ERF Working Papers Series

The Role of Global Value Chains in Outsourcing Greenhouse Gas Emissions

Halit Yanikkaya, Abdullah Altun and Pınar Tat

Economic Research Forum
منتدى البحوث الاقتصادية

Working Paper No. 1572
August 2022

THE ROLE OF GLOBAL VALUE CHAINS IN OUTSOURCING GREENHOUSE GAS EMISSIONS

Halit Yanikkaya,[1] Abdullah Altun,[2] and Pınar Tat[3]

Working Paper No. 1572

August 2022

Send correspondence to:
Pınar Tat
Gebze Technical University
Email: pinartat@gtu.edu.tr

This paper was originally presented during the ERF 28th Annual Conference entitled "Revisiting Macroeconomic Management in Times of Crisis and Beyond", held in March 26-30, 2022.

[1] Department of Economics, Gebze Technical University, Turkey (halityanikkaya@gtu.edu.tr).
[2] Department of Economics, Gebze Technical University, Turkey (aaltun@gtu.edu.tr).
[3] Department of Economics, Gebze Technical University, Turkey.

First published in 2022 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

This paper tracks the greenhouse gas (GHG) emissions embedded in global value chains (GVCs) in 186 countries for the period 1990-2015. It then looks at the determinants of the emissions considering both country- and sector-level variables in a gravity-like framework. Our graphical visualization displays that, as expected, developed countries appear to be both major GHG emission producers and outsourcers in the highly fragmented world. Indeed, the trade activities of China, the US, Germany, Japan, and Russia contribute 40 percent of total global emissions. Moreover, while higher capital stock is attributable to higher GHG emissions embedded in GVCs, our empirical results reveal that sectors' renewable energy consumption can be seen as an emission-decreasing factor. While higher income and financial development levels seem to decrease air quality, regional or global integration in trade agreements seems to be consistent with the current increasing efforts and concerns regarding environmental issues. Given the current trajectory and the findings of this paper, negotiating environmental policies across nations, an adaptation of greener production technologies in the production process, and cost-sharing plans between governments and producers should be carefully considered to decrease environmental degradation and sustain natural resources.

Keywords: Greenhouse gas emissions, GVCs, backward linkages, forward linkages, emission intensity.

JEL Classifications: Q01, Q27, Q56.

ملخص

تبحث هذه الدراسة في انبعاثات غازات الدفيئة المضمنة في سلاسل القيمة العالمية التي تضم 186 بلدًا من عام 1990 إلى عام 2015، ثم تبحث في محددات الانبعاثات مع الأخذ في الاعتبار المتغيرات على مستوى البلد والقطاعات. يُظهر تصورنا البياني أنه كما توقعنا، تظهر البلدان المتقدمة على إنها منتجة رئيسية لانبعاثات غازات الدفيئة ومستعينة بمصادر خارجية لها في العالم المجزأ إلى حد كبير. وفي الواقع، تساهم الأنشطة التجارية للصين، والولايات المتحدة الأمريكية، وألمانيا، واليابان، وروسيا بنسبة 40٪ من إجمالي الانبعاثات العالمية. وعلاوة على ذلك، تكشف نتائجنا التجريبية أنه بينما يُعزى ارتفاع أسهم رأس المال إلى ارتفاع انبعاثات غازات الدفيئة المتضمنة في سلاسل القيمة العالمية، قد يعتبر استهلاك الطاقة المتجددة للقطاعات عاملاً من عوامل خفض الانبعاثات. وبينما يبدو أن مستويات الدخل المرتفع والتنمية المالية تقلل من جودة الهواء، يظهر أن التكامل الإقليمي أو العالمي في الاتفاقات التجارية متسق مع الجهود والمخاوف الحالية المتزايدة المتعلقة بالقضايا البيئية. وبالنظر إلى المسار الحالي ونتائج هذا المقال؛ ينبغي النظر فيما يلي بعناية: التفاوض بشأن السياسات البيئية عبر الدول، والتكيف مع تقنيات الإنتاج الأكثر اخضرارًا في عملية الإنتاج، ووضع خطط تقاسم التكاليف بين الحكومات والمنتجين، وذلك لتقليل التدهور البيئي والحفاظ على الموارد الطبيعية.

1. Introduction

Literature on sustainable growth has drawn substantial attention to global warming, air quality, and the emission of harmful gases within the trade context. Several environmentally-related terms are currently the main motives for trade policies (ex. the EU's carbon border tariff under the 'Fit for 55' package (BBC, 2021) and the US proposal about tariffs on carbon-intensive imports (Bloomberg, 2021)). In the literature, studies can be divided into two main categories. The first focus on the trade-environment nexus (see Grossman and Krueger, 1995; Dinda, 2004; Dinda and Coondoo, 2006 for the Environmental Kuznets Curve and pollution heaven hypothesis). With the rapid growth of international trade and developments in global production networks, the second are global value chains (GVCs) studies tracking the environmental impacts of sectors over their production stages until their final consumption in the framework of input-output models, which is known as the economic input-output lifecycle assessment (Hendrickson et al., 2006).

The first category of the literature asserts that the expansion of economic activity (and therefore trade) can intensify environmental pollution. However, the trade of more environmentally-friendly products and access to better technology-embedded products through trade can also decrease the deterioration of the environment by promoting efficiency in the use of energy resources. Moreover, with an increase in national income, people are more likely to demand more and more environmentally-friendly products, processes, and compliance standards. In the second category of the literature, the main advantage of using input-output tables is that the entire economy is covered. As initial efforts, Lenzen (1998), Mongelli et al. (2006), and Pan et al. (2008) conduct their analysis to find emissions embodied in trade by utilizing country-level input-output tables for Austria, Italy, and China, respectively. Recent studies, such as Fan et al. (2019), Zhang et al. (2021), and Liu and Zhao (2021), significantly differ from the previous studies because they employ the value-added trade accounting method. Among these studies, some of them find that innovation, capital, and knowledge transfers/spillovers through participation in GVCs can be seen as important tools to cope with environmental hazards. In contrast, Dinda and Coondoo (2006) and Wang et al. (2019) find a negative association between trade and air quality. Yanikkaya et al. (2022) also analyze the association between forward GVC participation and greenhouse gas (GHG) emission intensity using the same dataset we utilize in this study but in a unilateral framework. They suggest that while the involvement of developed countries in GVCs is more likely to raise their GHG emission intensity, the involvement of developing countries is more likely to improve the air quality due to these countries' higher dependence on renewable energy resources and greater environmental regulations in the international markets.

Therefore, there is limited empirical evidence regarding this subject as almost all other studies are descriptive ones (Fan et al., 2019; Fei et al., 2020; Zhang et al., 2021). Empirical studies analyzing emissions through input-output tables only focus on CO_2 emissions for specific countries and sectors (Meng et al., 2018; Guedidi and Baghdadi, 2020) and trace and calculate emissions only in forward linkages with the unilateral dataset (Liu et al., 2020; Liu and Zhao, 2021), or they fail to utilize the more recent value-added decomposition methodology provided by Wang et al. (2017), which decomposes production based on the perspectives of producers and users.

Examining emissions in trade rather than emissions in production is vital to finding the actual values of emissions triggered by the countries. An exporting country generates emissions not only for domestic uses but also for imports. If an importing country had produced the tradable product instead of importing it from abroad, it would have caused more emissions caused by switching to its production. In this context, Pan et al. (2008) claim that even though developed economies assert their reduction of emissions, they switch their production to mainly developing countries like China. Jakob et al. (2021) also argue that the responsibility for emissions does not solely lie on producers or consumers, but that it should be shared by considering the whole value chain. Therefore, our main contributions to the literature are calculating GHG emissions with such a large bilateral dataset at the sectoral level by using the advanced value-added decomposition methodology and providing evidence for both backward and forward linkages. It is necessary to state that it is possible to calculate domestically released emissions and other relevant variables embodied in the exports of the suppliers using the usual lifecycle assessments based on the forward linkages. This can provide a valuable response to the question of who accounted for most of the emissions. Since countries have significant impacts on other countries' domestic productions based on their demands, how import demand affects emissions and other relevant variables are also important research questions. Thus, the responsibility for emissions is not only related to production and exports from the supplier side; it is also equally related to the imports and consumption from the demand side.

In the first step, we calculate the GHG emissions of sectors embedded in both backward and forward linkages by utilizing country and sectoral heterogeneities in our sample. We primarily present these statistics graphically in network visualization to reveal the interactions of countries regarding GHG transmission so that we can detect the level of responsibility of the country and the problematic transactions. In the second step, we estimate the determinants of emissions in exports or forward participation by controlling several sector- and country-level variables with a separate section devoted to the Middle East and North Africa (MENA) region.

Our network visualization below illustrates that developed countries appear as not only GHG producers but also as GHG outsourcers because their productions mainly depend on the major production/trade hubs of developing countries like China. While the imports of developed countries (67 percent of total world imports) are responsible for 66 percent of total emissions in total imports, the exports of developed countries (66 percent of total world exports) are responsible for 32 percent of total emissions in total exports, which firmly indicates the existence of emission outsourcers in developed countries. At the same time, China, the US, Germany, Japan, and Russia are the top five emitters of GHG emission flows in the world. In particular, GHG emissions are highly embedded in trade with China, the US, and Russia. When we look at the manufacturing and service sectors separately, while we can claim that GHG emissions embedded in the transaction of manufacturing products follow a similar pattern to overall sectors, the trade of service products with the US appears as a major threat to air quality and, consequently, climate change. Our empirical results for the full sample suggest that capital stock is positively associated with GHG emissions embedded in GVCs, while the opposite is true for renewable energy consumption. We also observe strong evidence for the environmental Kuznets curve hypothesis. Moreover, higher income and financialization seem to elevate environmental degradation, whereas trade agreements appear to be environmental protective factors. These results obtained from the full sample are generally similar to the results obtained from the six main aggregate sector groups and income levels of trading partners, but they considerably vary for the MENA region. Therefore, our results strongly reveal the importance of responsibility-sharing schemes between trading partners, green and clean production processes, and strict environmental rules and regulations.

The rest of the paper is organized as follows. The next section explains the data and methodology we employ. The third section presents the estimation results, and the final section concludes.

2. Data and methodology

Data

We employ both backward and forward linkages of sectors based on the global multi-regional input-output tables provided by the EORA (Lenzen et al., 2012, 2013), which cover 25 sectors[4] from 186 countries for the period 1990-2015. We utilize the total emissions of Kyoto GHGs, excluding land use, land-use change, and forestry CO2-e (Gg). GHGs cover carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), per-fluorocarbons (PFCs), and sulfur hexafluoride (SF_6). We first calculate the emissions embedded in GVC parts by utilizing the value-added trade accounting methodology of Wang et al. (2017) so that we can track the GHG emissions of individual sectors through the global production networks. We then follow the same calculation procedure to calculate the value-added embedded in the GVC so that we can measure the GHG emission intensity by dividing emissions by value-added.

The sectoral variables, such as value-added growth, capital intensity, and renewable energy consumption, are taken from the EORA database. To calculate capital stock, we employ the perpetual inventory method on gross fixed capital formation. The initial capital stock information is taken from the IMF (2015), and sector-specific depreciation rates are taken from the methodology notes of the WIOD database (Erumban et al., 2012). To express capital stock intensity, we then divide capital stock by labor compensation. Renewable energy sources are hydroelectric; geothermal; wind, solar, tide, and wave; and biomass and waste electricity (non-renewable electricity resources are natural gas, coal, petroleum, and nuclear power). We

[4] The sectors are agriculture and fishing; mining and quarrying; food and beverages; textiles and wearing apparel; wood and paper; petroleum, chemical and non-metallic mineral products; metal products; electrical and; machinery; transport equipment; other manufacturing; recycling; electricity, gas and water; construction; maintenance and repair; wholesale trade; retail trade; hotels and restaurants transport; post and telecommunications; financial intermediation and business activities; public administration education, health, and other services; private households; and others. See Table A1 in the Appendix for countries in our sample.

calculate the share of renewable energy resources out of all the energy resources that sectors utilized.

Country-level variables, such as real GDP per capita, GDP deflator, resource rents (natural gas, oil, and coal), and broad money are taken from the World Bank. While resource rents as a share of GDP are used as a proxy for resource abundance, broad money as a share of GDP shows the financial development of countries. The human capital index is taken from the Penn World Table (PWT). Gravity measures, such as being a signatory of WTO-FTA and being a member of GATT, are taken from the Institute for Research on the International Economy (Centre d'Etudes Prospectives et d'Informations Internationales - CEPII).

Table 1 presents the summary statistics of the variables. The first notable finding is that while GHG emission intensity in the backward linkages is similar for developed and developing countries, GHG emission intensity in the forward linkages of developing countries is significantly higher than that of developed countries (p=0.001). On the other hand, the share of renewable energy consumption of developing countries is twice that of developed countries. The detailed summary statistics regarding GHG emission intensity of six main sectors are given in Table A2 in the Appendix.

To understand the bilateral country relationship in terms of GHG emission intensity, we utilize network graphs. Figure 1 indicates the GHG emissions of four main country groupings based on income level (high-, upper middle-, lower middle-, and low-income countries) according to our calculations. Thick edges between the countries illustrate higher GHG emissions embedded in the trade of country pairs and vice versa. In Figure 1, we notice that GHG emissions embedded in trade flows from low-income countries to high-income countries as well as among high-income countries are quite higher than the flows from any other trade partners. Note that the imports of developed countries comprise 65 percent of the emissions in total imports. The same trend is observable in manufacturing industries (see Figure 2). These results are quite expected when the fragmented production in GVCs is considered. Many developed countries switch their manufacturing production places to developing countries to take advantage of the cheap labor force and resources in these countries, especially in the past three decades. In other words, developed countries outsource their GHG emissions elsewhere. For service industries, we also detect a substantial amount of GHG emissions embedded in the trade flows of high-income countries themselves, which also provides evidence for the rapid servicification and deindustrialization period of developed countries (see Figure 3).

Table 1: Summary statistics

	Total		Developed		Developing		MENA	
Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Emission Intensity_backward	52.62	634.04	50.85	610.48	52.93	638.17	50.91	612.51
Emission Intensity_forward	251.87	46,956.00	7.51	744.15	295.56	50,979.57	7.82	426.76
Value-added growth	0.00	0.03	0.00	0.01	0.00	0.04	0.00	0.01
Value-added growth_partner	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02
Capital stock intensity	3.94	236.07	0.01	0.01	4.65	256.30	0.01	0.01
Capital stock intensity_partner	0.09	1.10	0.09	1.10	0.09	1.10	0.09	1.08
Renewable energy	0.22	0.29	0.12	0.20	0.24	0.30	0.11	0.19
Renewable energy_partner	0.24	0.26	0.24	0.26	0.24	0.26	0.24	0.26
GDP per capita	10.54	16.66	45.88	15.53	4.23	4.58	16.96	19.81
GDP per capita_partner	10.47	16.54	10.20	16.25	10.52	16.59	10.57	16.65
Resource Rents	0.05	0.10	0.06	0.13	0.05	0.10	0.19	0.17
Resource Rents_partner	0.05	0.10	0.05	0.10	0.05	0.10	0.05	0.10
Human Capital Index	2.30	0.69	3.16	0.45	2.15	0.60	2.15	0.53
Human Capital Index_partner	2.31	0.69	2.31	0.68	2.31	0.69	2.33	0.69
Broad Money	0.50	0.40	0.96	0.60	0.42	0.28	0.65	0.25
Broad Money_partner	0.51	0.40	0.50	0.39	0.51	0.40	0.51	0.40
FTA_WTO	0.07	0.25	0.10	0.30	0.06	0.25	0.07	0.26
GATT	0.85	0.36	0.99	0.09	0.82	0.38	0.64	0.48
GATT_partner	0.85	0.36	0.85	0.36	0.85	0.36	0.86	0.35
# of Obs.	7,115,878		1,079,178		6,036,700		854,975	

Notes: See Table A1 in the Appendix for the country groupings. GHG emission intensities are the ratios of GHG emissions (kg) to real value-added in GVC transactions. Capital stock and GDP per capita are in thousands. Countries in the MENA region are Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the UAE, and Yemen.

Figure 1: Network diagram of polluters by country groupings (based on income categories and the average of the period 1990-2015)

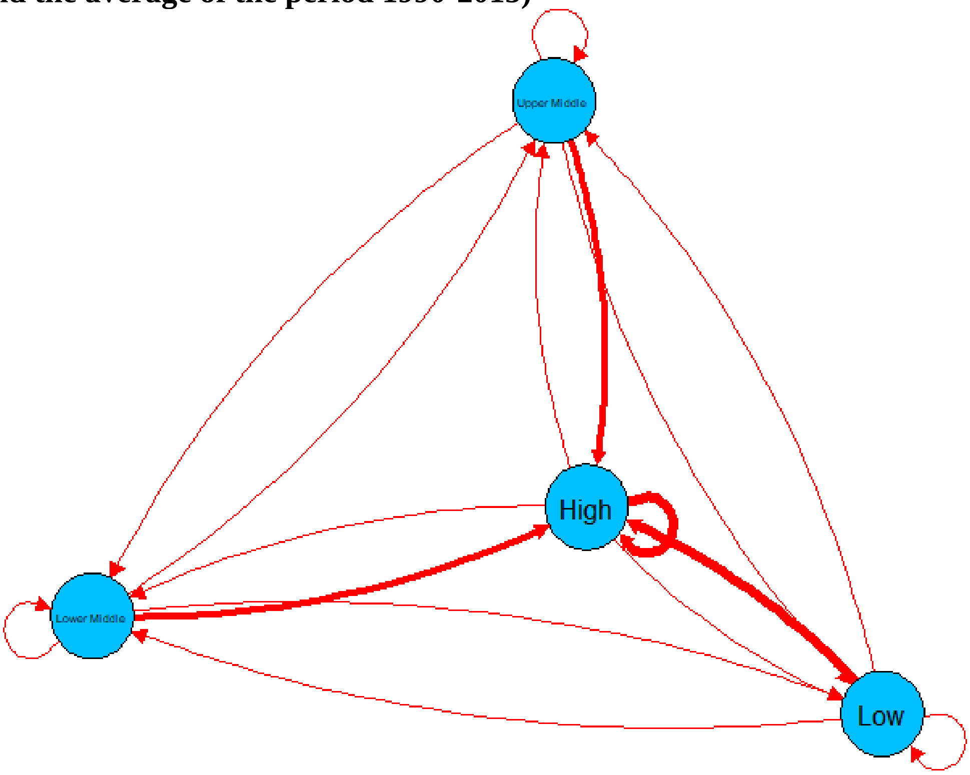


Figure 2: Network diagram of polluters by country groupings, manufacturing

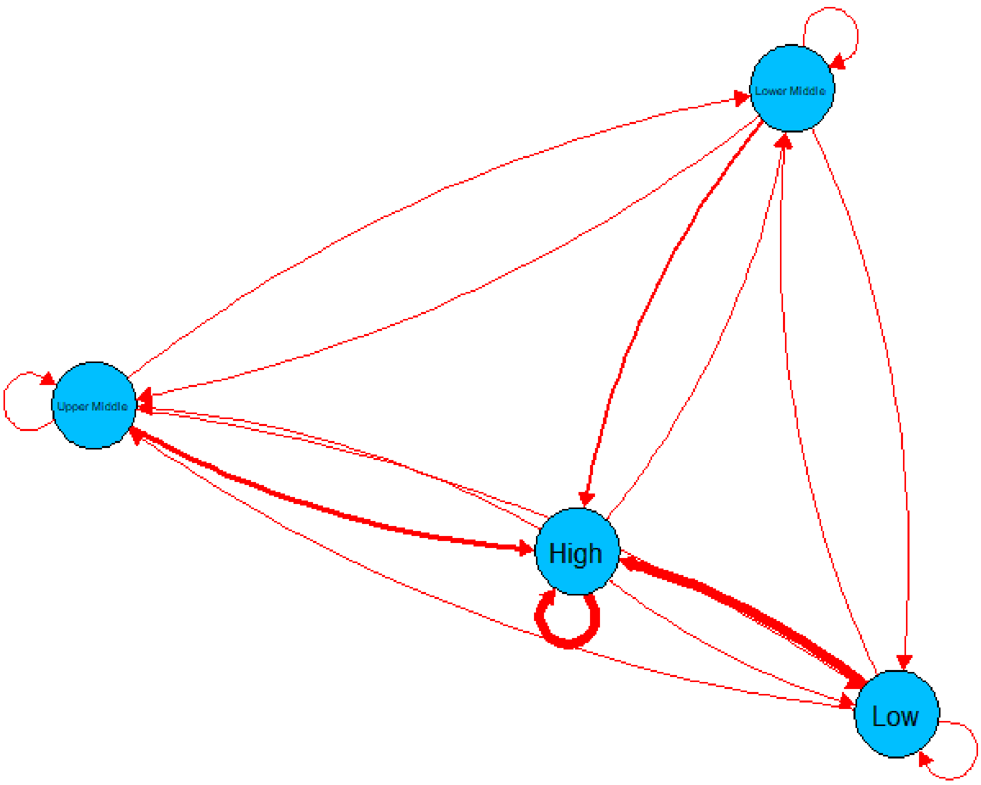
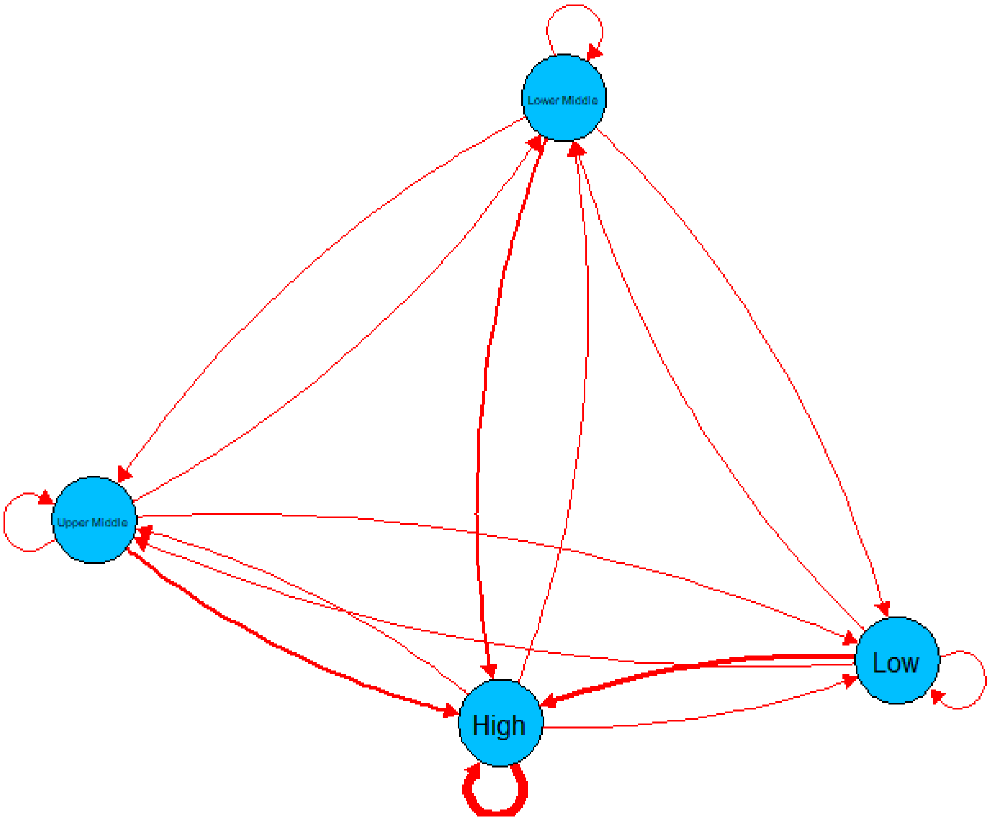


Figure 3: Network diagram of polluters by country groupings, service



We also present similar graphs for the GHG emissions of the top five emitters and the rest of the world in Figures A2-A4 in the Appendix for the total sample, manufacturing sector, and service sector, respectively. It is important to note that these five countries constitute 40 percent of GHG emissions in the world. We notice that China (responsible for 12 percent of total emissions), the US (12 percent), Germany (five percent), Japan (five percent), and Russia (five percent) are mainly responsible for increasing GHG emissions. This proves the higher centrality of these countries in terms of production and thereby trade as it provides a real target for environmental policy regulators to focus on. Trade with these five countries is the most important transaction that needs to be carefully regulated. Trade between China and the US and China and Japan deserves special attention. The detailed country positions are illustrated in Figure A1 in the Appendix.

We also present the graphs of two main sectoral groups: manufacturing and services. For manufacturing industries, we can observe nearly the same pattern with the overall sample. For service sectors, trade with the US is the most embedded with GHG emissions, which urgently calls for governments to decarbonize their economies.

Methodology

We specify equation 1 below by primarily following the model introduced in Liu and Zhao (2021) to analyze the producer- and consumer-related determinants of GHG emissions embedded in GVCs. Our main focus is on GVCs because product fragmentation is only possible with intense usage of the transportation system. This inevitably threatens air quality and contributes to climate change.

$$GHG_{c,s,p,t} = \beta_0 + \beta_1 S^d_{c,s,t} + \beta_2 S^f_{p,t} + \beta_3 C^d_{c,t} + \beta_4 C^f_{p,t} + \beta_5 T_t + \varepsilon_{c,s,p,t} \quad (1)$$

where c, s, p, and t stand for the home country, sectors, partner country, and year, respectively. $GHG_{c,s,p,t}$ stands for GHG emission intensity embedded in forward GVCs.[5] $S^d_{c,s,t}$ represents the vector of sectoral control variables such as value-added growth, capital intensity, and renewable energy consumption (Chiu and Chang, 2009; de Souza et al., 2018) of home countries, and $S^f_{p,t}$ stands for the same variables at the country level for partner countries. $C^d_{c,t}$ and $C^f_{p,t}$ signify the vector of country-level control variables, such as real GDP per capita, square term of real GDP per capita (Grossman and Krueger, 1991; Holtz-Eakin and Selden, 1995; Wang et al., 2019), resource rent as a share of GDP, the human capital index, and broad money as a share of GDP of both home and partner countries, respectively. We also control the gravity measures such as being a signatory of WTO-FTA and being members of GATT (Guedidi and Baghdadi, 2020). T_t stands for time dummies. We take the natural logarithm of GHG emission intensity, capital intensity, and GDP per capita.

The model is estimated by utilizing the two-way fixed effects (TWFE) estimation procedures to investigate the determinants of GHG emission intensity.[6]

3. Results

This section explains the results of determinants of GHG emissions embedded in forward GVCs considering both sector- and country-level characteristics in a gravity-like framework and utilizing sectoral heterogeneities. GHG emissions can be higher because of the rise in production (the scale effect) or increase in production of higher polluting industries (the composition effect) (World Development Report, 2020). Although higher production processes and trade lead to environmental degradation, the trade of environmentally-friendly goods, usage of clean and renewable energy resources, and technological enhancements for making the process environmentally friendlier may slow down the hazardous impacts of production and trade activities. Since the environmental repercussions of trade activities may differ depending on the development level of countries, we also study country-level heterogeneity considering

[5] We also estimate emissions in backward linkages, but the sign of estimates is just the opposite direction of what was found for forward linkages, as expected. Therefore, we provide only the results of forward linkages here, but the results of backward linkage are also available upon request.

[6] Since we estimate a kind of export supply function, the model we use here can be considered to have some endogeneity concerns. To address the endogeneity concerns that may arise, we also run our model by excluding renewable energy resources from the model. The results are similar to what we have estimated in the benchmark equations. As a second robustness check, we also include the institutional quality index of countries (these statistics are available after the year 1995 and are taken from the World Bank Development Indicators) in our model and rerun the regressions. Again, the results are very similar, and they are available upon request.

the income levels of countries (see Table A1 in the Appendix) in our sample thanks to the large coverage of the EORA database.

Table 2 presents the results for GHG emission intensity embedded in GVCs, that is the transaction of intermediates in global trade. The aggregate results (in column 1) suggest that while growth in value-added does not have any significant effect on emission intensity, an increase in the capital stock of an exporter country is more likely to raise emission intensity embedded in forward trade flows. The share of renewable energy resources for exporters appears to be one of the emission-decreasing factors.

When we consider country-level variables, we observe evidence for the Kuznets Curve hypothesis; meaning, GHG emission increases when GDP per capita rises until a specific point of GDP per capita, but then it declines. While higher resource rents for exporter countries are more likely to result in lower GHG emissions, the financial development levels of exporters are positively associated with emission intensity, as expected. Having free trade agreements with trading partners and being a GATT member are attributed to a lower level of GHG emission intensity. This may be related to the larger environmental concerns in the world and thereby the new chapters introduced into the negotiations among trading partners. From 1995 to 2016, the number of regional trade agreements addressing environmental objectives has increased (Martínez-Zarzoso, 2018). Therefore, we might argue that more economic activity can mitigate environmental degradation because of larger environmental concerns as countries become richer, which is indicated by the Kuznets Curve hypothesis. Moreover, foreign trade enables technology transfer between countries and sectors that may enrich the extensive use of cleaner technologies. Notice that emissions embedded in forward linkages are mainly related to the characteristics and behaviors of the exporters (the producers). The coefficients of almost all the variables for importer countries have opposite signs compared to those of exporter countries.

When we repeat our analysis by considering the income level of trading partners (columns 2-5 of Table 2), we notice that these results are quite parallel with the main results, regardless of the income levels of countries, but with several differences. One difference is the positive relationship between the renewable energy usage of developed nations and their emissions if they trade with developing countries. While we expect that these clean energy resources do not negatively affect air quality, different types of utilizations from this resource can produce different outcomes for countries. Therefore, we can assert that the usage of any energy resources should be carefully monitored in all economies. The second one appears in columns (2) and (3). We observe a U shape pattern between the income level of economies and emission intensity for developed countries as opposed to the standard shape of the Kuznets Curve. The third is that resource rents for exporter countries are negatively correlated with emissions embedded in the exports of developed nations, while they are positively associated with the emissions embedded in exports of developing countries. Overall, we can claim that sectors highly involved in the GVC part of international trade should be particularly careful about their production process given the significant results for capital intensity and share of renewable energy consumption.

Specifically, they should switch toward greener capital investment and minimize their consumption of non-renewable energy.

Tables 3 and 4 present the estimation results for the manufacturing and service samples (see footnote 4 to see the coverage of these main sectors). For the manufacturing industries in Table 3, all determinants significant in the benchmark analysis are generally significant in this sub-sample as well. It is noteworthy to mention that the relationship between the income level, resource rents, human capital level of exporter countries, and their emissions level embedded in forward linkages follow different patterns depending on the level of income of exporters. For instance, while resource rents are an emission-reducing factor for developed countries, they are an emission-inducing factor for developing markets. Therefore, we can assert that governments in emerging economies should particularly monitor the investment decisions of sectors and give incentives to sectors to lead them toward sustainable production.

For the service sectors in Table 4, we observe a similar relationship between right-hand side variables and GHG emission intensity embedded in GVCs. While capital stock, GDP per capita, and financial development are positively associated with emission intensity, the use of renewable energy resources, resource rents, having free trade agreements, and being a signatory of GATT significantly reduce emission intensity. Even though service sectors are not among the major emitters given these results, these sectors also seem to benefit from implementing measures to address environmental issues.

Table 2: GHG emission intensity embedded in GVCs by country groupings

	Total	**Developed-Developed**	**Developed-Developing**	**Developing-Developing**	**Developing-Developed**
	(1)	(2)	(3)	(4)	(5)
Value-added growth	-0.000	-0.134	-0.023	-0.000	-0.016
	(0.011)	(0.094)	(0.019)	(0.011)	(0.035)
Value-added growth_partner	-0.007	-0.124	-0.008*	0.008	0.078
	(0.006)	(0.183)	(0.004)	(0.013)	(0.158)
Capital stock intensity	0.060***	0.055***	0.050***	0.054***	0.059***
	(0.001)	(0.007)	(0.002)	(0.001)	(0.004)
Capital stock intensity_partner	-0.001*	-0.005	-0.002***	-0.002***	0.007
	(0.001)	(0.011)	(0.001)	(0.001)	(0.007)
Renewable energy	-0.043***	0.016	0.043***	-0.042***	-0.038***
	(0.002)	(0.023)	(0.006)	(0.002)	(0.006)
Renewable energy_partner	0.011***	0.039*	0.006**	0.006***	0.011
	(0.002)	(0.022)	(0.003)	(0.002)	(0.017)
GDP per capita	0.687***	-2.105***	-2.316***	1.025***	1.010***
	(0.009)	(0.390)	(0.107)	(0.014)	(0.043)
GDP per capita_sq	-0.058***	0.088***	0.097***	-0.083***	-0.081***
	(0.001)	(0.019)	(0.005)	(0.001)	(0.003)
GDP per capita_partner	-0.011	3.549***	-0.003	-0.006	2.376***
	(0.009)	(0.536)	(0.015)	(0.012)	(0.340)
GDP per capita sq_partner	-0.000	-0.176***	-0.001	-0.000	-0.117***
	(0.001)	(0.025)	(0.001)	(0.001)	(0.016)
Resource Rents	-0.022***	-0.519***	-0.516***	0.094***	0.104***
	(0.006)	(0.061)	(0.017)	(0.006)	(0.022)
Resource Rents_partner	0.018***	0.268***	-0.001	-0.005	0.205***
	(0.006)	(0.054)	(0.008)	(0.006)	(0.038)
Human Capital Index	0.003	0.282***	0.295***	-0.104***	-0.085***
	(0.004)	(0.019)	(0.004)	(0.005)	(0.017)
Human Capital Index_partner	-0.007*	0.015*	-0.009	-0.004	0.008
	(0.004)	(0.008)	(0.008)	(0.006)	(0.007)
Broad Money	0.058***	0.088***	0.086***	0.039***	0.040***
	(0.002)	(0.008)	(0.002)	(0.003)	(0.010)
Broad Money_partner	-0.005**	-0.030***	-0.017***	-0.011***	-0.027***
	(0.002)	(0.010)	(0.004)	(0.003)	(0.006)
FTA_WTO	-0.009***	-0.016**	0.008***	-0.014***	0.012**
	(0.002)	(0.007)	(0.002)	(0.002)	(0.005)
GATT	-0.030***	-0.096***	-0.109***	-0.024***	-0.023***
	(0.001)	(0.014)	(0.003)	(0.002)	(0.005)
GATT_partner	0.007***	-0.039***	0.011***	0.007***	-0.018***
	(0.001)	(0.013)	(0.002)	(0.001)	(0.007)
Constant	-1.144***	-5.861	13.276***	-2.230***	-14.297***
	(0.052)	(3.757)	(0.561)	(0.072)	(1.803)
# of Obs.	7,115,878	154,020	925,158	5,121,294	915,406
R-squared	0.880	0.584	0.698	0.896	0.836

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: GHG emission intensity embedded in GVCs by country groupings, manufacturing

	Total (1)	**Developed-Developed** (2)	**Developed-Developing** (3)	**Developing-Developing** (4)	**Developing-Developed** (5)
Value-added growth	0.003	-0.202	-0.037	0.007	-0.081
	(0.006)	(0.170)	(0.033)	(0.006)	(0.065)
Value-added growth_partner	-0.000	-0.423*	-0.097	-0.003	0.100
	(0.011)	(0.223)	(0.072)	(0.010)	(0.238)
Capital stock intensity	0.036***	0.041***	0.041***	0.031***	0.027***
	(0.001)	(0.014)	(0.003)	(0.002)	(0.005)
Capital stock intensity_partner	-0.001	-0.011	-0.004***	-0.003***	0.010
	(0.001)	(0.020)	(0.001)	(0.001)	(0.013)
Renewable energy	-0.053***	0.018	0.010	-0.044***	-0.045***
	(0.003)	(0.033)	(0.008)	(0.003)	(0.010)
Renewable energy_partner	0.020***	0.018	0.007*	0.012***	0.011
	(0.003)	(0.033)	(0.004)	(0.004)	(0.026)
GDP per capita	0.904***	-2.355***	-2.453***	1.255***	1.402***
	(0.017)	(0.673)	(0.154)	(0.023)	(0.079)
GDP per capita_sq	-0.072***	0.093***	0.101***	-0.097***	-0.108***
	(0.001)	(0.033)	(0.008)	(0.002)	(0.005)
GDP per capita_partner	-0.020	3.504***	-0.007	-0.015	5.465***
	(0.015)	(0.935)	(0.026)	(0.021)	(0.669)
GDP per capita sq_partner	-0.001	-0.174***	-0.000	0.000	-0.272***
	(0.001)	(0.044)	(0.002)	(0.001)	(0.032)
Resource Rents	-0.050***	-0.723***	-0.582***	0.091***	0.094**
	(0.012)	(0.116)	(0.025)	(0.012)	(0.046)
Resource Rents_partner	0.054***	0.262***	0.002	0.009	0.464***
	(0.010)	(0.093)	(0.011)	(0.009)	(0.082)
Human Capital Index	-0.005	0.429***	0.376***	-0.133***	-0.154***
	(0.007)	(0.037)	(0.007)	(0.009)	(0.033)
Human Capital Index_partner	-0.012	0.018	-0.012	-0.005	0.029***
	(0.007)	(0.014)	(0.014)	(0.011)	(0.011)
Broad Money	0.051***	0.107***	0.111***	0.019***	0.009
	(0.003)	(0.010)	(0.003)	(0.005)	(0.017)
Broad Money_partner	-0.015***	-0.028*	-0.022***	-0.034***	-0.062***
	(0.004)	(0.017)	(0.006)	(0.005)	(0.012)
FTA_WTO	-0.012***	-0.024**	0.009***	-0.012***	-0.007
	(0.003)	(0.012)	(0.004)	(0.003)	(0.008)
GATT	-0.030***	-0.165***	-0.119***	-0.023***	-0.021**
	(0.003)	(0.030)	(0.006)	(0.003)	(0.009)
GATT_partner	0.015***	-0.051***	0.010***	0.018***	-0.056***
	(0.002)	(0.017)	(0.003)	(0.003)	(0.011)
Constant	-1.787***	-3.833	14.125***	-2.979***	-30.984***
	(0.091)	(6.430)	(0.791)	(0.125)	(3.558)
# of Obs.	2,549,104	54,855	329,637	1,836,421	328,191
R-squared	0.793	0.566	0.711	0.816	0.716

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: GHG emission intensity embedded in GVCs by country groupings, services

	Total (1)	**Developed-Developed** (2)	**Developed-Developing** (3)	**Developing-Developing** (4)	**Developing-Developed** (5)
Value-added growth	0.008***	-0.074	-0.011	0.007***	-0.039
	(0.003)	(0.145)	(0.029)	(0.003)	(0.031)
Value-added growth_partner	-0.004	-0.091	-0.645	0.068	0.005
	(0.072)	(0.299)	(0.500)	(0.065)	(0.250)
Capital stock intensity	0.056***	0.121***	0.110***	0.045***	0.048***
	(0.001)	(0.012)	(0.004)	(0.001)	(0.003)
Capital stock intensity_partner	-0.000	0.011	-0.001	-0.001	0.009
	(0.001)	(0.016)	(0.001)	(0.001)	(0.008)
Renewable energy	-0.026***	0.095**	0.120***	-0.038***	-0.030***
	(0.002)	(0.040)	(0.010)	(0.002)	(0.007)
Renewable energy_partner	0.012***	0.053	0.006	0.007**	0.029
	(0.002)	(0.037)	(0.005)	(0.003)	(0.024)
GDP per capita	0.613***	-0.510	-1.323***	0.943***	0.874***
	(0.012)	(0.583)	(0.176)	(0.020)	(0.055)
GDP per capita_sq	-0.052***	0.014	0.050***	-0.077***	-0.072***
	(0.001)	(0.028)	(0.008)	(0.001)	(0.004)
GDP per capita_partner	-0.003	3.769***	-0.001	-0.003	2.251***
	(0.011)	(0.656)	(0.022)	(0.015)	(0.375)
GDP per capita sq_partner	-0.001	-0.189***	-0.001	-0.000	-0.112***
	(0.001)	(0.031)	(0.001)	(0.001)	(0.018)
Resource Rents	-0.018**	-0.322***	-0.400***	0.084***	0.099***
	(0.007)	(0.081)	(0.030)	(0.007)	(0.018)
Resource Rents_partner	0.015**	0.344***	-0.000	-0.009	0.223***
	(0.008)	(0.083)	(0.014)	(0.008)	(0.042)
Human Capital Index	0.010**	0.193***	0.245***	-0.082***	-0.037**
	(0.004)	(0.024)	(0.005)	(0.005)	(0.018)
Human Capital Index_partner	-0.007	0.013	-0.005	-0.004	0.007
	(0.005)	(0.013)	(0.011)	(0.007)	(0.009)
Broad Money	0.042***	0.042***	0.043***	0.032***	0.046***
	(0.003)	(0.013)	(0.004)	(0.004)	(0.013)
Broad Money_partner	-0.003	-0.028**	-0.018***	-0.010***	-0.021***
	(0.003)	(0.013)	(0.006)	(0.004)	(0.007)
FTA_WTO	-0.012***	-0.001	0.005	-0.017***	0.012
	(0.003)	(0.011)	(0.004)	(0.003)	(0.008)
GATT	-0.022***	-0.032*	-0.082***	-0.016***	-0.017***
	(0.002)	(0.018)	(0.005)	(0.002)	(0.006)
GATT_partner	0.008***	-0.036	0.015***	0.008***	-0.012
	(0.002)	(0.023)	(0.003)	(0.002)	(0.008)
Constant	-1.094***	-15.369***	8.019***	-2.125***	-13.361***
	(0.067)	(5.066)	(0.930)	(0.095)	(1.984)
# of Obs.	3,146,481	68,409	410,767	2,262,747	404,558
R-squared	0.863	0.416	0.480	0.889	0.836

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

We conduct the same empirical exercises for the other main sectors: agriculture and fishing, mining, construction and electricity, and gas and water. The results are given in the Appendix (Tables A3-A7), but it is noteworthy to state the general results in brief here. Almost all the significant determinants of GHG emissions are also statically significant and display the same signs in six sector groupings, except for resource rents. While resource rents are positively correlated with the emissions embedded in the GVC part of the mining sector, they are negatively associated with emissions for all other sectors. Still, we observe that higher emission intensity level is attributed to higher capital intensity, higher income, higher human capital, and better financialization, as well as a lower level of renewable energy consumption, resource rents, and a lack of any trade agreements. In this respect, enhancements in regulations and negotiations on the consumption of renewable energy resources in all countries can play an important role in addressing air quality.

The MENA region

It seems that the MENA region has comparable shares (three percent) in both world imports and total emissions in total imports. However, its share of exports (five percent) is almost half of the total emissions in total exports (nine percent). From a consumption point of view, these statistics imply that, similar to lower-income countries, the MENA region seems to be much less responsible for GHG emissions. Table 5 presents the estimation results we separately conduct for the MENA region by considering six main sectoral aggregates. Unlike the full sample of countries, value-added growth in own sectors or trading partners' sectors leads to lower emission intensity. However, there is strong evidence of environmental degradation in higher levels of income and environmental improvements in much higher levels of income, which is the inverted U-shape depicted by the Kuznets Curve. This may be related to the fact that after a specific turning point, higher environmental awareness and demand for environmentally-friendly products rise, and transparent and well-defined legislative procedures start to apply. This also held for all the sectors in the MENA region. Higher resource rents and human capital are negatively related to the emission intensity embedded in the GVC part in all sectors, except for the construction sector. Financial development and being a GATT member are positively associated with the emission intensity of all sectors. Therefore, we can claim that mutual negotiations with the MENA region with special chapters devoted to the environmental effects of the traded product should be further developed.

Table 5: GHG emission intensity embedded in GVCs of the MENA Region by sectors

Variables	Total (1)	Manufacturing (2)	Service (3)	Agriculture and Fishing (4)	Mining (5)	Construction (6)	EGW (7)
Value-added growth	-0.050**	-0.092*	-0.030	0.023	0.030	-0.071	0.211
	(0.023)	(0.047)	(0.021)	(0.055)	(0.021)	(0.104)	(0.292)
Value-added growth_partner	-0.011***	-0.178	-0.516	0.120	0.215	-0.006***	0.209
	(0.004)	(0.144)	(0.395)	(0.083)	(0.287)	(0.001)	(0.883)
Capital stock intensity	0.030***	-0.028***	0.021***	0.006	0.092***	0.289***	0.748***
	(0.002)	(0.004)	(0.003)	(0.015)	(0.006)	(0.013)	(0.035)
Capital stock intensity_partner	-0.001	-0.003	0.001	0.000	-0.000	-0.002	-0.002
	(0.001)	(0.003)	(0.001)	(0.004)	(0.002)	(0.004)	(0.012)
Renewable energy	0.037***	0.109***	0.125***	0.000	-0.070***	0.335***	-0.147
	(0.006)	(0.016)	(0.005)	(0.006)	(0.005)	(0.020)	(0.114)
Renewable energy_partner	0.010**	0.030***	0.004	0.015	-0.003	-0.002	-0.096**
	(0.004)	(0.008)	(0.005)	(0.010)	(0.008)	(0.014)	(0.041)
GDP per capita	0.944***	1.186***	1.061***	1.092***	0.679***	0.227**	2.708***
	(0.053)	(0.119)	(0.045)	(0.180)	(0.062)	(0.091)	(0.458)
GDP per capita_sq	-0.052***	-0.065***	-0.059***	-0.062***	-0.037***	-0.017***	-0.151***
	(0.003)	(0.006)	(0.002)	(0.010)	(0.003)	(0.005)	(0.024)
GDP per capita_partner	-0.004	-0.011	0.006	-0.052	0.007	-0.035	0.036
	(0.021)	(0.045)	(0.019)	(0.059)	(0.031)	(0.059)	(0.172)
GDP per capita sq_partner	-0.001	-0.003	-0.001	0.001	-0.000	0.002	0.010
	(0.001)	(0.003)	(0.001)	(0.004)	(0.002)	(0.004)	(0.012)
Resource Rents	-0.107***	-0.174***	-0.087***	-0.145***	-0.092***	0.280***	-0.223**
	(0.010)	(0.022)	(0.009)	(0.022)	(0.011)	(0.033)	(0.093)
Resource Rents_partner	0.023	0.083***	0.011	0.024	-0.003	-0.038	-0.315***
	(0.014)	(0.032)	(0.014)	(0.026)	(0.019)	(0.034)	(0.106)
Human Capital Index	-0.001	-0.082***	-0.034***	0.019	0.009	0.258***	-0.152*
	(0.010)	(0.024)	(0.009)	(0.027)	(0.015)	(0.021)	(0.081)
Human Capital Index_partner	-0.011	-0.023	-0.008	-0.015	0.001	0.001	0.057
	(0.010)	(0.022)	(0.008)	(0.029)	(0.014)	(0.022)	(0.081)
Broad Money	0.107***	0.072***	0.078***	0.110***	0.075***	0.149***	0.349***
	(0.008)	(0.017)	(0.005)	(0.018)	(0.011)	(0.012)	(0.063)
Broad Money_partner	-0.004	-0.022**	0.005	-0.011	0.000	0.008	0.064
	(0.005)	(0.011)	(0.005)	(0.016)	(0.008)	(0.015)	(0.041)
FTA_WTO	0.008**	0.020**	0.005	-0.001	0.005	-0.034***	-0.027
	(0.004)	(0.008)	(0.004)	(0.006)	(0.004)	(0.007)	(0.036)
GATT	0.045***	0.053***	0.041***	0.046***	0.040***	-0.039***	0.091***
	(0.003)	(0.006)	(0.003)	(0.009)	(0.004)	(0.006)	(0.027)
GATT_partner	0.007**	0.020***	0.007**	0.011	-0.004	-0.002	-0.087***
	(0.003)	(0.007)	(0.003)	(0.008)	(0.004)	(0.010)	(0.024)
Constant	-3.842***	-4.516***	-4.451***	-4.263***	-3.286***	-1.435***	-11.459***
	(0.245)	(0.546)	(0.218)	(0.848)	(0.314)	(0.464)	(2.210)
# of Obs.	854,975	304,002	380,849	69,241	34,634	33,159	33,090
R-squared	0.860	0.691	0.735	0.787	0.942	0.912	0.854

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

While a rise in capital intensity in the manufacturing sector is more likely to improve air quality, the opposite effect prevails for the other sectors. Contrary to common expectations about the negative effects of renewable energy consumption on the GHG emissions of sectors, we find a positive association between renewable energy use and GHG emission intensity in the manufacturing, services, and construction sectors. This may be related to an increase in the production of manufacturing, services, and construction products as a result of the large-scale deployment of energy resources. A higher share of renewable energy usage reduces only the pace of emission surge because emissions in the air increase as a result of the heat arising from the use of any energy source. Furthermore, one of the renewable energy sources, hydropower, is generally subject to debate because of its potential ecological effect. In other words, renewable energy consumption seems to raise emissions for the mining and electricity, gas, and water sectors in the region. Therefore, this specific finding for the MENA region should be carefully evaluated, and policymakers should take necessary actions regarding this concern.

Given the relatively higher average GHG emissions embedded in forward linkages for the electricity, gas, and water sector (see Table A2), it is crucial to strictly follow the production stages of this sector. Specifically, since emissions increase with more capital stock, countries and sectors should use physical capital in a more environmentally-friendly manner and the consumption of renewable energy usage should be encouraged. Countries in the MENA region should also adhere to strict environmental standards to alleviate the impact of higher income, financialization, and being a member of GATT on emissions embedded in forward linkages.

Since the GHG emissions embedded in the forward linkages of the manufacturing, service, and mining sectors are relatively lower in the MENA region compared to those of the whole sample, we can further argue that the MENA region has a comparative advantage in these sectors and can be integrated into GVCs with fewer emissions through these sectors.

4. Concluding remarks

In this paper, we calculate GHG emissions embedded in GVCs to assess the core responsibility of emissions and understand the determinants of emission intensity by utilizing the EORA database covering 186 countries and 26 sectors for the period 1990-2015. Our network graphs suggest that the environmental damage instigated by developed countries to the environment is not only caused by their products, but also their consumption or demand for intermediate products from abroad, which outsources a huge amount of their potential climate pollution to the developing economies. Moreover, in terms of individual countries, China, the US, Germany, Japan, and Russia hold a huge chunk of responsibility for the GHG emissions in GVCs. While this picture is mainly similar for manufacturing products, the US appears to be a top polluter in services. For the MENA countries, we observe relatively lower GHG emission intensity compared to other country groupings. Even though we have witnessed the great efforts of developed nations toward reducing emissions, in regard to the cumulative responsibilities of countries in the current situation of the global emissions and climate, it is very clear that developed nations account for the majority of outcomes. Meanwhile, many developing nations try to accomplish further development targets with increasing energy needs. The question here is whether some limitations within the context of emissions will prevent them from even providing a certain level of basic needs for their society and development. Therefore, it is important to discuss the responsibility-sharing scenarios between developed and developing countries in global value-sharing activities.

Our empirical findings suggest that some sector-specific characteristics are quite important to combat environmental degradation. While higher capital stock seems to raise environmental degradation, higher renewable energy shares are negatively related to GHG emissions embedded in GVCs. Even if this result is generally true regardless of the income level of countries and sectors, there are also some exceptions. Given these findings, sectors' investment decisions and energy-consuming processes play a curial role in precisely understanding the true effect of these two measures. Apart from the sector-level variables, country-level variables, such as resource rents, and gravity measures, such as being a signatory of GATT, also stand as significant factors to successfully fight against climate change, whereas higher income levels and deeper financialization seem to be alerting factors.

Our empirical results reveal the requirement for country- and sector-specific investigations of these measures to propose more precise policies and ultimately decouple economic growth from environmental hazards. For instance, further development of investment and energy consumption decisions that are in line with the global environmental standard should be encouraged, whereas the production and trading activities of top emitters should be highly regulated, and global environmental standards should be strictly enforced. In general, national and international environmental conservation policies, such as binding laws and regulations and strong financial incentives for emissions reduction and energy-efficient environmental projects, need to be further developed. For the MENA region specifically, monitoring the environmental responses of trading partners and implementing obligatory regulations in coordination with each other can help reach greener economic growth. We can further argue that boosting the usage of renewable resources, pricing environmental damage in the form of carbon taxes, and setting low carbon standards can be seen as effective tools to fight pollutants and sustain greener production.

References

BBC News (2021). EU unveils sweeping climate change plan. Retrieved from: https://www.bbc.com/news/world-europe-57833807

Bloomberg (2021). U.S. Can Build and Fight Climate Change at Same Time. Retrieved from: https://www.bloomberg.com/opinion/articles/2021-07-29/biden-trade-policy-can-advance-climate-goals-with-infrastructure

Chiu, C. L., and Chang, T. H. (2009). What proportion of renewable energy supplies is needed to initially mitigate CO2 emissions in OECD member countries? *Renewable and Sustainable Energy Reviews*, *13*(6-7), 1669-1674.

de Souza, E. S., de Souza Freire, F., and Pires, J. (2018). Determinants of CO2 emissions in the MERCOSUR: The role of economic growth, and renewable and non-renewable energy. *Environmental Science and Pollution Research*, *25*(21), 20769-20781.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological Economics*, *49*(4), 431-455.

Dinda, S., and Coondoo, D. (2006). Income and emission: A panel data-based cointegration analysis. *Ecological Economics*, *57*(2), 167-181.

Erumban, A., Gouma, R., de Vries, G., de Vries, K., and Timmer, M. (2012). WIOD socio-economic accounts (SEA): Sources and methods. *Groningen, April*.

Fan, J. L., Zhang, X., Wang, J. D., and Wang, Q. (2021). Measuring the impacts of international trade on carbon emissions intensity: A global value chain perspective. *Emerging Markets Finance and Trade*, *57*(4), 972-988.

Fei, R., Pan, A., Wu, X., and Xie, Q. (2020). How GVC division affects embodied carbon emissions in China's exports? *Environmental Science and Pollution Research*, *27*(29), 36605-36620.

Jakob, M., Ward, H., and Steckel, J. C. (2021). Sharing responsibility for trade-related emissions based on economic benefits. *Global Environmental Change*, *66*, 102207.

Grossman, G. M., and Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement* (No. w3914). National Bureau of Economic Research.

Grossman, G. M., and Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*(2), 353-377.

Guedidi, I., and Baghdadi, L. (2020). CO2 Emissions, Environmental Provisions and Global Value Chains in MENA Countries. ERF 26th Annual Conference.

Hendrickson, C. T., Lave, L. B., Matthews, H. S., and Horvath, A. (2006). *Environmental life cycle assessment of goods and services: an input-output approach*. Resources for the Future.

Holtz-Eakin, D., and Selden, T. M. (1995). Stoking the fires? CO2 emissions and economic growth. *Journal of Public Economics*, *57*(1), 85-101.

Institute for Research on the International Economy (Centre d'Etudes Prospectives et d'Informations Internationales – CEPII. Retrieved from: http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp

International Monetary Fund (2015). Investment and Capital Stock Dataset, 1960-2015. Retrieved from: https://data.imf.org/?sk=1CE8A55F-CFA7-4BC0-BCE2-256EE65AC0E4

Lenzen, M. (1998). Energy and greenhouse gas cost of living for Australia during 1993/94. *Energy*, *23*(6), 497-516.

Lenzen, M., Kanemoto, K., Moran, D., and Geschke, A. (2012). Mapping the structure of the world economy. *Environmental Science and Technology*, *46*(15), 8374-8381.

Lenzen, M., Moran, D., Kanemoto, K., and Geschke, A. (2013). Building Eora: a global multi-region input–output database at high country and sector resolution. *Economic Systems Research*, *25*(1), 20-49.

Liu, C., and Zhao, G. (2021). Can global value chain participation affect embodied carbon emission intensity? *Journal of Cleaner Production*, *287*, 125069.

Liu, H., Zong, Z., Hynes, K., and De Bruyne, K. (2020). Can China reduce the carbon emissions of its manufacturing exports by moving up the global value chain? *Research in International Business and Finance*, *51*, 101101.

Martínez-Zarzoso, I. (2018). Assessing the effectiveness of environmental provisions in regional trade agreements: An empirical analysis, OECD Trade and Environment Working Papers, 2018/02.

Meng, B., Peters, G. P., Wang, Z., and Li, M. (2018). Tracing CO2 emissions in global value chains. *Energy Economics*, *73*, 24-42.

Mongelli, I., Tassielli, G., and Notarnicola, B. (2006). Global warming agreements, international trade and energy/carbon embodiments: An input–output approach to the Italian case. *Energy Policy*, *34*(1), 88-100.

Pan, J., Phillips, J., and Chen, Y. (2008). China's balance of emissions embodied in trade: Approaches to measurement and allocating international responsibility. *Oxford Review of Economic Policy*, *24*(2), 354-376.

University of International Business and Economics (UIBE) GVC Index Team (2017). Data files structure of the UIBE GVC index system. Retrieved from: http://139.129.209.66:8000/d/daedafb854/

University of International Business and Economics (UIBE) (2017). Data files structure of the UIBE GVC index system. Retrieved from https://v2.fangcloud.com/share/a26979974d538c7e5aeb24b55a?folder_id=63000172546&lang=en

UIBE (2017). UIBE Global Value Chain Indexes System – Concept Note. Retrieved from: https://v2.fangcloud.com/share/a26979974d538c7e5aeb24b55a?folder_id=63000172546&lang=en

Wang, J., Wan, G., and Wang, C. (2019). Participation in GVCs and CO_2 emissions. *Energy Economics*, *84*, 104561.

Wang, Z., Wei, S.-J., Yu, X., and Zhu, K. (2017). Characterizing global value chains: Production length and upstreamness. (No. w23261). National Bureau of Economic Research.

World Bank (2020). World Bank Country and Lending Groups. Retrieved from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

World Development Report (2020). *Trading for Development: In the Age of Global Value Chains*. Washington: International Bank for Reconstruction and Development/The World Bank.

Yanikkaya, H., Altun, A., and Tat, P. (2022). The Role of Global Value Chains in Circular Economy, in Circular Economy and Sustainable Living, (ed. M. Bulut and C. Korkut), (pp. 45-100), TÜBA (Turkish Academy of Sciences), Ankara, 2022.

Zhang, D., Wang, H., Löschel, A., and Zhou, P. (2021). The changing role of global value chains in CO_2 emission intensity in 2000–2014. *Energy Economics*, *93*, 105053.

Appendix

Table A1. The country list (EORA)

High-income		Upper middle-income		Lower middle-income			Low-income	
Andorra	New Zealand	Antigua	Trinidad and Tobago	Albania	Guatemala	Syria	Afghanistan	Maldives
Aruba	Norway	Bahrain	Uruguay	Algeria	Iran	TFYR Macedonia	Bangladesh	Mali
Australia	Qatar	Barbados	Venezuela	Angola	Jamaica	Tajikistan	Benin	Mauritania
Austria	San Marino	Belarus		Argentina	Jordan	Thailand	Bhutan	Mozambique
Bahamas	Singapore	Brazil		Armenia	Kazakhstan	Tunisia	Burkina Faso	Myanmar
Belgium	Spain	Estonia		Azerbaijan	Kyrgyzstan	Turkey	Burundi	Nepal
Bermuda	Sweden	Gabon		Belize	Lebanon	Turkmenistan	Cambodia	Niger
Brunei	Switzerland	Greece		Bolivia	Malaysia	Ukraine	Central African Republic	Nigeria
Canada	Taiwan	Hungary		Bosnia and Herzegovina	Mauritius	Uzbekistan	Chad	Pakistan
Cayman Islands	UAE	Iraq		Botswana	Moldova	Vanuatu	China	Rwanda
Cyprus	UK	Latvia		Bulgaria	Mongolia	Yemen	DR Congo	Sao Tome and Principe
Denmark	USA	Libya		Cameroon	Montenegro	Zimbabwe	Egypt	Sierra Leone
Finland		Lithuania		Cape Verde	Morocco		Eritrea	Somalia
France		Macao SAR		Chile	Namibia		Ethiopia	South Sudan
French Polynesia		Malta		Colombia	Nicaragua		Gambia	Sri Lanka
Germany		Mexico		Congo	North Korea		Ghana	Sudan
Greenland		Netherlands Antilles		Costa Rica	Panama		Guinea	Tanzania
Hong Kong		New Caledonia		Cote dIvoire	Papua New Guinea		Guyana	Togo
Iceland		Oman		Croatia	Paraguay		Haiti	Uganda
Ireland		Portugal		Cuba	Peru		Honduras	Viet Nam
Israel		Russia		Czech Republic	Philippines		India	Zambia
Italy		Saudi Arabia		Djibouti	Poland		Indonesia	
Japan		Seychelles		Dominican Republic	Romania		Kenya	
Kuwait		Slovenia		Ecuador	Samoa		Laos	
Liechtenstein		South Africa		El Salvador	Senegal		Lesotho	
Luxembourg		South Korea		Fiji	Serbia		Liberia	
Monaco		Suriname		Gaza Strip	Slovakia		Madagascar	
Netherlands		Gabon		Georgia	Swaziland		Malawi	

Notes: Income classification is based on the country’s 1990 income level (World Bank, 2020). Developed countries are high-income countries whereas developing countries consist of upper middle-, lower middle-, and low-income countries.

Table A2. Summary statistics of GHG emission intensity by sectors

	Total		Developed		Developing		MENA	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Total								
Emission Intensity_backward	52.62	634.04	50.85	610.48	52.93	638.17	50.91	612.51
Emission Intensity_forward	251.87	46,956.00	7.51	744.15	295.56	50,979.57	7.82	426.76
Manufacturing								
Emission Intensity_backward	52.57	633.21	51.33	610.66	52.79	637.16	50.73	608.14
Emission Intensity_forward	206.73	54,273.82	1.88	155.76	243.11	58,897.02	8.84	322.24
Service								
Emission Intensity_backward	52.37	631.58	49.68	599.65	52.85	637.15	50.54	610.49
Emission Intensity_forward	285.23	50,772.07	14.56	1,106.90	333.85	55,142.23	5.50	567.51
Agriculture and fishing								
Emission Intensity_backward	53.09	638.80	52.30	624.49	53.24	641.33	51.67	619.99
Emission Intensity_forward	1.95	91.02	1.75	113.39	1.99	86.38	2.59	137.88
Mining								
Emission Intensity_backward	53.82	646.09	53.33	634.98	53.91	648.03	51.83	626.69
Emission Intensity_forward	0.74	3.06	0.42	1.54	0.80	3.25	0.22	0.49
Construction								
Emission Intensity_backward	51.97	626.97	49.56	594.76	52.40	632.64	50.80	609.72
Emission Intensity_forward	1.12	9.78	0.68	3.21	1.20	10.54	2.31	25.39
EGW								
Emission Intensity_backward	54.44	655.33	55.98	690.76	54.17	648.90	54.38	647.96
Emission Intensity_forward	1,303.29	15,714.64	4.95	12.84	1,531.63	17,030.37	49.57	50.32

Notes: See Table A1 for the country groupings and footnote 4 to see the coverage of these main sectors. GHG emission intensities are the ratios of GHG emissions (kg) to real value-added in GVC transactions. Countries in the MENA region are Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the UAE, and Yemen.

Figure A1. The share of GHG emissions embedded in GVCs by countries

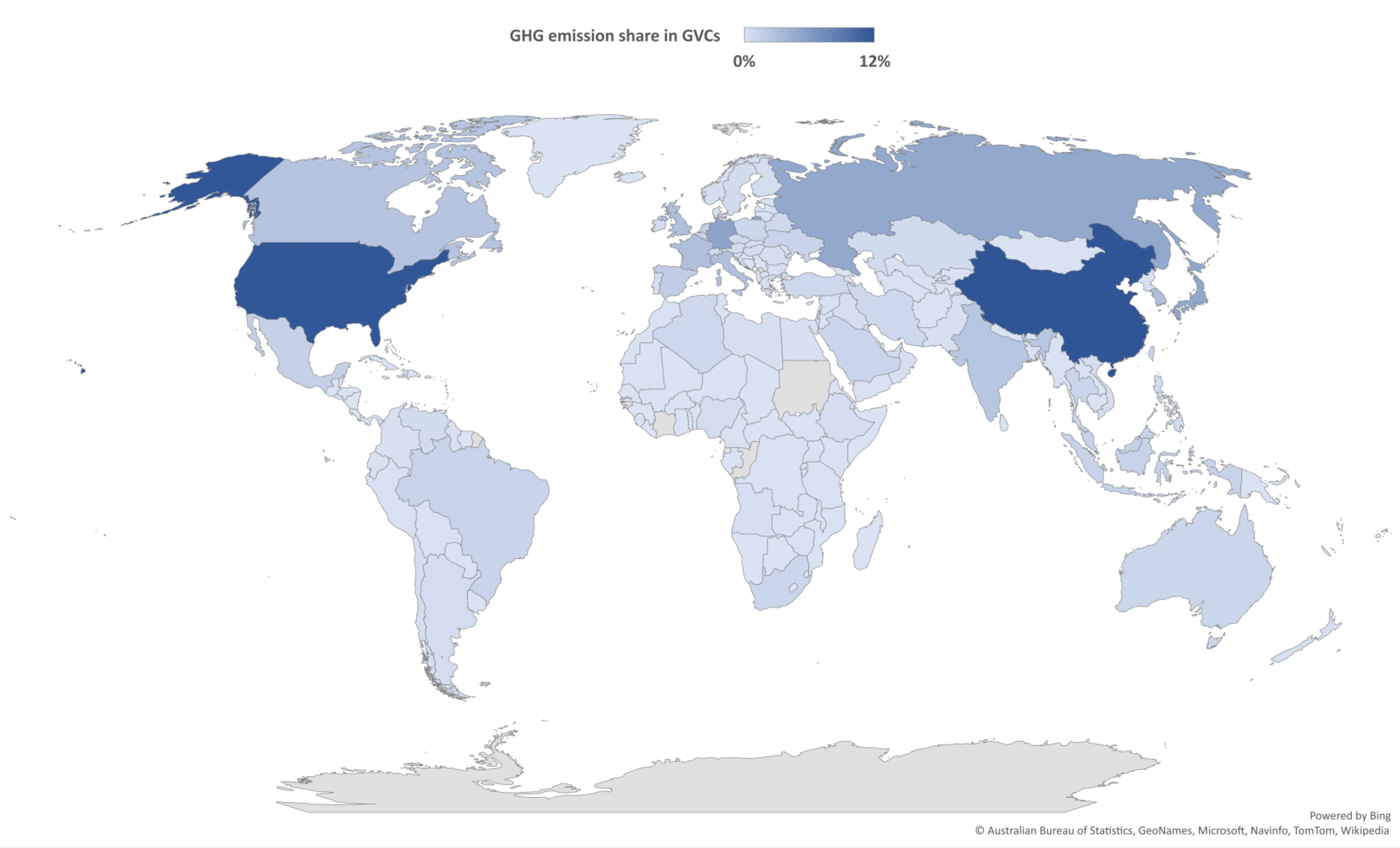


Figure A2. Network diagram of top polluters, all sectors (the average of the period 1990-2015)

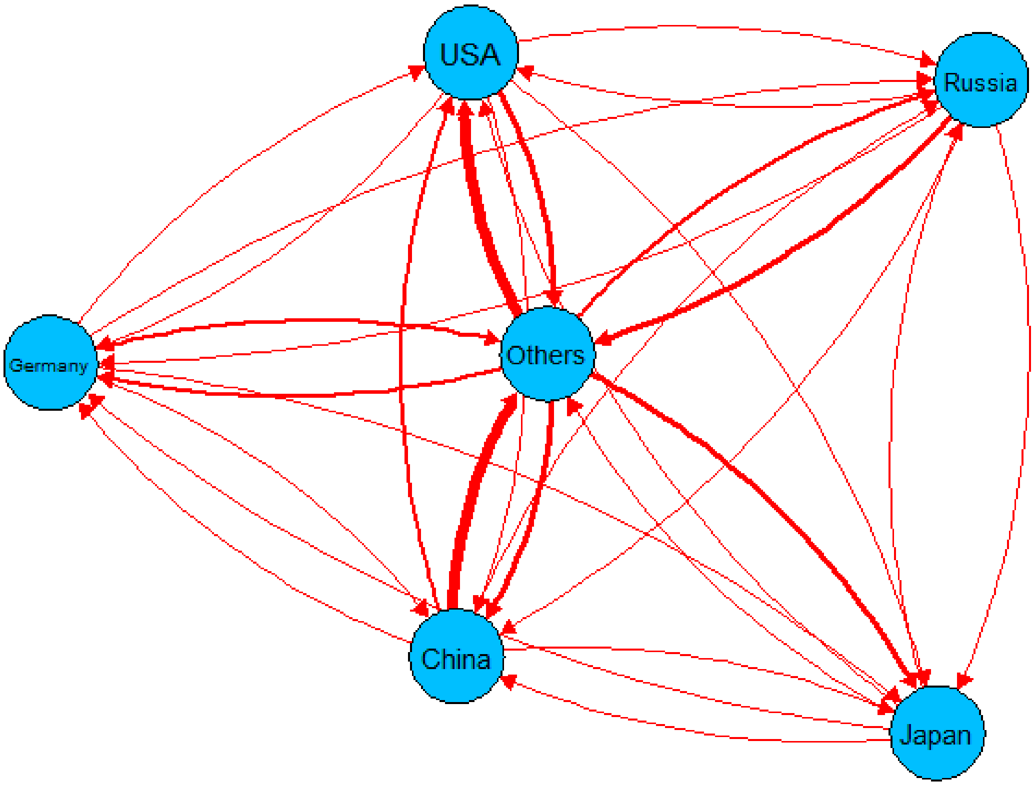


Figure A3. Network diagram of top polluters, manufacturing

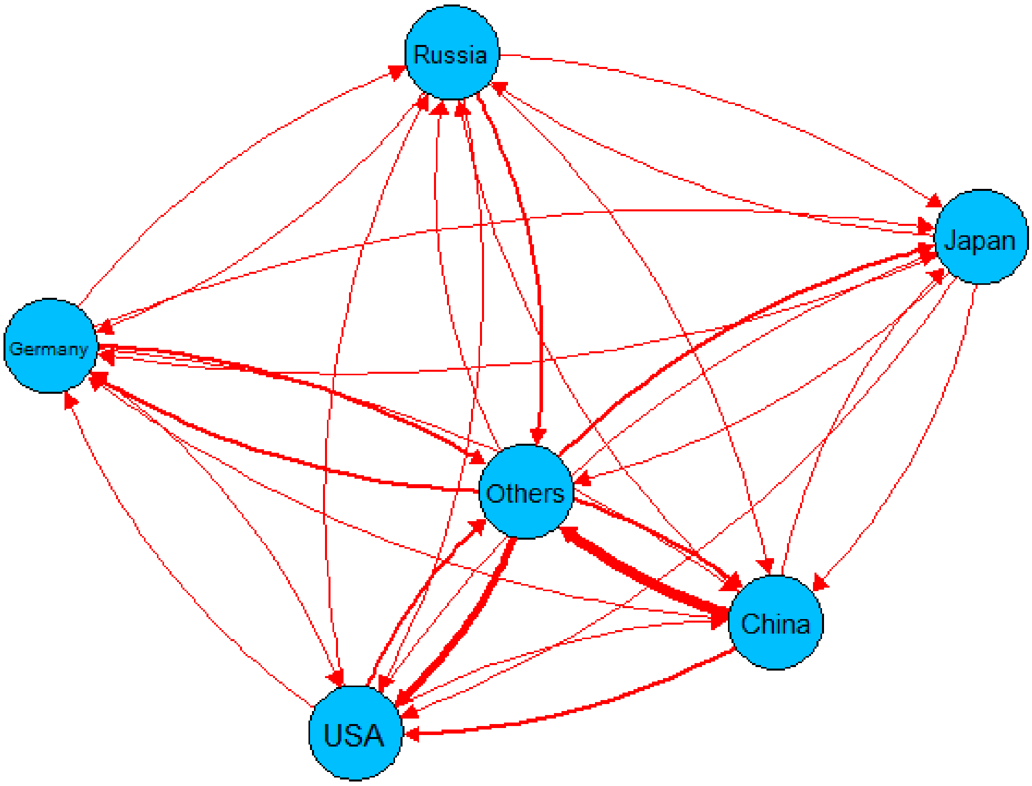


Figure A4. Network diagram of top polluters, service

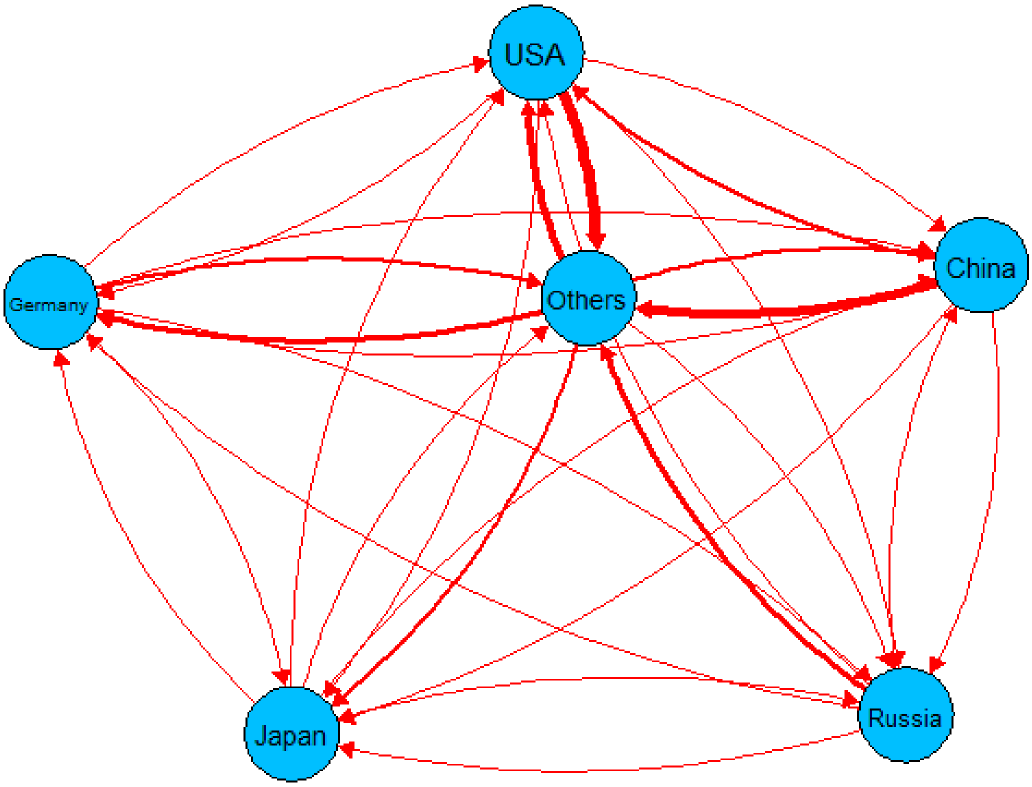


Table A3. GHG emission intensity embedded in GVCs by country groupings, agriculture and fishing

Variables	Total (1)	Developed-Developed (2)	Developed-Developing (3)	Developing-Developing (4)	Developing-Developed (5)
Value-added growth	-0.004	-0.250	-0.030	-0.003	-0.078
	(0.011)	(0.239)	(0.048)	(0.010)	(0.089)
Value-added growth_partner	-0.081	-0.354	0.305**	-0.144	-0.233
	(0.109)	(0.253)	(0.119)	(0.127)	(0.245)
Capital stock intensity	0.001	0.089*	0.096***	-0.004**	-0.006
	(0.002)	(0.052)	(0.011)	(0.002)	(0.005)
Capital stock intensity_partner	-0.001	-0.048	-0.004	-0.003	0.013
	(0.002)	(0.048)	(0.003)	(0.002)	(0.019)
Renewable energy	-0.060***	-0.065	0.002	-0.053***	-0.058***
	(0.003)	(0.057)	(0.008)	(0.003)	(0.011)
Renewable energy_partner	0.017***	0.001	0.016*	0.009*	0.006
	(0.005)	(0.068)	(0.009)	(0.005)	(0.049)
GDP per capita	0.716***	-3.657***	-3.852***	1.149***	1.025***
	(0.025)	(1.369)	(0.318)	(0.038)	(0.111)
GDP per capita_sq	-0.061***	0.159**	0.166***	-0.092***	-0.084***
	(0.002)	(0.066)	(0.015)	(0.003)	(0.008)
GDP per capita_partner	-0.030	9.660***	0.006	-0.017	3.994***
	(0.025)	(3.189)	(0.056)	(0.032)	(0.932)
GDP per capita sq_partner	-0.000	-0.468***	-0.002	0.000	-0.197***
	(0.002)	(0.150)	(0.004)	(0.002)	(0.044)
Resource Rents	-0.049***	-0.267	-0.475***	0.059***	0.074*
	(0.015)	(0.304)	(0.066)	(0.013)	(0.039)
Resource Rents_partner	0.034**	0.453**	0.004	-0.005	0.296***
	(0.014)	(0.195)	(0.019)	(0.014)	(0.076)
Human Capital Index	0.021**	0.168**	0.301***	-0.056***	0.005
	(0.010)	(0.069)	(0.014)	(0.012)	(0.048)
Human Capital Index_partner	-0.010	0.041	-0.012	-0.008	0.015
	(0.011)	(0.037)	(0.031)	(0.015)	(0.020)
Broad Money	0.096***	0.148***	0.124***	0.067***	0.080***
	(0.007)	(0.046)	(0.009)	(0.008)	(0.024)
Broad Money_partner	-0.011*	-0.124**	-0.029**	-0.015*	-0.049***
	(0.006)	(0.053)	(0.013)	(0.008)	(0.016)
FTA_WTO	-0.003	-0.028	0.011	-0.011*	0.033*
	(0.005)	(0.026)	(0.008)	(0.006)	(0.017)
GATT	-0.025***	-0.064	-0.118***	-0.015***	-0.020
	(0.004)	(0.040)	(0.007)	(0.004)	(0.012)
GATT_partner	0.012***	-0.100**	0.021***	0.011***	-0.034**
	(0.003)	(0.039)	(0.008)	(0.004)	(0.016)
Constant	-1.103***	-29.062	21.659***	-2.675***	-22.702***
	(0.143)	(19.803)	(1.693)	(0.192)	(4.921)
# of Obs.	570,816	12,439	74,686	410,349	73,342
R-squared	0.851	0.509	0.622	0.885	0.809

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4. GHG emission intensity embedded in GVCs by country groupings, mining

Variables	Total (1)	Developed-Developed (2)	Developed-Developing (3)	Developing-Developing (4)	Developing-Developed (5)
Value-added growth	0.008	0.055	0.110**	0.004	-0.022
	(0.016)	(0.121)	(0.044)	(0.015)	(0.075)
Value-added growth_partner	0.273	-19.572***	-0.665	0.317	0.079
	(0.173)	(5.809)	(0.541)	(0.194)	(0.469)
Capital stock intensity	0.036***	0.129***	0.126***	0.023***	0.032***
	(0.003)	(0.013)	(0.005)	(0.004)	(0.010)
Capital stock intensity_partner	-0.001	-0.001	-0.003	-0.002	0.004
	(0.002)	(0.028)	(0.003)	(0.003)	(0.023)
Renewable energy	-0.085***	-0.072***	-0.077***	-0.071***	-0.074***
	(0.003)	(0.015)	(0.004)	(0.004)	(0.011)
Renewable energy_partner	0.004	0.048	0.005	0.002	-0.012
	(0.006)	(0.074)	(0.009)	(0.007)	(0.067)
GDP per capita	0.596***	-2.115*	-1.905***	0.875***	0.822***
	(0.028)	(1.248)	(0.370)	(0.044)	(0.129)
GDP per capita_sq	-0.048***	0.084	0.073***	-0.068***	-0.063***
	(0.002)	(0.058)	(0.017)	(0.003)	(0.009)
GDP per capita_partner	-0.014	1.761	-0.017	-0.010	0.864
	(0.033)	(1.336)	(0.054)	(0.044)	(1.075)
GDP per capita sq_partner	0.001	-0.089	0.001	0.001	-0.042
	(0.002)	(0.063)	(0.004)	(0.003)	(0.051)
Resource Rents	0.222***	0.277**	0.137***	0.306***	0.332***
	(0.014)	(0.108)	(0.039)	(0.016)	(0.041)
Resource Rents_partner	0.005	0.114	0.005	0.001	0.023
	(0.018)	(0.114)	(0.023)	(0.021)	(0.088)
Human Capital Index	0.059***	0.390***	0.290***	-0.029**	-0.040
	(0.014)	(0.110)	(0.039)	(0.014)	(0.038)
Human Capital Index_partner	0.000	0.040	-0.011	0.003	0.002
	(0.014)	(0.029)	(0.024)	(0.019)	(0.029)
Broad Money	0.021***	0.095***	0.110***	-0.046***	-0.064**
	(0.007)	(0.021)	(0.008)	(0.011)	(0.029)
Broad Money_partner	-0.007	-0.015	-0.013	-0.007	-0.020
	(0.008)	(0.024)	(0.012)	(0.010)	(0.019)
FTA_WTO	-0.009*	-0.075**	0.003	-0.007	-0.000
	(0.005)	(0.037)	(0.007)	(0.007)	(0.014)
GATT	-0.085***	-0.106***	-0.087***	-0.077***	-0.091***
	(0.007)	(0.026)	(0.009)	(0.007)	(0.018)
GATT_partner	0.002	-0.026	0.007	0.001	-0.010
	(0.004)	(0.039)	(0.006)	(0.005)	(0.019)
Constant	-1.333***	3.093	11.259***	-2.207***	-6.532
	(0.180)	(8.988)	(1.959)	(0.250)	(5.618)
# of Obs.	284,755	6,105	36,690	205,277	36,683
R-squared	0.908	0.606	0.674	0.926	0.884

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A5. GHG emission intensity embedded in GVCs by country groupings, construction

Variables	**Total** (1)	**Developed-Developed** (2)	**Developed-Developing** (3)	**Developing-Developing** (4)	**Developing-Developed** (5)
Value-added growth	0.001	0.074	0.069	0.000	-0.054
	(0.009)	(0.168)	(0.067)	(0.009)	(0.107)
Value-added growth_partner	-0.007***	-	-0.002**	0.006	0.728*
	(0.002)		(0.001)	(0.011)	(0.407)
Capital stock intensity	0.028***	0.224***	0.213***	0.018***	0.019**
	(0.003)	(0.018)	(0.007)	(0.003)	(0.008)
Capital stock intensity_partner	-0.000	0.017	-0.002	0.001	0.015
	(0.002)	(0.029)	(0.003)	(0.002)	(0.018)
Renewable energy	-0.070***	0.134***	0.146***	-0.068***	-0.079***
	(0.003)	(0.043)	(0.014)	(0.004)	(0.010)
Renewable energy_partner	-0.005	0.119	-0.005	-0.006	0.082
	(0.006)	(0.084)	(0.011)	(0.007)	(0.062)
GDP per capita	0.691***	-6.443***	-5.262***	1.082***	1.135***
	(0.030)	(0.855)	(0.292)	(0.048)	(0.126)
GDP per capita_sq	-0.059***	0.288***	0.232***	-0.088***	-0.093***
	(0.002)	(0.040)	(0.014)	(0.004)	(0.009)
GDP per capita_partner	-0.011	-0.885	-0.011	-0.027	-1.540*
	(0.030)	(1.127)	(0.045)	(0.040)	(0.864)
GDP per capita sq_partner	0.001	0.042	0.000	0.001	0.076*
	(0.002)	(0.053)	(0.003)	(0.003)	(0.041)
Resource Rents	0.011	-0.374***	-0.383***	0.153***	0.144**
	(0.023)	(0.139)	(0.046)	(0.024)	(0.059)
Resource Rents_partner	-0.040**	0.026	-0.024	-0.022	-0.088
	(0.018)	(0.144)	(0.028)	(0.019)	(0.097)
Human Capital Index	-0.042***	0.359***	0.370***	-0.169***	-0.178***
	(0.012)	(0.039)	(0.013)	(0.014)	(0.039)
Human Capital Index_partner	-0.004	-0.012	-0.018	-0.010	-0.012
	(0.013)	(0.029)	(0.021)	(0.018)	(0.026)
Broad Money	0.056***	0.083***	0.054***	0.036***	0.058**
	(0.007)	(0.026)	(0.008)	(0.010)	(0.027)
Broad Money_partner	0.018***	0.029	0.014	0.018*	0.034**
	(0.007)	(0.023)	(0.013)	(0.009)	(0.015)
FTA_WTO	-0.007	0.001	0.013*	-0.010	0.017
	(0.006)	(0.021)	(0.007)	(0.008)	(0.016)
GATT	-0.010**	-0.030	-0.042***	-0.002	0.000
	(0.004)	(0.023)	(0.007)	(0.004)	(0.011)
GATT_partner	-0.002	0.043	-0.004	-0.002	0.045**
	(0.004)	(0.039)	(0.006)	(0.005)	(0.018)
Constant	-1.071***	39.593***	28.841***	-2.171***	5.307
	(0.171)	(7.721)	(1.587)	(0.237)	(4.597)
# of Obs.	283,728	6,219	37,343	203,756	36,410
R-squared	0.904	0.737	0.790	0.917	0.898

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6. GHG emission intensity embedded in GVCs by country groupings, electricity, gas and water

Variables	Total (1)	Developed-Developed (2)	Developed-Developing (3)	Developing-Developing (4)	Developing-Developed (5)
Value-added growth	0.001	0.011	0.056	-0.002	0.508
	(0.010)	(0.106)	(0.082)	(0.007)	(0.546)
Value-added growth_partner	0.275	0.019	-0.052	0.325	-0.245
	(0.425)	(0.084)	(0.173)	(0.507)	(0.798)
Capital stock intensity	0.868***	0.295***	0.273***	0.894***	0.898***
	(0.010)	(0.050)	(0.014)	(0.011)	(0.032)
Capital stock intensity_partner	-0.004	-0.000	-0.000	0.004	-0.062
	(0.005)	(0.050)	(0.003)	(0.005)	(0.057)
Renewable energy	-0.042**	-0.241***	-0.309***	-0.059***	-0.015
	(0.020)	(0.087)	(0.025)	(0.021)	(0.064)
Renewable energy_partner	-0.073***	0.045	-0.008	-0.040**	-0.245*
	(0.017)	(0.100)	(0.015)	(0.020)	(0.126)
GDP per capita	-0.052	-5.511***	-3.135***	-0.299**	-0.925***
	(0.089)	(1.238)	(0.340)	(0.118)	(0.328)
GDP per capita_sq	-0.005	0.267***	0.148***	0.010	0.055***
	(0.005)	(0.061)	(0.016)	(0.007)	(0.020)
GDP per capita_partner	0.028	-5.259**	-0.001	0.074	-22.030***
	(0.070)	(2.460)	(0.066)	(0.094)	(2.661)
GDP per capita sq_partner	0.008*	0.263**	0.001	-0.000	1.107***
	(0.005)	(0.117)	(0.005)	(0.006)	(0.126)
Resource Rents	-0.096*	-0.461***	-0.342***	-0.077	-0.126
	(0.055)	(0.169)	(0.066)	(0.062)	(0.191)
Resource Rents_partner	-0.251***	-0.394**	-0.026	-0.076*	-2.058***
	(0.043)	(0.192)	(0.028)	(0.044)	(0.215)
Human Capital Index	0.041	0.330***	0.362***	-0.218***	-0.169
	(0.034)	(0.041)	(0.012)	(0.044)	(0.127)
Human Capital Index_partner	0.036	-0.041	-0.010	0.016	-0.153**
	(0.032)	(0.034)	(0.036)	(0.048)	(0.061)
Broad Money	0.231***	0.084***	0.064***	0.318***	0.340***
	(0.015)	(0.024)	(0.008)	(0.025)	(0.074)
Broad Money_partner	0.048***	0.061	0.033**	0.146***	0.199***
	(0.017)	(0.042)	(0.017)	(0.022)	(0.047)
FTA_WTO	0.007	0.013	0.000	-0.019	0.138***
	(0.012)	(0.029)	(0.010)	(0.015)	(0.032)
GATT	-0.002	0.021	-0.047**	-0.022*	-0.027
	(0.011)	(0.094)	(0.020)	(0.012)	(0.032)
GATT_partner	-0.076***	0.095**	-0.021**	-0.094***	0.234***
	(0.010)	(0.048)	(0.008)	(0.012)	(0.060)
Constant	0.539	53.858***	15.926***	2.386***	114.411***
	(0.463)	(16.496)	(1.804)	(0.618)	(14.195)
# of Obs.	280,994	5,993	36,035	202,744	36,222
R-squared	0.909	0.928	0.955	0.899	0.866

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A7. GHG emission intensity embedded in GVCs by sectors

Variables	Total (1)	Manufacturing (2)	Service (3)	Agriculture and Fishing (4)	Mining (5)	Construction (6)	EGW (7)
Value-added growth	-0.000	0.003	0.008***	-0.004	0.008	0.001	0.001
	(0.011)	(0.006)	(0.003)	(0.011)	(0.016)	(0.009)	(0.010)
Value-added growth_partner	-0.007	-0.000	-0.004	-0.081	0.273	-0.007***	0.275
	(0.006)	(0.011)	(0.072)	(0.109)	(0.173)	(0.002)	(0.425)
Capital stock intensity	0.060***	0.036***	0.056***	0.001	0.036***	0.028***	0.868***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.010)
Capital stock intensity_partner	-0.001*	-0.001	-0.000	-0.001	-0.001	-0.000	-0.004
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
Renewable energy	-0.043***	-0.053***	-0.026***	-0.060***	-0.085***	-0.070***	-0.042**
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.020)
Renewable energy_partner	0.011***	0.020***	0.012***	0.017***	0.004	-0.005	-0.073***
	(0.002)	(0.003)	(0.002)	(0.005)	(0.006)	(0.006)	(0.017)
GDP per capita	0.687***	0.904***	0.613***	0.716***	0.596***	0.691***	-0.052
	(0.009)	(0.017)	(0.012)	(0.025)	(0.028)	(0.030)	(0.089)
GDP per capita_sq	-0.058***	-0.072***	-0.052***	-0.061***	-0.048***	-0.059***	-0.005
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
GDP per capita_partner	-0.011	-0.020	-0.003	-0.030	-0.014	-0.011	0.028
	(0.009)	(0.015)	(0.011)	(0.025)	(0.033)	(0.030)	(0.070)
GDP per capita sq_partner	-0.000	-0.001	-0.001	-0.000	0.001	0.001	0.008*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
Resource Rents	-0.022***	-0.050***	-0.018**	-0.049***	0.222***	0.011	-0.096*
	(0.006)	(0.012)	(0.007)	(0.015)	(0.014)	(0.023)	(0.055)
Resource Rents_partner	0.018***	0.054***	0.015**	0.034**	0.005	-0.040**	-0.251***
	(0.006)	(0.010)	(0.008)	(0.014)	(0.018)	(0.018)	(0.043)
Human Capital Index	0.003	-0.005	0.010**	0.021**	0.059***	-0.042***	0.041
	(0.004)	(0.007)	(0.004)	(0.010)	(0.014)	(0.012)	(0.034)
Human Capital Index_partner	-0.007*	-0.012	-0.007	-0.010	0.000	-0.004	0.036
	(0.004)	(0.007)	(0.005)	(0.011)	(0.014)	(0.013)	(0.032)
Broad Money	0.058***	0.051***	0.042***	0.096***	0.021***	0.056***	0.231***
	(0.002)	(0.003)	(0.003)	(0.007)	(0.007)	(0.007)	(0.015)
Broad Money_partner	-0.005**	-0.015***	-0.003	-0.011*	-0.007	0.018***	0.048***
	(0.002)	(0.004)	(0.003)	(0.006)	(0.008)	(0.007)	(0.017)
FTA_WTO	-0.009***	-0.012***	-0.012***	-0.003	-0.009*	-0.007	0.007
	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.006)	(0.012)
GATT	-0.030***	-0.030***	-0.022***	-0.025***	-0.085***	-0.010**	-0.002
	(0.001)	(0.003)	(0.002)	(0.004)	(0.007)	(0.004)	(0.011)
GATT_partner	0.007***	0.015***	0.008***	0.012***	0.002	-0.002	-0.076***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)	(0.010)
Constant	-1.144***	-1.787***	-1.094***	-1.103***	-1.333***	-1.071***	0.539
	(0.052)	(0.091)	(0.067)	(0.143)	(0.180)	(0.171)	(0.463)
# of Obs.	7,115,878	2,549,104	3,146,481	570,816	284,755	283,728	280,994
R-squared	0.880	0.793	0.863	0.851	0.908	0.904	0.909

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.