

► Advancing Green Trade and Employment under Global Uncertainty

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Abstract

This paper examines global trade patterns in green goods towards 2030. This is done in the context of current global trade tensions. The paper uses international trade flow data from WITS/COMTRADE, in conjunction with the IMF's classification of environmental goods.

The paper introduces a structural gravity model of trade to estimate the potential trade in green goods towards 2030. The paper also undertakes a counterfactual analysis to evaluate the potential impact of rising trade tensions on trade flows and employment outcomes. In the model's simulated scenarios, the United States increases tariffs on its major trading partners, prompting retaliatory measures. The model captures transformations in global trade patterns and highlights the risks that protectionist policies pose to sustainable and inclusive growth. Furthermore, the projected export dynamic is translated into employment outcomes: under the baseline, the growth of green exports to 2030 is associated with some 9.5 million additional jobs worldwide, of which around 530,000 are forgone once tariffs escalate and partners retaliate.

The study uses a multi-regional input-output model to estimate how green exports affect employment. This model combines the Organisation for Economic Co-operation and Development (OECD) Inter-Country Input-Output Tables with labour data from the ILOSTAT database. This approach enables the estimation of both direct and indirect employment effects across countries and sectors. Overall, this study makes a significant contribution to existing literature by jointly analysing green trade flows and employment generation dynamics using a unified quantitative framework. The results emphasize the significance of open trade and investment regimes in promoting the global dissemination of green technologies and generating quality employment opportunities across various regions.

JEL codes: F13, F14, F16, C67

Keywords: tariffs; trade tensions; multiregional input-output; labour market; global value chains

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► Introduction

The world faces an urgent environmental challenge that requires coordinated collective action (Calvin et al. 2023). According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Calvin et al. 2023), greenhouse gas emissions must fall by 30–50 per cent over the next two decades to avoid a global temperature increase above 1.5 °C.

Globalization has been one of the main drivers of rising emissions, as it has fragmented production processes and increased demand for goods and services (Hummels et al. 2001). Since 1948, the value of global merchandise exports has expanded substantially; by 2016, exports represented an average of 29 per cent of national GDP (Wiedmann & Lenzen, 2018). Yet the globalization of trade often shifts the environmental and social impacts of production away from the place of consumption and towards other countries. As a result, the energy use, pollution and employment effects associated with a certain good may be distributed across several economies.

In sustainable trade debates, “green trade” generally refers to trade practices and products that provide environmental benefits. However, the concept remains imprecisely defined, particularly regarding which goods should be included (Balineau & De Melo, 2013). Governments differ in their classifications, covering products such as renewable energy technologies, energy-efficient equipment, organically produced agricultural goods and certified biodiversity-based products. The Asia-Pacific Economic Cooperation (APEC) list of environmental goods, for example, was developed to improve access to environmental technologies and support green growth (Kuriyama, 2021). Given the absence of a unified definition, this study relies on the IMF’s environmental goods data (IMF, 2023). The IMF list was initially based on the EUROSTAT (2009) classification mapped to 2017 HS codes and later expanded through research and consultations on updates to the HS nomenclature. This list shares some similarities with the APEC classification of environmental goods.

This document provides a comprehensive examination of projected dynamic green goods exports over the period from 2023 to 2030. The main goal is to estimate the potential contribution of these specific groups of products to the overall labour market. This study employs a structural gravity model to assess the trade and employment impacts of green exports, following the theoretical framework developed by Anderson and Van Wincoop (2003) and extended by Anderson and Yotov (2016) and Yotov et al. (2016). The gravity approach models bilateral trade flows as a function of economic size, trade costs and multilateral resistance terms, which capture the relative ease or difficulty of market access in a general equilibrium setting.

We implement the model in two steps, building on recent methodological guidance by Larch et al. (2025). First, we estimate trade flows using a Poisson Pseudo-Maximum Likelihood (PPML) estimator. The model includes tariff data to identify the impact of trade policy on international versus intra-national trade. Second, we define a counterfactual policy scenario, in which countries engage in a tariff escalation with the United States, to simulate changes in bilateral trade costs and evaluate their effects on trade flows and employment creation towards 2030. To estimate the employment impacts associated with green goods exports, the study employs a multi-regional input-output (MRIO) model that integrates the Organisation for Economic Co-operation and Development’s (OECD) Inter-Country Input-Output tables (OECD, 2021) with labour statistics from the International Labour Organization’s (ILO) Statistics Database (ILO, 2025).

This study contributes to the recent literature of trade in sustainable products. Ernst et al. (2025) estimated the economic dimensions of green trade, considering its regional relevance in terms of exports and its impact on labour demand. Ernst et al. (2025) found that China and high-income

countries play a significant role in the global trade of these goods, although exports from middle-income countries are accelerating. Labour demand linked to green goods exports represents less than 1 per cent of total employment in most regions, except in the European Union where it accounts for around 2 per cent. We also contribute to the existing literature of multi-regional input-output models to examine the economic and environmental consequences of trade (Timmer et al. 2015). By explicitly linking trade flows to employment outcomes and providing insights into the quality of jobs associated with green exports, this methodological approach emphasizes the significance of global value chains, extending the work of Hummels et al. (2001) and Timmer et al. (2015) on trade in value-added. This document also contributes to the literature that measures the impacts of the recent trade conflict on trade flows and GDP. Recent applications assessing the impacts of trade tensions, using a gravity model, include Gopinath et al. (2025), Fajgelbaum et al. (2020) and Charandabi et al. (2021).

The remainder of this study is organized as follows: Section 1 presents an overview of global trends in green goods trade. Section 2 estimates the future evolution of green trade, including a trade-conflict scenario and projections to 2030. Section 3 analyses employment associated with projected green trade. The concluding remarks summarize the findings and outline potential lines for future research.

► 1 The international trade in green goods

This section analyses the dynamics of international trade in green goods, with a particular focus on trends in exports and imports during the period 2012–23. The study also analyses the fundamental characteristics of green trade, considering both regional and sectoral compositions. The evidence assembled in Ernst et al. (2025) indicates that the export of green goods by China and middle-income countries increased significantly over the past decade, while exports by high- and low-income countries demonstrated less substantial growth. Regarding the trade balance, that study finds that China, the European Union and the East Asia and Pacific region record the largest surpluses globally. Conversely, North America, Europe and Central Asia and Latin America exhibit the most substantial deficit, suggesting a potential imbalance resulting from a mismatch between a structural change in demand and the lack of technological capabilities to supply it.

Table 1 illustrates the growth of green trade between 2012 and 2023. A remarkable expansion of trade in green products at current values occurred, with a clear upward trajectory from 2021 onwards, reaching around US\$ 1.92 trillion in 2023. Because these figures are expressed at current values, the share of green goods in world trade is a more informative indicator of the underlying trend, since common price movements affect the numerator and the denominator alike. That share increased between 2013 and 2016 and remained relatively stable during the period 2016–19. The proportion of green goods as a percentage of world trade reached 8.5 per cent in 2020 and declined in the two following years. Between 2021 and 2022, the share of green trade remained higher than in the pre-pandemic period, and in 2023 it marked a new record of 9.2 per cent.

► **Table 1. Green and non-green trade, in USD trillion and growth rate (%), 2012–23**

Year	Green (USD tn)	Growth rate (%)	Non-green (USD tn)	Growth rate (%)	Share (%)
2012	1.06		14.26		6.9
2013	1.13	6.2	15.29	7.3	6.9
2014	1.18	4.2	15.56	1.8	7.0
2015	1.11	-5.4	13.72	-11.9	7.5
2016	1.12	0.5	13.31	-3.0	7.8
2017	1.25	11.4	15.06	13.2	7.6
2018	1.35	8.1	16.54	9.9	7.5
2019	1.36	0.9	15.84	-4.3	7.9
2020	1.35	-0.7	14.60	-7.8	8.5
2021	1.67	23.8	18.38	25.9	8.3
2022	1.82	8.7	20.28	10.4	8.2
2023	1.92	5.8	18.90	-6.8	9.2

Source: Author's calculations based on World Integrated Trade System (WITS)/UN COMTRADE.

Table 2 shows the composition of world trade in green goods by sector. In 2023, the three sectors with the largest shares are machinery (24.7 per cent), motor vehicles (20.7 per cent) and electrical equipment (18.2 per cent), which together account for 63.6 per cent of green exports.

Adding computers and electronics (15.2 per cent) brings the four leading sectors to just under four-fifths of the total. Chemicals represent 7.2 per cent and rubber and plastics 6.3 per cent, while the remaining sectors each account for less than 2 per cent. The concentration of green trade in these technology- and capital-intensive manufacturing branches highlights the vital role they play in the transition to a low-carbon global economy (Kirchherr & Urban, 2018).

► **Table 2. Green goods: Share in world trade by sector, values (USD billion) and shares (%), 2012 and 2023**

ICIO Sector	Description	X ₂₀₁₂	Share (%)	X ₂₀₂₃	Share (%)
C28	Machinery n.e.c.	339.84	31.97	473.83	24.65
C29	Motor vehicles	83.93	7.90	397.25	20.67
C27	Electrical equipment	155.19	14.60	350.52	18.24
C26	Computers & electronics	231.76	21.80	292.75	15.23
C20	Chemicals	71.82	6.76	138.29	7.20
C22	Rubber & plastics	78.51	7.39	120.69	6.28
C25	Fabricated metal products	30.05	2.83	35.59	1.85
C19	Coke & refined petroleum	21.01	1.98	16.89	0.88
C17_18	Paper & printing	13.44	1.26	14.69	0.76
C23	Non-metallic minerals	8.34	0.78	15.42	0.80
C10T12	Food, beverages & tobacco	10.43	0.98	16.70	0.87
C30	Other transport equipment	7.62	0.72	17.18	0.89
C13T15	Textiles & apparel	4.99	0.47	7.53	0.39
C31T33	Other manufacturing	2.82	0.27	4.51	0.23
C16	Wood products	1.76	0.17	2.09	0.11
B07_08	Mining (ores)	1.51	0.14	17.94	0.93

Source: Author's calculations based on WITS/COMTRADE.

Table 3 shows a marked transformation in the composition of green goods trade between 2012 and 2023. Although green exports were initially concentrated in intermediate and capital goods, such as photovoltaic cells, electrical equipment, plastics and machinery, the period is characterized by a strong expansion of electric passenger vehicles and related upstream inputs. Electric passenger vehicles (HS 870390) exhibit the most pronounced growth, increasing from US\$ 2.6 billion in 2012 (0.25 per cent of green exports) to over US\$ 300 billion in 2023, accounting for more than 15 per cent of green trade. Lithium-ion batteries (HS 850760) also experienced a substantial rise, reflecting their central role in the electrification of transport and energy systems.

At the same time, traditional, green-related manufacturing inputs, such as photovoltaic cells and LEDs, electrical control panels, valves, plastics and machinery, continued to expand in absolute terms, although their relative shares evolved more moderately. The overall pattern points to a structural shift towards final green products and strategic enabling technologies, consistent with the scaling-up of global value chains associated with electric mobility and renewable energy deployment.

► **Table 3. Main green products traded, values (USD billion) and shares (%) in 2012 and 2023**

HS6	Description (short)	X ₂₀₁₂	Share (%)	X ₂₀₂₃	Share (%)
870390	Passenger vehicles (electric)	2.62	0.25	300.37	15.63
850760	Lithium-ion batteries	9.04	0.85	113.05	5.88
854140	Photovoltaic cells and LEDs	44.51	4.19	87.60	4.56
853710	Electric control panels (≤1000V)	36.69	3.45	78.94	4.11
392690	Other plastic articles n.e.c.	42.98	4.04	72.17	3.75
848180	Valves, taps and similar appliances	43.18	4.06	56.60	2.95
854370	Electrical apparatus n.e.c.	24.57	2.31	48.84	2.54
847989	Machinery n.e.c.	29.30	2.76	45.14	2.35

Source: Author's calculations based on WITS/COMTRADE, under nomenclature HS 2012.

► 2 Estimating the dynamic of green trade

This section provides an estimate of the dynamics of green exports for the 2023–30 period. This estimation is carried out using the gravity model (GM), which is inspired by Newton's equation of gravity. The basic idea, originally proposed by Tinbergen (1962) and later developed by Anderson (1979), is that the volume of trade between two countries depends mainly on the relative size of their economies and the distance between them as a proxy of bilateral frictions. It is expected that a pair of countries with larger size and lower frictions will demonstrate larger trade flows than a pair of countries with smaller size and higher frictions.

This section introduces the framework of the structural gravity model, following the model developed by Anderson and Yotov (2016) and the practical guidance set out in Yotov et al. (2016). This approach emphasizes how trade is interconnected, responding to barriers or frictions that arise from both natural and policy-driven factors. The model developed in this section also follows the best practices summarized carefully in Larch et al. (2025) and Yotov (2022), considering the potential biases and inconsistencies associated with a naive implementation of the model.

To evaluate the potential dynamics of green trade, a business-as-usual scenario is developed for the period 2023–30. This scenario incorporates exogenous projections for key economic variables, including the annual GDP growth rate, as presented in the World Economic Outlook (IMF, 2025). In addition, a trade conflict scenario is simulated to estimate the potential limitations that could hinder the growth of green goods exports over the next decade. The main goal is to provide an overall estimate of the potential employment created by these new exports, while considering how trade tensions could limit the positive impact of trade on the labour market.

Recent applications assessing the impacts of different trade policies, using a gravity model, include the impact assessment of Brexit (Dhingra et al. 2017), the United States–China trade conflict (Fajgelbaum et al. 2020) and the African Continental Free Trade Area (World Bank, 2020).

Methodology

The analytical framework is based on a structural gravity model of trade (Anderson et al. 2017). This framework captures the complex interrelations between trade and economic outcomes in a general equilibrium setting. The bilateral trade from country originating i and hosted in country j is formally expressed as:

(1)

$$X_{ijt} = \frac{Y_{it} E_{jt}}{Y_t} \left(\frac{t_{ijt}}{\Pi_{it} P_{jt}} \right)^{1-\sigma},$$

where X_{ijt} denotes the nominal trade flows from exporter i to destination j ; E_j is the total expenditure on importer j , Y_i is the value of total production in exporter i ; Y is the value of the world output; t_{ijt} denotes bilateral trade frictions between partners i and j , and $\sigma > 1$ is the elasticity of substitution among goods from different countries.

The variables p_j and Π_j are structural parameters defined by Anderson and Van Wincoop (2003) as the inward and outward multilateral resistance terms, respectively. They represent the general equilibrium impacts of bilateral trade frictions.

(2)

$$p_j = \left[\sum_{i=1}^N \left(\frac{t_{ji}}{\Pi_j} \right)^{1-\sigma} \frac{Y_j}{Y} \right]^{\frac{1}{1-\sigma}}$$

(3)

$$\Pi_j = \left[\sum_{i=1}^N \left(\frac{t_{ji}}{p_j} \right)^{1-\sigma} \frac{E_j}{Y} \right]^{\frac{1}{1-\sigma}}$$

These multilateral resistance terms aggregate the bilateral trade costs faced by each country, thereby indicating how global trade integration impacts individual economies.

Equation (4) is a restatement of the market-clearing condition according to which, at delivered prices, the value of output in country j is equal to the value of total sales. In its current version, equation (4) captures the inverse relationship between the outward multilateral resistance faced by the producers in country j and their factory-gate prices.

(4)

$$E_j = p_j Y_j$$

Factory-gate prices in equation (5) refer to the cost of goods as they leave the production facility, excluding transportation, distribution and retail markups. In structural gravity models of trade, they play a crucial role in determining a country's competitiveness. Lower factory-gate prices, driven by lower production costs, wages, or subsidies, make goods more attractive for exports.

(5)

$$p_j = \left(\frac{Y_j}{\sum_{i=1}^N Y_i} \right)^{\frac{1}{1-\sigma}} \frac{1}{y_j \Pi_j}$$

As outlined in earlier discussions, Equation (6) delineates the value of production in a country as a function of factor demand.

(6)

$$Y_j = p_j A_j L_j^{1-\alpha_j} K_j^{\alpha_j}$$

The following generic econometric gravity equation can be estimated to obtain estimates of trade costs and trade elasticities:

(7)

$$X_{j,i,t} = \exp(\pi_{i,t} + \chi_{j,i,t} + t_{j,i}) \varepsilon_{j,i,t}$$

Equation (7) is estimated with the PPML estimator (Silva & Tenreyro, 2006), using a panel of intra-national and international trade data with yearly intervals, and controlling for exporter-time fixed effects (π_{it}) and importer-time fixed effects (χ_{it}).

(8)

$$t_{j,i} = \beta_t \tau_{j,i} + \beta_{rta} RTA_{j,i} + \beta_{cntg} CNTG_{j,i} + \beta_{smc} SMCTRY_{j,i} \\ + \beta_{dst} \log(DIST_{j,i}) + \beta_{lng} LANG_{j,i} + \beta_{cly} CLNY_{j,i}$$

where $t_{j,i}$ are the trade cost estimates that include all the usual bilateral gravity variables, such as regional trade agreements (RTA), common border (CNTG), domestic flows (SMCTRY), distance (DIST), common language (LANG) and historical colony relationships (CLNY). The representative non-uniform trade policy, $\tau_{j,i}$, corresponds to the continuous variable for MFN tariff. Finally, $\varepsilon_{j,i,t}$ is a stochastic error term that is assumed to not carry any systematic information about trade costs.

This second step entails defining the counterfactual experiment of interest. The counterfactual scenario involves the introduction or removal of trade barriers, which will result in a change in bilateral trade costs. The definition of trade policy variables for counterfactual trade costs will depend on the policy question under investigation (Larch et al. 2025).

Any adjustment to the trade policy variables specified in the structural gravity model will result in a new matrix of counterfactual (CFL) bilateral trade costs. The differences between the baseline trade costs defined in the equation (8) and the counterfactual trade costs reported; this is the initial trade policy shock introduced in the general equilibrium system. As demonstrated above, this shock will translate into changes in key economic indicators of interest to the policymaker, such as trade and real consumption.

The scenarios under analysis

To evaluate the potential impacts of different trade policies and economic conditions, a business-as-usual (BAU) scenario is developed first to establish a baseline.

- The Scenario BAU, “Business as Usual”, is used for calibration and comparison with alternative policy interventions. The temporal window for the simulation spans from 2023 to 2030. It incorporates exogenous projections for key economic variables, including the annual GDP growth rate from the World Economic Outlook-IMF.

This section derives an additional policy shock from recent trade conflicts between the United States and its main trading partners. The objective is to forecast a long-term outcome and to assess the potential risk of this negative shock in affecting green trade and employment, harming economic integration and reversing globalization.

- The Scenario RETAL, “Deepening Trade conflict with Retaliation”, involves the United States expanding tariffs by adding to existing rates, based on declarations made by the United States government in April 2025. This increase applies to key trade partners, including the European Union and China. In response to the initial tariff increase imposed by the United States, the rest of the world also implements retaliatory measures, increasing their tariffs by the same amount on the United States imports. The rates used correspond to those announced in April 2025; the scenario should therefore be read as a stylised upper bound on tariff escalation rather than as a forecast of the tariffs finally implemented.

This scenario will allow us to evaluate the potential macroeconomic and sectoral impacts of rising trade protectionism, considering changes in green trade flows, trade balances and production adjustments across regions.

Results

The estimation of the gravity model, as summarized in Table 4, reveals significant information on the determinants of bilateral green trade flows. Consistent with theoretical expectations, geographic and historical factors, such as colonial ties, shared borders and shorter distances, substantially influence trade volumes. While common language appears to be statistically insignificant, institutional factors demonstrate substantial impacts. Trade agreements significantly enhance bilateral exchanges by around 26 per cent. Furthermore, the estimated coefficient on the bilateral tariff is statistically significant and identifies $(1 - \sigma)$, that is, the trade elasticity, with a value of around -5. This implies an elasticity of substitution of about 6, which is in line with the range usually reported in the gravity literature and which drives the size of the counterfactual effects reported below.

► Table 4. Gravity model estimation results (2012-23)

Variable	Coefficient	Robust std. error	z-value	P-value	95% confidence interval
CLNY***	1.0117	0.2174	4.65	0.000	[0.5855, 1.4378]
CNTG***	0.6022	0.0756	7.96	0.000	[0.4540, 0.7505]
LANG	-0.0440	0.1013	-0.43	0.664	[-0.2425, 0.1546]
ln_DIST***	-0.5520	0.0333	-16.55	0.000	[-0.6173, -0.4866]
SMCTRY***	2.2109	0.1469	15.05	0.000	[1.9230, 2.4987]
RTA***	0.2305	0.0699	3.30	0.001	[0.0936, 0.3675]
ln(1+Tariff)***	-5.0345	1.4646	-3.44	0.001	[-7.9051, -2.1638]

Source: Author's estimation.

Notes: CLNY = colonial relationship; CNTG = contiguity; LANG = common language; ln DIST = logarithm of distance; SMCTRY = same country; RTA = regional trade agreement; ln(1+Tariff) = logarithm of bilateral tariff. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Importer, exporter and time fixed effects not reported.

Number of observations = 7,803; Number of parameters = 310;

Pseudo log-likelihood = -3,775.55; Pseudo R² = 0.9865.

This section presents the outcomes of the simulation exercises described in the preceding section. The baseline scenario (BAU) is compared with the alternative policy scenario, which includes the trade conflict case. The analysis focuses on changes in green trade flows, providing a comprehensive view of how external shocks and policy decisions reshape economic dynamics. Quantitative results are reported for key indicators at the national level.

In the absence of trade conflict, long-term trends show a broadly positive trajectory. Export performance improves across most of the participating economies. Under the baseline scenario, countries such as China (+49 per cent), Japan (+78 per cent), Korea (+92 per cent), Germany (+51 per cent), Canada (+51 per cent) and Mexico (+52 per cent) experience substantial export growth relative to the base year. These results suggest an expansion of trade ties, particularly for economies that are deeply integrated into global value chains or have preferential trade access. Emerging economies such as Viet Nam (+70 per cent) also register significant export growth, underscoring potential gains from continued integration and diversification strategies.

The simulation results reveal significant and asymmetric impacts of the trade conflict scenario (RETAL) on key participating economies. The United States, as the initiator of the tariff escalation, experiences the most severe export contraction, with exports declining by 23.3 per cent. Among the United States trade partners, effects vary widely depending on their level of integration and exposure. Mexico and Canada, due to their high economic integration with the United States and their exclusion from this trade conflict so far, show export increases of 8.4 and 9.9 per cent, respectively.

In contrast, several emerging economies, especially from Asia, experience significant trade losses. Viet Nam's exports fall by 2.3 per cent, Thailand's exports decline by 3 per cent and Indonesia's exports fall by 2 per cent. European economies are also affected, though the impacts are less severe, as they face a smaller tariff increase (20 percentage points) than the most exposed Asian exporters. Germany, France and Italy register modest export losses of 0.3, 0.8 and 1.1 per cent, respectively. China, which experienced a 104 percentage-point increase in bilateral tariffs with the United States, sees its exports decline by 10.8 per cent, indicating some insulation due to broader diversification, but also notable vulnerability.

► **Table 5. Simulation results: Green exports in 2030**

Country	Exports base year (USD bn)	% chg. BAU (wrt. base year)	% Tariff chg. (p.p.)	% chg. RETAL (wrt. BAU)
ARG	2	37	10	-5.4
AUS	4	72	10	1.6
AUT	18	34	20	-0.5
BEL	21	36	20	-0.5
BRA	6	38	10	-7.2
CAN	23	51	10	9.9
CHE	23	36	31	-1.7
CHL	1	50	10	1.8
CHN	189	49	104	-10.8
COL	0	48	10	-0.9
CZE	24	35	20	-0.5
DEU	320	51	20	-0.3
DNK	15	40	20	-0.7
ESP	19	40	20	-0.9
EST	1	41	20	-0.5
FIN	6	42	20	-1.1
FRA	44	42	20	-0.8
GBR	36	47	10	0.0
GRC	1	49	20	-0.5
HRV	1	35	20	-0.3
HUN	18	33	20	-0.7
IDN	13	71	32	-2.0
IRL	5	40	20	-1.6

Country	Exports base year (USD bn)	% chg. BAU (wrt. base year)	% Tariff chg. (p.p.)	% chg. RETAL (wrt. BAU)
ISR	5	49	17	-3.4
ITA	48	43	20	-1.1
JPN	106	78	24	-2.6
KOR	68	92	25	-1.3
LTU	2	39	20	-0.2
MEX	40	52	10	8.4
NLD	32	39	20	-0.8
NOR	3	43	15	-1.1
NZL	1	63	10	-0.1
PAK	0	79	29	-4.9
POL	24	36	20	-0.5
PRT	5	34	20	-0.5
RUS	3	44	10	-4.2
SAU	3	48	10	-3.3
SGP	13	71	10	0.1
SVK	8	42	20	-0.4
SVN	4	37	20	0.0
SWE	15	39	20	-1.2
THA	17	75	36	-3.0
TUN	1	37	28	-1.3
TUR	13	41	10	-0.2
USA	138	50	0	-23.3
VNM	22	70	46	-2.3
ZAF	4	46	30	-4.4

Source: Author's estimation.

Notes: Simulated changes in green exports by 2030. Tariff changes refer to percentage-point increases in bilateral tariffs vis-à-vis the United States. RETAL denotes the retaliation scenario. The base year is 2023. Because tariff changes are measured vis-à-vis the United States, the United States row is zero by construction and the decline in its exports arises from the retaliation of its partners. The economies reported account for roughly 70 per cent of world green trade in the base year.

► 3 The employment related to green exports

This section presents an analysis of the labour dimension of green trade exports, with a focus on the quantity of jobs created, both directly and indirectly, due to the export of these products. One technique frequently used for such estimation is the input-output model. Multisectoral models have a long tradition, with their origins in the seminal work of Leontief (1959). These models present a simplified framework of the circular flow, similar to the *Tableau Economique* of Quesnay (1758).

As previously outlined, this paper employs a multi-regional input-output approach (OECD, 2021; Timmer et al. 2015). To facilitate meaningful cross-country comparisons of employment, considering the relationship between final demand and the structure of the world economy is essential. This section provides a concise overview of the methodology used to estimate this employment-trade link, followed by a presentation of the main findings.

Methodology

The multiregional input-output model can be represented by the following subset of matrices and vectors, starting from the expenditure side:

(9)

$$x = Ze + F$$

Where x is the vector of gross output values, Z is the matrix of intermediate uses, e is a column vector of ones and F is the matrix of final demand. After some algebraic steps, dividing and multiplying the elements of the matrix Z by the gross output, it is possible to reformulate equation (9) as follows:

(10)

$$x = Ax + F$$

A is the matrix of input-output coefficients, which describes the units of intermediate inputs needed to produce one unit of gross output.

Finally, after passing elements from one side of the equation to the other, the following expression is obtained:

(11)

$$x = (I - A)^{-1}F$$

The $B = (I - A)^{-1}$ matrix is the so-called Leontief matrix, or total requirements matrix. Each element of this matrix represents the direct and indirect requirements of input i by activity k , in a country n from a partner m . To calculate how much employment is generated directly and indirectly by the green exports, it is necessary to recover the diagonal matrix θ , whose elements contain the labour to output coefficients.

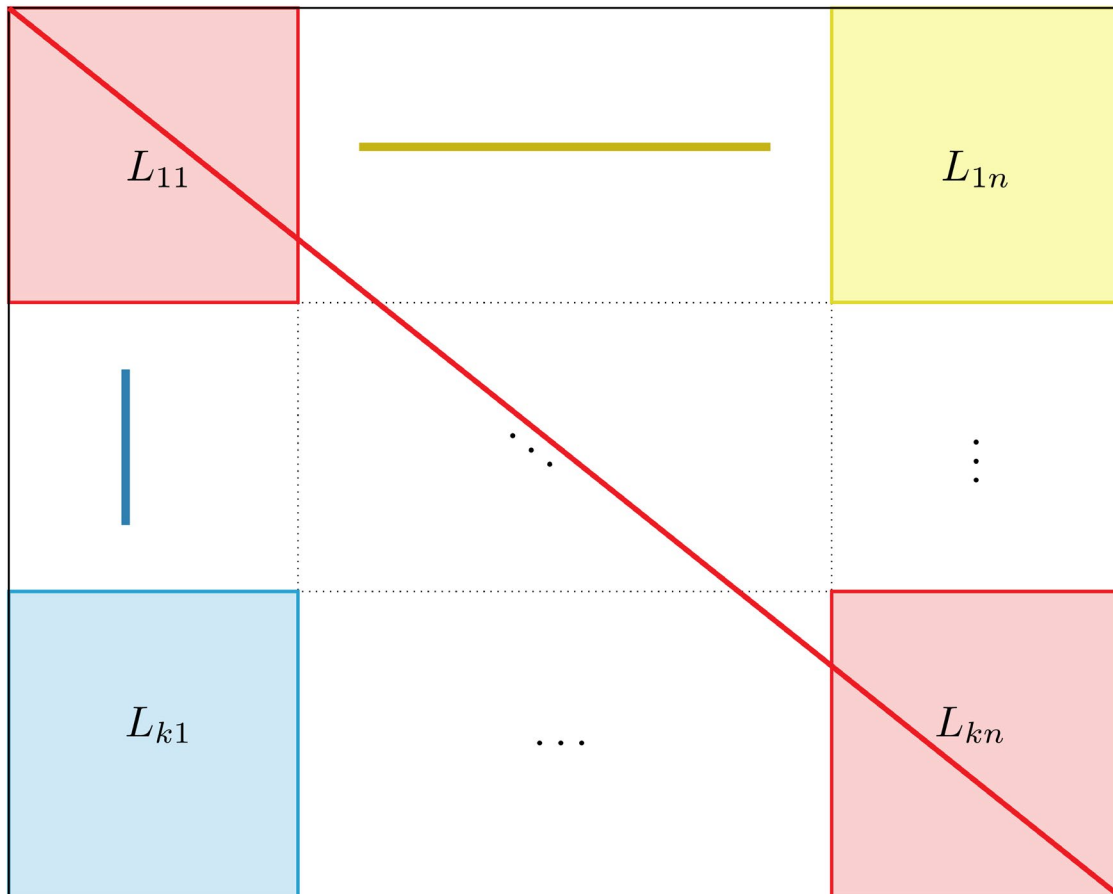
Finally, by multiplying the matrix θ by B and the gross green exports matrix, ΔE , yields the matrix, which shows the absolute change between the period.

(12)

$$\Delta L = \theta(I - A)^{-1} \Delta E$$

Matrix L provides all relevant information to estimate the employment included in the gross exports of sustainable goods. Following a similar classification to that in the value-added analysis (Aslam et al. 2017), it is possible to estimate the domestic labour input (DLI), the exported labour input (DLX) and the foreign labour input (FLI), which are highlighted in equation (12) as different components of the matrix. The diagonal blocks of the matrix, shown in red, make up the DLI. The sum of the off-diagonal elements in each column, highlighted in blue, makes up the FLI indicator, while the sum of the off-diagonal elements in each row, highlighted in yellow, makes up the DLX indicator.

► Figure 1: Block structure of matrix L highlighting selected submatrices



This empirical analysis focuses on the DLI indicator for each country, which is given by the diagonal blocks of the L matrix and represents the domestic labour content embedded in the gross exports of green goods. This estimation excludes, by definition, the foreign labour content in exports, as contained in the FLI indicator. It is also important to note that DLI includes both direct and indirect employment related to green trade. This means that the result is influenced by

national vertical integration, as well as some minor domestic value that returns home via imports and double-counted exports produced domestically (Aslam et al. 2017).

Results

This subsection presents aggregate figures about the employment sustained by green trade up to 2030, using the matrix calculations presented in the previous section. To ascertain the impact on the labour market, the exports were multiplied by the Leontief inverse and the labour-to-output ratio; this calculation provides the necessary data. As the gravity estimation was carried out using an aggregate green trade sector, it is assumed that the sectoral composition remained similar to the baseline. Another key issue to consider is the impact of productivity on final labour demand, which is a crucial element in a long-run estimation. In this regard, the input-output analysis has been recognized as an effective tool for performing short-run estimations of different policy scenarios. However, it should be noted that the use of this analysis for long-run estimations is not without caution, due to the potential for significant technological change over time (La Marca & Xiao, 2021). Considering this limitation, we proceed to present the main findings of this section.

Table 6 shows the projected change in labour demand associated with green exports growth up to 2030. The results show that China will account for most of the increase in absolute terms, with over 3.6 million jobs, followed by East Asia and the Pacific, with 2.4 million, the European Union, with 1.6 million and North America and Latin America, with 0.6 and 0.7 million, respectively. In the case of South Asia and Africa, regions with lower income per capita in the sample, the employment creation will be modest, adding fewer than 90,000 jobs to their economy. In most high- and middle-income regions, direct employment creation accounts for around half of the total outcome. However, this figure is markedly lower in China, East Asia, South Asia and Africa, primarily due to stronger domestic linkages compared to other regions. As illustrated in the lower section of the table, China and high-income economies are projected to generate most employment opportunities in green trade-related activities by 2030.

► **Table 6. Change in employment demand (thousands of jobs) in the baseline scenario (with respect to the base year), by region and income group**

	Direct	Indirect	Total
By region			
Africa	36	51	87
China	934	2,699	3,633
East Asia & Pacific	797	1,577	2,374
Europe & Central Asia	192	201	393
European Union	847	798	1,645
Latin America & Caribbean	307	354	661
Middle East	13	12	25
North America	317	262	579
South Asia	16	62	78
Total	3,459	6,016	9,475

	Direct	Indirect	Total
By income level			
China	933	2,698	3,633
High income	1,809	2,079	3,888
Lower middle income	196	531	727
Upper middle income	521	708	1,229
Total	3,459	6,016	9,475

Source: Author's estimation.

Notes: Direct and indirect effects are reported in headcount values; totals correspond to their sum.

When the impact is measured in relative terms to the total current employment in the economy, as shown in Table 7, the European Union holds the top position, exceeding 0.8 per cent. The East Asia and Pacific region and China recorded rates of 0.54 per cent and 0.48 per cent, respectively. North America and LAC countries display figures of approximately 0.3 per cent, and ECA slightly above 0.2 per cent. For the remaining countries, the share is less than 0.2 per cent.

► **Table 7. Change in employment demand (as per cent of total employment) in baseline scenario (with respect to base year), by region and income group**

	Headcount	% of total employment
By region		
Africa	87	0.06
China	3,633	0.48
East Asia & Pacific	2,374	0.54
Europe & Central Asia	393	0.22
European Union	1,645	0.82
Latin America & Caribbean	661	0.30
Middle East	25	0.12
North America	579	0.32
South Asia	78	0.01
Total	9,475	-
By income level		
China	3,633	0.48
High income	3,888	0.70
Lower middle income	727	0.07
Upper middle income	1,229	0.30
Total	9,475	-

Source: Author's estimation.

Table 8 illustrates the sectoral distribution of direct employment creation by region and by income. Direct employment effect is defined as the labour requirements necessary to export a certain amount of green goods. The 45 activities in the MRIO have been aggregated into a small number of branches and a residual "Other sectors" category. The aggregation is not the same in Tables 8 and 9, because the activities that generate direct and indirect employment differ: Table

8 reports the manufacturing branches that produce green goods, while Table 9 reports the upstream and service activities that supply them.

Across most regions and income levels, machinery and equipment are among the dominant contributors to direct employment creation, accounting for around 30–40 per cent of total green trade-related employment. This dominance is particularly pronounced in high-income economies, the European Union and North America. Electrical and electronic equipment is the leading source of direct employment in China and in Latin America, and the second most significant elsewhere, notably in the East Asia and Pacific region, reflecting its central role in global green manufacturing value chains.

Motor vehicles, metal products and chemical sectors all make modest contributions, although these vary considerably from region to region. In lower-middle-income economies, employment effects are more dispersed across sectors, as reflected in the relatively large share of the other sectors category. The table indicates that green employment is concentrated in capital- and technology-intensive manufacturing sectors. It also reveals that there are structural differences in how green trade translates into employment across regions and income groups.

► **Table 8. Change in direct employment demand in baseline scenario (with respect to base year), sectoral decomposition (%)**

Sector	By region									By income level		
	AFR	CHN	EAP	ECA	EU	LAC	ME	NAM	SAS	HI	LMI	UMI
Basic metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical	8.3	0.5	3.5	6.2	4.0	2.0	8.3	3.8	6.2	3.7	5.6	3.5
Electrical equip.	11.1	31.7	10.8	9.4	13.3	33.6	8.3	23.3	6.2	13.7	12.8	24.4
Electronic equip.	2.8	17.9	28.6	12.5	15.8	3.6	16.7	12.6	0.0	21.5	9.2	6.5
Machinery	33.4	18.4	20.6	33.4	36.9	30.3	25.0	42.3	0.0	34.6	5.6	28.5
Metal products	5.6	5.4	7.7	5.7	4.0	7.2	8.3	1.6	0.0	2.8	21.9	8.3
Motor vehicles	5.6	5.4	11.9	11.5	9.4	7.5	0.0	5.4	0.0	10.3	3.1	9.0
Other sectors	33.2	20.7	16.9	21.3	16.6	15.8	33.4	11.0	87.6	13.4	41.8	19.8
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Author's estimation.

Notes: Entries report sectoral shares by region and income group. Shares are column-normalized so that each column sums exactly to 100; adjustments are purely proportional and preserve the original distribution up to rounding. Basic metals contribute no direct employment because the IMF green-goods list contains no products classified to that branch; the corresponding requirements appear as indirect employment in Table 9. Columns for regions with a small base, in particular South Asia, should be read with caution. Regional acronyms: AFR = Africa; CHN = China; EAP = East Asia and Pacific; ECA = Europe and Central Asia; EU = European Union; LAC = Latin America and the Caribbean; ME = Middle East; NAM = North America; SAS = South Asia. Income groups: HI = High income; LMI = Lower middle income; UMI = Upper middle income (excluding China).

Table 9 reports the sectoral composition of indirect employment demand generated by green exports in the baseline scenario, disaggregated by region and income group. Indirect employment effects capture the labour embodied in domestic intermediate inputs, such as services, logistics and upstream goods, that are used in the production of green products for export. This reflects employment generated by the domestic supply chain, rather than within exporting sectors themselves.

Across most regions and income levels, trade, transport, professional services and agriculture are the primary channels generating indirect employment. These sectors account for roughly 40 to 55 per cent of total indirect employment linked to green exports in most regions, and for more than 70 per cent in South Asia and in lower-middle-income economies. The prominence

of these sectors reflects the intensive use of logistics, wholesale and retail services and primary inputs in green production chains.

Heterogeneity is marked across regions. In South Asia and lower-middle-income economies, agriculture is a dominant source of indirect employment. In high-income economies and the European Union, indirect employment is more strongly concentrated on trade-related and professional service activities. The relatively large share of the other sectors category in several regions underscores the diffuse and service-intensive nature of indirect employment effects.

► **Table 9. Change in indirect employment demand in baseline scenario (with respect to base year), sectoral decomposition (%)**

Sector	By region									By income level		
	AFR	CHN	EAP	ECA	EU	LAC	ME	NAM	SAS	HI	LMI	UMI
Agriculture	11.8	19.8	14.1	2.5	2.1	5.4	0.0	1.1	75.4	1.7	34.8	13.7
Basic metals	5.9	6.0	3.9	2.5	2.8	1.4	0.0	2.3	0.0	4.0	0.9	2.0
Metal products	2.0	4.0	2.9	6.0	8.5	5.9	0.0	5.7	0.0	5.9	1.7	4.7
Professional services	7.8	1.4	4.3	7.0	8.6	9.0	8.3	10.7	0.0	8.1	0.6	6.2
Trade	25.5	21.6	30.5	25.9	18.9	35.2	33.3	28.0	11.5	24.7	31.6	32.0
Transport	5.9	5.0	5.1	7.5	3.6	4.8	8.3	3.4	3.3	4.7	4.9	4.8
Other sectors	41.1	42.2	39.2	48.6	55.5	38.3	50.1	48.8	9.8	50.9	25.5	36.6
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Author's estimation.

Notes: Entries report sectoral shares of indirect effects by region and income group. Shares are column-normalized so that each column sums exactly to 100; adjustments are minimal and purely proportional, preserving the original distribution up to rounding. Regional acronyms: AFR = Africa; CHN = China; EAP = East Asia and Pacific; ECA = Europe and Central Asia; EU = European Union; LAC = Latin America and the Caribbean; ME = Middle East; NAM = North America; SAS = South Asia. Income groups: HI = High income; LMI = Lower middle income; UMI = Upper middle income (excluding China).

Table 10 shows the change in employment generated under the trade war scenario. In this simulation, the results show a significant trade reallocation at the global level. China and the United States are the most affected countries. If only green goods are considered, the trade conflict could cost China almost 400 thousand jobs. North America, driven by the United States, loses slightly under 100 thousand jobs.

The European Union loses around 9 thousand jobs relative to the baseline. Latin America, driven by Mexico, exhibits a positive value. This indicates an increase in employment due to the trade diversion effect triggered by the tariff conflict. In East Asia, the total employment loss is around 50 thousand, a relatively limited number considering the size of its labour force. The expected tariff of the United States on Asian countries generates a decline in these countries. It also leads to the relocation of demand to other countries. Most of these countries benefit from the import substitution resulting from the trade conflict, such as Mexico and Canada. Taken together, the losses under the trade conflict amount to about 5.6 per cent of the employment created in the baseline, so protectionism slows the pace of green job creation without reversing it.

► **Table 10. Change in employment (thousand jobs) demand in policy scenario (with respect to baseline scenario)**

By region		By income level	
Region	Total	Income level	Total
Africa	-3.2	China	-392.5
China	-392.5	High income	-137.1
East Asia & Pacific	-50.6	Lower middle income	-17.8
Europe & Central Asia	-4.8	Upper middle income	17.1
European Union	-9.1		
Latin America & Caribbean	33.6		
Middle East	-0.8		
North America	-99.0		
South Asia	-3.9		
Total	-530.3	Total	-530.3

Source: Author's estimation.

The following formula illustrates the observed bias across different employment groups: gender, age, skill and formality status. In this context, "bias" is defined as the percentage-point (pp) difference between the observed share of a reference group (formal workers or youth) supported by green trade and the economy-wide average. For example, if the female employment rate in green trade-related jobs is 51 per cent and the rate for all sectors is 50 per cent, the estimated bias is 1 percentage point. This analysis provides insight into the distinctive characteristics of green trade-related employment.

(13)

$$bias_i = \frac{\sum_j x_{ij}^{green}}{\sum_j x_j^{green}} - \frac{\sum_j x_{ij} (i=1)}{\sum_j x_j}$$

Table 11 illustrates the bias in labour characteristics for direct employment creation. The results show that there is a positive bias in the proportion of formal employment worldwide, and a negative bias in female employment in green trade-related sectors. At the same time, there is no appreciable bias in terms of skills or age. Manufacturing core sectors such as machinery, metals and chemicals explain this orientation of labour commanded by green exports.

The same table shows the bias in indirect employment arising from new green goods exports. Once again, there is a positive bias in the proportion of formal employment, but a negative bias in terms of gender, indicating a difference. This difference is explained by the importance of sectors, such as trade and agriculture, in terms of the indirect employment demanded by green exports. Indirect labour demand also shows a small negative bias in terms of skill and age, although in both the direct and the indirect case these two dimensions remain close to neutral.

► Table 11. Bias by gender, age, skill and formal status employment, direct and indirect employment

Direct employment bias		Indirect employment bias	
Youth	-0.8	Youth	-1.3
Female	-19.0	Female	-17.9
Skilled	0.1	Skilled	-2.0
Formal	41.5	Formal	17.5

Source: Author's estimation.

► Concluding remarks

This document presented a comprehensive analysis of green trade flow dynamics towards 2030 and their associated employment impacts. By establishing a connection between comprehensive labour data from ILOSTAT, the IMF green goods list and the OECD's input-output tables, the study found valuable insights into the impact of green exports on job creation in the mid-term scenario.

The results suggest that high-income countries and China will have a disproportionate influence on green exports in the coming years. In the absence of trade conflict, most economies experience strong growth in green exports. China (49 per cent), Japan (78 per cent), Viet Nam (70 per cent), Korea (92 per cent), Germany (51 per cent), Canada (51 per cent) and Mexico (52 per cent) lead the trend, reflecting deeper integration in global value chains.

Under the policy scenario, which simulates a more protectionist environment in the coming years, these gains are unevenly affected. The United States, as the initiator, sees exports fall by 23.3 per cent. China, facing the most relevant tariff hike, registers a 10.8 per cent decline in exports. Viet Nam, Thailand and Indonesia also experience modest losses. Conversely, Mexico (8.4 per cent) and Canada (9.9 per cent) gain from trade diversion and are largely shielded from the conflict. European countries face mild impacts because of relatively low tariff exposure. Green trade growth also supports substantial job creation. Under the baseline, China generates over 3.6 million new jobs, followed by East Asia and the Pacific (2.4 million), the European Union (1.6 million), Latin America (0.7 million) and North America (0.6 million). In lower-income regions such as South Asia and Africa, employment gains remain modest. In the trade conflict scenario, China and the United States lose the most jobs. Mexico, however, shows positive employment effects due to import substitution. The European Union is relatively unaffected. East Asia sees limited job losses.

These results carry three policy messages. First, because the trade elasticity estimated here is large, tariffs on environmental goods are a costly instrument: the escalation simulated in RETAL removes around 530,000 of the jobs that green trade would otherwise support, with losses falling most heavily on the economies most exposed to it. Keeping barriers to environmental goods low is therefore a labour-market objective as much as a climate one. Second, the jobs that green exports command are not neutral in composition. They are markedly more formal than the economy-wide average, which is a gain for job quality in middle-income economies, but substantially less female-intensive, both directly and through the supply chain, because they are concentrated in machinery, electrical equipment and motor vehicles. Without deliberate action on training and recruitment, an expansion of green trade risks widening the gender gap in employment. Third, the gains are concentrated: China and high-income economies capture the bulk of the additional jobs, while South Asia and Africa add fewer than 90,000 between them. Building the productive and technological capabilities that would allow lower-income economies to enter these value chains is a precondition for a green transition that is also inclusive.

Further research could examine more detailed occupational structures and skill demand within each country and their interactions with international trade dynamics. This could help identify how countries can adapt their labour force and human capital to upgrade productive capacities and benefit from the green transition, which is crucial for economic transformation. Future research should also incorporate the “green jobs” dimension to provide a more comprehensive understanding of the implications of green trade for labour markets, including the contribution and quality of green jobs and their potential to drive structural transformation as economies transition towards a low-carbon scenario.

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