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# Technological Innovation and Political Stability: A Geographic Distribution of Green Trade in OIC Nations

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## Abstract

**Purpose:** Global warming is increasingly aggravated by environmental degradation, a challenge that can be mitigated through strategic logistic policies. This study introduces the dynamics of green trade in environmental goods for the Organisation of Islamic Cooperation (OIC) nations. It is a region known for its high environmental degradation, political risk and instability. This study examines how technological innovation and political factors influence the geographic distribution of green trade among OIC nations from 1994 to 2021 using the structural gravity model. The COVID-19 pandemic further emphasised the need for resilient and eco-friendly approaches. **Research design, data and methodology:** The main objective of the study is to analyse the impact of technological innovation along with scrutinising political determinants of green trade in the OIC region from 1994 to 2021 using the structural gravity model. **Results:** The results reveal geographic proximity, RTA, and innovation significantly boost green trade. Similarly, OIC's green trade performance has been impeded by high political risk and instability. **Conclusions:** The research recommends fostering political stability, and conducting further research using longitudinal studies and machine learning to strengthen the understanding of innovation and green trade in the OIC. This will inform policies for sustainable economic growth through green trade.

**Keywords:** Green Trade Distribution, Political Instability, Sustainability, Structural Gravity Model, Innovation, Logistics

**JEL Classification Code**: F180, O3, Q5, P4

## 1. Introduction

Global warming is increasingly aggravated by environmental degradation, a challenge that can be mitigated through strategic trade policies. Trade plays a crucial role in combating climate change by facilitating the international exchange of innovative technologies and solutions that enhance energy efficiency and minimize ecological harm. The adoption of green goods—a category of products specifically designed to lessen environmental impact—is recognized as an effective strategy for sustainable development. As noted by Can et al. (2022), promoting the use and distribution of these environmentally friendly products is essential for reducing a country's environmental footprint. Moreover, Dai (2021) and Sauvage (2014) highlights how global energy efficiency and environmental health benefit significantly from the enhanced dissemination and application of cleaner energy sources enabled by trade. The United Nations Environment Programme (UNEP, 2014) and Wang et al. (2024)

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accentuates the importance of international trade in green goods and services, positing it as foundational to fostering a sustainable global economy. Particularly for developing regions within the OIC, liberalizing trade in environmental goods (EGs) not only makes cleaner technologies more accessible but also catalyzes environmental and economic benefits.

Trade liberalization in underdeveloped economies facilitates the acquisition of advanced technologies and income generation from exports, providing a significant impetus for economic and technological development. Specifically, trade in environmental goods supports environmental protection, global collaboration, technological transfer, and sustainable development, contributing to a more sustainable economic model (Kumar et al., 2021). However, as the market economies of OIC states expanded post-1980s reforms, the environmental toll from rapid industrialization became apparent, with increased air and water pollution, deforestation, and land degradation becoming critical concerns (Farooq et al., 2020).

Amid these challenges, OIC countries have recognized the necessity to pivot towards sustainability, prioritizing the trade of eco-friendly goods to mitigate environmental impacts such as ozone depletion, biodiversity loss, natural resource depletion, and the severe consequences of climate change like rising sea levels and extreme weather events that disproportionately affect the economically vulnerable and island states within the bloc (Butt, 2020; Ziaul & Shuwei, 2023). Such conditions necessitate a concerted effort to foster environmental sustainability, stimulate innovation, and enhance economic resilience through the promotion of green trade (GT), which offers economic opportunities while safeguarding ecosystems (Kalirajan, 2016).

This study explores the critical role of technological innovation in fostering green trade, underscoring its impact on the expansion of international trade and economic development. Technological advancements redefine trade dynamics by introducing new products, enhancing production processes, and promoting more efficient business practices, which in turn facilitate trade expansion and specialization in high-tech industries (Bierut & Dybka, 2021). These advancements have led to the specialization in high-tech industries, thereby enriching the global market with diverse and quality goods, and highlighting the crucial role of technology in promoting economic efficiency and supporting global economic development (Peerally et al., 2022). Moreover, by facilitating the transfer of advanced technologies from industrialized to developing nations, trade liberalization bolsters production quality and quantity, thereby enhancing global economic integration (Alam & Murad, 2020). Additionally, technological innovation plays a pivotal role in sustainable development by enabling the adoption of more energy-efficient and environmentally friendly manufacturing processes. This dual impact of technological progress can, however, have mixed effects on environmental outcomes: while it can reduce the reliance on fossil fuels and decrease $CO_2$ emissions by fostering the development of new energy services (Shahbaz et al., 2020), it may also lead to increased energy consumption and emissions due to economic expansion (Dzator & Acheampong, 2020). Thus, understanding the nuanced effects of technological innovation on both green trade and environmental sustainability forms the cornerstone of this research.

Hassan et al. (2010) provide evidence that the extent of trade among the OIC nations is influenced by political intent. They contend that the crucial factor for the growth of Islamic nations' infrastructure and transport systems is the political determination of their leaders. Political stability, or the lack thereof, significantly affects these dynamics within the OIC. Political unrest and instability generate uncertainties that hinder long-term investment and trade strategies, complicating international negotiations and the execution of trade agreements, which are further exacerbated by internal and external conflicts such as terrorism (Abidin & Sahlan, 2013; Bakar et al., 2015). Additionally, corruption and lack of effective governance in some OIC states undermine trust in investment and trade policies, posing further challenges to economic growth and global trade engagement (Erum & Hussain, 2019). Continuing political concerns hinder the advancement of trade talks and result in delays or cancellations of accords (Hoekman & Kostecki, 2009).

There is a lack of comprehensive exploration and understanding of the interplay between technological innovation, political determinants, and green trade logistics within the OIC nations. While previous studies have highlighted the importance of technological advancements and trade liberalization in fostering trade, there is a dearth of research that integrates political factors and technological innovation to analyse their combined impact on green trade dynamics. Additionally, there is limited empirical research focusing specifically on the OIC region, despite its unique characteristics such as low technological innovation in many areas, high climate change vulnerability, and political instability, which present distinct challenges and opportunities for promoting green trade. Thus, this study aims to fill this gap by providing insights into the mechanisms driving green trade within the OIC, particularly by examining the role of technological innovation and political determinants in shaping trade patterns and outcomes.

The focus of the study is on the evolution of trade in green goods among 57 OIC nations for the period 1994-2021. OIC region has been chosen because the area of trade in green goods is not yet vastly explored for this region compared to the rest of the world and developed nations. Along with this, a low level of technological innovation and a high level of climate change in the region call for an urgent need for research in this area. In addition to this, there is high political instability in the area. All these issues will be tackled by using the structural gravity model of trade by following De Melo and Solleder (2020). Our model departs from them by adding political determinants along with technological innovation as the main determinant of GT. This not only advances theoretical frameworks within international trade and economic development but also yields practical insights for policymaking aimed at promoting sustainable growth and environmental protection in the OIC, thereby enhancing both the academic and practical understanding of green trade dynamics in a complex regional context. Trade in environmentally friendly goods is considered GT in this study, following Can et al. (2022). Using panel data from 54 OIC countries out of 57, we employed the PPML technique on the structural gravity model of trade. Côte d'Ivoire, Palestine and Syria are omitted from the analysis due to the non-availability of GT data for these countries.

The next section comprehensively discusses theoretical foundations and hypothesis testing. Then, we discuss the methodology and empirical model of the study. The next section is about the discussion of results. Finally, the last section concludes the whole discussion.

## 2. Theoretical Foundations and Hypothesis Testing

Ali et al. (2015) defined technological innovation as 'the continuous process of improvement in total scientific knowledge, skill, applied science, and the technical efficiency/ability to convert the existing factor of production into more output, available to any human society for industry, art, science etc.' Trade liberalization encourages the spread of modern and advanced technologies from industrialized to developing nations (Alam & Murad, 2020), increasing production and enhancing product quality with quantity. Technological advancement and trade are intricately connected. Technological innovations can boost efficiency and open up new markets.

The framework linking technological innovation and the trade of EGs is complex and starts with the advent of innovation in high-tech companies. These companies are essential centres for creating innovative solutions to environmental problems, such as improvements in sustainable production methods, eco-friendly materials, and renewable energy technology. The dissemination of innovation leads to knowledge spillover throughout various businesses and sectors, which facilitates the adoption and adaptation of environmentally friendly technology by non-high-tech firms into their production processes (Tian et al., 2023). This broad adoption makes it easier to produce environmentally friendly products with lower environmental effects, like those with improved energy efficiency, fewer carbon emissions, and the use of sustainable materials. Consequently, companies that manufacture these eco-friendly products sell their goods to other countries to earn profit from global marketplaces (Kularathna & Dilrukshi, 2023). Therefore, we hypothesized that:

**H1:** Technological innovation may positively and significantly impact green intra-OIC trade flows.

The policy decisions and regulatory frameworks implemented by governments have a crucial impact on shaping economic activities, such as trade. As stated by Rodrik (2018), government policies and interventions can have either a positive or negative impact on trade in some industries, depending on their goals and priorities. Within the framework of GT, governments of OIC nations have the authority to implement environmental rules, offer financial assistance to green enterprises, and engage in trade negotiations that give precedence to sustainability. For example, implementing rules that support the use of renewable energy or provide incentives for eco-friendly industrial methods encourages the expansion of environmentally sustainable trade (Saleem et al., 2022).

Furthermore, political institutions and governance systems can influence environmental laws and regulations. Robust institutions can support the creation and execution of efficient environmental governance structures, hence creating favourable conditions for sustainable trade (DeCaro et al., 2017). On the other hand, inadequate institutions and political instability might impede attempts to foster sustainability (Abbas et al., 2023). Transparent and accountable governance methods can improve regulatory compliance and enforcement, hence promoting the expansion of GT (Tietenberg & Lewis, 2018). In addition, well-defined standards help to promote international trade by minimising technical obstacles and uncertainty for exporters. Therefore, it is hypothesized that:

**H2:** Political factors may significantly positively/negatively impact green trade among OIC nations.

By promoting the exchange of green goods and services (including green technologies), increasing resource efficiency, creating economic opportunities, and creating jobs, GT can facilitate the transition to a green economy when coupled with appropriate regulation. To help eliminate GHGs, the additional wealth created by international trade should be used to adopt technological solutions that mitigate climate change rather than hasten its occurrence.

## 3. Methodology

### 3.1. Theoretical Base of Structural Gravity Model

Recent discoveries have led to the creation of gravity equations linked to new-style structural models of international trade, despite the classic gravity model lacking strong theoretical grounding in the past. The section introduces a theoretical framework that is a modification of the Eaton and Kortum (2002) model, including roundabout production. Nevertheless, the same outcomes shown in this study may also be obtained within the frameworks of Anderson and Wincoop (2003) to develop our structural gravity equation. This equation enables us to determine the complete influence of country-specific factors on the flow of trade between two countries, as well as estimate the trade elasticity, without relying on data related to tariffs or prices. Afterwards, we convert our theoretical model into an estimating equation. Thus, the given structural gravity system of equations is:

$$X_{ij,t} = \frac{Y_{i,t}E_{j,t}}{Y_t}\left(\frac{t_{ij,t}}{P_{j,t}\Pi_{i,t}}\right)^{1-\sigma}, \quad (1)$$

$$\Pi_{i,t}^{1-\sigma} = \sum_j \left(\frac{t_{ij,t}}{P_{j,t}}\right)^{1-\sigma} \frac{E_{j,t}}{Y_t}, \quad (2)$$

$$\mathrm{P}_{j,t}^{1-\sigma} = \sum_j \left(\frac{t_{ij,t}}{\Pi_{i,t}}\right)^{1-\sigma} \frac{Y_{i,t}}{Y_t}, \quad (3)$$

The variable $Y_{i,t}$ represents the overall production value in exporter 'i'. $Y_t$ represents the global output value. The variable $t_{ij,t}$ represents the bilateral trade frictions between partners 'i' and 'j'. Theoretically, equation (3.10) has two terms; first is size term $\frac{Y_{i,t}E_{j,t}}{Y_t}$, and second is trade cost term $\left(\frac{t_{ij,t}}{P_{j,t}\Pi_{i,t}}\right)^{1-\sigma}$. The size term represents frictionless trade between countries 'i' and 'j' with no trade cost (Alvarez & Lucas, 2007). Frictionless trade means that all countries will bear the same price of a commodity regardless of their place and expenditures from the source country. Overall, size term carries the information about country size and bilateral trade flows between nations such as: firstly, major producers will export more towards all destinations. Secondly, huge and wealthy markets will import more from all sources. Lastly, trade flows between two countries, 'i' and 'j', will be greater if the trading partners are similar in size.

The trade cost term $\left(\frac{t_{ij,t}}{P_{j,t}\Pi_{i,t}}\right)^{1-\sigma}$ refers to the difference between actual and frictionless trade and has three components such as: firstly, the literature commonly approximates the bilateral trade cost between partners 'i' and 'j', $t_{ij,t}$, by considering factors such as bilateral distance, tariffs, and the existence of regional trade agreements (RTAs) between the parties. Anderson and Wincoop (2003) used the structural terms $P_{j,t}$ and $\Pi_{i,t}$ to refer to the inward and outward multilateral resistances, respectively. The multilateral trade cost term in equation (1) encompasses the inward multilateral bilateral trade cost, which is calculated as a weighted average of all bilateral trade costs borne by consumers (can also be interpreted as consumer price index) or importer's ease of market access. The outward multilateral resistance term in equation (2) is the weighted average of all bilateral trade costs incurred by producers in each nation. This term quantifies the ease of market access for exporter 'i' in the event of a change in trade policy or other trade costs in factory gate prices and consequently, the value of national output between the two partners. Therefore, any changes in multilateral resistance terms can be referred to as the response of the real GDP of each nation to any changes in their trade costs in the economic system worldwide.

### 3.2. From Theory to Empirics

Various adaptations to the basic gravity concept are constantly produced and utilized in the literature. Anderson and Van Wincoop's (2003) variation gravity equation is one of the most famous derivations. This study follows Beverelli et al. (2018). The model will undergo minor modifications by including bilateral trade variables as well as political and technological innovation factors. So, from equation (1) to (3), the model is estimated by fixed effects and the trade flow equation can be derived as follows:

$$X_{ij} = exp\left(\mathrm{T}_{ij}\beta + \pi_i + \mathcal{X}_j\right)e_{ij} \quad (4)$$

Where $\mathrm{T}_{ij}$ a vector of variables comprising different determinants of trade and also includes several elements of trade such as distance, language, contiguity, RTA and country-specific trade factors such as technological innovation, $\pi_i$ is a set of exporter fixed effects, $\mathcal{X}_j$ is importer fixed effects and $e_{ij}$ is the error term. The above equations have fixed effect specifications that account for multilateral resistances. The exporter-time fixed effects will also absorb the exporter value of output as well as all other observable and unobservable exporter-specific characteristics. Similarly, importer-time fixed effects will control for the inward multilateral resistances and will absorb importer expenditure as well as any other observable and unobservable importer-specific characteristics that may influence bilateral trade. Now starting with the traditional gravity model:

$$X_{ij} = exp\left(\mathrm{GRAV}_{ij}\beta + \pi_i + \mathcal{X}_j\right)e_{ij} \qquad (5)$$

Here $\mathrm{T}_{ij}$ trade cost variable is replaced with a vector of $\mathrm{GRAV}_{ij}$ that includes distance, language, contiguity, border, regional trade agreements etc. $\pi_i$ is a set of exporter fixed effects which control the value of output (GDP) and act as inward multilateral effects. While for outward multilateral resistance term, $\mathcal{X}_j$ controls for expenditure and is used for importer fixed effects. Now to proceed with proxies of technological innovation by applying parametric assumptions on country-specific trade costs. So, the trade flow equations look like:

$$X_{ij} = exp\big(\mathrm{GRAV}_{ij}\beta + \pi_i + \mathcal{X}_j - \vartheta(b + c)lnTI_j + \varepsilon_{ij}\big) \qquad (6)$$

$$X_{ij} = exp\big(\mathrm{GRAV}_{ij}\beta + \pi_i + \mathcal{X}_j - \vartheta alnTI_j\big) \qquad (7)$$

$\vartheta alnTI_j$ is importer specific and will be absorbed into $\mathcal{X}_j$ and $\varepsilon_{ij}$ is the error term. Hence, the coefficient before $TI_j$ in the above specification will represent $\vartheta(b + c - a)$, which specifically denotes the impact of technological innovation on the international trade flows in comparison to the internal flow as follows:

$$X_{ij} = exp\big(\mathrm{GRAV}_{ij}\beta + \pi_i + \mathcal{X}_j + border + lnTI_j \times border + \varepsilon_{ij}\big) \qquad (8)$$

The variable 'border' is a dummy variable, with a value of 1 representing international trade flows and a value of 0 representing domestic trade flows. Incorporating a border dummy, as shown by Beverelli et al. (2018), provides persuasive evidence that the border impact is an essential component of international trade costs. Neglecting to incorporate this factor may result in biased results.

Similarly, $lnTI_i$ also produces the same results and will be absorbed into $\mathcal{X}_j$. It indicates that regardless of either side's measure is used, the estimation of the technological innovation will remain unchanged or its interpretation will include the combined impacts of exporting and importing, compared to the internal effect.

### 3.3. Model Specification

This study uses the structural gravity model used by Beverelli et al. (2018), Han (2021), and Han and Li (2022). On the other hand, our study is different because we are using technological innovation and political determinants of GT.

In particular, two model specifications have been used in empirical analysis. First, panel data setting with gravity variables, data varying across importers and exporters while including intra-OIC green trade flows. So, it is possible to get the estimates of 'TI' and other determinants of intra-OIC green trade with importer and exporter specific effects. Secondly, panel setting with importer time, exporter time and country pair fixed effects is used to identify 'TI' and other determinants of intra-OIC green trade flows. Country pair fixed effects allow to control for observable and unobservable frictions in bilateral trade and also mitigate to possibility of endogeneity which can arise due to bilateral policy variables in gravity equations (Baier & Bergstrand, 2007).

The study uses panel data analysis with a structural gravity model. An econometric benefit of employing panel data is that it allows for the inclusion of individual heterogeneity, which is not possible with time series data (Hsiao, 2022). Utilising panel data would provide more comprehensive and insightful information, increased variability, reduced collinearity among the variables, more degrees of freedom, and enhanced efficiency. In addition, it permits the relaxation and examination of the assumptions made in the cross-sectional study (Wooldridge, 2010).

To identify the impact of 'TI' and other factors on green trade in gravity model framework, following identification strategy is used. First, the model with gravity variables is used in the analysis using the PPML approach with exporter and importer specific effects. Therefore, following gravity models are used:

$$GT_{ij,t} = exp\big(dist_{ij} + border + cont_{ij} + col_{ij} + lang_{ij} + RTA + lnZ_{jt} \times border + \varepsilon_{ij,t}\big) \qquad (9)$$

Where $GT_{ij}$ is green trade (exports and imports). '$dist'$ denotes the geographical distance between countries, '$cont$' is contiguity, '$col$' is a colony, '$lang$' is a language while 'RTA' is used for regional trade agreements. Whereas $Z_j$ represents independent variables such as proxies of technological innovation and political determinants of GT.

### 3.4. Rational behind using Green Trade other than General Trade

Green trade, focusing on the trade of environmental goods, is designated as the explained variable in this study for several compelling reasons. Firstly, green goods are essential to sustainable development and help address global challenges like climate change and environmental degradation—issues-particularly in OIC countries due to their vulnerability to climate impacts and their often resource-dependent economies. These products, unlike conventional goods, contribute directly to environmental protection by minimizing ecological footprints through more efficient resource usage and reduced emissions.

Secondly, the promotion of GT aligns with international environmental agreements and sustainable economic policies, encouraging nations to pivot towards less environmentally damaging trade practices. This shift is not only strategic for environmental reasons but also for economic diversification and innovation, which are crucial for the economic resilience of OIC nations.

Lastly, focusing on GT rather than general trade allows for a substantial analysis of the specific barriers and opportunities in trading environmentally friendly goods. This includes examining the impact of technological innovations and political factors unique to the environmental sector, such as regulatory frameworks and international environmental commitments, which might not be as pivotal in the trade of conventional goods. Thus, understanding GT provides valuable insights into how trade can be leveraged for both economic and environmental benefits in the OIC context.

## 4. Data Sources and Description of Variables

### 4.1. Descriptive Statistics

Table 1 shows descriptive stats of the variables used. The mean value of green exports is 451.810, with a considerable standard deviation of 7781.625, suggesting a wide variation in export volumes among the OIC nations. On average, OIC countries import green products at a mean of 368.058, with a higher standard deviation of 7980.754, indicating substantial variability in import quantities. Variables like patents, researchers in R&D, and R&D expenditure show varying means and deviations, highlighting differences in technological advancement across OIC nations. Factors such as political terror scale, political instability, regulatory quality, and political risk demonstrate disparities in political stability, regulatory frameworks, and risk perception across the observed countries. These statistics reveal the considerable variability and disparities in the levels of GT and its determinants among the OIC nations, indicating the diverse economic, environmental, financial, and political landscapes within the region. The data description and sources are given in Table 2. All standard gravity variables have been taken from the CEPII Gravity Database.

**Table 1:** Descriptive Statistics

| Variables | Observations | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Green Exports | 81,648 | 451.810 | 7781.625 | 0 | 727426.1 |
| Green Imports | 81,648 | 368.058 | 7980.754 | 0 | 1031831 |
| Patents | 30,160 | 1290.206 | 2420.260 | 2 | 16259 |
| Researchers in R&D | 81,648 | 568.609 | 89.677 | 194.674 | 967.906 |
| R&D Expenditure | 81,648 | 0.316 | 0.024 | 0.132 | 0.416 |
| Political Terror Scale | 80,164 | 3.077 | 0.999 | 1 | 5 |
| Political Instability | 65,849 | -1.32 | 0.208 | -1.649 | -0.713 |
| Regulatory Quality | 12,443 | -1.195 | 1.036 | -4.143 | 0.299 |
| Political Risk | 60,831 | 4.051 | 0.217 | 3.045 | 4.425 |

### 4.2. Poisson Pseudo Maximum Likelihood (PPML)

The gravity model estimate module uses the PPML estimator, which is a specific instance of the Generalized Linear Model framework, to estimate the structural gravity equation. When using PPML, there are many options for including fixed effects. A viable and theory-consistent empirical variant of the gravity equation for panel data with a structural gravity model is:

$$X_{ij} = exp[\gamma_{it} + \eta_{jt} + \lambda_{ij} + \beta Z_{ijt}] + \epsilon_{ijt} \qquad (10)$$

The term $\gamma_{it}$ refers to exporter time-varying fixed effects, $\eta_{jt}$ represents importer time-varying fixed effects, $\lambda_{ij}$ denotes exporter-importer time-invariant fixed effects, and $Z_{ijt}$ represents the vector of time-variant bilateral determinants of trade. (Fally, 2015) find an additive characteristic of the PPML estimator that makes it completely compatible with a large class of structural gravity models.

We use the PPML methodology as outlined by Silva and Tenreyo (2022). The PPML model operates on the assumption that the variance is directly proportional to the mean. Therefore, for the PPML model to be consistent, it is only necessary to correctly provide the conditional mean. The PPML method assigns equal weight to each observation during the estimate, making it a suitable choice when there is little information on the heteroscedasticity in the trade

**Table 2:** Variables and Sources of Data

| Variables | Description | Source | Expected Sign |
|---|---|---|---|
| Green Trade | Trade in 54 Environmental Goods categorized under the six-digit Harmonized System given by APEC (2012). | UNComtrade database | Dependent |
| Patents | Patents are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention--a product or process that provides a new way of doing something or offers a new technical solution to a problem (Number). | WDI | Positive |
| Researchers in R&D | The number of researchers engaged in R&D are professionals who conduct research and improve or develop concepts, theories, models techniques instrumentation, software of operational methods. R&D covers basic research, applied research, and experimental development (per million people). | WDI | Positive |
| R&D Expenditures | They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development (% of GDP). | WDI | Positive |
| Political Terror Scale | Political terror is a violation of basic human rights to the physical integrity of the person by agents of the state within the territorial boundaries of the state. | Political Terror Scale | Negative |
| Political instability | Political instability measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. 2.5 (strong) to -2.5 (weak) | WGI | Negative |
| Regulatory Quality | Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.<br>2.5 (strong) to -2.5 (weak) | WGI | Positive |
| Political Risk | The political risk rating aims to provide a means of assessing the political stability of the countries covered by ICRG on a comparable basis. 0 (Very high risk) -12 (Lower risk) | ICRG/PRS | Negative |

data. Due to its non-linear nature, the PPML estimator is capable of accommodating zero trade flows throughout the estimate process. Therefore, the PPML estimator is consistent with zero trade observations. By appropriately executing the aggregate, one may get the "gravity with gravitas" model as shown above in Equations (1-3).

When using panel data, it is common to incorporate time-varying importer and exporter fixed effects to account for the impact of multilateral resistances in a theoretically coherent way (Fally, 2015). Additionally, country-pair fixed effects are often used to address endogeneity issues that arise when variables measuring RTA are included. The inclusion of fixed effects in the econometric specification is required, but it prevents researchers from obtaining coefficients for variables that only show either within or between variation, and not both.

### 4.3. Multinomial Pseudo Maximum Likelihood (MPML)

MPML deals with zero and missing trade values as mentioned by Head and Mayer (2014). MPML model assumes that market shares are more appropriate as dependent variables in gravity equations, the dependent variable takes the form:

$$\pi_{ij} = \frac{y_{ij}}{y_j} \quad (11)$$

Here $\pi_{ij}$ demonstrates nation 'i' market share of in 'j' nation; $y_{ij}$ is exports of green goods to nation 'j' by nation 'i'; while $y_j$ is world exports of green goods to nation 'j'. $\pi_{ij}$ is the sum of GT across all nations 'i' to any 'j', therefore gravity variables can be estimated using the MPML estimator. This is the approach of estimating developed by Eaton et al. (2012), used for a finite number of buyers and sellers. The MPML has another advantage as the model is essentially the same as the PPML method since the estimator takes care of the zeros issue. Eaton et al. (2012) highlighted in a footnote, the format of the above-described model compared to the log-linear and PPML models. Their distinction is in assigning penalties or "weight" to the deviation of large and trivial trade flows. The log-linear presumes that proportional deviations are similar for large and small trade flows, while PPML sets a more significant penalty on proportional deviations in large trade flows compared to small trade flows. MPML depowers high amounts of trade but also guarantees that the dependent parameter is not more than one. Therefore, MPML takes care of the "weight" deviations issue.

## 5. Data Analysis and Discussion

Table 3 investigates green exports model with technological innovation. Panel A comprises the estimations based on gravity variables with time-varying fixed effects, and the findings with a symmetric country pair fixed effect and time-varying fixed effects using the PPML estimates are displayed in Panel B.

Findings show that there is an inverse relationship between the geographical distance separating two countries and the level of trade they engage in. The distance between them significantly influences the amount of trade among the OIC nations. The average drop in exports is estimated at 0.85% units as the distance between countries 'i' and 'j' increases. Therefore, the proximity of trading countries negatively correlates with the volume of trade. On the contrary, when the geographical distance between trading nations increases, the volume of trade diminishes (Borchert & Yotov, 2017). This outcome is consistent with the findings of traditional gravity models.

Border dummy shows a negative and significant relationship with green exports. Bilateral trade expenses are a fundamental aspect of the border effect. Firms encounter several supplementary expenses when they opt to participate in the export market and engage in international trade. The primary expenses are associated with geographical factors, such as transportation costs across a specific distance and trade policies implemented by states. Due to the necessity of traversing international borders, international trade necessitates the commodities being exchanged to undergo customs inspections at designated checkpoints (Glick & Rose, 2016). The various hassles, restrictions, and rules have the effect of hindering and dampening trade movements. Border walls have the potential to intensify the impact of border-related phenomena through many mechanisms, such as resource allocation diversion, increased limitations at entrance points, and the propagation of negative symbolic connotations (Kamwela, 2019).

The variables contiguity, colony and RTA are significant and positive in all models. Contiguity (common border) is expected to be positive. Countries sharing common borders do more trade (Borchert & Yotov, 2017). Hence, most economies in OIC share a common border and thus will trade green goods by 3.2% more on average than those that do not share a common border. The common colony variable showcases the impact of past colonial associations on GT within the OIC region. The assumption is that countries colonized by the same country have an advantage in exchanges over countries that do not. The estimated parameter for the common colony is 0.42% on average.

Language is of significant importance in affecting exports between nations since it directly affects market penetration and communication methods. Language dummy is insignificant yet positive here. The use of comprehensible language to the intended audience boosts the attractiveness of exported

**Table 3:** Green Trade and Technological Innovation

| Variables | Panel A (2021) | | | Panel B (1994-2021) | | |
|---|---|---|---|---|---|---|
| | Export | Export | Export | Export | Export | Export |
| Distance(log) | -0.850*** | -0.835*** | -0.854*** | | | |
| | (0.154) | (0.152) | (0.156) | | | |
| Border | -17.34*** | -22.36*** | -3.377** | | | |
| | (5.329) | (4.113) | (1.441) | | | |
| Contiguity | 3.142*** | 3.217*** | 3.211*** | | | |
| | (0.732) | (0.747) | (0.743) | | | |
| Colony | 0.359* | 0.415* | 0.363* | | | |
| | (0.228) | (0.228) | (0.227) | | | |
| Language | 0.210 | 0.211 | 0.217 | | | |
| | (0.317) | (0.320) | (0.316) | | | |
| RTA | 0.514** | 0.500** | 0.519** | 0.966*** | 0.849*** | 0.859*** |
| | (0.256) | (0.252) | (0.256) | (0.441) | (0.307) | (0.305) |
| Patents*Bor | 2.057*** | | | 0.517*** | | |
| | (0.729) | | | (0.187) | | |
| Researchers*Bor | | 3.086*** | | | 0.400* | |
| | | (0.619) | | | (0.228) | |
| R&D Exp*Bor | | | 5.401*** | | | 0.966** |
| | | | (1.118) | | | (0.449) |
| Constant | 21.84*** | 21.72*** | 21.88*** | 16.63*** | 15.78*** | 17.42*** |
| | (1.316) | (1.300) | (1.329) | (0.751) | (0.688) | (0.296) |
| Pair Fixed Effects | No | No | No | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.772 | 0.752 | 0.752 | 0.968 | 0.965 | 0.964 |
| Observations | 25,668 | 74,087 | 74,087 | 10,565 | 30,394 | 30,394 |

****, **, * is 1%, 5%, 10% significance levels, respectively.*

products and services, augmenting their likelihood of success in international marketplaces (Egger & Lassmann, 2012). The presence of a shared language also promotes comprehension of legislation, compliance standards, and market entrance prerequisites, hence facilitating the process of exporting. Competency in language plays a crucial role in determining the efficacy and achievement of international trade activities among countries (Maghssudipour et al., 2023).

Three proxies for technological innovation are used in Table 3. Patents used as a proxy for technological innovation are insignificant in Panel A, while in pair PPML (Panel B), patents show positive yet highly significant results. Brunel and Zylkin (2022) show that patents are an influencing factor in trade. The absence of patenting rights is frequently acknowledged in policy circles as a significant impediment to trade, and the inclusion of patent protection measures has gained prominence in international accords aimed at facilitating and governing trade. On the other hand, researchers in R&D and R&D expenditures are significant in both specifications. Overall results show that the promotion of trade of EGs will be facilitated by enhancing the innovation capabilities of nations, as depicted by (Cantore & Cheng, 2018).

The benchmark results of the gravity model shown in Table 3 portray that exports of green goods are significantly impacted by technological innovation. To shape the trade dynamics of environmentally friendly goods, technological innovation is essential. The export panorama of environmentally friendly items is highly influenced by technological progress, as it enhances both the quality and quantity of these products. Technological advancements play a pivotal role in fostering the creation of novel and enhanced environmentally sustainable products, hence augmenting their attractiveness within international markets (Cantore & Cheng, 2018). These advancements address the growing worldwide need for environmentally friendly products and enhance the export prospects of such goods. As a result, technical advancements significantly impact the export market's growth for environmentally sustainable products, as they enhance several aspects such as quality, quantity, competitiveness, and worldwide attractiveness (United Nations Industrial Development Organization, 2016).

The results of the import model of GT in Table 4 depict that patents are insignificant in the import model. Several factors might be attributed to the lack of a visible influence of patent rights on imports of EGs. Patents confer exclusive privileges to inventors and commonly serve as incentives for fostering creativity and promoting technical progress (Palangkaraya et al., 2017). In contrast, researchers in R&D and research and development expenditures are significant in both specifications. An increase in researchers in R&D within OIC will increase the import of green goods by 0.80% on average, while this number decreases to 0.15% for expenditures in R&D. Overall researchers in R&D (knowledge) show an increase in imports as compared to exports (0.40%) while expenditures in R&D show a boosting increase in exports (0.96%) as compared to imports. Advanced R&D initiatives frequently lead to the production of novel and technologically sophisticated commodities.

**Table 4:** Green Trade and Technological Innovation

| Variables | Panel A (2021) | | | Panel B (1994-2021) | | |
|---|---|---|---|---|---|---|
| | Import | Import | Import | Import | Import | Import |
| Distance(log) | -1.254*** | -1.062*** | -1.065*** | | | |
| | (0.154) | (0.164) | (0.165) | | | |
| Border | -5.651** | -14.00*** | -0.581 | | | |
| | (2.597) | (1.807) | (1.431) | | | |
| Contiguity | 2.571*** | 3.308*** | 3.308*** | | | |
| | (0.639) | (0.667) | (0.666) | | | |
| Colony | -0.264 | -0.0471 | -0.0555 | | | |
| | (0.335) | (0.359) | (0.358) | | | |
| Language | -0.119 | -0.378 | -0.380 | | | |
| | (0.384) | (0.327) | (0.327) | | | |
| RTA | 0.00371 | 0.202 | 0.207 | 0.149 | 0.466* | 0.455* |
| | (0.243) | (0.425) | (0.425) | (0.291) | (0.285) | (0.288) |
| Patents*Bor | 0.321 | | | -0.131 | | |
| | (0.321) | | | (0.271) | | |
| Researchers*Bor | | 1.638*** | | | 0.797** | |
| | | (0.267) | | | (0.404) | |
| R&D Exp*Bor | | | 2.634** | | | 0.149** |
| | | | (1.137) | | | (0.394) |

| Variables | Panel A (2021) | | | Panel B (1994-2021) | | |
|---|---|---|---|---|---|---|
| | Import | Import | Import | Import | Import | Import |
| Constant | 24.18*** | 24.11*** | 24.13*** | 16.81*** | 16.06*** | 17.41*** |
| | (1.349) | (1.355) | (1.360) | (0.496) | (0.683) | (0.190) |
| Pair Fixed Effects | No | No | No | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.780 | 0.740 | 0.739 | 0.969 | 0.963 | 0.963 |
| Observations | 28,458 | 80,135 | 80,135 | 14,043 | 34,458 | 34,458 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

Nations that want cutting-edge technology or specialist commodities import these goods. The global demand for R&D goods increases imports. A robust R&D industry generates knowledge and advances technology, encouraging worldwide cooperation and partnerships. Sharing knowledge may lead to importing nations relying on other countries' R&D experience, innovation, and specialist products, increasing their imports. Investing in R&D improves the quality, effectiveness, and competitiveness of imported goods. This makes them more desired in global markets, influencing imports more than exports in certain cases.

Table 5 shows an analysis of political determinants and green exports. Since politics impacts trade policies, legislation, and international relations, it has a big impact. Political stability and a suitable regulatory framework foster a stable and protected business climate, boosting commerce by reducing uncertainty for local and foreign investors. Political entities negotiate bilateral and international agreements to reduce taxes, quotas, and trade barriers, promoting economic cooperation between governments. Political choices affect commercial alliances, sanctions, and diplomatic ties, affecting foreign policy. Therefore, these factors affect trade dynamics. Political stability encourages long-term investments, which boosts the economy and trade. In general, political issues are crucial to fostering international trade and economic cooperation.

**Table 5:** Green Trade and Political Determinants

| Variables | Panel A (2021) | | | | Panel B (1994-2021) | | | |
|---|---|---|---|---|---|---|---|---|
| | Exports | Exports | Exports | Exports | Exports | Exports | Exports | Exports |
| Distance(log) | -0.830*** | -0.817*** | -0.444 | -0.871*** | | | | |
| | (0.164) | (0.156) | (0.321) | (0.173) | | | | |
| Border | -2.188** | -9.441*** | -1.977 | -0.744 | | | | |
| | (1.041) | (1.395) | (1.742) | (4.075) | | | | |
| Contiguity | 2.909*** | 3.064*** | 2.600* | 2.942*** | | | | |
| | (0.761) | (0.763) | (1.592) | (0.878) | | | | |
| Colony | 0.336 | 0.425* | -0.505 | 0.262 | | | | |
| | (0.273) | (0.238) | (0.453) | (0.275) | | | | |
| Language | 0.270 | 0.338 | 0.768 | 0.555* | | | | |
| | (0.332) | (0.348) | (0.765) | (0.332) | | | | |
| RTA | 0.518* | 0.318 | 1.760*** | 0.380* | 0.890*** | 1.005*** | 1.269** | 0.965** |
| | (0.265) | (0.270) | (0.590) | (0.276) | (0.329) | (0.360) | (0.498) | (0.421) |
| Political Terror*Bor | -0.0808 | | | | -0.702*** | | | |
| | (0.262) | | | | (0.183) | | | |
| Political Instability*Bor | | -4.908*** | | | | -0.207 | | |
| | | (0.741) | | | | (0.473) | | |
| Regulatory Quality*Bor | | | 0.434* | | | | 0.573*** | |
| | | | (0.320) | | | | (0.129) | |
| Political Risk*Bor | | | | -0.422 | | | | -1.059* |
| | | | | (0.978) | | | | (0.634) |
| Constant | 21.75*** | 21.87*** | 18.29*** | 21.97*** | 17.89*** | 16.77*** | 17.23*** | 18.96*** |
| | (1.385) | (1.319) | (2.639) | (1.502) | (0.327) | (0.388) | (0.399) | (1.306) |
| Pair Fixed Effects | No | No | No | No | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9367 | 0.9875 | 0.9806 | 0.9396 | 0.9654 | 0.9864 | 0.9709 | 0.9666 |
| Observations | 2,231 | 2,511 | 2,580 | 2,048 | 29,656 | 25,831 | 34,563 | 23,332 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

Geographic distribution (Distance), border, contiguity and RTA in the export model show expected signs and levels of significance in Table 5. On the other hand, language and colony show mixed findings. Firstly, the political terror scale has been introduced into the export model. It has been found that the political terror scale negatively impacts green exports. Results show that exports of green goods decrease by 0.70% on average with increased political terror. Terrorist organisations use economic attacks to persuade governments to meet their political goals. Trading partner terrorism has various negative repercussions on economic activity. These effects include higher transaction costs, transportation costs, uncertainty, lower revenue, and more firm spending. Such expenditures include tougher border controls and higher insurance prices. These negative effects hurt exports (Bandyopadhyay et al., 2018).

Similarly, political instability is significant and negative in Panel A at an average 4.91% decrease in GT. Critics of globalization argue that state that implements socially challenging policies such as trade liberalization face a substantial likelihood of heightened political instability. It is plausible for a society to encounter instances of social and political turmoil in the period immediately preceding and following the implementation of economic liberalization policies (Bussmann et al., 2006). Our findings are consistent with Bashir et al. (2013).

Regulatory quality is positive and shows a 0.57% increase in exports of EGs. Trade liberalisation or economic integration can increase or intensify regulatory measures. Integration of firms and industrial components into global marketplaces has boosted mobility. Thus, rules can be a competitive advantage or disadvantage, motivating businesses to move to a country with better regulations (Silberberger & Königer, 2016). Hence, the impact of regulation on exports is contingent upon the degree of economic integration within a given country.

Political risk, on the other hand, is negative and significant. As political risk increases, exports of green goods in OIC decline by 1.06% on average. An unexpected shift in government foreign policy from favourable to unfriendly creates contextual ambiguity and political danger. With political uncertainty rising, bilateral trade may shrink. Traders worry that governments may ban some goods and limit others. There may also be trade contract doubts. Official trade relations may stop altogether in the worst case (Oh & Reuveny, 2010).

**Table 6:** Green Trade and Political Determinants

| Variables | Panel A (2021) | | | | Panel B (1994-2021) | | | |
|---|---|---|---|---|---|---|---|---|
| | Imports | Imports | Imports | Imports | Imports | Imports | Imports | Imports |
| Distance(log) | -1.203*** | -1.113*** | -0.966*** | -1.222*** | | | | |
| | (0.152) | (0.147) | (0.199) | (0.140) | | | | |
| Border | -1.305* | -5.163* | -2.571*** | -9.035 | | | | |
| | (0.947) | (2.841) | (0.957) | (6.050) | | | | |
| Contiguity | 2.258*** | 2.227*** | 2.124** | 2.444*** | | | | |
| | (0.584) | (0.594) | (0.968) | (0.551) | | | | |
| Colony | -0.430 | -0.206 | 0.00581 | -0.492* | | | | |
| | (0.342) | (0.316) | (0.340) | (0.323) | | | | |
| Language | -0.0332 | 0.0615 | -0.603* | -0.0423 | | | | |
| | (0.357) | (0.343) | (0.450) | (0.359) | | | | |
| RTA | 0.176 | 0.0260 | 0.515* | 0.163 | -0.0588 | -0.405 | -0.608* | -0.176 |
| | (0.215) | (0.220) | (0.272) | (0.205) | (0.199) | (0.401) | (0.320) | (0.219) |
| Political Terror*Bor | -0.569** | | | | -0.621*** | | | |
| | (0.265) | | | | (0.195) | | | |
| Political Instability*Bor | | -1.694 | | | | -0.107 | | |
| | | (1.957) | | | | (0.997) | | |
| Regulatory Quality*Bor | | | 0.357* | | | | 0.355*** | |
| | | | (0.214) | | | | (0.0983) | |
| Political Risk*Bor | | | | -2.943** | | | | -5.811*** |
| | | | | (1.490) | | | | (1.388) |
| Constant | 25.02*** | 24.50*** | 23.87*** | 25.23*** | 17.92*** | 17.54*** | 18.35*** | 22.40*** |
| | (1.167) | (1.133) | (1.402) | (1.067) | (0.131) | (0.287) | (0.139) | (1.123) |
| Pair Fixed Effects | No | No | No | No | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9481 | 0.9663 | 0.9462 | 0.9442 | 0.9642 | 0.9896 | 0.9756 | 0.9647 |
| Observations | 2,651 | 2,387 | 1,730 | 2,678 | 33,312 | 29,064 | 36,424 | 27,705 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

The findings of the import model indicate that there is a negative correlation between terrorism and the import of green goods, with a fall of 0.62% on average. Terrorist attacks in commercial partnerships harm economic activity. The effects include higher transaction prices, transportation costs, uncertainty, lower income, and higher firm expenditures. Such expenditures include tighter border control and higher insurance premiums. This ultimately hurts imports (Agu et al., 2023). Findings related to political instability show a negative and insignificant relationship with imports.

Regulatory quality is significant and positive in both specifications. With improved regulatory quality in OIC, the imports of green goods are hampered by 3.5% on average. The level of regulatory quality highly influences the import of goods, as it directly affects the convenience and efficiency of trade procedures inside a given nation. Reducing bureaucratic obstacles, minimizing administrative barriers, and improving predictability and consistency in trade operations contribute to creating a favourable atmosphere for greater imports (Das et al., 2016) Contrary to this, political risk is negative and significant in both panels. Foreign and domestic violent conflicts caused by political risk can hurt trade. This can cause commodity destruction, distribution delays, and transportation infrastructure damage. The damage requires traders to pay more for insurance, longer trade routes, and more cargo protection workers. Some merchants may depart from the market due to rising costs, while others may lose customers due to price increases. As trade volume decreases, national production and income may fall, which may lower exports and imports (Oh & Reuveny, 2010).

## 5.1. Robustness

For robustness, the MPML approach has been used for green exports and green imports models only. The results of green imports are given in Appendix B below. Table 7 displays the outcomes of robustness estimates of green export share and examines the intricate connection between green export share and technological innovation (see results of imports share in Appendix A). Standard gravity variables show varying results. The inclusion of patents, the number of researchers in R&D (knowledge) and R&D expenditure reveals intricate effects and yields diverse consequences for green export share. The only difference in exports share here reveals that technological innovation is not significant in any of the proxies used in Panel B where pair fixed effects are used. The phenomenon of international trade is anticipated to contribute to economic growth through several mechanisms, such as the diffusion of technology, the transfer of knowledge, and the intensification of competition, among other factors (Yakubu et al., 2018).

**Table 7:** Green Exports Share and Technological Innovation

| Variables | Panel A (2021) | | | Panel B (1994-2021) | | |
|---|---|---|---|---|---|---|
| | Exports Share | | | Exports Share | | |
| Distance(log) | -1.115*** | -1.113*** | -1.119*** | | | |
| | (0.133) | (0.131) | (0.133) | | | |
| Border | -9.151*** | -14.87*** | -2.561* | | | |
| | (2.233) | (4.572) | (1.323) | | | |
| Contiguity | 2.367*** | 2.420*** | 2.396*** | | | |
| | (0.604) | (0.617) | (0.606) | | | |
| Colony | 0.280 | 0.303 | 0.294 | | | |
| | (0.240) | (0.236) | (0.237) | | | |
| Language | -0.337 | -0.330 | -0.326 | | | |
| | (0.279) | (0.275) | (0.276) | | | |
| RTA | 0.919*** | 0.906*** | 0.914*** | 0.644*** | 0.638*** | 0.627*** |
| | (0.228) | (0.224) | (0.225) | (0.218) | (0.215) | (0.214) |
| Patents*Bor | 1.064*** | | | -0.238 | | |
| | (0.298) | | | (0.205) | | |
| Researchers*Bor | | 2.085*** | | | -0.272 | |
| | | (0.704) | | | (0.236) | |
| R&D Exp*Bor | | | 3.666*** | | | 0.685 |
| | | | (1.025) | | | (0.627) |
| Constant | 16.34*** | 16.33*** | 16.37*** | 9.797*** | 9.810*** | 9.522*** |
| | (1.097) | (1.079) | (1.094) | (0.471) | (0.459) | (0.221) |
| Pair Fixed Effects | No | No | No | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9188 | 0.9253 | 0.9189 | 0.9347 | 0.9349 | 0.9349 |
| Observations | 1975 | 1,959 | 1,959 | 28,678 | 28,693 | 28,693 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

**Table 8:** Green Exports Share and Political Determinants

| Variables | Panel A (2021) | | | | Panel B (1994-2021) | | | |
|---|---|---|---|---|---|---|---|---|
| | Exports Share | | | | Exports Share | | | |
| Distance(log) | -1.086*** | -1.098*** | -0.751*** | -1.008*** | | | | |
| | (0.134) | (0.130) | (0.219) | (0.148) | | | | |
| Border | -2.133** | -5.745*** | -3.470*** | -2.091 | | | | |
| | (0.859) | (1.185) | (1.097) | (3.001) | | | | |
| Contiguity | 2.484*** | 2.455*** | 3.593*** | 2.226*** | | | | |
| | (0.616) | (0.602) | (0.994) | (0.679) | | | | |
| Colony | 0.311 | 0.303 | -0.358 | 0.463** | | | | |
| | (0.241) | (0.243) | (0.387) | (0.203) | | | | |
| Language | -0.337 | -0.316 | 0.547 | 0.335 | | | | |
| | (0.281) | (0.288) | (0.570) | (0.252) | | | | |
| RTA | 0.868*** | 0.773*** | 1.330** | 0.489** | 0.614*** | 0.722*** | 0.663 | 0.407 |
| | (0.229) | (0.235) | (0.615) | (0.208) | (0.216) | (0.226) | (0.413) | (0.330) |
| Political Terror*Bor | 0.212 | | | | -0.546** | | | |
| | (0.224) | | | | (0.214) | | | |
| Political Stability*Bor | | -2.959*** | | | | -0.0166 | | |
| | | (0.662) | | | | (0.779) | | |
| Regulatory Quality*Bor | | | 0.249 | | | | 0.617*** | |
| | | | (0.215) | | | | (0.148) | |
| Political Risk*Bor | | | | 0.136 | | | | -0.828 |
| | | | | (0.750) | | | | (0.775) |
| Constant | 16.12*** | 16.39*** | 12.14*** | 14.72*** | 9.727*** | 9.278*** | 8.661*** | 10.03*** |
| | (1.097) | (1.070) | (1.803) | (1.323) | (0.197) | (0.354) | (0.357) | (1.358) |
| Pair Fixed Effects | No | No | No | No | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9310 | 0.9775 | 0.8879 | 0.9339 | 0.9653 | 0.9649 | 0.9768 | 0.9612 |
| Observations | 2,133 | 2,822 | 2,423 | 1,802 | 28,693 | 25,184 | 4,534 | 22,924 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

Table 8 demonstrates the outcomes of robustness estimates in a structural gravity model of several political determinants of the share of green exports across OIC nations. The results of some models indicate that the effectiveness of political determinants in influencing green export share varies significantly (see results of imports share in Appendix A).

## 6. Conclusion

This section aims to give closing thoughts on the research, which pertains to the effect of technological innovation on the distribution of green goods in OIC nations, along with the major political determinants of GT. The rationale for examining the trade of environmentally friendly products and technological innovation in OIC countries arises from several crucial aspects, including environment sustainability, the promotion of economic development, and the need to tackle global issues like climate change. The COVID-19 epidemic heightened the importance of these investigations. Initially, the epidemic brought attention to the weaknesses in worldwide logistic networks, leading to a reassessment of economic practices in favour of more robust and environmentally friendly approaches.

Several investigations have been done to examine the impact of technological innovation on GT. Findings show that geographical proximity emerges as a significant factor influencing trade volumes, while border-related costs and policy constraints notably hinder trade movements. Variables like contiguity, colonial ties, and RTA positively impact GT. Despite language's insignificance, technological innovation, notably represented by patents, R&D activities, and expenditures, plays a pivotal role in improving competitiveness and influencing the dynamics of green goods trade. However, disparities in innovation capacities between wealthier and poorer OIC nations magnify the influence of technological differences on GT. Bridging these disparities and enhancing innovation capacities across all member states emerge as crucial steps for fostering equitable and sustainable intra-OIC GT.

Results highlight both adverse and positive influences of political factors. The political terror scale negatively affects GT, indicating a decline in GT with increased political terror. Similarly, political instability shows a significant and negative impact, with a substantial decrease in GT.

Economic integration policies, like trade liberalization, can precede periods of social and political unrest, disrupting trade activities within a society. Regulatory quality emerges as a positive and significant factor, indicating a surge in green goods trade. Conversely, political risk demonstrates a negative and significant influence, leading to a decline in the trade of green goods. Escalating political uncertainty might result in trade apprehensions due to potential government regulatory changes and contract fulfilment doubts, potentially stalling official trade connections. In short, political determinants highlight the need for stable political environments, favourable regulatory conditions, and reduced political uncertainties to foster increased trade in environmentally friendly products.

Based on the findings, it is recommended that OIC member states prioritize the enhancement of research and development in green technologies through increased funding and support, and strengthen political stability via diplomatic engagement and conflict resolution. Additionally, improving regulatory frameworks is crucial to fostering an environment conducive to green trade, ensuring transparency and effective enforcement of trade regulations that support environmental sustainability. Direct efforts towards enhancing political stability and minimising unpredictability through diplomatic involvement, resolving conflicts, and promoting peace and stability among member states of the OIC. Political volatility impedes trade, and implementing strategies to mitigate these risks bolsters international partnerships and trade connections, fostering a favourable atmosphere for sustainable trade. These strategies are vital for promoting sustainable economic growth within the OIC region.

The study's shortcomings arise from the availability of data, particularly extensive databases for technological innovation. There are certain inconsistencies or gaps in data across different OIC nations such as Afghanistan and Palestine has a lot of missing data for many variables. The limited proxies result in inadequate representation or oversimplification of some elements of technological innovation. The study's results and consequences can be limited by the unique setting of the OIC members. The application of results to other regions and nations can be limited by factors specific to that area, such as cultural, economic, or political issues. The research may face challenges in comprehensively accounting for all external variables such as determinants that influence GT.

Future studies should perform longitudinal research to monitor the impact of technological advancements on environmentally friendly trade logistics across lengthy timeframes. Examine patterns and evaluate the influence of technical progress in certain industries on the development and trends of environmentally friendly trade among OIC states. Machine learning techniques can be used in gravity models instead of the traditional practice of using PPML. To get a more profound comprehension of the association between technological advancement and environmentally friendly trade-in OIC countries, it is imperative to focus on these aspects in future research endeavours. This will provide valuable insights for policy-making and the promotion of sustainable economic growth.

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# APPENDIX A

**Table A-1:** Green Imports Share and Technological Innovation

| Variables | Panel A (2021) | | | Panel B (1994-2021) | | |
|---|---|---|---|---|---|---|
| | Imports Share | | | Imports Share | | |
| Distance(log) | -0.924*** | -0.935*** | -0.934*** | | | |
| | (0.172) | (0.173) | (0.172) | | | |
| Border | 3.644*** | 0.579 | -1.847 | | | |
| | (1.267) | (5.020) | (1.443) | | | |
| Contiguity | 2.024*** | 2.075*** | 2.079*** | | | |
| | (0.328) | (0.337) | (0.338) | | | |
| Colony | 0.0771 | 0.102 | 0.106 | | | |
| | (0.321) | (0.325) | (0.324) | | | |
| Language | 0.116 | 0.108 | 0.107 | | | |
| | (0.278) | (0.278) | (0.278) | | | |
| RTA | 0.197 | 0.188 | 0.189 | 0.0264 | 0.0479 | 0.0482 |
| | (0.247) | (0.248) | (0.249) | (0.253) | (0.265) | (0.265) |
| Patents*Bor | -0.780*** | | | -0.738* | | |
| | (0.162) | | | (0.391) | | |
| Researchers*Bor | | -0.387 | | | -0.0847 | |
| | | (0.801) | | | (0.498) | |
| R&D Exp*Bor | | | 0.0236 | | | -0.187 |
| | | | (1.122) | | | (0.549) |
| Constant | 13.52*** | 13.61*** | 13.61*** | 10.12*** | 8.384*** | 8.099*** |
| | (1.598) | (1.599) | (1.599) | (1.049) | (1.230) | (0.266) |
| Pair Fixed Effects | No | No | No | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9388 | 0.9353 | 0.9389 | 0.9547 | 0.9549 | 0.9549 |
| Observations | 2,275 | 2,279 | 2,279 | 32,487 | 32,522 | 32,522 |

****, **, * is 1%, 5%, 10% significance levels, respectively*

**Table A-2**: Green Imports Share and Political Determinants

| Variables | Panel A (2021) | | | | Panel B (1994-2021) | | | |
|---|---|---|---|---|---|---|---|---|
| | Imports Share | | | | Imports Share | | | |
| Distance(log) | -0.961*** | -0.914*** | -1.097*** | -0.959*** | | | | |
| | (0.193) | (0.163) | (0.148) | (0.186) | | | | |
| Border | 0.409 | 0.823 | -3.261*** | 19.78*** | | | | |
| | (1.024) | (1.850) | (0.666) | (1.967) | | | | |
| Contiguity | 1.986*** | 2.067*** | 2.848*** | 2.017*** | | | | |
| | (0.333) | (0.335) | (0.630) | (0.367) | | | | |
| Colony | 0.00634 | 0.108 | -0.442 | -0.0671 | | | | |
| | (0.350) | (0.317) | (0.376) | (0.415) | | | | |
| Language | 0.0437 | 0.113 | -0.599 | 0.156 | | | | |
| | (0.280) | (0.271) | (0.426) | (0.304) | | | | |
| RTA | 0.299 | 0.100 | 0.342 | 0.272 | 0.0432 | 0.0650 | -0.811** | -0.219 |
| | (0.245) | (0.241) | (0.257) | (0.274) | (0.236) | (0.277) | (0.354) | (0.282) |
| Political Terror*Bor | -0.884*** | | | | -1.016*** | | | |
| | (0.343) | | | | (0.192) | | | |
| Political Stability*Bor | | 2.044 | | | | 2.055** | | |
| | | (1.376) | | | | (0.926) | | |
| Regulatory Quality*Bor | | | 0.0988 | | | | 0.337*** | |
| | | | (0.110) | | | | (0.0836) | |
| Political Risk*Bor | | | | -5.365*** | | | | -6.913*** |
| | | | | (0.485) | | | | (1.473) |
| Constant | 13.78*** | 13.36*** | 14.83*** | 13.90*** | 9.091*** | 8.791*** | 8.310*** | 19.12*** |
| | (1.777) | (1.487) | (1.160) | (1.736) | (0.221) | (0.446) | (0.150) | (2.284) |
| Pair Fixed Effects | No | No | No | No | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.9321 | 0.9675 | 0.8979 | 0.9139 | 0.9387 | 0.9301 | 0.9681 | 0.9429 |
| Observations | 2,233 | 2,872 | 423 | 1,602 | 28,693 | 25,184 | 4,534 | 22,924 |

****, **, * is 1%, 5%, 10% significance levels, respectively*