978**, C.E.P.R.

Palmer, K.; Oates, W.E.; Portney, P.R. (1995), Tightening Environmental Standards: The Benefits-Cost or the No-Cost Paradigm? **Journal of Economic Perspectives**, 9(4), pp.119-32.

Panayotou, T. (2000), Economic Growth and the Environment, CID Working Paper No. 56, forthcoming in K.-G- Mäler and J. Vincent eds., **Handbook of Environmental Economics**, Amsterdam: North-Holland.

Pargal, S. and Wheeler, D. (1996), Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia**, Journal of Political Economy**, 104 (6), December.

Pearson, Charles (2000), **Economics and the Global Environment**, Cambridge: Cambridge University Press.

Pethig, R., (1976), Pollution, Welfare, and Environmental Policy in the Theory of Comparative Advantage, **Journal of Environmental Economics and Management,** 2(3), pp.160-69.

Pitigala, N. (2005), What Does Regional Trade in South Asia Reveal about Future Trade Integration?, Some Empirical Evidence, **Policy Research Working Paper No. 3497,** Washington, D.C.: World Bank.

Porter, M.E. and C. van der Linde (1995), Toward a New Conception of the Environment-Competitiveness Relationship, **Journal of Economic Perspectives**. 9(4), pp.97-118.

Porter, M.E. and C. van der Linde (1995a), Green and competitive: ending the stalemate, **Harvard Business Review**, September-October, pp. 120-134

Rauscher, M. (1994), On Ecological Dumping, **Oxford Economic Papers,** 46(5), pp. 822–840.

Rauscher, M. (1997**)**, **International Trade, Factor Movements and the Environment**, Oxford: Clarendon Press.

Ren, L. and Huang, C. (2015), The Effects of Environmental Regulation home and Abroad on China Exports, **Journal of World Economy**, vol (5), pp.59-80.

Robison, H. D. (1988), Industrial Pollution Abatement: The Impact on Balance of Trade, **Canadian Journal of Economics,** 21(1), pp.187–199.

Rodríguez, F. and Rodrik, D. (2000), Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, **NBER/Macroeconomics Annual**, vol 15(1), pp.261-325.

Rothman, D.S., (1998), Environmental Kuznets Curves-real progress or passing the buck? A case for consumption-based approaches, **Ecological Economics,** 25(2), pp. 177-194.

Sachs, Jeffrey, D. and Warner, Andrew, M. (1999), The Big Rush, Natural Resource Booms and Growth, **Journal of Development Economics**, 59(1), pp. 43-76.

Shafik, N. and Bandyopadhyay, S. (1992), Economic growth and environmental quality: Time series and cross-country evidence. **Background Paper for the World Development Report**, Washington, DC: The World Bank.

Shen, N. et al. 2019), Different types of environmental regulations and the heterogeneous influence on the environmental total factor productivity: Empirical analysis of China's industry, **Journal of Cleaner Production, vol** (211), pp. 171–184.

Siebert, H. (1974), **Environmental Protection and International Specialization**. Welt. Arch.110, pp. 494-508.

Siebert, H. et al. (1980), **Trade and Environment: A Theoretical Enquiry** Amsterdam**:** Elsevier /North Holland.

Sorsa, P. (1994), Competitiveness and Environmental Standards: Some Exploratory Results, **Policy Research Working Paper 1249**, Washington, DC: World Bank.

Stavins, R. N. (1992), Making Use of the Market: Taxes, Tradeable Permits, and Global Climate Change, **Issues in Science and Technology**, 9, pp. 22–23.

Stavropoulos, P. et al. (2018), Environmental regulations and industrial competitiveness: evidence from China, **Applied Economics**, Taylor & Francis Journals, vol. 50(12), pages 1378-1394.

Steenblick (2005), Environmental Goods: A Comparison of the APEC and
OECD Lists, **OECD Trade and Environment Working Paper No. 2005-04,** OECD.

Steininger, K. W. (1999), General Models of Environmental Policy and Foreign Trade. In J.C.J.M. and van den Bergh, **Handbook of Environmental and Resource Economics**. Cheltenham: Edward Elgar.

Strutt, A. and Anderson, K. (2000), Will Trade Liberalization Harm the Environment? The Case of Indonesia to 2020, **Environmental and Resource Economics**, 17(3), pp. 203-32.

Tinbergen, J. (1962), **Shaping the World Economy: Suggestions for an International Economic Policy**. New York: The Twentieth Century Fund.

Tobey, J.A. (1990), The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test**, Kyklos**, 43(2), pp. 191-209.

UN Comtrade (2021), Un Comtrade data set, **https://comtrade.un.org**/.

UNCTAD (2002), **Trade and Development Report 2002**, Geneva: UNCATD.

UNCTAD (2008), South-South Trade in Asia: The Role of Regional Trade Agreements, **Trade Analysis Branch DITC**, Geneva: UNCTAD.

UNEP (2020), **COVID-19: Implications for Trade and Environment**, UNEP, Nairobi, Kenya

UNIDO (2000), Industrial Policy and Environment in Pakistan, Industrial Policy and Environment, report, NC/Pak/97/018. **UNIDO**.

USITC (1998), The Year in Trade: Agreements Program During 1997, **USITC 49$^{TH}$ Report.**

Van Beers, C., and Van den Bergh, J.C.K.M. (1997), An Empirical Multi-Country Analysis of the Impact of the Environmental Regulations on Foreign Trade Flows. **Kyklos,** 50(1), pp.29-46.
Van Beers, C., and Van den Bergh, J.C.K.M. (2000), The Impact of Environmental Policy on Foreign Trade, **Tinbergen Institute Discussion Paper no. TI 2000-069/3**. Amsterdam.

Van Beers, C., and Van den Bergh, J.C.K.M. (2001) Perseverance of Perverse Subsidies and Their Impact on Trade and Environment, **Ecological Economics**, 36, pp.475-486.

Vollrath, T. L. (1991), A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage, **Weltwirtschaftliches Archive**, Vol.127, pp.265-280.

Walter, Ingo (1973), The Pollution Content of American Trade, **Western Economic Journal** 11(1), 61–70.

Walter, Ingo (1975a), **International Economics of Pollution**. Palgrave. London.

Walter, Ingo (1975b), International Trade and Environmental Controls: Reply, **Review of World Economics**, vol.111, pp.568.

Wang, Z., et al. (2016), The Effect of Environmental Regulation on External trade: Empirical Evidence from Chinese Economy**, Journal of Cleaner Production**, vol 114(2), pp.55-61.

Wilson, J.S. et al. (2002), Dirty Exports and Environmental Regulation: Do Standards Matter to Trade? **Policy Research Working** Paper no 2806, World Bank, Washington, D.C.: The World Bank.

Wonnacott, Paul, and Mark Lutz (1989), Is There a Case for Free Trade Areas?, In Jeffrey J. Schott (Ed.), **Free Trade Areas and US Trade Policy**, 59-84. Washington DC: Institute of International Economics.

Wu, Y. et al. (2014), An Empirical Analysis of the impact of Environmental Regulation on China's Manufacturing industry Innovation Capacity, **Advanced Material Research**, 1010-1012,1989-1992.

Xie, R.-H. et al.(2017), Different types of environmental regulations and heterogeneous influence on "Green" productivity: Evidence from China. **Ecological Economics**, 132, 104–112.

XU, Xinpeng (1999), Do Stringent Environmental Regulations Reduce the International Competitiveness of Environmentally Sensitive Goods? A Global Perspective, **World Development,** 27(7), pp.1215-1226.

XU, Xinpeng (2000), International Trade and Environmental Regulation: Time Series Evidence and Cross Section Test**, Environmental & Resource Economics**, vol. 17(3), pp.233-257.

XU, Xinpeng (2000a), **International Trade and Environmental Regulations: A Dynamic Perspective**. Nova Science: UK.

Yeats, A. J. (1985), On the Appropriate Interpretation of the Revealed Comparative Advantage Index: Implications of Methodology Based on Industry Sector Analysis, **Weltwirtschaftliches Archiv**, 121(1), pp. 61-73.

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