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THREE ESSAYS ON INTRA-INDUSTRY TRADE

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DECLARATION OF ORIGINALITY

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ABSTRACT

THREE ESSAYS ON INTRA INDUSTRY TRADE

This thesis analyzes how trade within industries corresponds with other economic indicators and its implications in the light of three different theoretical backgrounds and to conduct a deeper empirical study on this issue. In the thesis, firstly, the Environmental Kuznets Hypothesis has been studied to show the effects of trade inside an industry on the environment. We studied with 23 OECD countries from 1970 to 2019. The environmental impact of trade in the same industry is studied with income, energy use, government expenditures as well as expanded trade by long-run estimators. The study worked with mean group (MG), pooled mean group (PMG), common correlated effects mean group (CCEMG), and cross-sectionally augmented autoregressive distributed lag (CS-ARDL) estimators. According to the country-specific CS-ARDL estimator, significant findings were found only in 6 countries and according to the PMG estimator for the panel, a U-shaped relationship was found. The study's most significant finding was that trading within an industry can slow down pollution. Throughout the second study, to reveal the terrorism-trade relationship through empirical studies, we ran a one-way gravity model with Turkey's 71 most exporting trading partners. We used information and communication technology (ICT) service exports per capita as a proxy variable for inter-industry trade in our model. We also used GDP and manufacturing industry similarities of the countries to reveal the terrorism-trade relationship. According to our findings, we concluded that Turkey is engaged in inter-industry trade when it comes to ICT service exports. We also found that terrorist incidents in Turkey negatively affect trade, but the occurrence of terrorism in the country of trade does not negatively affect exports. In addition to this, we have shown through econometric analysis that Turkey has intra-industry trade in terms of GDP and manufacturing industry similarities. In the third study, we conducted a sectoral and individual Smooth Adjustment Hypothesis (SAH) analysis using two different datasets. The research depends on the concept that employees who experience intra-industry trade will shift positions within the same sector and relocate to a new industry in the absence of it. To analyze this concept throughout 90 sectors,

we used the system-generalized method of moments (GMM) estimator. Our findings helped us understand that trade within industries exists in all 90 sectors. The second study, utilizing TURKSTAT survey data, further supported intra-industry trade. The analysis with TURKSAT's survey data displays the effects of factors like inflation, age, marital status, education level, and gender.

Keywords: Environmental Kuznets hypothesis, intra-industry trade, gravity model, smooth adjustment hypothesis



ÖZET

ENDÜSTRİ İÇİ TİCARET ÜZERİNE ÜÇ MAKALE

Bu tez, endüstri-içi ticaretin diğer ekonomik göstergelerle etkileşimini ve sonuçlarını üç farklı teorik arka plan ışığında analiz etmekte ve bu konuda daha derin bir ampirik çalışma yürütmektedir. Tezde ilk olarak, endüstri-içi ticaretin çevre üzerindeki etkilerini ortaya koymak amacıyla Çevresel Kuznets Hipotezi incelenmiştir. Çalışmada 23 OECD ülkesi için 1970-2019 dönemi baz alınmış ve endüstri-içi ticaret ile gayrisafi yurtiçi hasıla (GSYH), enerji tüketimi, devletin nihai tüketim harcamaları (GFCE) ve ticari açıklığın karbon emisyonları üzerindeki etkileri uzun dönem heterojen tahmincilerle tahmin edilmiştir. Çalışmada yatay kesit genişletilmiş ARDL (CS-ARDL), ortak korelasyonlu etkiler ortalama grup (CCEMG), havuzlanmış ortalama grup (PMG) ve ortalama grup (MG) tahmincileri kullanılmıştır. Ülkeye özgü CS-ARDL tahmincisine göre sadece 6 ülkede anlamlı bulgular elde edilmiş, panel için PMG tahmincisine göre ise U şeklinde bir ilişki bulunmuştur. En önemlisi, çalışmada endüstri-içi ticaretin çevresel bozulma üzerinde azaltıcı bir etkisi olduğu sonucuna varılmıştır.

İkinci çalışmada, terörizm-ticaret ilişkisini ampirik çalışmalarla ortaya koymak için, Türkiye'nin en çok ihracat yapan 71 ticaret ortağı ile tek yönlü bir çekim modeli çalıştırdık. Modelimizde endüstri içi ticaret için vekil değişken olarak kişi başına bilgi iletişim teknolojisi (BİT) hizmet ihracatını kullandık. Terörizm-ticaret ilişkisini ortaya çıkarmak için ülkelerin GSYH ve imalat sanayi benzerliklerini de kullandık. Bulgularımıza göre, BİT hizmet ihracatı söz konusu olduğunda Türkiye'nin endüstriler arası ticaret yaptığı sonucuna vardık. Ayrıca, Türkiye'deki terör olaylarının ticareti olumsuz etkilediğini, ancak ticaret yapılan ülkede terörün meydana gelmesinin ihracatı olumsuz etkilemediğini tespit ettik. Buna ek olarak, ekonometrik analiz yoluyla Türkiye'nin GSYİH ve imalat sanayi benzerlikleri açısından endüstri içi ticarete sahip olduğunu gösterdik.

Üçüncü çalışmada, iki farklı veri seti kullanılarak sektörel ve bireysel Uyum Hipotezi (UH) analizi yapılmıştır. Analiz, endüstri içi ticaretin varlığında, çalışanların aynı sektör içinde iş değiştirdiği, aksi durumda ise farklı bir sektöre geçtiği hipotezine

dayanmaktadır. Sistem GMM tahmincisini 90 sektör için kullandık. Bulgular 90 sektörün tamamında endüstri-içi ticaretin varlığına işaret etmektedir. TÜİK anket verilerini kullanan ikinci çalışma, endüstri-içi ticareti daha da desteklemiştir. TÜRKSAT'ın anket verileriyle yapılan analiz, enflasyon, yaş, medeni durum, eğitim seviyesi ve cinsiyet gibi faktörlerin etkilerini göstermektedir.

Anahtar Kelimeler: Endüstri-içi ticaret, yumuşak uyum hipotezi, çevresel Kuznets eğrisi, çekim modeli.



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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
AMG	Augmented mean group
ARDL	Augmented autoregressive distributed lag
CADF	Covariate augmented Dickey Fuller
CCE	Common correlated effects
CCEMG	Common correlated effects mean group
CD	Cross-sectional dependence
CES	Constant elasticity of substitution
CIPS	Cross-sectionally augmented Im-Pesaran-Shin
CS-ARDL	Cross-sectionally augmented autoregressive distributed lag
CS-DL	Cross sectionally augmented distributed lag
CU	Customs union
DOLS	Dynamic ordinary least square
DSUR	Dynamic seemingly unrelated regression
EKC	Environmental Kuznets curve
EU	European Union
FDI	Foreign direct investment
FE	Fixed effects
FMOLS	Fully modified ordinary least squares
FOB	Free on board
FSI	Fragile states index
FTA	Free trade agreement
GDP	Gross domestic product
GL	Grubel-Lloyd index
GMM	Generalized method of moments
GTD	Global terrorism database
GTI	Global terror index
HAC	Heteroskedasticity and autocorrelation consistent
ICT	Information and communication technology

IIT	Intra-industry trade
ITERATE	International terrorism: attributes of terrorist events
MG	Mean group
MIIT	Marginal intra-industry trade
MMQR	Method of moments quantile regression
OLS	Ordinary least squares
PMG	Pooled mean group
PPI	Producer price index
PPML	Poisson pseudo-maximum likelihood
PPMLHDFE	Poisson pseudo-likelihood regression with multiple levels of fixed effects
PSTKR	Panel smooth transition kink regression
RE	Random effects
RTA	Regional trade agreement
SADC	South African development community
SAH	Smooth-adjustment hypothesis
VAR	Vector autoregressive

1. CHAPTER

Introduction

Globalization, the expansion of trade agreements between countries, and the development of the transportation sector thanks to technology, products and services have become increasingly interconnected. This interconnectedness has not only transformed the economic landscape but has also given rise to complex interactions between nations, industries, and individuals. With this setting, intra-industry trade (IIT) has become an important component shaping the structure of commerce. As globalization progresses and trade barriers diminish, understanding the implications of intra-industry trade becomes essential. This thesis delves into the multifaceted dimensions of intra-industry trade, exploring its effects on environmental sustainability, geopolitical relationships, and labor market dynamics. Through a comprehensive analysis rooted in various theoretical frameworks, our study tries to add further knowledge and perspective on globalization, trade and economic development. This thesis explores the dynamics of intra-industry trade and its implications, drawing insights from three distinct theoretical frameworks. We empirically analyzed trade in the same industry and its implications in three dimensions: environmental economics, terrorism-trade, and the smooth adjustment hypothesis (SAH) using extensive dataset.

In the first research, we review the effect of intra-industry trade on environmental consequences, examining the Environmental Kuznets Hypothesis. We use long-run heterogeneous estimators, such as cross-sectionally augmented autoregressive distributed lag (CS-ARDL), common correlated effects mean group (CCEMG), pooled mean group (PMG), and mean group (MG). Our data covers 23 OECD countries from 1970 to 2019. We estimated the effects of trade within the same industry on income, energy use, government final consumption, expenditure as well as trade openness. Noteworthy findings include a U-shaped relationship revealed by the PMG estimator for the panel, signifying that intra-industry trade can mitigate environmental degradation.

The second study focuses on the terrorism-trade relationship, utilizing a one-way gravity model with Turkey's top 71 trading partners. We evaluate the effect of terrorism on Turkey's exports using information and communication technology (ICT) service exports per capita as a proxy for trade in the same industry. The findings highlight that Turkey engages in inter-industry trade concerning ICT service exports. Moreover, econometric analysis demonstrates that terrorist incidents in Turkey negatively impact trade, while terrorism in the trading partner's country does not have a similar negative effect on exports. Additionally, we reveal through econometric analysis that Turkey engages in intra-industry trade based on GDP and manufacturing industry similarities.

In the third study, we studied the Smooth Adjustment Hypothesis (SAH) on a sectoral and individual level. By employing system GMM estimator and using two distinct datasets for Turkey, we tested whether employees change jobs in the same industry or shift to different industries based on the trade decomposition of the country. We found evidence that Turkey has an intra-industry trade decomposition across 90 sectors. In addition to supporting intra-industry trade, supplemental research employing TURKSTAT survey data clarifies the effects of characteristics including educational attainment, age, relationship status, gender, and inflation on changes in employment.

Collectively, this thesis unfolds a comprehensive exploration of intra-industry trade, offering insights into its environmental, geopolitical, and labor market dimensions, and contributing valuable perspectives.

2. CHAPTER: THE ENVIRONMENTAL KUZNETS HYPOTHESIS IN 23 OECD COUNTRIES: CS-ARDL AND PMG MODEL

ABSTRACT

The concept of the Environmental Kuznets Curve (EKC) is investigated in this study using a sample of 23 OECD nations from 1970 to 2019. The interaction between intra-industry trade (IIT), energy use, trade openness, government final consumption, expenditure and CO₂ emissions is examined using four estimators: CS-ARDL, CCEMG, PMG, and MG. Our results show that a U-shaped association can only be found when the PMG estimator is applied. The findings imply that, of the 23 nations examined, evidence for the EKC hypothesis is discovered in six of them using country estimations. Among these, Finland, Italy and Japan exhibit an inverted U-shaped relationship, while the link between economic development and carbon dioxide pollution is U-shaped in both the United States, Ireland and the Netherlands. Our findings help us understand the effects of trade decomposition, economic advancement as well as energy consumption's implications on the environmental deterioration.

Keywords: Environmental Kuznets Curve Hypothesis, intra-industry trade, trade openness, energy consumption, CS-ARDL, CCEMG, PMG, MG.

2.1. Introduction

Globally, humanity has achieved significant economic progress, contributing to improved well-being. With globalization, increased international trade and reduced access to products have increased consumption, especially in developed countries. Governments have increased the well-being of citizens by spending on health and education institutions. This development has come with the cost of environmental degradation. CO₂ emissions, one of the most important measures of environmental degradation, are the contributing effect of increasing greenhouse gas emissions.

According to (Kuznets, 1955, p. 23) theory, there are initially distortions in the distribution of wealth in low-income countries, but they tend to disappear as these countries grow economically. According to Kuznets, as economic prosperity rises, there is a clearer link between income growth and more fair distribution. He also argues that there is generally more economic equality in high-income nations.

After (Grossman & Krueger, 1995, 1991) studies, the Environmental Kuznets Curve (EKC) had a lot of academic interest. In their (Grossman and Krueger, 1995, p. 363) study the researchers observed a noteworthy trend. There is a noticeable decline in ecological damage with rising wealth, even in low-income nations with subpar air and water quality. There's an obvious reversal in environmental deterioration beyond a certain economic range. Theories about this phenomenon include increased environmental consciousness among individuals as well as companies and the Government, technological developments, and an increasing tendency toward ecologically friendly purchase habits as income levels rise.

(Grossman & Krueger, 1991, p. 4) study turned attention to the environment. Environmental concerns were raised by activists following NAFTA, associating trade expansion and heightened trade activity with potential adverse impacts on production techniques and resultant environmental degradation. Since that time, there was not a complete study on trade expansion and its complications on the environment. Their study revealed that expanding trade through agreements could increase income, subsequently intensifying environmental pressures and, paradoxically, leading to a decrease in environmental issues.

Many researchers have studied the link between wealth and ecological metrics, the effects of commerce and energy use, and the fast urbanization that follows (Grossman & Krueger, 1991, p. 36) and (Grossman & Krueger, 1995, p. 371). Understanding these relational dynamics, they have proposed policies and strategies for sustainable development. However, this is still an area of ongoing research.

Moreover, high energy consumption, especially in developed countries, continues to increase CO₂ emissions. The importance and priority of the issue has been addressed especially by the European Union and efforts have been made to cut back the use of oil and gas from the production sector also from transportation and agriculture. (EU Parliament, 2018)

Increased energy consumption, as well as government spending, has led to climbing CO₂ emissions. Numerous studies examined the link between government spending, various ecological metrics employing different econometric methods. (Le & Ozturk, 2020, p. 22680) studied the Kuznets hypothesis for 47 developing economies by testing government expenditures including variables such as energy consumption, quality of government index, financial development. According to the research findings, they concluded that not only energy consumption, government expenditures but also economic development reduces ecological degradation.

(Azam et al., 2023, p. 1961) looked into how government funding, natural assets, and alternative energy affected France's carbon dioxide emissions between 1990 and 2018. According to their long-run estimations, they concluded that wealth reduces carbon emissions and investments have a negative effect. Using the ARDL approach, (Sarkodie & Ozturk, 2020, p. 10) examined the EKC hypothesis for Kenya by taking into account factors such total agricultural area, production, urbanization, green power, and household consumption and expenditures. Their study reveals that not only energy consumption but also rise in GDP per capita and household spending and expenditure has an additive effect on CO₂ emissions. However, urbanization keeps its positive trend on the CO₂ emissions, energy import seems to be ineffective, thus their study confirms an inverted-U shape for EKC.

According to (IEA, 2023)'s report for the year 2022, in broad terms, activities like trade, production, and transportation are anticipated to exert an increasing impact

on the greenhouse gasses which is the consequence of extensive fuel use. Nevertheless, a distinct scenario may emerge when considering intra-industry trade. One of the most influential study conducted by (Roy, 2017), is related to the intra-industry trade and environment relationship. (Roy, 2017, p. 65)'s study investigated ecological effects of trade in the same industry across 200 countries. They came to the conclusion that commerce inside an industry helps the environment and poses less of a threat to it than does general trade. Moreover, trade within industries and clean energy sources have a mitigating effect on the emissions for nations that are members of the European Union. (Leitão and Balogh, 2020, p. 210). Furthermore, trading among the Portuguese and Spanish industries has a long-term detrimental effect on CO₂ emissions. (Leitão, Koengkan, et al., 2022, p. 17).

By analyzing the connections between energy use, government final consumption expenditures, international commerce, intra-industry trade (IIT), economic development, and environmental degradation, this research seeks to further the current conversation. Utilizing panel data models covering 23 OECD countries from 1970 to 2019, this study incorporates IIT, government consumption expenditure, trade openness, and energy consumption to comprehensively analyze their influence on emission of carbon dioxide in great detail.

Multicollinearity becomes cause for concern in the model since gross domestic product (GDP) and squared GDP are considered. Notably, previous studies have often omitted reporting the Variance Inflation Factor (VIF) in such cases. In this study, we have employed the orthogonal term, as recommended by (Draper and Smith, 1998, p. 370; Panayotou 1997, p. 470), to mitigate this multicollinearity issue.

The six sections that together make up this study provide an extensive review of the Environmental Kuznets Curve (EKC) theory. A summary of the former literature is given in Section 2.2, with an emphasis on important research and arguments. We outline the conceptual basis that guides our study in Section 2.3. Section 2.4 provides a detailed description of the data sets and empirical approach used in this investigation. The estimation findings of our investigation are presented in Section 2.5, offering insights into the connection between environmental deterioration and economic progress. In Section 2.6, we provide a summary of our research and make inferences from the provided evidence.

2.2. Literature Review

The results of several research carried out in different parts of the world utilizing various econometric techniques to look at the feasibility of the EKC hypothesis are included in this overview of the literature. Detailed summary of the related literature is presented in Table 1 below.

The classic studies by (Grossman & Krueger, 1991) and (Grossman & Krueger, 1995) have had a considerable influence on research on the environment and commerce relationship. After the North American Free Trade Agreement (NAFTA) was passed, (Grossman & Krueger, 1991, p. 3) focused their academic research on the environmental effects of it. Activists voiced environmental apprehensions in the wake of NAFTA, linking trade expansion and heightened trade activity to potential shifts in production techniques and subsequent environmental deterioration. The influence of lowered trade barriers on air quality was not fully explored before in a study before (Grossman & Krueger, 1991). In their study, (Grossman & Krueger, 1991, p. 35) showed that the removal of trade barriers would augment Mexico's GDP, subsequently heightening environmental pressures and paradoxically resulting in a decrease in environmental issues. Following this study, (Grossman & Krueger, 1995, p. 353) investigated the effects of environmental degradation in more depth. (Grossman & Krueger, 1995, p. 372) study revealed a remarkable trend: although low-income nations often have poorer air and water quality, there is an apparent decrease in environmental deterioration as wealth rises. An important income level represents a tipping point and demonstrates a turnaround in the destruction of the environment. It is hypothesized that as technology advances and people's understanding of the environment grows, so will their choice for environmentally friendly purchases as their income levels improve.

Many research has examined the link between economic development and environmental deterioration since the groundbreaking work of (Grossman & Krueger, 1991) and (Grossman & Krueger, 1995). The subsequent studies have mostly focused on the analysis of CO₂ emissions. In addition, trade openness has become a widely used explanatory variable in the investigation of the possible relationship between environmental harm and economic activity, including the share of GDP accounted for

by imports and exports. Studies by (Dogan & Seker, 2016), (Churchill et al., 2018), (Lau et al., 2019), (Erdogan et al., 2020), (Köksal et al., 2020), (Zhongwei & Liu, 2022), (Fakher et al., 2023) and (Wang et al., 2023) are among the notable contributions to this line. The combined results of these research provide insight on the possible impacts of trade activity on environmental outcomes and further helps us understand the role that trade expansion plays in ecological deterioration.

Numerous econometric techniques have been employed in the literature to investigate the Environmental Kuznets Curve (EKC) models. Numerous research works have employed the Fully Modified Ordinary Least Squares Estimator (FMOLS) and Dynamic Ordinary Least Square (DOLS) to analyze the long-term link between ecological degradation and economic growth. (Jebli et al., 2016, p. 826), (Apergis, 2016, p. 264), (Lau et al., 2019, p. 20), (Erdogan et al., 2020, p. 23659), (Aminu et al., 2023, p. 4), (Wang et al., 2023, p. 8). In contrast, the Augmented Mean Group Estimator (AMG) has been widely used in a number of research (Churchill et al., 2018, p. 390), (Erdogan et al., 2020, p. 23659) and (Zhongwei & Liu, 2022, p. 135) in place of other techniques.

The Autoregressive Distributed Lag (ARDL) estimator is another popular econometric technique when groups are cross sectionally dependent and heterogeneity exists. This approach has been employed by (Zhang et al., 2020, p. 5), (Vo et al., 2022, p. 6) and (Mekhzoumi et al., 2022, p. 99). The ARDL estimator is particularly useful when variables have different integration orders.

Furthermore, the Common Correlated Effects Mean Group Estimator (CCEMG) has been used in certain investigations which accounts potential common correlated effects among countries (Apergis, 2016 p. 264). Dynamic Seemingly Unrelated Regression (DSUR) and Panel Smooth Transition Kink Regression (PSTKR) have also been employed in specific studies (Dogan & Seker, 2016, p. 14651) and (Maneejuk & Yamaka, 2022, p. 45).

Researchers can examine the relationship between income growth and ecological deterioration using a variety of instruments provided by diverse econometric approaches. These methods are in line with certain study goals and take into account the unique qualities of the data.

The EKC does not hold when estimated using the AMG estimator, according to (Erdogan et al., 2020 p. 23662) who used FMOLS, DOLS, and AMG estimators to assess data from 25 OECD nations. Their econometric analysis confirms the hypothesis and that trade expansion was insignificant in the study.

In research by (Apergis, 2016, p.263), data covering 15 nations examined the validity of the Kuznets hypothesis. Through econometric analysis, they proved the validity of hypothesis for most of the countries in their study.

(Jebli et al., 2016, p. 826) studied with OECD nations by employing FMOLS and DOLS estimators to examine the relationship. While they confirm the hypothesis, through Granger causality test, they find causality from commerce to greenhouse gasses as well as mutual causality between exports and green energy usage.

(Kang, 2021, p. 18) test the hypothesis with various countries, they revealed evidence of the hypothesis. This pattern was notably observed in both countries in the study. When examining CO₂ emissions associated with global trade, the observed pattern aligned with the conventional EKC hypothesis. Within this framework, emissions rose in the initial stages of GDP growth and then decreased after a certain income level was reached. Moreover, developing nations tended to be net exporters of carbon dioxide, whereas industrialized nations likely to be net importers.

(Maneejuk & Yamaka, 2022, p. 41) studied the hypothesis for the OECD countries. Their model included GDP, sulfur dioxide (SO₂) emissions, population, energy consumption, and the financial development index. They also verify the validity of the hypothesis in their study.

(Churchill et al., 2018, p.391) studied with a sample of OECD countries by employing multiple estimators, including MG, CCEM, AMG, and PMG. EKC was proved only in nine nations. Furthermore, the study conducted by (Churchill et al., 2020, p. 9) aimed to investigate the hypothesis in relation to Australia's eight states. According to their research, there is an inverse U-shaped link between economic expansion and environmental deterioration, which first rises and then finally falls after a tipping point.

(Lau et al., 2019, p. 20) studied 18 OECD countries and employed a dynamic panel data approach with GMM estimator and FMOLS. Their findings confirm the hypothesis.

(Aminu et al., 2023 p. 8) studied the hypothesis covering Sub-Saharan African countries using FMOLS estimator. In addition to CO₂ emissions, their study included industrial performance, industrial employment rate, foreign direct investment, and energy consumption as variables. Their study results were in the favor of the hypothesis.

(Kalim et al., 2023, p. 6) studied with 147 countries between 2008 and 2018. Their study emphasized the risks of pursuing economic growth without considering the environment. The findings highlighted the importance of a demand-based strategy and the growth of a knowledge.

Between 1990 and 2018, (Wang et al., 2023, p. 5) carried out an extensive analysis utilizing a significant amount of data collection that included 208 nations. Their study concentrated on analyzing the effects of trade, environmental sources, clean energy sources, and on national and global greenhouse gases. Their findings revealed that clean energy sources help decrease carbon emissions in most countries. Furthermore, based on human assets, nations that have passed the threshold have reduced their carbon emissions more than others. In order to encourage green growth and lessen reliance on fossil fuels, the study's conclusion advises governments to put environmental management, environmental laws, and incentives into place.

(Fakher et al., 2023, p. 10), examined how the ecological indices of OPEC countries from 1994 to 2019 correlated with the usage of alternate forms of energy. Using the Dynamic Seemingly Unrelated Regression model, their investigation showed that while using green energy is preferable for the environment, using fossil fuels makes the environment worse. The study also discovered an N-shaped correlation between deteriorating environmental indicators and GDP.

(Dogan & Seker, 2016, p. 14653) looked at the EKC link in sixteen OECD nations. Their study's conclusions showed that while energy consumption was shown to be positively related with a rise in emissions, trade openness and financial expansion had a moderating influence on carbon emissions, resulting in a drop. The

EKC theory is supported by the evidence. Additionally, the study found a one-way Granger causation link, meaning that variations in real income affected CO₂ emissions and that real income was influenced by energy use. Furthermore, a two-way Granger causality between trade openness and CO₂ emissions was found, indicating reciprocal causal relationships between the two variables.

Using the CS-ARDL estimator, (Vo et al., 2022, p. 6) investigated the EKC hypothesis in 37 OECD nations. Their findings suggest that the EKC does not hold during the period from 1990 to 2015. However, the study did not examine country-specific coefficients.

The study by (Zhang et al., 2020, p. 16) demonstrates an inverse U-shaped association between population increase, capital formation, GDP growth, green power, and ecological disturbance. Instead of commonly used CO₂ emissions, ecological disorder was employed as the dependent variable. The study utilized a panel ARDL approach for estimation.

Additionally, (Zhongwei & Liu, 2022, p. 135) used the CS-ARDL estimator and used the AMG and CCEMG estimators to do a robustness assessment. From 1995 to 2019, they looked at the connections between the GDP, trade openness, human capital, and renewable power use in G20 nations. The usage of renewable energy and the selected variables were shown to be positively correlated by the study. It has been discovered that eco-friendly inventions influence developments in corporate procedures, infrastructure, transportation, and technology. This calls for a change in the ways that energy is consumed, which raises the need for renewable energy. Trade liberalization makes it possible for nations to get resources for the creation of renewable energy and energy-efficient technology.

(Mekhzoumi et al., 2022, p. 99) used the CS-ARDL, CS-DL, and MG estimators to explore the Environmental Kuznets Curve (EKC). After examining data from 31 nations, they discovered that the EKC holds, showing an inverted N-shaped link between the chosen nations from 1980 to 2019. The dependent variable in the model under consideration was CO₂ emissions, whereas the independent variables were GDP per capita, energy consumption, globalization index, and population

density. With the exception of the globalization index, the model demonstrated the relevance of both the short-run and long-run factors.

(Mehmood et al., 2022, p. 10) studied the impact of aging populations and natural resources on CO₂ using panel data from 1990 to 2020. They used the panel CS-ARDL estimator and the Westerlund cointegration test. The factors in the model, which included CO₂ emissions, natural resources, globalization, economic expansion, and aging populations, showed a substantial connection, according to the research.

Economic activity causes environmental degradation and numerous empirical studies have demonstrated the consequences of this. (Acheampong & Opoku, 2023, p. 15) highlighted environmental deterioration could slow economic growth through routes such as health, foreign direct investment, and technological innovation. (Huo et al., 2023, p. 12) made the conclusion that financial innovation affects the environment and influences economic globalization indirectly. Furthermore, it has been demonstrated that environmental technologies have an impact on the ecological damage brought on by economic globalization, both directly and indirectly. The research conducted by (Luo et al., 2023, p. 6) revealed a robust positive association, especially in low-income nations, between carbon emissions and natural resource rents. In addition to these, (Qamri et al., 2022, p. 9)'s study shows that foreign direct investment (FDI) contributes to economic development and positively impacts the environment.

To date, the EKC theory has been the focus of a large number of scholarly investigations. They made contributions to the literature on the environmental Kuznets curve hypothesis using a range of econometric techniques and variables.

Table 1*Literature on Environmental Kuznets Curve Hypothesis*

Research Paper	Period	Specified Dependent Variable	EKC holds?	Region	Econometric Method
(Erdogan et al., 2020)	1990-2014	CO2, GDP, GDP2, oil price, green power use, fossil fuel use, trade openness.	Valid for FMOLS DOLS, not valid for AMG.	25 OECD countries	FMOLS, DOLS, AMG
(Apergis, 2016)	1960-2013	CO2, GDP, GDP2.	Yes for 15 countries	15 countries	CCE, FMOLS
(Jebli et al., 2016)	1980-2010	CO2, GDP, GDP2, export, import, renewable energy, CPI, population.	Yes	25 OECD countries	Pedroni Panel Cointegration., FMOLS, DOLS, Granger Causality
(Kang, 2021)	2005-2015	CO2 emissions included in total exports, trade surplus/deficit, GDP, energy, consumption, renewable energy consumption.	Yes	OECD and non-OECD countries	POLS, FE, RE, Pedroni Cointegration, Granger Causality
(Maneejuk & Yamaka, 2022)	1970-2016	GDP, SO2, population, energy consumption, the financial development index.	Yes	22 OECD countries	Panel smooth transition kink regression (PSTKR)
(Churchill et al., 2018)	1870-2014	CO2, GDP, GDP2, population, trade openness.	Yes for 9 countries	20 OECD countries	MG, CCEM, AMG, PMG
(Lau et al., 2019)	1995-2015	CO2, GDP, GDP2, nuclear electricity % of total,	Yes	18 OECD	GMM, FMOLS,

		electricity production sourced renewables, trade openness.		countries	Dumitrescu-Hurlin Causality Test
(Vo et al., 2022)	1990–2015	CO2, GDP, renewable electricity usage % in total energy, non-renewable energy usage % in total energy, trade openness, financial development index.	No	37 OECD countries	CS-ARDL
(Aminu et al., 2023)	1995-2019	CO2, FDI, industrial performance, energy usage, industrial employment rate	Yes	Sub-Saharan African Countries	FMOLS, Pedroni Cointegration
(Kalim et al., 2023)	2008-2018	CO2 emissions, renewable energy consumption, population density, money supply, technology readiness, innovation, higher education and training, institutional quality	Yes	147 countries	FMOLS
(Wang et al., 2023)	1990-2018	CO2, GDP, human capital, green energy use, natural resources, trade openness	Yes	208 countries	GMM, FMOLS, Pedroni, Kao Cointegration
(Fakher et al., 2023)	1994-2019	GDP, fossil fuel use, green power use, population density, trade openness.	Yes	13 OPEC countries	Westerlund Cointegration, Dynamic Seemingly Unrelated Regression
(Dogan & Seker, 2016)	1975-2011	CO2, GDP, energy use, financial development, trade openness.	Yes	16 OECD countries	Dynamic Seemingly Unrelated Regression
(Zhang et al., 2020)	1990–2013	Ecological disorder, renewable energy, economic	Yes	15 developing	CS-ARDL

		growth, capital formation, population growth.		Asian countries	
(Zhongwei & Liu, 2022)	1995 to 2019	Renewable electricity consumption, environment related technologies, trade openness, human capital, GDP.	Yes	G20 economies	CS-ARDL, AMG, CCEMG
(Mekhzoumi et al., 2022)	1980-2019	CO2, GDP, energy consumption, globalization index, population density.	Yes	31 industrialized countries	MG, CS-DL, CS-ARDL
(Mehmood et al., 2022)	1990–2020	CO2, globalization index, GDP, natural resource rents (% of GDP), number of patents, ageing population.	Yes	G11 countries	Westerlund Cointegration, CS_ARDL
(Churchill et al., 2020)	1990-2017	CO2, Gross State Product, urbanization, trade openness of States.	Yes	8 Australian States	MG, AMG, CCEMG, DCCEMG, DCCEMG-IV

2.3. Theoretical Framework

The Environmental Kuznets Curve has its basis from Simon Kuznets's influential study (Kuznets, 1955, p. 14), he suggests the analysis of household income, excluding individuals in education or retirement, into distinct shares or quantiles. The common expectation is that, with the advancement of an economy, the distribution of income will initially exhibit a deterioration, followed by a recovery as the economy attains higher levels of development.

This study examines the link between economic development and its environmental implications as the theoretical foundation. According to the environmental Kuznets curve hypothesis, there is an increase in environmental deterioration during the early stages of economic expansion and industrialization because of higher resource use and energy needs. However, as economies advance and societies achieve greater affluence, a turning point is reached, resulting in a reduction of environmental degradation. This shift is credited to an increased environmental awareness and the adoption of advanced technologies and sustainable practices.

The EKC hypothesis gained prominence following the research by (Grossman & Krueger, 1991, p. 3) and (Grossman & Krueger, 1995, p. 353), which investigated how lowering barriers to trade affected the environment. Their findings revealed that lowering trade barriers can influence the environment by expanding economic activity, altering its composition, and leading to changes in production methods. Specifically, they observed that concentrations of SO₂ and smoke tend to increase with national income but decrease at higher levels of GDP.

In analyzing the EKC hypothesis, researchers commonly employ a model that incorporates various explanatory variables, including factors other than CO₂. The following equation represents a typical formulation:

$$CO2_{it} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 GDP_{it}^2 + \alpha_3 GDP_{it}^3 + \alpha_4 Z_{it} + \varepsilon_{it} \quad (1)$$

Carbon dioxide emissions, in Equation-1 are determined with the parameters α_0 , α_1 , α_2 and α_3 , which represent the coefficients associated with GDP_{it} , (GDP_{it}^2) , and (GDP_{it}^3) , respectively. The parameter α_4 represents the coefficient for other relevant variables denoted as Z_{it} , while ε_{it} captures the error term.

A thorough examination of the Environmental Kuznets Curve hypothesis and its implications for understanding the connections between economic development, environmental degradation, and related factors is made possible by this theoretical framework along with the addition of extra explanatory variables.

Energy consumption, particularly that which comes from fossil fuels, has been a major factor in the production of greenhouse gas emissions and consequent climate change (IEA, 2023). Addressing this issue involves the integration of cleaner technologies through technological innovations. Moreover, the implementation of robust governmental policies and regulations is instrumental in advocating sustainable practices, setting emission standards, and facilitating the shift towards a low-carbon economy.

Within the theoretical framework employed in this study, several key factors are considered. Firstly, the influence of income levels on environmental degradation is examined. Higher incomes often correspond to increased consumption patterns and resource utilization. The role of international trade and globalization is also analyzed, as they can shape production and consumption patterns, thereby affecting environmental outcomes on both domestic and global scales.

This study aims to offer significant details into the relationships between government final consumption expenditure (LGFCE), intra-industry trade (IIT), primary energy consumption per capita (LENCONS), trade openness (LTROPEN), and carbon emissions (LCO2) by utilizing this theoretical framework. Through a comprehensive analysis, this research will contribute to a deeper understanding of the underlying mechanisms, providing policymakers with informed strategies to achieve sustainable development goals while minimizing environmental impact.

$$\begin{aligned} \text{LCO2}_{it} = & \beta_0 + \beta_1 \text{LGDP}_{it} + \beta_2 \text{LGDP}_{it}^2 + \beta_3 \text{IIT}_{it} + \beta_4 \text{LENCONS}_{it} + \beta_5 \text{LTROPEN}_{it} \\ & + \beta_6 \text{LGFCE}_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Expected coefficient signs of the model are as follows:

- $\beta_1 = \beta_2 = 0$ No relationship
- $\beta_1 > 0, \beta_2 = 0$ Linear relationship
- $\beta_1 < 0, \beta_2 = 0$ Decreasing relationship
- $\beta_1 < 0, \beta_2 > 0$ U-shaped relationship
- $\beta_1 > 0, \beta_2 < 0$ Inverted U-shaped relationship

2.4. Empirical Model and Data

The Environmental Kuznets Curve (EKC) theory is examined in this study with regard to OECD countries from 1970 to 2019. For 23 OECD nations, annual statistics on CO2 emissions, real GDP per capita, trade openness, intra-industry trade (IIT), primary energy use per capita, and government final consumption expenditure are evaluated. Intra-industry trade (IIT) is computed based on SITC-1 classifications, encompassing various sectors. The model utilizes variables detailed in Table 2.

Table 2

The sources and variable definitions.

Variable	Definition	Source
LCO2	Metric tons of CO2 emissions per person.	(The WorldBank, 2023)
LGDP	Real gross domestic product per capita.	(The WorldBank, 2023)
LGDP2	Due to multicollinearity, orthogonal term is assigned to the model as proxy.	(The WorldBank, 2023)
IIT	Intra-industry trade (Grubel-Lloyd index) calculated from SITC-1 classifications	(UN Comtrade, 2022)

LENCONS	Primary energy use (gigajoule per capita)	(BP, 2021)
LTROPEN	Trade % of GDP	(The WorldBank, 2023)
LGFCE	Government final consumption expenditure	(The WorldBank, 2023)

In the following sections, the tests employed in the model are explained in theoretical terms.

2.4.1. Cross Sectional Dependency

Cross-sectional dependency is tested using the Pesaran CD test (Pesaran, 2004, p. 5). The test's hypothesis is;

$$H_0: \rho_{ij} = 0, H_a: \rho_{ij} \neq 0,$$

where 'i' and 'j' are cross sectional units, and for unbalanced panel;

$$CD = \sqrt{\frac{2}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \sqrt{T_{ij} \hat{\rho}_{ij}} \right) \quad (3)$$

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^T e_{it} e_{jt}}{(\sum_{t=1}^T e_{it}^2)^{1/2} (\sum_{t=1}^T e_{jt}^2)^{1/2}} \quad (4)$$

e_{it} represents residuals, T is the number of observations, and the null hypothesis indicates cross section independence, $CD \sim N(0,1)$.

2.4.2. Homogeneity

The slope homogeneity test is used (Pesaran & Yamagata, 2008, p. 62).

$$y_{it} = \beta_i + x_{1it}\beta_{1i} + x_{2it}\beta_{2i} + \varepsilon_{it} \quad (5)$$

Or it can be expressed as,

$$y_{it} = z_{1it}\phi_i + x_{2it}\gamma_{2i} + \varepsilon_{it} \quad (6)$$

Where,

$$z_{1it} = (1, x_{1it}), \phi_i = (\beta_i, \beta_{1i}) \quad (7)$$

X_{1it} as k_1 regressors and X_{2it} has k_2 regressors. We are interested in the coefficients β_i , and the hypothesis of slope homogeneity is:

$$H_0: \beta_{2i} = \beta_2 \text{ for all } i=1, \dots, N$$

The model of (Pesaran & Yamagata, 2008, p. 62) is as following for slope coefficient homogeneity:

$$\tilde{\Delta} = \sqrt{N} \left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}} \right) \quad (8)$$

And Δ is $\sim N(0,1)$ under the null hypothesis. Also, adjustment coefficient homogeneity,

$$\tilde{\Delta}_{adj} = \sqrt{N} \sqrt{\frac{T+1}{(T-k-1)}} N^{-1}\tilde{S} - 2k \quad (9)$$

$$S = \sum_{i=1}^N (\tilde{y}_i - \tilde{y}_{WFE}) \frac{X_i' M_{\tau} X_i}{\tilde{\sigma}^2} (\tilde{y}_i - \tilde{y}_{WFE}) \quad (10)$$

WFE denotes weighted fixed effects, M_{τ} , $\tilde{\sigma}^2$ and k are matrix. Together, these elements contribute to the computation of 'S' in equation-10, wherein S is the sum of a specific expression involving weighted fixed effects, matrices, and variance terms.

This calculation is integral to the homogeneity test methodology proposed by (Pesaran & Yamagata, 2008, p. 62).

2.4.3. Unit Root Test

The unit root test, which was introduced by (Pesaran, 2003) as well as (Pesaran, 2007), is used in this investigation to deal with the issues of heterogeneity and cross-sectional dependency. The covariate augmented Dickey Fuller test (CADF test), developed by (Pesaran, 2007), adds the lagged cross-sectional mean and its first difference to the augmented Dickey Fuller (ADF) model. Whether there is a mismatch between the number of cross-sections and the time period, or the opposite, this method effectively takes cross-sectional dependency into account and produces reliable and effective estimates for panel data analysis.

The CADF test is advantageous because it retains its efficiency even when ($N > T$) or vice versa ($T > N$). T refers to time span and N refers to cross sectional units. This is particularly useful in situations where the panel data has an imbalanced structure. (Pesaran, 2007).

The general representation of the test is;

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \beta_i \bar{y}_{t-1} + \sum_{j=0}^k \gamma_{ij} \Delta y_{it-1} + \sum_{j=0}^k \delta_{ij} y_{it-1} + \varepsilon_{it} \quad (11)$$

The answer to the question of whether a unit root is present in the panel is reliant on the computation of the arithmetic mean of the CADF values for every distinct cross section. Therefore, the CIPS (Cross-Sectionally Augmented Im-Pesaran-Shin) test statistic, which is the average of the CADF model, is utilized. The following are the test's hypotheses: $H_0: \delta_i = 0$ for all i , (There is a unit root in all cross sections of the series) $H_a: \delta_i < 0$. (There is no unit root in at least one cross section of the series). It has the following mathematical representation:

$$CIPS = N^{-1} \sum_{i=1}^N CADF_i \quad (12)$$

Here, CADF stands for the ADF test statistic for the " i^{th} " unit, and N is the number of cross-sectional units.

2.4.4. Cointegration Test

Westerlund error-correction-based panel cointegration tests, as suggested by Persyn, (Persyn & Westerlund, 2008) also (Westerlund, 2007), are used to address the presence of cross-sectional dependency in the model. These tests are used to investigate whether there is cointegration by examining the presence of error correction within each member of the panel or the panel collectively. According to the error correction model, every variable is integrated of order one ($I(1)$).

$$\Delta y_{it} = \hat{\delta}'_i d_t + \hat{\alpha}_i y_{i,t-1} + \hat{\lambda}'_i x_{i,t-1} + \sum_{j=-q_i}^{p_i} \hat{\gamma}_{ij} \Delta x_{i,t-j} + \sum_{j=1}^{p_i} \hat{\alpha}_{ij} \Delta y_{i,t-j} + \hat{e}_{it} \quad (13)$$

λ_i is a long-run parameter while γ_i, α_i are short-run parameters and can be estimated with/without constant, trend, with constant and trend options.

Along with an error correction term, the error correction model also adds lags in the dependent variable's and explanatory variables' differences. The coefficient α_i measures the speed at which the series corrects towards the long-run equilibrium. The G_α and G_t test statistics evaluate the hypothesis.

$$H_0: \alpha_i = 0 \text{ for all } i \text{ versus}$$

$$H_a: \alpha_i < 0 \text{ for at least one } i.$$

These statistics are computed based on weighted averages of estimated α_i values and t-values.

Evidence of cointegration in at least one cross-sectional unit is provided by the rejection of H_0 . To test, the P_α and P_t test statistics combine data from all cross-sectional units. The panel as a whole may be cointegrated if H_0 is rejected.

Two forms of valuation are allowed for the autoregressive parameter: individual-specific or for the entire panel. In the first type of statistics called "Panel Variance Ratio Statistics," (P_α and P_t) the autoregressive parameter is assumed as constant across units. "Group Mean Variance Ratio Statistics," (G_α and G_t) the autoregressive parameter varies from unit to unit. To obtain the group mean statistics G_a and G_t , in the initial stage, the model is estimated using OLS for each unit. The lag length (p_i) varies across units. Therefore, in cases where the panel is heterogeneous, these statistics are more reliable. (Westerlund, 2007)

In the second stage α_i is estimated and G_α and G_t statistics are obtained.

$$\hat{\alpha}_i(1) = 1 - \sum_{j=1}^{p_i} \hat{\alpha}_{ij} \quad (14)$$

$$G_\tau = \frac{1}{N} \sum_{i=1}^N \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad (15)$$

$$G_\alpha = \frac{1}{N} \sum_{i=1}^N \frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \quad (16)$$

P_α and P_t test statistics are computed using panel-wide data. The initial step mirrors the process for obtaining group mean statistics. This involves selecting the suitable lag length (p_i) calculating d_t for Δy_{it} and y_{it-1} , determining lag values for Δy_{it} , obtaining current and lagged values of x_{it-i} and Δx_{it} , and computing residuals from the regression. (Westerlund, 2007)

$$\Delta \tilde{e}_{it} = \Delta y_{it} - \hat{\delta}'_i d_t - \hat{\lambda}'_i x_{i,t-1} - \sum_{j=1}^{p_i} \hat{\alpha}_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \hat{\gamma}_{ij} \Delta x_{i,t-j} \quad (17)$$

$$\tilde{e}_{it-1} = y_{it-1} - \hat{\delta}'_i d_t + \hat{\lambda}'_i x_{i,t-1} + \sum_{j=1}^{p_i} \hat{\alpha}_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \hat{\gamma}_{ij} \Delta x_{i,t-j} \quad (18)$$

Next, we proceed to estimate the error correction parameter, α , and its standard error by utilizing $\Delta \tilde{y}_{it}$ and $\tilde{y}_{i,t-1}$. Specifically, we calculate,

$$\hat{\alpha} = \left(\sum_{i=1}^N \sum_{t=2}^T \tilde{y}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^N \sum_{t=2}^T \frac{1}{\hat{\alpha}_i(1)} \tilde{y}_{it} \quad (19)$$

The standard error is estimated as,

$$SE(\hat{\alpha}) = (\hat{S}_N^2)^{-1} \sum_{i=1}^N \sum_{t=2}^T \tilde{y}_{i,t-1}^2 \quad (20)$$

In the last step the statistics for the panel are employed,

$$P_{\tau} = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \quad (21)$$

And

$$P_{\alpha} = T_{\hat{\alpha}}$$

2.4.5. Estimators Employed in the Study

All models are estimated with Stata 18. As for the Mean Groups Estimator (MG) `xtmg` command (Eberhardt, 2013) is used. `xtmg` command offers several estimation methods for panel time series data. These methods account for the presence

of varying slope coefficients among different members within a group and also address the issue of correlation among panel members, also known as cross-section dependence.

To estimate heterogenous, cross sectional dependent panel data, consider the following model; for each 'i' falling between 1 to N and t falling between 1 to T, we have the equation,

$$y_{it} = \beta_i x_{it} + u_{it} \quad (22)$$

In this equation, the u_{it} represents the error term that includes both observed factors and the individual error term ε_{it} .

$$u_{it} = \alpha_{1i} + \lambda_t f_t + \varepsilon_t \quad (23)$$

Where α_{1i} represents the group fixed effects capturing time-invariant heterogeneity across groups, and λ_i represents the unobserved common factor with heterogenous factor loadings and can capture time-varying heterogeneity and cross section dependence.

A standard technique is followed by all Mean Group (MG) type estimators and consists of the following steps: First, ordinary least squares (OLS) regressions unique to N groups are performed, where each regression focuses on a particular group. Subsequently, the estimated coefficients obtained from each group-specific regression are aggregated by taking their average across all groups. This step aims to provide an overall estimation that accounts for the characteristics of multiple groups. (Eberhardt, 2013)

By including trend, the Mean Group estimator is used to estimate the first heterogeneous static model. (Pesaran & Smith, 1995) presented the Mean Group (MG) estimator; nevertheless, it does not have a dedicated technique to manage cross-section dependency. It operates under the assumption that the unobservable factors, represented by λ_{ift} can be effectively modeled using a linear trend. As a result, the equation-22 is individually estimated for each panel member 'i'. This estimation

includes an intercept term to account for fixed effects and, if it is necessary, a linear trend term to capture time-varying unobservable factors. The coefficients β_i obtained from these individual estimations are averaged across all panel members. The weights can be employed in the averaging process, although the standard implementation typically employs an unweighted average. (Eberhardt, 2012), (Eberhardt, 2013).

The CCEMG (Common Correlated Effects Mean Group) estimator, which was created by (Pesaran, 2006) is the second estimator with trend that is used to address the empirical framework shown in the preceding equations. Cross-section dependency, time-varying unobservable variables that have different effects on panel members, and identification problems when the regressor contains f_t are all involved.

The CCEMG adds cross-section/panel averages of the dependent and independent variables $\bar{y}_t, \bar{x}_t$ to the group-specific regression equation in order to solve the identification problem and take into account the unobserved common factor. The coefficients $\hat{\beta}_i$, representing the heterogeneous impact, are then averaged across panel members using possible weightings.

In practical situations, the average estimates and coefficients computed for the cross-section averaged variables lack significance. Their inclusion serves just to reduce the bias resulting from the unobservable common component.

Cross-Section Augmented ARDL (CS-ARDL) is the third econometric technique we used to estimate the long-run and short-run coefficients. CS-ARDL focuses on work by (Chudik & Pesaran, 2013) as well as (Chudik et al., 2016a). We implemented `xtdcce2` (Ditzen, 2019) command in Stata. CS-ARDL(p_y, p_x) model which can be specified as:

$$y_{i,t} = \alpha_i + \sum_{l=1}^{p_y} \lambda_{il} y_{i,t-l} + \sum_{l=0}^{p_x} \beta_{il} x_{i,t-l} + \sum_{l=0}^{p_z} \psi'_{il} \bar{z}_{t-l} + e_{it} \quad (24)$$

The CS-ARDL approach follows a two-step process, beginning with the estimation of short-run coefficients, and the long-run coefficients. This methodology has an advantage of obtaining a comprehensive set of estimates for both short-run and

long-run coefficients. This model can be transformed into an Error Correction Model (ECM) to ensure consistency in the estimation of long-run coefficients. To account for cross-sectional dependence, the extended formulation incorporates cross-sectional averages into the equation mentioned above.

$$y_{i,t} = \alpha_i + \sum_{l=1}^{p_y} \lambda_{l,i} y_{i,t-l} + \sum_{l=0}^{p_x} \beta_{l,i} x_{i,t-l} + \sum_{l=0}^p \bar{v}_{t-l} + e_{i,t} \quad (25)$$

where,

$$\bar{v}_{t-1} = (\bar{y}_{i,t}, \bar{x}_{i,t-1}) \quad (26)$$

The long-run coefficients are determined by performing the following calculations:

$$\theta_{CS-ARDL,i} = \frac{\sum_{l=0}^{p_x} \hat{\beta}_{l,i}}{1 - \sum_{l=1}^{p_y} \lambda_{l,i}} \quad (27)$$

(Pesaran et al., 1999)'s Pooled Mean Group Estimator is employed in the model as well. xtmpg command is used. Heterogeneity only exists for the short-run coefficients. Heterogeneity is allowed in the model other than ϕ . The model can be stated as:

$$\Delta Y_{it} = \phi(Y_{it-1} - \theta'X_{it-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta Y_{it-j} + \sum_{j=0}^{p-1} \delta_{ij} \Delta X_{it-j} + \mu_i + \varepsilon_{it} \quad (28)$$

2.5. Estimation Results

This section shows the outcomes of our investigation spanning 1970 to 2019, with 23 OECD countries. Using intra-industry trade, energy consumption, trade openness, and government final consumption and spending, the main goal is to

evaluate the validity of the Environmental Kuznets Curve Hypothesis. The descriptive statistics of the variables in our model are shown in detail in Table 3, and the correlation matrix illustrating the links between the variables is presented in Table 4. Table 5 shows the Variance Inflation Factor (VIF) for each individual variable as well as the total model to provide insights into multicollinearity. The cross-section dependence test findings for the variables and the overall model are given in Tables 6 and 7, respectively. The results of the tests to determine slope homogeneity are shown in Table 8, and the results of the unit root tests for the variables are shown in Table 9. The estimation outcomes of the Westerlund cointegration test are displayed in Table 10. Tables 11 and 12 include the findings of long-run country-specific heterogeneous regression using the CS-ARDL estimator, as well as details on model estimates using the CCEMG, MG, PMG, and CS-ARDL estimators.

This study suggests the model below:

$$\begin{aligned} \text{LCO2}_{it} = & \beta_0 + \beta_1 \text{LGDP}_{it} + \beta_2 \text{LGDP}_{it}^2 + \beta_3 \text{IIT}_{it} + \beta_4 \text{LENCONS}_{it} + \beta_5 \text{LTROPEN}_{it} \\ & + \beta_6 \text{LGFCE}_{it} + \varepsilon_{it} \end{aligned} \quad (29)$$

As for the PMG estimator,

$$\Delta \text{LCO2}_{it} = \phi_i (\text{LCO2}_{it-1} - \theta' X_{it-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{it-j} + \sum_{j=0}^{p-1} \delta_{ij} \Delta X_{it-j} + \mu_i + e_{it} \quad (30)$$

Table 3

Descriptive Statistics

Variable	Mean	Median	Max	Min	Std Dev	N
LCO2	1.938	2.01	3.097	0.077	0.633	1150
LGDP	9.374	9.593	11.298	5.622	1.117	1149
LGDP2	0	719.412	6087.072	-37043	5430.891	1149
IIT	0.675	0.747	0.917	0.208	0.187	1148
LENCONS	4.974	5.099	6.096	2.713	0.688	1150

LTROPEN	3.997	4.021	5.53	2.208	0.54	1139
LGFCE	2.857	2.926	3.33	1.983	0.279	1139

By observing the descriptive statistics, we can state the following key points: the mean LCO2 is approximately 1.94, with a median of 2.01. The data points to a disparity in CO2 emissions amongst the countries, ranging from a minimum of 0.08 to a high of 3.10. The standard deviation of 0.63 suggests a moderate level of dispersion around the mean. The average LGDP is around 9.37, with a median of 9.59. The range of LGDP spans from 5.62 to 11.30, indicating substantial disparities in economic output among the countries. The GDP per capita standard deviation of 1.12 indicates a very high degree of variability. The mean of LGDP2 is extremely close to zero (-0.00000042), because we used the orthogonal term, indicating that the distribution of squared LGDP values is centered around zero. The data exhibits a wide range, with values ranging from a negative value of -37,042.96 to a positive value of 6,087.07. The large standard deviation of 5,430.89 further demonstrates the significant variability in squared LGDP. The average IIT is approximately 0.67, with a median of 0.75. The range, which goes from 0.21 to 0.92, shows that the nations' levels of intra-industry trade differ. The relatively low standard deviation of 0.19 suggests a moderate level of dispersion around the mean. The mean LENCONS is approximately 4.97, with a median of 5.10. The data shows differences in patterns of energy use, ranging from a minimum of 2.71 to a high of 6.10. The standard deviation of 0.69 suggests a moderate level of variability in energy consumption per capita. The average LTROPEN is around 3.99, with a median of 4.02. The range of LTROPEN extends from 2.21 to 5.53, suggesting varying degrees of trade openness among the countries. The standard deviation of 0.54 indicates a moderate level of dispersion around the mean. The mean LGFCE is approximately 2.86, with a median of 2.93. The data ranges from a minimum of 1.98 to a maximum of 3.33, indicating differences in government consumption expenditure across the countries. The standard deviation of 0.28 suggests a relatively low level of variability in government consumption expenditure.

Table 4*Correlation Matrix*

Variables	LCO2	LGDP	LGDP2	IIT	LENCONS	LTROPEN	LGFCF
LCO2	1.000						
LGDP	0.562	1.000					
LGDP2	0.462	0.645	1.000				
IIT	0.374	0.476	0.442	1.000			
LENCONS	0.875	0.707	0.482	0.398	1.000		
LTROPEN	0.160	0.469	0.258	0.470	0.320	1.000	
LGFCF	0.559	0.550	0.450	0.421	0.661	0.395	1.000

LCO2 shows a strong positive correlation with energy consumption (LENCONS) at 0.8751. This suggests that nations with higher energy use tend to have more CO2 emissions per capita. LCO2 also demonstrates a positive correlation with LGFCF (log of government consumption expenditure) at 0.5587. This implies that countries with greater government consumption expenditure tend to have higher CO2 emissions per capita. LGDP (log of GDP per capita) exhibits a positive correlation of 0.5617 with LCO2. Orthogonal term of LGDP2 has a correlation of 0.4624 with LCO2. Although the correlation is weak, it suggests that countries with higher values for the orthogonal term LGDP2 (derived from regressing LGDP on LGDP2) may have slightly higher CO2 emissions per capita. Intra-industry trade (IIT) has a weak positive correlation of 0.3740 with LCO2. This suggests that nations with higher intra-industry trade index may also have slightly higher CO2 emissions per capita. Trade openness (LTROPEN) shows a weak positive correlation of 0.1597 with LCO2. This implies that countries with greater trade openness may have slightly higher CO2 emissions per capita.

These findings provide insights into the correlation between carbon emissions and the various variables analyzed. Further analysis and modeling will be necessary to

understand the underlying factors influencing CO2 emissions per capita, which will be detailed in the next section of this study.

Table 5 Variance Inflation Factor (VIF) Values

Variable	VIF	1/VIF
LGDP	3.01	0.333
LGDP2	1.86	0.539
IIT	1.55	0.644
LENCONS	2.58	0.388
LTROPEN	1.51	0.662
LGFCF	1.98	0.504
Mean VIF	2.08	

Addressing potential multicollinearity concerns in the model, an orthogonal term (Ericson & Zinoviev, 2001, p. 230) and (O'Neill, 2006, p. 102) can be incorporated as a substitute variable for squared GDP. This involves regressing GDP2 with GDP and utilizing the resulting residual. Based on the provided VIF values, it can be affirmed that there is no noteworthy issue of multicollinearity in the model. The introduction of the orthogonal term for LGDP2 has effectively mitigated potential collinearity concerns. Both the individual variable VIF values and the mean VIF value (2.08) are below the widely accepted threshold of 5, indicating that the linear dependence between predictor variables is not a cause for concern. This methodology is suggested by (Panayotou, 1997, p. 470) and (Draper & Smith, 1998, p. 370), and used in studies (Sinha & Bhattacharya, 2017, p. 882), (Villanthenkodath & Arakkal, 2020, p. 36517), (Rodríguez García et al., 2021, p. 12) and (Chandra Voumik et al., 2022, p. 4).

These results show that the model's variables, which do not exhibit multicollinearity that would skew the interpretation of the regression results, can be thought of as separate contributions to the explanation of CO2 emissions per capita.

Table 6*Variable specific cross sectional dependence test*

Variable	CD-Test	p-value
LCO2	18.29	0.000
LGDP	102.78	0.000
LGDP2	69.78	0.000
IIT	48.75	0.000
LENCONS	49.66	0.000
LTROPEN	72.89	0.000
LGFCF	33.76	0.000

Notes. (Pesaran, 2004, p. 5) H_0 : cross-section independence $CD \sim N(0,1)$.

Based on the cross-sectional dependence test results, all variables (LCO2, LGDP, LGDP2, IIT, LENCONS, LTROPEN, LGFCF) exhibit significant cross-sectional dependence. The substantial CD-test statistics for each variable suggest that the cross-sectional units (countries) in the panel are highly dependent on one another.

The cross-sectional independent null hypothesis is rejected by the p-values that were obtained, all of which are 0.000. This shows a correlation among cross-sectional units, signifying that observations from different countries are not independent of each other.

Cross-sectional dependency in panel data may be detected with the use of the CD-test, which also emphasizes the necessity of taking this reliance into account while doing statistical analysis. When evaluating the findings and carrying out additional panel data analysis, it is crucial to take cross-sectional dependency into account.

Table 7*Cross sectional dependence test for the model*

Cross Sectional Dependence Test	CD	Prob Value
CD-Test	-2.12	0.034**

Note. ** indicates significance at 5%. Average correlation coefficients (Pesaran, 2004, p. 5) CD test. H_0 : cross-sectional independence, $N(0,1)$.

$$H_0: \beta_i = 0$$

Due to the unbalanced nature of our data and the requirement for balanced panel data for the Breusch Pagan LM test, it could not be used to assess cross-sectional dependency. Based on the CD test results, the model exhibits cross-sectional dependence. The CD test statistic of -2.12 indicates that there is of cross-sectional dependence, and the p-value of 0.034 suggests the significance at 5%. We estimated cross-sectional dependence the model is estimated with the MG estimator, CD results after the estimators are also presented in Table 11.

Cross-sectional dependence implies that the observations within the panel (countries) are not independent of each other and that there are correlations or interdependencies among the cross-sectional units. The validity of statistical inference and the effectiveness of parameter estimations may be impacted by this breach of the cross-sectional independence assumption.

To address cross-sectional dependence, considering 2nd generation unit root tests is mentioned. Unit root tests are commonly used to examine the presence of non-stationarity in time series data, and 2nd generation tests specifically account for cross-sectional dependence. These tests can provide further insights into the nature and extent of cross-sectional dependence to help analyze the panel data more appropriately.

Table 8*Test for slope homogeneity (Pesaran & Yamagata, 2008)*

Statistic	Value	P-Value
Δ	35.975	0.000
Δ_{adj}	39.298	0.000
Δ_{hac}	38.154	0.000
$(\Delta_{hac})_{adj}$	41.678	0.000

Notes. Testing for slope heterogeneity. Δ and Δ_{adj} (Pesaran & Yamagata, 2008)

H_0 : slope coefficients are homogenous. Δ_{hac} and $(\Delta_{hac})_{adj}$ (Blomquist & Westerlund, 2013)

hac: Hac refers to heteroskedasticity, autocorrelation consistent. H_0 : slope coefficients are homogenous.

There is considerable amount of slope heterogeneity in the model. Strong evidence opposing the null hypothesis of slope homogeneity is shown by the enormous test statistics and the p-values of 0.000 for every variable.

The homogeneity test examines whether the slope coefficients (parameters) for the variables are the same across all countries in the panel. The null hypothesis assumes slope homogeneity, implying that the relationships between the variables are consistent across all countries. However, the test results indicate significant heterogeneity in the slope coefficients, suggesting that the relationships between the variables differ across countries.

The use of heteroskedasticity and autocorrelation consistent (HAC) estimators in the test further accounts for potential issues of heteroskedasticity and autocorrelation in the data. We reject H_0 in the HAC test showing that the slope coefficients are still heterogeneous even in the presence of these considerations.

The presence of slope heterogeneity shows that the slope coefficients can change across countries. It is important to consider this heterogeneity when interpreting the results and making inferences from the model. When developing

policies or plans based on the study, it is important to consider how the correlations between variables vary throughout nations.

Table 9

Covariate Augmented Dickey Fuller (CADF) Test (Pesaran, 2003) (Pesaran, 2007)

Variables	Level				1 st Difference			
	Constant		Constant & Trend		Constant		Constant & Trend	
	t-bar	p-value	t-bar	p-value	t-bar	p-value	t-bar	p-value
LCO2	-1.497	0.918	-2.546	0.130	-4.200	0.000	-4.384	0.000
LGDP	-2.799	0.003	0.950	0.829	-10.492	0.000	-8.806	0.000
LGDP2	0.242	0.596	-1.112	0.133	-9.117	0.000	-7.452	0.000
IIT	-1.403	0.080	-1.602	0.055	-11.321	0.000	-9.904	0.000
LENCONS	-1.850	0.342	-2.638	0.052	-3.931	0.000	-4.144	0.000
LTROPEN	-2.675	0.004	0.200	0.579	-9.852	0.000	-7.719	0.000
LGFCE	-1.248	0.106	0.869	0.808	-7.482	0.000	-5.030	0.000

Based on (Pesaran, 2003)'s CADF unit root test results, the variables in the model are integrated of order 1, denoted as I(1). This indicates that the variables are non-stationary in their original form. However, after taking the first differences of the variables, they become stationery and exhibit stationarity properties.

The unit root test results suggest that the series LCO2, LGDP, LGDP2, IIT, LENCONS, LTROPEN, and LGFCE are all non-stationary in their levels. This means that these variables have a stochastic trend and do not revert to a constant mean over time.

Regarding the presence of a trend component, the unit root test results provide evidence suggesting there is a trend for LGDP and LTROPEN. Both the constant and constant with trend specifications reject the H_0 of a unit root, indicating that these variables have a trend component. The unit root tests, however, do not offer solid proof that a trend exists for the other variables.

When examining the links between the variables and conducting additional econometric modeling for panel time series, it is crucial to take into account their stationarity qualities. Taking the first differences of the variables helps remove the stochastic trend and allows for the analysis of stationary time series data.

Table 10

Westerlund Cointegration Test (Westerlund, 2007)

	Bivariate Model						Full Model
	LGDP	LGDP2	IIT	LENCONS	LTROPEN	LGFCF	
G_{τ}	0.205	-0.505	-0.927	-1.678***	-0.047	-0.210	-2.869***
G_{α}	0.190	-0.224	-2.359	-4.496*	-0.351	-0.663	-11.641***
P_{τ}	0.314	-3.023	-4.033	-6.945***	-0.435	-1.031	-11.225
P_{α}	0.037	-0.240	-1.507	-2.467**	-0.107	-0.456	-7.590

Note. Westerlund Cointegration Test is employed. (Westerlund, 2007) Bootstrap errors are estimated on 500 repetitions. H_0 : No cointegration. Lag and lead are 1. The significance levels for (***), (**), (*) are 1%, 5%, 10%, respectively.

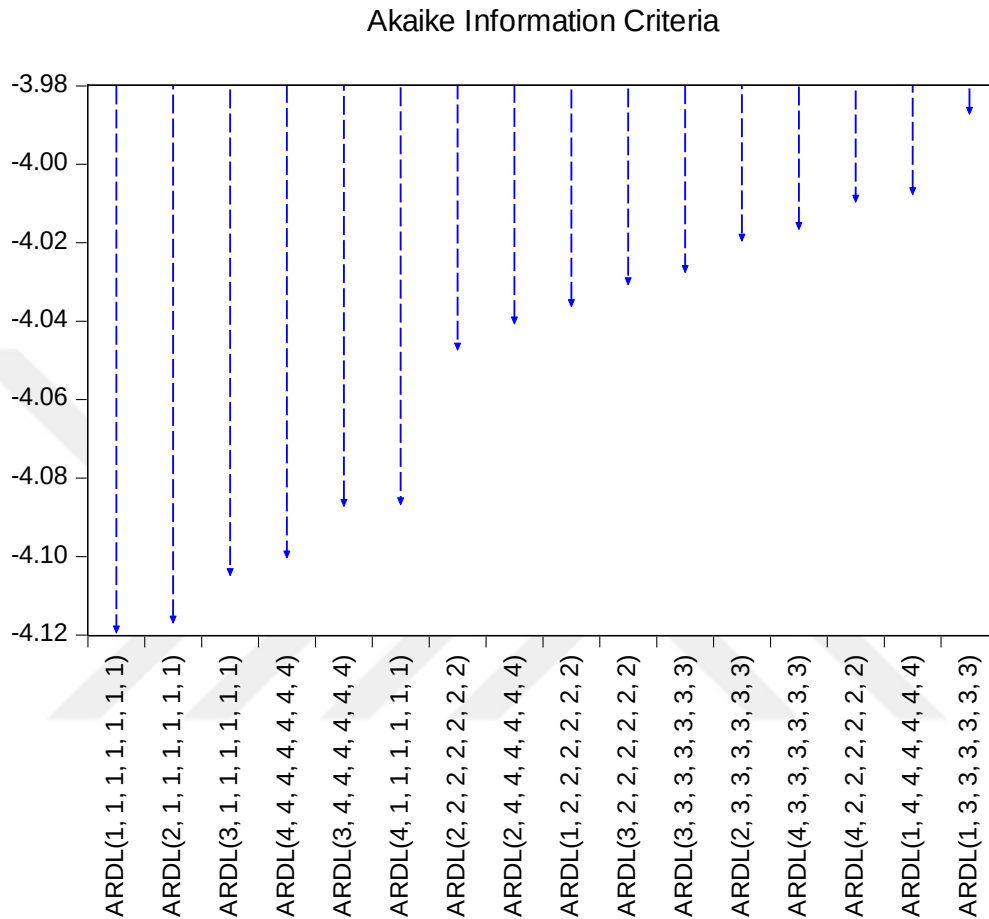
According to Westerlund Panel Cointegration test, related to the full model values, as for G_{τ} , the test statistic is -2.869 at 5%. The robust p-value is also provided, which is 0.004. The p-values strongly show that null hypothesis, suggesting no cointegration for G_{τ} . For G_{α} , the test statistic is -11.641, the z-value is 1.275, and the p-value is 0.899. The robust p-value is 0.002. The p-values suggest strong evidence against the null hypothesis indicating the absence of cointegration for G_{α} .

The test statistic, z-value, and p-value for P_{τ} , are -11.225, -0.864, and 0.194, respectively. 0.138 is the robust p-value. The p-values show that there is not enough data to disprove the null hypothesis, which states that P_{τ} does not exhibit cointegration. The result of the test statistic, z-value, and p-value for P_{α} , are -7.590, 1.324, and 0.907, respectively. The p-values indicate that there is not enough data to disprove the null hypothesis, which states that P_{α} does not exhibit cointegration.

Lag Selection Criteria for PMG estimator (ARDL approach) is as follows:

Figure 1

Akaike Information Criteria



Based on the Akaike Information Criteria (AIC), the optimal lag for the PMG model is identified as ARDL (1 1 1 1 1 1), as illustrated in the accompanying graph. Both the graph and the PMG model were estimated using EViews.

Table 11*Estimation results with CS-ARDL, CCEMG, PMG, MG estimators.*

	CS-ARDL	CCEMG with trend	PMG	MG
ECT	-0.701*** [-19.68]	0.276*** [6.18]	-0.182*** [-5.01]	
Long-Run Coefficients				
LGDP	-0.027** [-1.97]	-0.010 [-0.28]	-0.094*** [-7.00]	
LGDP2	0.000003 [0.89]	0.00001* [1.84]	.00001*** [5.65]	
IIT	-0.215*** [-2.69]	-0.110 [-0.89]	-0.121* [-1.68]	
LENCONS	0.521*** [6.43]	0.551*** [5.39]	1.012*** [30.52]	
LTROPEN	-.0733*** [-3.18]	0.026 [0.49]	-0.006 [-0.25]	
LGFCF	-.0252 [-0.53]	0.065 [0.68]	0.008 [0.22]	
Short-Run Coefficients				
Δ LGDP	-0.036* [-1.65]	0.106** [2.29]	0.059*** [3.47]	0.035 [1.43]
Δ LGDP2	0.000004 [0.76]	-0.00002 [-1.20]	-0.0000007 [-0.21]	0.000003 [0.54]
Δ IIT	-0.321** [-2.46]	0.024 [0.22]	0.030 [0.63]	-0.001 [-0.02]
Δ LENCONS	0.720*** [6.21]	0.222*** [3.08]	0.699*** [7.10]	0.864*** [9.76]
Δ LTROPEN	-0.103*** [-2.82]	0.081 [1.28]	0.071*** [3.07]	0.071* [1.90]
Δ LGFCF	-0.050 [0.538]	0.078 [0.94]	0.110*** [2.77]	0.051 [1.08]
Trend		-0.003 [-1.50]		-0.003*** [-2.99]
CD	0.749 (0.454)	-2.12 (0.034)		3.99 (0.000)
Integration Order (CADF)	I(0) -10.003 (0.000)	I(0) -15.506 (0.000)		I(0) -12.098 (0.000)

Notes. [], () indicate z-stats. And p-values respectively. ***, **, * denotes significance at 1%, 5% 10% respectively.

In Table 11; the standard errors are also provided for reference. ARDL(1,1,1,1,1,1,1) regression is used in the model. H0: errors are weakly cross-sectional dependent for cross-sectional dependence test. CS-ARDL: (Chudik et al., 2016b) (Dynamic) Common Correlated Effects Estimator, CCEMG: (Pesaran, 2006) Common Correlated Effects Mean Group estimator. PMG: Pooled Mean Group Estimator (ARDL Approach) MG: (Pesaran & Smith, 1995) Mean Group estimator, estimation results for MG are represented for level variables.

In the CS-ARDL model, shows heterogenous short-and long-run coefficients (Chudik et al., 2016c). In particular, trade openness (LTROPEN), intra-industry trade (IIT), primary energy consumption per capita (LENCONS), and real gross domestic product per capita (LGDP) all have a substantial impact on CO2 emissions. However, the squared term of LGDP (LGDP2) and government final consumption expenditure (LGFCE) are not statistically significant.

For the panel as a whole, the results refute the Environmental Kuznets Curve (EKC) theory. Nevertheless, to further explore the relationship, country-specific coefficients are estimated and presented in the subsequent Table 12, which allows for an extended analysis.

Over an extended period, a 1% rise in GDP is linked to a statistically significant reduction of 0.0267% in carbon dioxide emissions. Intra-industry trade's (IIT) negative coefficient raises the possibility that it might lower CO2 emissions. The coefficient for trade openness (LTROPEN) is also negative, meaning that for every 1% increase in trade openness, CO2 emissions are reduced by 0.0733%.

The coefficient for energy consumption (LENCONS), which is a powerful indicator of CO2 emissions, is noteworthy since it is statistically significant at the 1% level for all estimates.

Moreover, the z-statistic of -19.68 indicates a very high estimated coefficient of the error correcting term (ECT) of -0.701161. Given that the coefficient represents the rate of adjustment towards the long-run equilibrium, this suggests a robust and highly significant long-run link between the variables. This outcome is in line with the study's Westerlund Cointegration test. This supported the analysis's robustness and offered more proof that cointegration existed in the model.

Also, the diagnostic tests show that the residuals of the model have no cross-sectional dependence (CD) and exhibit an integration order of $I(0)$, as indicated by the CD test statistic of 0.749 and the CADF test statistic of -10.003. These results suggest that the model is properly specified in terms of residual diagnostics.

The CS-ARDL model suggests that LGDP, IIT, LENCONS, and LTROPEN have significant effects on LCO₂, while LGDP2 and LGFCE do not show statistically significant associations. The error correction term indicates existence of a long-run relationship between the variables. The model has passed the diagnostic tests for cross-sectional dependence and integration order.

The second estimator used in the model is the Common Correlated Effects Mean Group estimator with trends (CCEMG) developed by (Pesaran, 2006). In the long-run, the squared term of real gross domestic product per capita (LGDP2) and energy consumption (LENCONS) exhibit statistically significant coefficients. However, in the short-run, only LGDP and energy consumption show significant coefficients. Interestingly, despite the error correction term (ECT) being statistically significant at the 1% level, the Environmental Kuznets Curve (EKC) hypothesis does not hold.

The third estimator employed is the Pooled Mean Group Estimator (PMG). In the long-run, LGDP, LGDP2, IIT, and LENCONS have significant coefficients. The findings support the EKC hypothesis, indicating a U-shaped relationship between CO₂ emissions and real gross domestic product per capita. Intra-industry trade (IIT) also exhibits a negative coefficient, consistent with the CS-ARDL estimation at 10% level. However, energy consumption (LENCONS) shows a positive coefficient, indicating that it leads to an increase in CO₂ emissions.

Regarding the short-run estimations using the PMG estimator, LGDP2 does not have a significant coefficient. On the other hand, LGDP, LENCONS, trade openness (LTROPEN), and government final consumption expenditure (LGFCE) show significant coefficients. In the short-run, both energy use and trade openness contribute to an increase in carbon emissions.

The Static Mean Group Estimator (MG) provides short-run coefficients only. In this estimation, neither LGDP nor LGDP2 are statistically significant. Only energy

consumption (LENCONS) exhibits a significant coefficient at the 1% level, indicating its impact on CO₂ emissions. Trade openness shows a significance level of 10%. Our estimation results with MG estimator is consistent with (Erdogan et al., 2020 p. 23662) that hypothesis is not verified.

These findings highlight the importance of the different estimation methods used in examining the relationship between the emissions and various factors. According to the estimations, while some variables exhibit consistent effects across different estimators, others show varying degrees of significance or even different signs.

The Pooled Mean Group Estimator (PMG) deserves further attention due to its notable findings on the Environmental Kuznets Curve hypothesis. The long- and short-term coefficients for crucial variables are revealed by the PMG estimate findings, providing insight into the complex interaction between CO₂ emissions and several economic aspects.

In the long-run, the PMG estimator reveals a U-shaped relationship between CO₂ emissions and real gross domestic product per capita (LGDP), indicating that as economies initially experience growth, CO₂ emissions tend to increase. However, as countries attain higher income levels, there is a turning point where further economic development becomes associated with a decline in CO₂ emissions. This finding contrasts with the initial expectation of the EKC hypothesis; nonetheless, it suggests the presence of a sustainable path of economic growth that leads to environmental improvement.

Moreover, the negative coefficient of intra-industry trade (IIT) in the long-run, consistent with the CS-ARDL estimation, suggests that countries engaging in intra-industry trade may experience lower CO₂ emissions. This finding could be attributed to the potential for knowledge spillovers, technological advancements, and efficiency gains within industries, which can lead to cleaner production processes and reduced environmental impacts. The empirical results in this study are consistent with prior studies such as (Roy, 2017, p. 65), (Leitão & Balogh, 2020, p. 210) and (Leitão, Koengkan, et al., 2022, p. 16), they also estimated IIT with a negative coefficient.

On the other hand, the long-term positive coefficient of energy consumption (LENCONS) suggests that growing energy consumption is a factor in rising CO₂ emissions. This highlights how crucial it is to switch to greener, more sustainable energy sources in order to lessen the damage that energy use does to the ecosystem.

As for the PMG estimator's short-run results, the significant coefficients of LGDP, LENCONS, trade openness (LTROPEN), and government final consumption expenditure (LGFCE) suggest that these variables have a more immediate impact on CO₂ emissions. As income, government final consumption expenditure, trade openness and energy use rise, carbon emissions rise as well, highlighting the challenges faced in achieving immediate environmental improvements while pursuing economic growth.

The findings seem to contradict the EKC hypothesis, which holds that CO₂ emissions and economic development have an inverse U-shaped connection. A U-shaped association between these factors is suggested by the research. It is imperative to appropriately analyze the data and communicate that the results contradict the conventional EKC hypothesis, which suggests an inverted U-shaped connection.

However, it is crucial to interpret these findings with caution and consider the broader economic context. While the EKC provides a theoretical framework, other factors such as technological advancements, policy interventions, and institutional quality can significantly influence the connection between income and emissions. So as to improve our perception of the relationships between environmental sustainability and economic development, future studies should go further into these aspects.

Table 12

Country specific heterogenous regression results (CS-ARDL Long Run Coefficients)

Country	LGDP	LGDP2	IIT	LENCON	LTROPEN	LGFCE	EKC holds?
Australia	0.003 [0.13]	0.000 [1.02]	-0.261 [-1.08]	0.837** [2.56]	0.077 [0.71]	-0.013 [-0.12]	No

Austria	-0.030 [-0.78]	0.000 [0.04]	0.034 [0.11]	0.565** [2.11]	0.173** [2.02]	-0.310** [-2.03]	No
Belgium	-0.143** [-2.42]	0.000 [1.32]	-1.420*** [-3.12]	0.259 [1.20]	-0.295*** [-3.03]	-0.052 [-0.32]	No
Canada	-0.032 [-1.17]	-0.000 [-0.45]	-1.084*** [-2.92]	0.393** [2.39]	-0.039 [-0.57]	-0.553*** [-4.64]	No
Chile	-0.083 [-0.98]	0.000*** [3.21]	-0.303 [-0.85]	0.600*** [4.04]	-0.212*** [-2.79]	-0.080 [-0.57]	No
Colombia	-0.110 [-1.59]	0.000 [0.78]	-0.067 [-0.28]	0.794*** [3.70]	-0.032 [-0.20]	0.026 [0.27]	No
Denmark	-0.005 [-0.06]	0.000*** [2.73]	-1.450* [-1.74]	1.849*** [5.04]	-0.115 [-0.40]	1.025*** [2.78]	No
Finland	0.080** [2.15]	-0.000*** [-3.12]	-0.486 [-1.57]	0.389*** [2.67]	-0.188*** [-2.75]	0.025 [0.21]	Inverted U-shaped $\beta_1 > 0$, $\beta_2 < 0$
France	-0.138* [-1.70]	0.000 [0.80]	-1.287 [-1.32]	-0.430 [-1.12]	-0.239* [-1.66]	-0.810** [-2.20]	No
Germany	0.019 [0.62]	-0.000 [-1.27]	-0.677*** [-3.36]	1.224*** [13.28]	-0.137*** [-4.53]	-0.196** [-2.02]	No
Ireland	-0.047** [-2.55]	0.000** [2.13]	0.344*** [6.49]	0.912*** [9.60]	-0.104** [-2.38]	0.099** [2.10]	U-shaped $\beta_1 < 0$, $\beta_2 > 0$
Italy	0.132** [1.97]	-0.000** [-2.23]	-0.061 [-0.28]	1.290*** [4.83]	-0.202*** [-4.48]	0.065 [0.44]	Inverted- shaped $\beta_1 > 0$,

							$\beta_2 < 0$
Japan	0.263** [2.39]	-0.000*** [-3.05]	0.900*** [2.62]	0.596 [1.13]	-0.015 [-0.17]	-0.326 [-1.30]	Inverted U-shaped $\beta_1 > 0$, $\beta_2 < 0$
Mexico	-0.249** [-2.11]	0.000 [1.57]	-0.384** [-2.43]	1.041*** [3.96]	-0.011 [-0.13]	0.150 [1.16]	No
Netherlands	-0.069** [-2.53]	0.000** [2.50]	0.187 [0.70]	0.600*** [4.28]	-0.040 [-0.56]	-0.053 [-0.57]	U-shaped $\beta_1 < 0$, $\beta_2 > 0$
New Zealand	0.016 [0.09]	0.000 [0.55]	0.321 [0.47]	0.1461 [0.41]	0.339 [1.60]	-0.672* [-1.80]	No
Norway	-0.015 [-0.29]	-0.000 [-1.62]	-0.154 [-0.67]	-0.125 [-0.81]	-0.161 [-0.67]	0.622** [2.45]	No
Spain	-0.010 [-0.14]	-0.000** [-2.07]	-0.231 [-1.49]	1.594*** [5.40]	-0.289*** [-2.62]	-0.120 [-0.94]	No
Sweden	-0.151* [-1.87]	-0.000 [-1.19]	-1.252 [-1.44]	0.091 [0.51]	-0.550*** [-4.34]	-0.334 [-0.94]	No
Switzerland	-0.062 [-1.02]	-0.000 [-0.43]	-0.409 [-0.44]	0.703*** [2.85]	-0.166 [-0.88]	-0.070 [-0.22]	No
Turkey	-0.092 [-1.39]	0.000* [1.91]	0.156 [1.13]	0.842*** [8.91]	0.017 [0.48]	0.079 [1.56]	No
United Kingdom	-0.017 [-0.47]	-0.000** [-2.04]	0.346*** [2.77]	1.582*** [6.41]	-0.107 [-1.03]	0.392*** [3.91]	No
United	-0.080***	0.000***	-0.158**	0.825***	-0.079**	-0.048	U-shaped

States	[-4.39]	[3.80]	[-2.46]	[5.31]	[-2.29]	[-0.67]	$\beta_1 < 0,$ $\beta_2 > 0$
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Note. [] indicates z-statistics, ***, **, * denote significance at 1%, 5% and 10% respectively.

Based on the country-specific estimation results using the CS-ARDL estimator, the Environmental Kuznets Curve (EKC) hypothesis holds in three out of the 23 nations analyzed. While three countries exhibit U-shaped pattern. Both of these six countries are developed nations. The interaction between per capita CO₂ emissions and other economic indicators exhibits different patterns across these countries.

In the case of Finland, the results indicate an inverted U-shaped relationship, suggesting that initial economic growth leads to an increase in CO₂ emissions. However, as the economy further develops, the relationship becomes negative, implying a reduction in CO₂ emissions. Notably, energy consumption is found to have a positive effect on CO₂ emissions, while trade openness has a negative effect.

Conversely, for Ireland, a U-shaped relationship is observed, indicating that initial economic growth is associated with higher CO₂ emissions, followed by a decline as the economy progresses. In this context, intra-industry trade (IIT), energy use, and LGFCE contribute to an increase in CO₂ emissions, while trade openness leads to a decrease in LCO₂.

Italy exhibits an inverted U-shaped relationship, implying that CO₂ emissions initially increase with economic growth but decrease at higher income levels. In this country, IIT and trade openness have a negative impact on CO₂ emissions, while energy consumption and government final consumption expenditure contribute to higher emissions.

In Japan, an inverted U-shaped relationship is also observed. Similar to Ireland, IIT has a positive coefficient, suggesting that it contributes to higher CO₂ emissions. Energy use and trade openness do not exhibit a significant relationship with CO₂ emissions.

The Netherlands shows a U-shaped relationship, LENCONS shows a positive effect on the emissions. For the United States, a U-shaped relationship exists, IIT, and

LENCONS and trade openness have significant effect on the CO₂ emissions, and IIT has negative effect.

Our country-specific estimation results for Austria, Finland, Germany, Japan, Sweden and Switzerland is consistent with (Churchill et al., 2018, p. 391) results for GDP and the square of GDP. As for trade openness, the estimation results for Austria, Denmark, Finland, France (at 10% level), Germany, Italy, Switzerland and the UK are consistent with (Churchill et al., 2018, p. 393). Moreover, the US, however for the UK, the Netherlands and Ireland it increases CO₂ emissions.

It is important to note that these findings highlight the heterogeneity in the relationship between economic development and CO₂ emissions across countries. The presence of varying patterns emphasizes the importance of considering country-specific factors and policies when addressing environmental challenges.

Furthermore, the analysis underscores the role of energy consumption as a key driver of CO₂ emissions in many countries. Policymakers should prioritize the development and implementation of sustainable energy strategies to mitigate environmental impacts.

Overall, these country-specific estimation results contribute to our understanding of the complex dynamics between economic growth, trade, energy consumption, and CO₂ emissions, emphasizing the need for tailored policy interventions to promote sustainable development and environmental stewardship.

2.6. Conclusion

This study used panel data from 23 OECD nations covering the years 1970–2019 to analyze the Environmental Kuznets Curve (EKC) hypothesis. To analyze the relationship, we employed four different estimators, namely CS-ARDL, CCEMG, PMG (ARDL approach), and static MG, were employed.

The findings from the PMG estimation provide robust evidence supporting that there is a U-shaped relationship. Specifically, for the long-run parameters of GDP, the

square of GDP, intra-industry trade (IIT), and energy consumption were found to be statistically significant.

Furthermore, the CS-ARDL and CCEMG estimations show detailed relationship between the selected variables. While these estimators consider cross-sectional dependence and heterogeneity, they did not support the EKC hypothesis.

For country-specific estimations, it was found that out of the 23 countries analyzed, evidence for the EKC hypothesis was observed in six countries. Among these, three countries exhibited an inverted U-shaped relationship, indicating that as income increases, the emissions initially increase before decreasing. The remaining three countries displayed a U-shaped relationship, indicating a direct association between economic development and CO₂ emissions.

The estimation results are in line with (Churchill et al., 2018, p. 393)'s study only for Finland and Japan, but the time span of their study has a wider time frame from 1870 to 2014. Also, at the panel level, our findings are consistent with (Vo et al., 2022, p. 8).

These results emphasize the significance of taking into account various estimators as well as regional differences when examining the connection between environmental outcomes and economic growth. Comprehending these linkages and creating suitable solutions to accomplish sustainable development objectives while reducing the ecological consequences of economic operations becomes essential for policymakers.

However, there are some limitations of this study. First, the analysis is based on aggregated panel data, which may overlook within-country heterogeneity. Second, the study focused solely on CO₂ emissions, while other environmental indicators may provide a more comprehensive assessment of environmental sustainability. Lastly, the analysis covered a specific set of OECD countries and a limited time period, which may restrict the generalizability of the findings.

Future research could address these limitations by employing more granular data, including additional environmental indicators, and extending the analysis to a broader range of countries. By doing this, a greater comprehension of the connection

between environmental outcomes and economic growth may be attained, which will aid in the creation of evidence-based policies.

In summary, this study gives empirical support to the continuing debate around the Environmental Kuznets Curve hypothesis, in a sample of OECD nations, there is a U-shaped relationship between CO₂ emissions and economic development. The results emphasize the significance of sustainable economic policies and the necessity of ongoing studies and legislative actions to solve the environmental issues brought on by economic expansion.



3. CHAPTER-TRADE IN THE FACE OF TERROR: EXAMINING TURKEY’S EXPORT DYNAMICS

ABSTRACT

In the preceding 11 years, Turkey has witnessed 925 terrorist incidents, resulting in the tragic loss of 1439 lives. Concurrently, the neighboring nations, Syria and Iraq, have also experienced a multitude of terrorist activities. This study's main objective is to explore how these events have affected Turkey's exports and intra-industry trade. The investigation is centered on Turkey's trade relationships with 71 countries, representing its primary trading partners, employing a one-way trade model. Utilizing the Poisson pseudo-likelihood regression with multiple levels of fixed effects (PPMLHDFE) estimator, the study spans the timeframe from 2012 to 2022. The findings underscore the adverse impact of domestic terrorist incidents, casualties in other countries, and the global terrorism index on Turkey's exports. Surprisingly, the investigation finds a positive connection between Turkey's exports and terrorist incidents in both neighboring and non-bordering countries. Furthermore, the empirical analysis sheds light on Turkey's engagement in intra-industry trade concerning both manufacturing industry and GDP similarities. However, the scenario changes for information and communication technology (ICT) exports, revealing a inter type industry trade.

Keywords: Intra-industry trade, terrorism, exports, PPMLHDFE, gravity model

3.1. Introduction

According to (Enders & Sandler, 2000, p. 309) terrorism is the intentional use of deadly violence or threats to further partisan goals, instilling fear or intimidation among a sizable portion of the general population. A crucial aspect of this definition is the presence of a political motive driving terrorist actions. It's important to differentiate such acts from criminal activities lacking clear political motives, like extortion for financial gain. Additionally, the use of extreme violence, often aimed at attracting media attention, is another significant characteristic of terrorism.

While the geographical location of countries can positively impact foreign trade, it's crucial to understand the effects of geopolitical risks, threats, terrorist incidents on international trade. According to (UN Comtrade, 2023), the terrorism threat from ISIS and the PYD/PKK in Syria had adverse effects on Turkey's exports to Syria, decreasing from 1.6 billion US\$ in 2011 to 498 million US\$ in 2012. Similarly, following the 2011 Libyan conflict, Turkey's exports to Libya dropped from 1.9 billion US\$ in 2010 to 748 million US\$ in 2011. However, in subsequent years, Turkey's exports showed signs of recovery, such as an increase to 1.2 billion US\$ to Syria in 2013 and 2.1 billion US\$ to Libya in 2012.

Between 2012 and 2022, Turkey experienced 925 terrorist incidents, resulting in 1439 reported fatalities, according to data from the (Institute for Economics & Peace (IEP), 2023). Despite this significant incidence of terrorism, the existing literature on the subject remains surprisingly limited, with few studies exploring effects of terrorist incidents on commerce. Research explicitly examining their impact on intra-industry trade is few.

While some studies examined the effects of terrorist incidents on different areas, for instance, on the Turkish stock market (Aksoy & Demiralay, 2019), (Gok et al., 2020), on foreign direct investment (FDI); (Çetin et al., 2019) and (Ibrahim & Ari, 2021), and on domestic bank loans (Ilarslan & Yildiz, 2022), No specific study, as far as we are aware, has examined the correlation between terrorism, trade, and intra-industry trade specifically in the context of Turkey.

Intra-industry trade provides a platform for both workers and businesses to improve their skills and expertise in particular products, with a keen emphasis on specific segments within the value chain. This level of specialization not only encourages innovation but also leverages economies of scale, rendering intra-industry trade more beneficial alongside with trade spanning different industries. Consequently, a close analysis of how terrorism impacts trade, especially intra-industry trade, becomes essential for comprehending the unique challenges and influences that could potentially affect Turkey.

To achieve our research goals, we implemented six unique one-way gravity models, employing terrorism data sourced from the (Institute for Economics & Peace (IEP), 2023). These models were designed to address the following inquiries: (i) What impact do the global terror index (GTI), the frequency of terrorism incidents, and the number of fatalities among Turkey's trading partners have on Turkey's exports? (ii) In light of terrorist attacks, how do Turkey's exports be impacted by the economic similarities with its trade partners? (iii) What effect does Turkey's manufacturing industry similarities with those of the countries it trades with have on Turkey's exports in the case of terrorist incidents? (iv) How does terrorism affect Turkey's intra-industry trade, introducing a novel variable—relative endowment (RELEN) of information and communication technology (ICT) service exports compared to population size—to capture the intra-industry trade context?

This chapter of the thesis has two major contributions to the literature. Firstly, it considers three distinct terrorism variables: the global terror index (GTI), the number of incidents, and the number of fatalities in each incident. Secondly, it stands as the inaugural study addressing the terror-trade relationship with a one-way gravity model, specifically tailored for Turkey and its top 71 export destination countries.

The arrangement of the study is as follows: Section 3.2, provides comprehensive definitions relevant to the research context. Section 3.3 comprises a thorough literature review, where we explore existing studies and theories pertinent to the intersection of terrorism and international trade. Moving to Section 3.4, we outline the empirical strategy and explain data sources. Section 3.5 is devoted to the model estimation process and the presentation of our estimation results. Section 3.6 summarizes key insights from the study and suggesting avenues for future research.

3.2. Theoretical Framework

The theoretical background for the gravity model, rooted in Newton's law of universal gravitation. The model suggests that the trading volume between two nations is positively correlated with their economic magnitudes and negatively correlated with the distance that separates them. This idea originates from (Tinbergen, 1962, p. 264), who applied Newton's gravity theory, the model mathematically expresses the total trade (TT) between countries i and j as a function of their GDPs, distance, and an error term.

This can be expressed mathematically,

$$TT_{ij} = \beta_0 \left(\frac{GDP_i^{\beta_1} GDP_j^{\beta_2}}{D_{ij}^{\beta_3}} \right) \epsilon_{ij} \quad (31)$$

in logarithmic form:

$$\ln(TT_{ij}) = \beta_0 + \beta_1 \ln(GDP_i) + \beta_2 \ln(GDP_j) - \beta_3 \ln(D_{ij}) + \epsilon_{ij} \quad (32)$$

The study employs the Poisson pseudo maximum likelihood high dimensional fixed effects (PPMLHDFE) estimator, created by (Correia et al., 2020). This estimator effectively addresses challenges in the gravity model, such as the zero-trade problem and numerous dummy variables. While the PPML estimator resolves the zero-trade issue, it does not handle the problem of numerous dummy variables. Given the study's use of Stata 18 and large values in the dependent variable, like import or export data, PPMLHDFE is preferred over alternatives like ordinary least squares (OLS) or fixed effects (FE) to mitigate potential collinearity problems.

The zero-trade problem may result from a lack of trade relations or extremely low trade values, leading to their exclusion from the dataset due to reporting in thousands. Inconsistency may arise from measurement errors linked to covariates. Heteroskedasticity is a common challenge in gravity models, making OLS inconsistent. Attempts to address heteroskedasticity with robust standard errors under

OLS may yield inaccurate estimations. Additionally, heteroskedasticity can produce highly inconsistent estimates for fixed effects when log-linearizing the gravity equation, as opposed to estimating in levels (Silva & Tenreyro, 2006, p. 641). PPMLHDFE is highly used in gravity models, some of the research which used this estimator are;(Alhassan & Payaslioglu, 2020), (Esteve-Pérez et al., 2020), (Dutt et al., 2022), (Kamin, 2022), (Robertson, 2023), (Tandrayen-Ragoobur et al., 2023), (Tang, 2003), (Wenke et al., 2023), (Yang & Hillberry, 2023), (Heid & Stähler, 2024) and (Yayi, 2024).

The specification is as follows:

$$TT_{ij} = \exp[\alpha_0 + \alpha_1 \ln(GDP_i) + \alpha_2 \ln(GDP_j) - \alpha_3 \ln(\text{Distance}_{ij})] \varepsilon_{ij} \quad (33)$$

The model incorporates dummy variables like common language, religion, colonial history, common border, free trade agreement (FTA), and regional trade agreement (RTA) to enhance its scope.

The foundational work on the gravity model by (Anderson, 1979) focused on product-related aspects. The initial economic basis involved defining the expenditure function as a Constant Elasticity of Substitution (CES) function. (Anderson & van Wincoop, 2003, p. 6) emphasized the central role played by multilateral resistance and general equilibrium effects in shaping trade flows in response to variations in trade costs.

(Bergstrand, 1989, p. 146) emphasized that the gravity equation aligns with the Heckscher-Ohlin model of interindustry trade and the Helpman-Krugman-Markusen models of intra-industry trade, incorporating microeconomic implications into generalized gravity equations.

3.3. Literature Review

(Sandler & Enders, 2008, p. 17) underscored the diverse economic ins and outs of terrorism, and identified the ways in which targeted nations bear financial burdens. These implications span trade restrictions, infrastructure destruction, the diversion of

Foreign Direct Investment (FDI), changes in the public investment toward security. Noteworthy research has delved into the impact of terrorism on various economic variables, including its impact on FDI (Polyxeni & Theodore, 2019), (Arif et al., 2020), (Lanouar & Shahzad, 2021) and (Dimitrova et al., 2022). A comprehensive understanding of these connections is essential for assessing the broader impact on GDP and overall economic growth.

Simultaneously, terrorist attacks impose a numerous of costs on nations, causing tangible damages to critical infrastructure and property, as well as intangible losses like human lives, labor, and increased insurance risk premiums. The consequences extend to reduced profitability for businesses, a decline in tourist visits, and an increased demand for enhanced security measures. These multifaceted economic implications highlight the necessity of comprehending the interconnectedness of terrorism and various economic sides. For example, (Bilgel & Karahasan, 2017a, p. 6) investigated the effects of terrorism to the Turkish exports. They revealed that between 1988 and 2001, when the study was conducted, income per person in the eastern regions of the country was revealed to have declined by 6.6%.

While numerous studies have explored the intricate relationships between GDP, imports, exports, FDI, and terrorism, none of them provide a comprehensive understanding of the dynamics surrounding trade in the same industry or the nuanced impacts of terrorism. (Haq et al., 2018, p.66) studied the effects of terror incidents on bilateral trade, utilizing a gravity model across 50 developing and developed nations with intense terror incidents from 1990 to 2013. Their research revealed that terrorism exerts an unfavorable effect on both imports and exports, particularly when developing nations engage in trade with wealthier counterparts.

(Bandyopadhyay et al., 2016, p. 304) extended this investigation into the realm of terror incidents on bilateral trade. Their findings indicated that compared to domestic terrorism, terrorist activities abroad have a more pronounced negative impact on overall manufactured trade, including exports, imports, and other categories. Interestingly, this negative effect is more perceivable on imports than on exports.

(Chaudhury & Sinha, 2019, p. 57) examined the effects of terrorist activities on GDP and international commerce by using a panel vector autoregressive (VAR) model to examine 44 industrialized and developing nations between 1991 and 2015. Its findings demonstrated that while terror attacks have a greater negative impact on foreign trade in underdeveloped countries, its influence is less noticeable in rich countries.

(Julius et al., 2019, p. 1155) contributed to the discourse by examining the implications of terror incidents on commerce within the South African Development Community (SADC) countries, utilizing the PPML estimator. Their findings suggested that terrorism has an extremely low effect on bilateral trade, with low-middle-income countries experiencing positive effects, while high-income countries observe negative impacts from terror activities.

In a departure from the direct impact of terrorism on trade, (Okafor & Piesse, 2018, p. 12) shifted the focus towards understanding the factors contributing to terrorism. Their examination spanned from 2005 to 2014, involving 38 countries from various regions with the highest ranks on the Fragile States Index (FSI). Their results indicated that factors such as the proportion of refugees, youth unemployment, countries with unstable economies, all positively influence terrorism. Additionally, foreign direct investment (FDI) was identified as having an adverse effect on terrorism.

(Pham & Nguyen, 2024, p. 35) investigated the impact of terrorist incidents in one country on a neighboring country. According to the results of panel data analysis with more than 160 countries, it was found that trade with countries neighboring the country with terrorist incidents decreased and it was concluded that this effect was mostly in the Sub-Saharan Africa region.

(Meierrieks & Schneider, 2021, p. 13) examined how terrorism affected global economic policy for a sample of 170 nations. They indicate that in reaction to terrorism, governments adopt more restrictive foreign economic policies in an effort to prevent the formation and funding of terrorism, restrict capital flight, stabilize state finances, and demonstrate political determination. More importantly they argue that the impact of terrorism is especially critical for smaller nations.

Some scholar studied GDP-terror relationship with different econometric methodologies. (Enders et al., 2016, p. 11), in their study established a Lorenz curve for terrorism to demonstrate the higher concentration of both domestic and international terrorist strikes in middle-income nations, pointing to a nonlinear link between income and terrorism. Their study is significant in the sense that they assume the relationship to be non-linear, also they employed diverse data from both The International Terrorism: Attributes of Terrorist Events (ITERATE) and also Global Terrorism Database (GTD). They also shed light to poverty and terrorism literature and answered questions whether poverty stimulates terrorism.

Several regional studies have revealed the intricate link among the economic indicators and terrorism. (Sezgin, 2019, p. 64) devised a novel index for Turkey spanning the years 1970 to 2016, showing the growth in trade volume relative to the growth of terror incidents. Despite a lack of empirical evidence, the study challenges the prevailing notion that terrorist attacks negatively impact international trade. Notably, (Sezgin, 2019, p. 65)'s investigation failed to identify any substantial evidence supporting the negative influence of terrorism on Turkey's trade.

(Ruiz Estrada et al., 2018, p. 81) studied the effects of terrorism on Turkey's economic performance. Employing a terrorist attack vulnerability evaluation model covering terror incidents, GDP distribution, and income distribution, they argued that economic decline escalated between 1990 and 2016. Additionally, (Bilgel & Karahasan, 2019, p. 16) focused on the PKK terror group's influence on the Turkish economy, utilizing the synthetic control method for the period 1955-2008. Their findings suggested that Turkey's GDP per capita could have been 13.8% higher if not for the exposure to PKK terrorism.

While existing studies have extensively explored the connections between terrorism and broader economic indicators, such as GDP, imports, exports, and foreign direct investment, there's a gap in the literature concerning the nuanced effect of terrorism on intra-industry trade. Limited scholarly attention has been given to understanding how terrorism influences the intra-industry trade patterns of nations.

By looking at the unexplored realm of the link between terror and intra-industry commerce, this study seeks to close this significant gap. As far as we know, this study

is the first of its type to focus on this particular issue, offering a distinctive viewpoint on the financial effects of terrorism. By analyzing the data through the lens of the proxy relative endowment (RELEN) calculated from ICT service exports per capita and introducing novel variables such as GDP similarity and manufacturing output similarity, we aim to enrich our understanding of the interaction between terrorism and the broader economic structure, albeit at a broader level than specific industries.

This approach not only contributes to the existing trade-terror relationship literature but also sheds light on the potential implications for policy-making. This study seeks to broaden the discourse on terrorism's economic impact, particularly in the realm of intra-industry trade dynamics, thereby offering fresh insights that extend beyond the current scope of scholarly investigation.

(Helpman & Krugman, 1987, p. 131,) proposed the use of differences in GDP per capita among countries and economic similarity as proxies for analyzing intra-industry trade. Subsequent studies have adopted a similar approach, they employed these variables as proxies in understanding intra-industry dynamics. Some examples include (Antonucci & Manzocchi, 2006, p. 168), (Ülengin et al., 2015, p. 5) and (Karacan & Korkmaz, 2022, p. 33).

In summary, the literature review provides information on complex relationships between terrorism, economic indicators, and trade dynamics. While existing studies have made significant additions in understanding the macroeconomic impacts of terrorism, a notable gap remains in the exploration of the trade in the same industry specifically. The goal of this work is to close this gap by focusing on Turkey's exports to 71 countries, employing one-way gravity model and contributing novel insights to the interplay between terrorism and trade, particularly at the intra-industry level.

3.4. Empirical Model and Data

Using Turkey's export data, we run a one-way gravity model with the 71 countries to which Turkey exports the most, accounting for 89.50% of Turkey's total exports. The panel data model covers an 11-year period from 2012 to 2022. We

obtained the export (EXP) dependent variable used in the model from the IMF database and presented in thousands (IMF, 2023). Apart from the export dependent variable we used in the model, we used different dependent variables to investigate the terrorism-trade relationship. Global terrorism index (GTI), the number of incidents (INC) and the number of fatalities (FTL) were obtained from (Institute for Economics & Peace (IEP), 2023) and covers the period 2012-2022, which was a limitation for our study. Other explanatory variables in the model are the sum of the gross domestic product (GDP) of Turkey and the trading country (SUMGDP), economic similarities (SIMGDP), manufacturing industry similarities (SIMMANUF), relative factor endowments (RELEN) calculated by information and communication technology (ICT) service exports and population (POP), distance between the capital cities of the two nations, customs union dummy (CU) (1 if Turkey is a member of the customs union, 0 otherwise), colony dummy (1 if Turkey has a colonial history with Turkey, 0 otherwise), border neighbor dummy (1 if Turkey is a border neighbor, 0 otherwise). All data for dummies and distance data are retrieved from (CEPII, 2023).

The following are variable computations: (Helpman & Krugman, 1987, p. 169)

$$\text{SIMGDP}_{ijt} = \ln \left[1 - \left(\frac{\text{GDP}_{it}}{\text{GDP}_{it} + \text{GDP}_{jt}} \right)^2 - \left(\frac{\text{GDP}_{jt}}{\text{GDP}_{it} + \text{GDP}_{jt}} \right)^2 \right] \quad (34)$$

$$\text{SIMMANUF}_{ijt} = \ln \left[1 - \left(\frac{\text{MANUF}_{it}}{\text{GDP}_{it} + \text{GDP}_{jt}} \right)^2 - \left(\frac{\text{MANUF}_{jt}}{\text{GDP}_{it} + \text{GDP}_{jt}} \right)^2 \right] \quad (35)$$

$$\text{RELEN}_{ijt} = \left(\ln \frac{\text{ICT}_{it}}{\text{POP}_{it}} - \ln \frac{\text{ICT}_{jt}}{\text{POP}_{jt}} \right) \quad (36)$$

In this study, we introduce a novel measure known as relative endowment (RELEN), calculated as the ratio of Information and Communication Technology (ICT) service exports (measured in Balance of Payments, current US\$) to the population (POP) of each country. This measure, expressed as ICT per capita (ICT/POP), serves as a proxy for capturing the Linder effect in international trade.

According to (Linder, 1961, p. 87) commerce between nations is more likely when their demand patterns are comparable.

Employing relative endowment based on ICT per capita, we aim to show the similarity in the demand structures of trading entities. A higher relative endowment indicates a greater similarity in the per capita consumption of ICT services between two countries, aligning with the underlying Linder effect.

Using ICT per capita as a proxy for relative endowment enhances our ability to explore the relationships between countries, providing insights into the potential determinants of their trading patterns. This measure contributes to our broader examination of factors influencing international trade dynamics and provides a unique depth of demand similarities in shaping trade relationships.

The variable RELEN, denoting relative endowment. It is calculated as the ratio between the logarithm of ICT service exports with the population of Turkey and the corresponding values of its trading partner. This metric captures the relative endowment of Information and Communication Technology (ICT) service exports in relation to the population size for both entities 'i' and 'j' at time 't'. The differences in the resource mix of two entities are captured by relative factor endowments. A favorable effect indicates a willingness on the part of the entities to participate in inter-industry trade, while a negative coefficient for (RELEN) is anticipated in the context of trade in the same industry.

When we examine prior studies, including (Antonucci & Manzocchi, 2006, p. 168), the variables SIMGDP, SUMGDP, and RELEN were utilized. It's worth noting that (Antonucci & Manzocchi, 2006, p. 168) employed GDP within the computation of relative factor endowment. Building upon this research, subsequent studies by (Ülengin et al., 2015, p. 5) and (Karacan & Korkmaz, 2022, p. 33) extended the exploration by incorporating Capital Stock per capita as a key component within their relative endowment analyses. These studies collectively contribute to our understanding of economic factors influencing trade dynamics. The GDP, manufacturing value added, and ICT service exports data received from The World Bank WDI database (The World Bank, 2023), and correspondingly derived from GDP (current US\$), manufacturing value added (current US\$), and ICT service exports

(Balance of Payments (BoP), current US\$). Building on this data, we calculated relative endowment using ICT service exports as a key component, allowing for a broader understanding of trade dynamics and economic relationships.

The metric in consideration (SIMGDP) pertains to the assessment of "similarity" in size, and its impact can be either positive or negative, manifesting within a numerical range from -0.69 (indicating perfect similarity) to infinity (indicating perfect dissimilarity). In the context of trade in the same industry. Conversely, when trade extends across different industries, a negative coefficient is expected, reflecting the inclination towards dissimilarity in size (Helpman & Krugman, 1987, p. 169). The variable SIMMANUF is the metric that serves as a measure of similarity in the manufacturing sector between two entities, 'i' and 'j', for duration 't'. The numerator of each fraction shows the manufacturing output (MANUF) of the respective entities, while the denominators account for the total economic activity represented by the sum of their GDPs. Similar to the previously introduced variable (SIMGDP), the range of (SIMMANUF) lies within the logarithmic space, with values approaching zero indicating a high degree of similarity in manufacturing output between entities i and j, and higher values representing increasing dissimilarity. This logarithmic transformation is applied to maintain symmetry in the measurement scale and to capture proportional differences effectively. The SIMMANUF variable represents the logarithm of the complement of the squared proportion of manufacturing output for two countries, adjusted for their respective GDPs. It is designed to capture the similarity in manufacturing composition between the two nations.

To estimate the terror incidences on export of Turkey, we applied augmented gravity model with Poisson Pseudo Maximum Likelihood Estimator (PPML). All variables except the dependent variable and the dummies are in log form.

In total, we estimated 6 models and included the SUMGDP variable in three of these models and the SUMMANUF variable in the other three. In this way, we investigated the effect of similarities in both GDP and manufacturing industries on Turkish exports for 71 countries trading with Turkey. To analyze the effect of terrorism on Turkey's exports, we separately include the global terrorism index (GTI), the number of terrorist incidents (INC) and the number of fatalities in terrorist

incidents (FTL). We also include Border*INC, Border*FTL and Border*GTI interaction variables to estimate the impact of terrorist incidents in countries bordering Turkey. We also added the GTI*FTL interaction variable in order to have more information on the terrorism index and the number of deaths in countries that do not border Turkey. The model specifications of augmented gravity models are as follows:

$$\begin{aligned} \text{EXP}_{ijt} = & \alpha + \beta_1 \text{GTI}_{jt} + \beta_2 \text{GTI}_{it} + \beta_3 \text{SUMGDP}_{ijt} + \beta_4 \text{SIMGDP}_{ijt} + \beta_5 \text{RELEN}_{ijt} \\ & + \beta_6 \text{POP}_{jt} + \beta_7 \text{POP}_{it} + \beta_8 \text{Distance}_{ij} + \beta_9 \text{Border}_{ij} + \beta_{10} \text{Colony}_{ijt} \\ & + \beta_{11} \text{CU}_{jt} + \varepsilon_{ijt} \end{aligned} \quad (37)$$

$$\begin{aligned} \text{EXP}_{ijt} = & \alpha + \beta_1 \text{INC}_{jt} + \beta_2 \text{INC}_{it} + \beta_3 \text{SUMGDP}_{ijt} + \beta_4 \text{SIMGDP}_{ijt} + \beta_5 \text{RELEN}_{ijt} \\ & + \beta_6 \text{POP}_{jt} + \beta_7 \text{POP}_{it} + \beta_8 \text{Distance}_{ij} + \beta_9 \text{Border}_{ij} + \beta_{10} \text{Colony}_{ijt} \\ & + \beta_{11} \text{CU}_{jt} + \beta_{12} \text{Border} * \text{INC}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (38)$$

$$\begin{aligned} \text{EXP}_{ijt} = & \alpha + \beta_1 \text{FTL}_{jt} + \beta_2 \text{FTL}_{it} + \beta_3 \text{SUMGDP}_{ijt} + \beta_4 \text{SIMGDP}_{ijt} + \beta_5 \text{RELEN}_{ijt} \\ & + \beta_6 \text{POP}_{jt} + \beta_7 \text{POP}_{it} + \beta_8 \text{Distance}_{ij} + \beta_9 \text{Border}_{ij} + \beta_{10} \text{Colony}_{ijt} \\ & + \beta_{11} \text{CU}_{jt} + \beta_{12} \text{Border} * \text{FTL}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (39)$$

$$\begin{aligned} \text{EXP}_{ijt} = & \alpha + \beta_1 \text{GTI}_{jt} + \beta_2 \text{GTI}_{it} + \beta_3 \text{FTL}_{jt} + \beta_4 \text{FTL}_{it} + \beta_5 \text{SUMMANUF}_{ijt} \\ & + \beta_6 \text{SIMGDP}_{ijt} + \beta_7 \text{RELEN}_{ijt} + \beta_8 \text{POP}_{jt} + \beta_9 \text{POP}_{it} + \beta_{10} \text{Distance}_{ij} \\ & + \beta_{11} \text{Border}_{ij} + \beta_{12} \text{Colony}_{ijt} + \beta_{13} \text{CU}_{jt} + \beta_{14} \text{GTI} * \text{FTL}_{jt} \\ & + \beta_{15} \text{Border} * \text{GTI}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (40)$$

$$\begin{aligned} \text{EXP}_{ijt} = & \alpha + \beta_1 \text{INC}_{jt} + \beta_2 \text{INC}_{it} + \beta_3 \text{SUMGDP}_{ijt} + \beta_4 \text{SIMMANUF}_{ijt} + \beta_5 \text{RELEN}_{ijt} \\ & + \beta_6 \text{POP}_{jt} + \beta_7 \text{POP}_{it} + \beta_8 \text{Distance}_{ij} + \beta_9 \text{Border}_{ij} + \beta_{10} \text{Colony}_{ijt} \\ & + \beta_{11} \text{CU}_{jt} + \beta_{12} \text{Border} * \text{INC}_{ijt} + \varepsilon_{ijt} \end{aligned} \quad (41)$$

$$\begin{aligned}
EXP_{ijt} = & \alpha + \beta_1 GTI_{jt} + \beta_2 GTI_{it} + \beta_3 SUMGDP_{ijt} + \beta_4 SIMMANUF_{ijt} + \beta_5 RELEN_{ijt} \\
& + \beta_6 POP_{jt} + \beta_7 POP_{it} + \beta_8 Distance_{ij} + \beta_9 Border_{ij} + \beta_{10} Colony_{ijt} \\
& + \beta_{11} CU_{jt} + \varepsilon_{ijt}
\end{aligned}
\tag{42}$$

The following nations are covered in the analysis: Algeria, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Côte d'Ivoire, Croatia, Czech Republic, Denmark, Egypt, Finland, France, Georgia, Germany, Greece, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Japan, Kazakhstan, Korea Republic, Libya, Lithuania, Malaysia, Mauritania, Mexico, Moldova, Morocco, Netherlands, Norway, Oman, Pakistan, Peru, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Singapore, Slovak Republic, Republic of Slovenia, Spain, Sweden, Switzerland, Syrian Arab Republic, Thailand, Tunisia, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, United States, Uzbekistan, Venezuela, Vietnam.

A summary of our dataset, data calculations, and interaction terms are given in this section. We have also presented the specifications of the six models used in our analysis. Detailed explanations and discussions related to our estimation method, model assumptions, model results, model validation, and statistical significance can be found in subsequent dedicated sections for each of these aspects.

The empirical analysis uses the Poisson pseudo maximum likelihood high dimensional fixed effects (PPMLHDFE) estimator. This estimator is created and developed by (Correia et al., 2020). The most important problem in the gravity model is the zero-trade problem. A further issue with the model is an excessive number of dummy variables. The PPML estimator was able to solve the zero-trade problem, but the large number of dummy variables in the model did not create the convergence problem. Since all of the analyzes in this study were performed with Stata 18, and when the dependent variable has very big values such as import or export data, the regressors can face collinearity problem. Thus, PPMLHDFE could be used rather than other estimators such as ordinary least squares (OLS) or fixed effects (FE).

Zero trade could occur due to no-trade relationship between two countries or the trade values are too low and fall from the dataset since trade values are reported in

thousands. Inconsistency will result from the measurement error depending on the covariates.

Heteroskedasticity is also a common issue in gravity models which makes OLS inconsistent. As OLS is inconsistent in the initial hold, employing robust standard errors to ease worries related to heteroskedasticity, will lead to inaccurate estimation. Also, heteroskedasticity can produce remarkably inconsistent estimates for fixed effects when the gravity equation is log-linearized as opposed to being estimated in levels. (Silva & Tenreyro, 2006, p. 642).

Gravity model specification:

$$T_{ij} = \beta_0 GDP_i^{\alpha_1} GDP_j^{\alpha_2} D_{ij}^{\alpha_3} \omega_{ijt} \quad (43)$$

T_{ij} is trade, 'i' and 'j', D_{ij} is a dummy, ω_{it} is the error term, $\alpha_0, \alpha_1, \alpha_2, \alpha_3$ are the coefficients.

Model specification for the PPMLHDFE:

$$X_{itj} = \exp(\alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln D_{ij}) \omega_{ijt} \quad (44)$$

3.5. Estimation Results

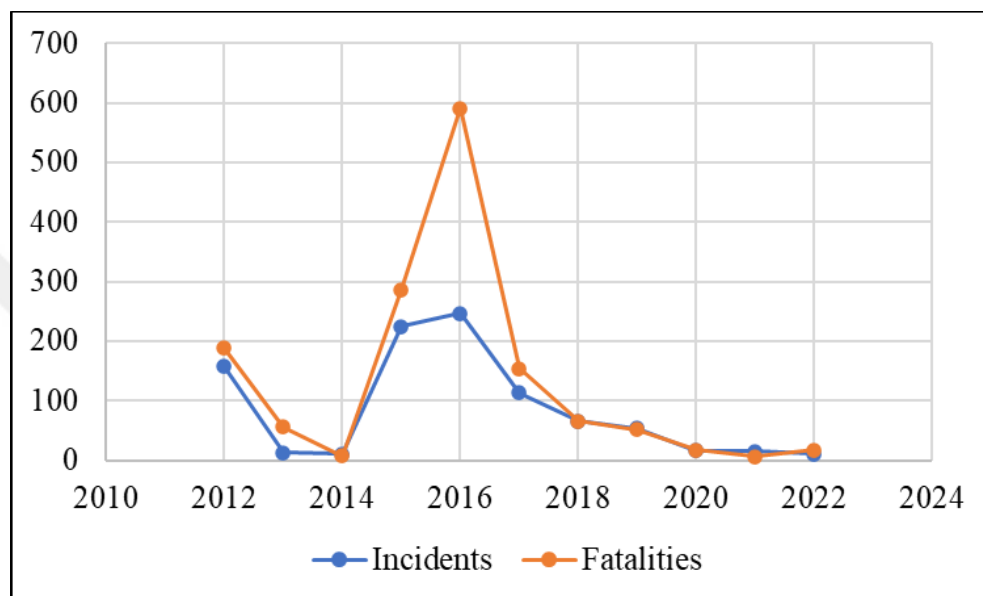
This part of the research, we present a complete analysis of the estimation results relating to Turkey's exports and intra-industry trade, with a particular focus on the relationship between terrorism indicators and trade dynamics. Before delving into the detailed results, we provide a brief overview of the descriptive statistics, a correlation matrix, and graphical representations to offer a holistic understanding of the dataset.

Accompanying our quantitative analysis are two graphical representations. Figure 2 focuses on the domestic landscape, portraying the evolution of terror incidents and fatalities within Turkey. Figure 3 expands our scope to a global perspective, encapsulating similar incidents in 71 countries, with Turkey as a focal

point. Each graph is explained to explain patterns and trends observed in the data. These preliminary elements serve as a foundation for the subsequent presentation of our estimation results.

Figure 2

The number of terror incidents and fatalities in Turkey



Note. The figure is created by the author.

Figure 2 illustrates the dynamics of Turkey's Global Terror Index (GTI_T) and the fatalities between 2012 and 2022. During the period from 2012 to 2014, GTI_T witnessed a decrease, followed by an increase from 2014 to 2016, ultimately reaching its peak. Concurrently, fatalities as a result of incidents followed the same trend.

Subsequently, between 2016 and 2018, both terrorist incidents and fatalities dropped sharply. This trend continued until the end of 2022. By 2022, the number of terror incidents were the lowest since 2014 which was 10.

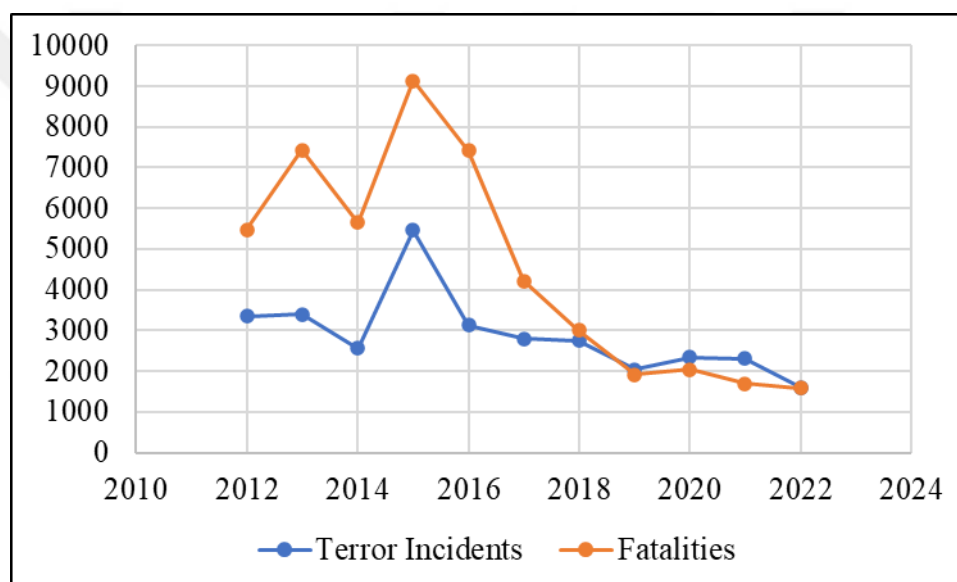
In 2016, FETO terrorist organization had a coup attempt. 2,000 people were injured and 246 people died during the coup attempt. The Turkish Parliament and the Presidential Palace were two of the several government structures that were bombarded. This coup attempt was thwarted and democracy and the rule of law were upheld by the Turkish people, the Prime Minister, the Government, the Members of

the Grand National Assembly, and the President as stated by (Republic of Türkiye Ministry of Foreign Affairs, 2022).

Although terrorist incidents in Turkey are mostly committed by the PKK terrorist organization and its fractions, after 2016, as a result of the disappearance of the influence of ISIS and the successful operations of the Turkish Army, PKK terrorist group lost its influence and as a result, the number of terrorist incidents has decreased.

Figure 3

The number of terror incidents and fatalities in 72 countries



Note. The figure is created by the author.

Figure 3 illustrates the occurrences of terrorist incidents and associated fatalities in 71 countries, including Turkey, spanning the years 2012 to 2022. Notably, there is an ascending trend from 2012 to 2013, marked by a relatively high number of fatalities. Despite the similarity in the number of terrorist incidents in 2012 and 2013, the latter witnessed a significant surge in fatalities. The subsequent period, from 2013 to 2014, witnessed a decline in both terrorist incidents and fatalities. However, 2015 saw a substantial increase in both metrics. From 2015 onward, there is a consistent downward trajectory in both the number of terror incidents and fatalities.

The subsequent period, from 2013 to 2014, witnessed a decline in both terrorist incidents and fatalities. However, 2015 saw a substantial increase in both metrics. From 2015 onward, there is a consistent downward trajectory in both the number of terror incidents and fatalities.

Examining specific incidents, in 2012 and 2013, notable events occurred in various regions, involving entities such as Hamas, Terror Group PKK, Al-Qaida, PYD and IS. The escalation in 2015 involved additional conflicts like the India-Pakistan conflict in Kashmir, ISIS terror group in Iraq, and multiple incidents in Pakistan, Algeria, Tunisia, Ukraine, involving various terror groups. Turkey, particularly regions like Hatay, Gaziantep, and Şanlıurfa, witnessed an impact due to the expansion of ISIS terrorist activities, reaching its zenith in 2015. ISIS' influence extended beyond the Middle East, reaching Bangladesh. The persistence of ISIS activities continued in 2016; however, in 2019, President Donald Trump announced the killing of ISIS' top replacement, resulting in a significant reduction in terror incidents from 5466 in 2015 to 2334 in 2020.

Table 13
Descriptive Statistics

Variable	N	Mean	Std Dev	Min	Max
Export	777	2,318,208	3,221,849	1,076.295	20,900,000
GTI _{jt}	622	1.023199	.9012771	-1.847249	2.302585
GTI _{it}	781	1.933972	.1175257	1.722821	2.10088
INC _{jt}	397	2.367859	1.919142	0	7.997663
INC _{it}	781	3.775824	1.22168	2.302585	5.509388
FTL _{jt}	285	2.815059	2.150316	0	8.477828
FTL _{it}	781	3.987466	1.443061	1.791759	6.381816
SUMGDP _{ijt}	769	27.98953	.6183538	27.31452	30.9032
SIMGDP _{ijt}	769	-.8053502	1.055817	-4.272657	.6787645
SIMMANUF _{ijt}	723	-1.017771	1.220882	-5.2206	.6580708
RELEN _{ijt}	703	-1.575865	2.08306	-7.357108	2.750075
POP _{jt}	781	16.93991	1.465356	14.0184	21.07193
POP _{it}	781	18.21169	.0403801	18.13669	18.26217
Distance _{ij}	781	8.005693	.8032186	6.658591	9.582772

The presented descriptive statistics in Table 13 lay the groundwork for the subsequent analysis. The correlation matrix is presented in Table 14. Highlighting key correlations aids in identifying potential relationships that may guide our interpretation.

Our estimation results are presented in Table 15. We conducted six distinct models to analyze the relationship between terrorism, Turkey's exports, and intra-industry trade. The results of our estimations reveal several noteworthy findings. Distance exerts a negative influence on Turkey's exports, while countries with colonial ties and those engaged in a customs union (CU) relationship with Turkey demonstrate a positive impact on exports. Remarkably, just two of the models show that Turkey's exports benefit from having a neighboring border.

Turkey's population exhibits a positive effect on exports, and this effect is statistically significant in two of the models. Conversely, the population of the trading partner exerts a negative and significant influence in both models. The calculated relative factor endowments, derived from ICT service exports, suggest an inter-industry type of trade.

The inclusion of GDP size similarity in the first three models and manufacturing industry size similarity in the subsequent three models provides further insights. Both SIMGDP and SIMMANUF coefficients are positive, indicating intra-industry trade. This implies that Turkey and its partner countries are engaging in intra-industry trade, corroborating the findings of (Karacan & Korkmaz, 2022, p. 36). SUMGDP also exhibits a positive coefficient in both models, emphasizing its statistical significance. The positive coefficient of the global terror index of Turkey's trading partner is expected, because Turkey's neighbors such as Syria, Iraq exhibit a relatively high terror index compared to other partners. However, Turkey's own global terror index has a negative impact on its exports. This result aligns with the findings of (Bilgel & Karahasan, 2017, p. 6) as well as (Bilgel & Karahasan, 2019, p. 16), cause Turkey's exports have an important share in the calculation of GDP.

In relation to terror incidents (Model-2), the number of incidents in the partner country is insignificant. However, terror incidents within Turkey demonstrate a diminishing effect on the country's exports. Moving to third model, the number of

fatalities in the partner country is statistically insignificant, while the number of fatalities in Turkey reveals a negative impact on Turkey's exports.

Models 4, 5, and 6 incorporated SIMMANUF instead of SIMGDP. In both cases (Model-4, 5, and 6), SIMMANUF proves significant with a positive coefficient sign, suggesting that Turkey engages in intra-industry trade within the manufacturing industry.

Instrument variables, namely border and incidents (Border*INC), border and fatalities (Border*FTL), and border and global terrorism index (Border*GTI), were introduced to the models. All these variables exhibit significance with a positive sign, indicating that terrorist incidents and fatalities in Turkey's neighboring countries exert an increasing effect on Turkey's exports. This finding is consistent with Turkey's geopolitical position, where despite enduring terrorist incidents in neighboring regions for years, Turkey's exports have persisted.

In summary, these findings align with the insights of (Chaudhury & Sinha, 2019, p. 58), suggesting that Turkey, as a developing country, appears to be less sensitive to the adverse impacts of terror activities.

Table 14*Correlation Matrix*

	Export	GTI _{jt}	GTI _{it}	INC _{jt}	INC _{it}	FTL _{jt}	FTL _{it}	SUMGDP _{ijt}	SIMGDP _{ijt}	SIMMANUF _{ijt}	RELEN _{ijt}	POP _{jt}	POP _{it}	Distance _{ij}
Export	1.000													
GTI _{jt}	0.129	1.000												
GTI _{it}	-0.042	0.075	1.000											
INC _{jt}	0.135	0.870	0.032	1.000										
INC _{it}	-0.005	0.074	0.838	0.030	1.000									
FTL _{jt}	0.056	0.857	0.110	0.778	0.122	1.000								
FTL _{it}	-0.039	0.054	0.897	0.027	0.918	0.118	1.000							
SUMGDP _{ijt}	0.542	-0.017	-0.010	-0.123	0.000	-0.081	-0.006	1.000						
SIMGDP _{ijt}	0.420	0.012	-0.081	-0.006	-0.029	-0.037	-0.079	0.731	1.000					
SIMMANUF _{ijt}	0.219	-0.093	-0.033	-0.138	-0.000	-0.157	-0.034	0.686	0.909	1.000				
RELEN _{ijt}	-0.327	0.389	-0.093	0.253	-0.118	0.395	-0.109	-0.333	-0.267	-0.287	1.00			
POP _{jt}	0.139	0.377	-0.039	0.239	-0.013	0.328	-0.038	0.591	0.663	0.663	0.277	1.000		
POP _{it}	0.0856	-0.044	-0.330	-0.069	-0.150	-0.135	-0.288	-0.000	0.198	0.119	0.0212	0.047	1.000	
Distance _{ij}	-0.314	-0.146	-0.059	-0.156	-0.064	-0.140	-0.069	0.251	0.278	0.336	0.296	0.345	0.029	1.000

Table 15*Estimation results*

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
GTI _{jt}	0.265*** (5.37)			0.119** (2.20)		0.352*** (6.80)
GTI _{it}	-0.863*** (-2.96)			-0.099 (-1.04)		-1.097*** (-3.32)
INC _{jt}		0.020 (1.19)			0.0349* (1.73)	
INC _{it}		-0.040** (-2.10)			-0.047** (-2.10)	
FTL _{jt}			-0.008 (-0.45)	0.175 (1.27)		
FTL _{it}			-0.041** (-2.17)	0.001 (0.03)		
SUMGDP _{ijt}	0.484*** (5.29)	0.758*** (8.15)	0.808*** (7.61)	1.154*** (16.91)	1.221*** (19.82)	0.817*** (10.38)
SIMGDP _{ijt}	1.508*** (8.36)	1.387*** (6.80)	1.310*** (5.37)			
SIMMANUF _{ijt}				0.336*** (3.85)	0.235*** (2.80)	0.493*** (3.02)
RELEN _{ijt}	0.071*** (3.11)	0.073*** (2.71)	0.080*** (2.96)	0.0698** (2.23)	0.068** (2.20)	0.024 (0.91)
LPOP _{jt}	-0.188*** (-4.63)	-0.267*** (-6.48)	-0.281*** (-6.62)	-0.219*** (-4.90)	-0.165*** (-3.77)	-0.046 (-1.08)
LPOP _{it}	0.621 (0.74)	1.190** (2.10)	1.154* (1.75)	0.758 (1.15)	2.202*** (3.08)	1.351 (1.49)
Distance _{ij}	-0.862*** (-20.31)	-0.925*** (-19.88)	-0.934*** (-18.01)	-0.934*** (-15.00)	-0.986*** (-18.56)	-0.848*** (-19.34)
Border _{ij}	0.336** (2.10)	-2.121*** (-5.92)	-0.968*** (-3.72)	-5.805*** (-5.39)	-2.551*** (-6.02)	0.371** (2.10)

Colony _{ij}	0.314*** (3.29)	0.313** (2.28)	0.388*** (2.87)	0.359*** (2.64)	0.066 (0.45)	0.099 (1.04)
CU _{jt}	0.280*** (3.28)	0.337*** (3.37)	0.402*** (3.60)	0.657*** (6.54)	0.584*** (5.71)	0.527*** (5.37)
Border*INC		0.501*** (9.53)			0.598*** (8.61)	
Border*FTL			0.329*** (9.32)			
GTI*FTL				-0.132* (-1.83)		
Border*GTI				3.540*** (7.05)		
Constant	-0.215 (-0.01)	-17.620 (-1.64)	-17.867 (-1.38)	-20.227* (-1.75)	-49.081*** (-3.89)	-24.339 (-1.43)
N	561	358	253	244	349	546
Pseudo R ²	0.7662	0.8835	0.9073	0.9006	0.8577	0.7282
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Reset Test	[0.610]	[0.184]	[0.793]	[0.276]	[0.435]	[0.290]

Note. (), [] denote t-statistics and p-values respectively. (*), (**), (***) indicate significance at 10%, 5% and 1 % respectively.

3.6. Conclusion

This research employed a one-way gravity model to analyze the relationship between Turkey's exports and terrorism, employing panel data with 71 major trading partners, representing approximately 89.50% of Turkey's total exports from 2012 to 2022. The investigation considered the impact of various variables, including the global terror index (GTI), the number of terror incidents, and the number of fatalities, in both Turkey and its trading partners. Additionally, economic similarity, manufacturing industry, and relative endowment were scrutinized. The PPMLHDFE estimator was employed to address the zero-trade problem and heteroskedasticity.

The empirical findings revealed that Turkey engages in intra-industry trade when economic similarity (SIMGDP) and manufacturing similarity (SIMMANUF) are considered. However, concerning ICT service exports, Turkey exhibits inter-industry trade. The estimation results are in line with the findings of (Karacan & Korkmaz, 2022, p. 36) as well as (Ruiz Estrada et al., 2018, p. 84). Notably, terrorist incidents within Turkey were found to have a diminishing impact on the nation's trade, while incidents in trading partner countries increased Turkey's trade. Similar results were observed when employing both the global terror index and fatalities in the models, consistent with the findings of (Chaudhury & Sinha, 2019, p. 58).

Furthermore, given that exports constitute a significant component of GDP, the study uncovered that terror incidents, fatalities, and Turkey's global terror index collectively exert a reducing effect on exports. This observation is consistent with the findings of (Bilgel & Karahasan, 2017b, p. 6) and also (Bilgel & Karahasan, 2019, p. 16) indicating a decline in GDP per capita in the Southeastern and Eastern regions of Turkey due to terrorism. This research provides insightful information about the relationship between commerce and terrorism, with a focus on the effects on Turkey's economy.

4. CHAPTER 4-EXAMINING THE SMOOTH ADJUSTMENT HYPOTHESIS AND INTRA-INDUSTRY TRADE IN TURKEY

ABSTRACT

This study examines the Smooth Adjustment Hypothesis (SAH) in the Turkish labor market using industry and individual-level data covering 2010-2020. The SAH predicts that intra-industry trade (IIT) reduces labor market adjustment costs, as labors are less likely to switch industries when trade expands within industries. We employ a panel data approach and estimate the relationship between trade patterns and labor market adjustment costs using dynamic panel data models for industry-level data and panel logit models for survey data. Estimation results indicate that only one of the six industry-level models estimated with marginal-intra industry trade (MIIT) supports the SAH for the Turkish labor market, suggesting that the expansion of intra-industry trade reduces labor market adjustment costs. However, none of the industry-level models estimated with IIT supports the SAH. Our findings highlight the importance of exploring various specifications and methodologies to understand how trade patterns affect labor market dynamics. We also find that educational attainment, gender, marital status, age, inflation rate, significantly affect labors' likelihood of changing industries. By presenting evidence, these findings make a valuable contribution to the existing literature on the impact of trade patterns on labor market adjustment costs in Turkey.

Keywords: Intra-industry trade, marginal intra-industry trade, international trade, manufacturing, smooth adjustment hypothesis, System-GMM estimation, Panel Logit estimation

4.1. Introduction

The Smooth Adjustment Hypothesis (SAH) assumes that the nature of international trade changes significantly influences labor-market adjustment costs. Specifically, the hypothesis asserts that when trade shifts involve intra-industry transactions (IIT), the associated adjustment costs are expected to be less pronounced compared to shifts of the inter-industry type. In the context of intra-industry trade, where both exports and imports within a particular sector increase, the necessary resource transfers occur within the sector, resulting in more manageable adjustment costs. On the contrary, inter-industry trade changes require resource transfers between sectors, and the magnitude of adjustment costs escalates with the degree of factor requirement disparities between sectors. This hypothesis underscores the importance of the trade pattern in determining the impact on labor-market adjustments and emphasizes the potential economic benefits associated with intra-industry trade dynamics.

In labor markets, one can readily observe temporary unemployment and wage or price variation among different production components. These occurrences can be ascribed to the relatively slow rate at which prices adjust and the constrained mobility of resources, especially labor. Such limitations hinder the smooth transition of workers into industries experiencing a surge in demand, thereby contributing to the prevalence of these phenomena.

The smooth-adjustment hypothesis (SAH) proposed by (Brülhart, 2000, p. 425) posits that intra-industry trade (IIT) reduces labor-market adjustment costs, particularly in cases of transitions within industries, as opposed to inter-industry trade. These adjustment costs within the workforce, as highlighted by (Brülhart & Elliott, 2002a, p. 209), result in transitory inefficiencies such as unemployment and elevated prices. According to the SAH, a decrease in job-relocation distances and the associated costs depends on the emergence of new trade opportunities within IIT. As fluctuations in industry employment intensify, these adjustment costs diminish. This hypothesis has gained considerable scholarly attention, leading researchers to utilize a variety of dependent variables as approximations for labor-market adaptation. Econometric models frequently leverage observed shifts in industry-level employment

for this purpose. For measuring IIT, the static measure by (Grubel & Lloyd, 1975) is commonly employed to capture changes, while for dynamic evaluations, a marginal intra-industry trade (MIIT) measure, such as ‘the A-index proposed by (Brühlhart, 1994, p. 604)’, is utilized.

Previous studies on the SAH for Turkey have been based solely on industry-level data by (Erlat & Erlat, 2006, p. 5), however our study enhances the literature by incorporating both industry-level data and microdata from labor-force statistics obtained from Turkish Statistical Institute for the period 2010-2020. We adopted a panel-data approach and estimated industry-level data using a dynamic panel-data model and a system generalized method of moments (GMM) estimator. We utilized a panel logit model for individual-level survey data.

We estimated 11 different models using both static IIT and dynamic MIIT variables. However, only the estimation with the MIIT variable was significant and had a negative coefficient, confirming the SAH. Our findings show that the SAH also holds for individual-level data and that factors such as gender, age, educational attainment, marital status, and inflation rate significantly impact a worker’s likelihood of changing industries.

This paper comprises six sections that analyze the SAH. We extensively review the previous research to provide a comprehensive background to our study in Section 4.2. In Section 4.3, we present the theoretical framework that underpins our analysis. To outline our empirical approach and define the data sources employed in this research, we explain them in Section 4.4. We subsequently show our estimation results in Section 4.5. Finally, we provide a concise summary of our findings in Section 4.6.

4.2. Literature Review

The Smooth Adjustment Hypothesis (SAH) is built on the monopolistic-competition model of Intra-Industry Trade (IIT) introduced by (Helpman, 1981) and (Helpman & Krugman, 1987, p. 241). This model suggests that IIT presents fewer adaptation obstacles than inter-industry trade due to homogeneity in the factors of

production for goods within an industry, thereby reducing any costs related to product movement. International economic research is now focusing on structural adjustment and labor market issues thanks to the notion of marginal intra-industrial trade, which was introduced by (Brülhart, 1994, p. 604). Additionally, (Abd-el-Rahman, 1991, p. 95) and (Greenaway et al., 1995, p. 1509) proposed a distinction between horizontal intra-industry trade and vertical IIT, which was established in models proposed by (Krugman, 1979, p. 473) and (Lancaster, 1980, p. 154) based on price-based product differentiation, thus further developing the analysis of international trade.

Researchers such as (Balassa, 1966) and (Brülhart, 2000) have also contributed to the literature on the challenges of labor market adjustment and its impacts on the manufacturing industries. Econometric investigations have used a variety of indices to capture the costs related to adjusting to labor market changes. To build on these studies, it should be noted that the main indicator used is to analyze the observed changes in employment at the industry level. However, the studies on labor market adjustment costs have used different econometric methods and focused on various countries, resulting in variations in the methodology and context of the research. Further literature on this topic is listed in Table 16.

Different proxy variables were employed in previous studies to assess the validity of SAH. In their studies (Brülhart & Thorpe, 2000, p. 730), (Erlat & Erlat, 2006, p. 10), (Faustino & Leitão, 2009, p. 10), (Fertő & Attila Soós, 2010, p. 498), (Rasekhi & Ghaderi, 2012, p. 42), (Thorpe & Leitão, 2012, p. 126), (Chemsripong, 2014), (Fainstein, 2020, p. 144), (Leitão, Braz, et al., 2022, p. 356) used absolute changes in employment as a proxy variable for adjustment costs, while (Brülhart et al., 2006a, p. 528) considered the share of occupation moves as well as individual-level industry and occupation moves.

(Fainstein, 2020, p. 144) utilized the absolute change in employment in the industrial sector in a given year as a proxy variable to measure smooth adjustment hypothesis (SAH). (Fainstein, 2020, p. 147)'s study examined the implications of trade expansion on Estonia's market adjustment costs using a GMM-sys dynamic model for 25 industries over a decade (2005-2015). The study concluded that Estonia does not conform to the SAH and finds a negative relationship between industrial

productivity changes and employment, suggesting that the labor market's response to trade expansion is not always positive.

In their empirical analysis (Pinto et al., 2019, p. 149) employed a dynamic estimator to investigate the SAH for the Brazilian economy. They showed that the SAH does not seem to fit to the Brazilian economy. They utilized the net value of workers and added the effect of composition, which includes not only sectors but also skill groups of employees, as a proxy for changes in the employment sector.

(White & Chen, 2012, p. 18) conducted a study to test the Smooth Adjustment Hypothesis (SAH) using manufacturing industry data from 1992 to 2005. Their findings suggest that when it comes to trade, adjusting within industries requires fewer costs compared to adjusting between industries. This conclusion is supported by the impact on the industry-level employment and manufacturing industry workers within industries. While the MIIT variable alone did not exhibit a negative parameter, the interaction term (MIIT*Trade Openness) demonstrated a negative parameter, which is consistent with the predictions of the SAH model. The study considered three distinct dependent variables: changes in sector-level labor on a yearly basis, modifications in production at the sector level annually, and adjustments in non-production labor at the sector level year by year.

In a series of studies examining the Smooth Adjustment Hypothesis (SAH), Brülhart and colleagues (Brülhart & Elliott, 1998, p. 226), (Brülhart, 2000, p. 424), (Brülhart & Thorpe, 2000, 732), (Brülhart & Elliott, 2002a, p. 207), (Brülhart et al., 2004, p. 14) and also (Brülhart et al., 2006b, p. 527) employed various econometric methods to investigate the association between marginal intra-industry trade and the cost of labor's job changes. These studies went beyond analyzing industry-level data and also incorporated individual-level data, employing various econometric methods. Subsequently, (Brülhart et al., 2006b, p. 527) and also (Elliott & Lindley, 2006, p. 20) utilized individual-level data and conducted panel logit models with industrial and occupational moves of employees as proxy variables. Both studies focused on UK data and revealed that their models support the SAH. These findings highlight the need for further evaluation of the SAH across diverse contexts, as the evidence thus far has been mixed.

The Smooth Adjustment Hypothesis (SAH) has been tested for different countries' data, for instance (Erlat & Erlat, 2006, p. 10) conducted a study for the Turkish market, using industry-level data, where they employed the absolute value of employment changes as an indicator for assessing the Smooth Adjustment Hypothesis (SAH). However, their findings did not support of the hypothesis. Similarly, (Faustino & Leitão, 2009, p. 10) applied the system GMM estimator to data from 22 industries in Portugal and did not find evidence favoring the SAH. (Ferto, 2008, p. 383) used Fixed Effects Estimator on Hungary's data for 18 industries and concluded that SAH does not hold. Additionally, (Rasekhi & Ghaderi, 2012, p. 42) examined Iranian industries and found no support for the SAH.

According to recent studies, the SAH holds true in certain contexts. (Chemsriping, 2014, p. 129) used Pooled Ordinary Least Square (POLS) and Fixed Effects Estimators (FE) to examine SAH in Thailand's 120 manufacturing industries and found support for the hypothesis. (Leitão, Braz, et al., 2022, p. 356) studied Portugal employed the method of moments quantile regression (MMQR) and fully modified generalized least squares (FMOLS) and found evidence that SAH holds for Portugal. Additionally, (Fertő & Attila Soós, 2010, p. 500) employed the Difference GMM estimator to analyze data from Hungary and Poland and found support for the SAH in these countries.

The literature lays stress on the crucial role of various components when assessing the suitability of the Smooth Adjustment Hypothesis (SAH). The application of SAH is influenced not only by the data but also by the chosen econometric methodology and the specified dependent variable, which serves as a proxy for employment changes. The literature review is also listed in Table 16.

Table 16 Literature on SAH

Research Paper	Period	Specified Dependent Variable	SAH holds?	Country	No of Industries	Econometric Method
(White & Chen, 2012)	1989-2005	Total yearly industry employment alterations. Yearly alterations in both production and employment levels within a specific industry. Yearly alterations in employment levels within non-production sector of a particular industry.	Yes	USA	415 industries	FE
(Fainstein, 2020)	2005-2015	The total difference in employment levels within the production sector “i” during a specific year “t”.	No	Estonia	25 industries	System GMM
(Erlat & Erlat, 2006)	1974-1975 1998-1999	Difference in employment levels between “t” and “t-n”.	No	Turkey	29 industries	Difference GMM
(Pinto et al., 2019)	1997-2008	Overall employment changes in industry “i” in year “t”.	No	Brazil	81 industries	POLS, FE, System GMM
(Faustino & Leitão, 2009)	1996-2003	Change in total employment	Yes	Portugal	22 industries	System GMM
(Rasekhi & Ghaderi, 2012)	2002-2006	Absolute value of employment changes.	No for MIIT, yes for VIIT & HIIT	Iran	Iranian manuf. sectors	POLS, FE, RE
(Brülhart &	1980-1990	Employment changes.	No	Ireland	Irish	POLS

Elliott, 1998)	1985-1990				manufacturing industries	
(Brülhart et al., 2006b)	1995-2000 (industry moves) 1986-1991 (occupational moves)	The percentage of labor in a specific sector "i" who relocate between industries or professions during the time period from "t" to "t+n" years.	Yes	UK	22 SIC 2-digit manufacturing industry; 77 1-digit, 359 3-digit for occupations, 3-digit SIC80 for industry-level data.	GMM, panel logit models.
(Elliott & Lindley, 2006)	1995-2000	Within an industry moves, between industries moves, stayers.	Yes	UK	23 SIC92 2-digit manufacturing industries, 103 sub-industries (for within moves)	Panel Multinomial Logit
(Brülhart, 2000)	1977-1991	Employment rotation in intra-industry	Yes	Ireland	64 industries	FE
(Brulhart & Thorpe, 2000)	1970-1994	Absolute value of employment changes.	No	Malaysia	Manufacturing trade data	FE
(Thorpe & Leitão, 2012)	1992-2000	Employment changes between two consecutive years.	Yes	Australia	27 industries	System GMM
(Cabral & Silva, 2006)	1995-1997 1997-1999	Absolute value of employment changes.	Yes	Portugal	98 industries	POLS, FE
(Chemsripong,	2002-2011	Employment changes.	Yes	Thailand	120 industries	POLS

2014)

(Leitão, Braz, et al., 2022)

2000-2018

Employment changes.

Yes

Portugal

Manufacturing industries

Method of Moments Quantile Regression, FMOLS

(Ferto, 2008)

1992-2002

Employment changes.

No

Hungary

18 industries

FE

(Fertő & Attila Soós, 2010)

1990-1998

Employment changes.

Yes

Hungary
Poland

28 industries.

Difference GMM

4.3. Theoretical Framework

The smooth adjustment hypothesis proposes that the costs of adjusting to trade expansion will be less than the overall expansion of trade. This hypothesis has its roots in (Balassa, 1966, p. 472)'s seminal work on the impact of the Common Market on international trade. Balassa's empirical analysis demonstrated that the Common Market resulted in lower tariffs and increased competitiveness in the manufacturing industry, challenging the notion that dominant suppliers can displace exporters from developing nations in cooperative marketplaces. Moreover, Balassa underscored the importance of examining the impact of reduced tariffs on imports from other countries.

The intra-industry trade (IIT) has been widely studied in international trade. Early efforts aimed to develop a unified measure that could capture horizontal and vertical IIT. (Falvey, 1981, p. 503) proposed the vertical intra-industry trade (VIIT) model, which expanded upon the Heckscher-Ohlin-Samuelson theorem by incorporating vertical differentiation in the international trade of products while maintaining the presumption that expanding gains are fixed. This approach challenged the conventional notion that international trade primarily occurred between economically similar countries and led to a period of distinction between horizontal and vertical trade in international trade theory.

Many researchers have made significant contributions to the development of IIT theory. (Greenaway et al., 1995, p. 1509) and also (Verdoorn, 1960, p. 299) worked on quantifying IIT, while (Balassa, 1966, p. 472) rejected the claims of dependency theorists that developing countries transfer extra revenue to developed countries and that international trade restricts their economic growth. Their evidence showed that developing countries have reduced income disparities with developed countries and that trade expansion leads to better employment, wage, and income distribution outcomes. Overall, these studies support the smooth adjustment hypothesis and highlight the benefits of trade expansion for developing countries.

(Brühlhart & Elliott, 2002b, p. 211) investigated the effects of a demand shock on a small open economy caused by eliminating trade protection. This event changes the

relative prices of goods, prompting resources to shift between sectors. If a specific industry experience increased import competition, the demand for its production factors decreases, with labor being the first to experience adjustment pressure. Per the Smooth Adjustment Hypothesis (SAH), when import and export shocks happen at the same time within a single sector, the adjustment costs will be lower than if the shocks impacted different industries.

In this context, to test the adjustment cost, various proxy variables are used, the most common variable is the absolute value of employment changes, some studies are; (Brulhart & Thorpe, 2000, p. 730), (Erlat & Erlat, 2006, p. 10), (Ferto, 2008, p. 380), (Fertó & Attila Soós, 2010, p. 498) and also (Thorpe & Leitão, 2012, p. 126).

There are two main categories of adjustment costs. The primary type of adjustment cost occurs in open economies where prices are flexible, and resources need to be reallocated in response to trade-induced changes resulting in temporary factor-price discrepancies that lower net trade gains. The other kind occurs due to market flaws, such as downwardly inflexible wages, which can exceed trade advantages. Some studies suggest that trade liberalization can enhance real wages and reduce unemployment, provided overall productivity increases (Felbermayr et al., 2011, p. 58). Measuring adjustment costs is crucial, and research often focuses on factors related to these costs.

The most frequent measurement for intra-industry trade is the Grubel–Lloyd Index (GL) (Grubel & Lloyd, 1975), as shown below, where X denotes exports and M denotes imports. It is total trade minus the absolute value of the difference between exports and imports divided by total trade for “ i ” industry. $i=1 \dots N$, $t=1 \dots T$

$$GL_{it} = 1 - \frac{|X_{it} - M_{it}|}{(X_{it} + M_{it})} \quad (45)$$

To evaluate trade flows, a dynamic computation called the "index of marginal intra-industry trade" (MIIT) was introduced by (Hamilton & Kniest, 1991, p. 361) (HK index) to complement the Grubel-Lloyd index of intra-industry trade (IIT). The MIIT was developed to address the issue of comparing IIT indexes across time, as a

rise in the IIT index due to an increase in inter-industry trade flows may not necessarily indicate an increase in intra-industry trade. By focusing on the proportion of a particular industry's increase in imports or exports that corresponds to a rise in exports or imports of the same sector, the MIIT highlights new trade flows, providing insight into the importance of trade in the same industry in commerce liberalization.

The “A index”, derived from (Brühlhart, 1994, p. 604) is a valuable measurement which evaluates the structure of variations in import and export flows. It ranges from 0 to 1, with 0 indicating inter-industry trade dominance and 1 representing intra-industry trade dominance. (Brühlhart, 1994, p. 604).

The Marginal intra-industry index (A-Index) calculation is, (Brühlhart, 1994, p. 604).

$$MIIT_{it} = A_{it} = 1 - \frac{|(X_{it} - X_{i,t-n}) - (M_{it} - M_{i,t-n})|}{|X_{it} - X_{i,t-n}| + |M_{it} - M_{i,t-n}|} \quad (46)$$

GL index captures intra-industry trade (IIT) for a specific year, but trade adjustment is a dynamic process. Their research, (Hamilton & Kniest, 1991, p. 361) proposed using "marginal" IIT (MIIT) measures to study trade-induced adjustment. MIIT reflects parallel changes in imports and exports within an industry, accounting for potential uneven trade flow changes and inter-industry adjustments. Several dynamic metrics were introduced, including a simple approach that adapts the GL index to analyze first differences in sectoral trade flows. Like the GL index, the MIIT index ranges from 0 to 1, signifying inter-industry and intra-industry trade dominance, respectively. The MIIT index shares many statistical properties with the GL index.

In summary, the smooth adjustment hypothesis and various indexes like GL, MIIT, and contribute to understanding trade-induced adjustment processes. Assessing the validity of the Smooth Adjustment Hypothesis (SAH) within the context of our study involves evaluating the directionality of the IIT or MIIT variable, with a negative parameter sign indicating its alignment with the hypothesized relationships.

4.4. Empirical Model and Data

The study utilized an extensive dataset collected annually from the Turkish Statistical Institute. The first model was based on 90 industries classified according to the ISIC Rev4, 4-digit classification system from 2010 to 2020. Microdata for the ‘Household Labor Force Survey’ was accessed through a special request made to the Turkish Statistical Institute (TURKSTAT, 2023b) for the same period. This section defines the variables and their formulas and provides a clear description and calculation for the empirical model as presented in Table 17. ISIC codes and definitions are provided in Appendix A.

Table 17 Data sources, description of industry-level data

Notation	Variable	Description	Source
LDEMPCH	Employment Change	The absolute value of employment changes between two consecutive years in logarithmic form.	(TURKSTAT, 2023)
IIT	Intra-industry trade	Grubel-Lloyd index. (Grubel & Lloyd, 1975)	(TURKSTAT, 2023)
MIIT	Marginal intra-industry trade	A-index. (Brühlhart, 1994, p. 604)	(TURKSTAT, 2023)
LTREX	Trade openness	Sum of exports and imports per value added for each sector in logarithmic form.	(TURKSTAT, 2023)
LDAPCONS	Change in apparent consumption	The absolute value of the sum of production and imports minus exports between periods t and $(t-1)$ in logarithmic form.	(Central Bank of the Republic of Turkey, 2023)
LDPROD	Productivity per labor	Absolute value of changes in productivity per labor, in log form years t to $(t-1)$.	(TURKSTAT, 2023)
LINF	Inflation	The data refers to the domestic producer price index (PPI) (2003=100) and comprises annual data from the Turkish Statistical Institute for the NACE Rev2 industry category.	(TURKSTAT, 2023)

In our examination of industry-level data, we adopted the methodology defined by (Brühlhart, 1999, p. 56) to compute the variable, employment changes (LDEMPCH), capturing the absolute logarithmic shifts in employment. Similarly, in the study by (Erlat & Erlat, 2006, p. 10), the same method was employed.

To understand complex connections between variables, we introduced interaction terms such as $IIT*LTROPEN$ and $MIIT*LTROPEN$. These terms show both immediate values and the lag of $IIT*LTROPEN$ across different models. This strategic incorporation enabled us to see the effects that co-varying IIT and trade openness (LTROPEN), as well as MIIT and LTROPEN, might yield. The core aim was to show how these relationships might shift based on trade-openness levels.

We increased our model's predictive capacity by incorporating multiple variables, including inflation and its lag, the lag of MIIT, and an interaction term ($MIIT*Trade\ Openness$), along with its lag. This approach enhanced our insight into how these factors collectively influenced the outcome variable.

The production data used for apparent consumption calculations, are sourced from the Turkish Statistical Institute. These figures, originally presented in Turkish lira (TRY), were then converted to United States (US) dollars using annual average exchange rates from the Turkey Central Bank database (Central Bank of the Republic of Turkey, 2023).

Furthermore, a positive coefficient is expected for trade openness, as suggested by (Brulhart & Thorpe, 2000, p. 730). Meanwhile, for the SAH to hold, both IIT and MIIT are anticipated to carry a negative sign. Similarly, the interaction terms, $IIT*LTROPEN$ and $MIIT*LTROPEN$, are expected to have negative coefficients in our estimations.

We expect a positive sign for productivity because enhanced productivity can augment labor-force engagement, wages, and overall employment levels. Apparent consumption is also expected to have a positive parameter sign in the estimation results because a rise in product demand boosts production and employment.

The model is augmented by employing the producer price index (PPI) for inflation to understand its influence on Turkey's SAH. Notably, Saygılı (2023, p. 24)

highlights a robust association between inflation and economic integration, attributed to Turkey's associated monetary policies with partner nations. The influence of high inflation on costs, profitability, and investment capacity underscores the significance of accounting for inflation, ensuring precise coefficient estimation and enriching the depth of SAH analysis.

We consider the following model specifications with IIT:

μ_i individual effects

ε_{it} stochastic error term

$$\text{LDEMPCH}_{it} = \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{IIT}_{it} + \beta_6 \text{LINF}_{it} + \mu_i + \varepsilon_{it} \quad (47)$$

$$\text{LDEMPCH}_{it} = \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{IIT}_{it} + \beta_6 \text{IIT}_{it-1} + \beta_7 \text{LINF}_{it} + \mu_i + \varepsilon_{it} \quad (48)$$

$$\text{LDEMPCH}_{it} = \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{IIT}_{it} + \beta_6 \text{IIT}_{it-1} + \beta_7 (\text{IIT} * \text{LTROPEN})_{it} + \beta_8 \text{LINF}_{it} + \mu_i + \varepsilon_{it} \quad (49)$$

$$\text{LDEMPCH}_{it} = \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{IIT}_{it} + \beta_6 \text{IIT}_{it-1} + \beta_7 (\text{IIT} * \text{LTROPEN})_{it} + \beta_8 (\text{IIT} * \text{LTROEPN})_{it-1} + \beta_9 \text{LINF}_{it} + \mu_i + \varepsilon_{it} \quad (50)$$

$$\text{LDEMPCH}_{it} = \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{IIT}_{it} + \beta_6 \text{LINF}_{it} + \beta_7 \text{LINF}_{it-1} + \mu_i + \varepsilon_{it} \quad (51)$$

Model specifications with MIIT are as follows:

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} \\ & + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{MIIT}_{it} + \beta_6 \text{LINF}_{it} + \mu_i + \varepsilon_{it} \end{aligned} \quad (52)$$

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} \\ & + \beta_3 \text{LDPROD}_{it} + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{MIIT}_{it} + \beta_6 \text{MIIT}_{it-1} + \beta_7 \text{LINF}_{it} \\ & + \mu_i + \varepsilon_{it} \end{aligned} \quad (53)$$

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} \\ & + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{MIIT}_{it} + \beta_6 \text{MIIT}_{it-1} + \beta_7 (\text{MIIT} * \text{LTROPEN})_{it} \\ & + \mu_i + \varepsilon_{it} \end{aligned} \quad (54)$$

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} \\ & + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{MIIT}_{it} + \beta_6 \text{MIIT}_{it-1} + \beta_7 (\text{MIIT} * \text{LTROPEN})_{it} \\ & + \beta_8 \text{LINF}_{it} + \beta_9 \text{LINF}_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \quad (55)$$

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDAPCONS}_{it} + \beta_3 \text{LDPROD}_{it} \\ & + \beta_4 \text{LTROPEN}_{it} + \beta_5 \text{MIIT}_{it} + \beta_6 \text{LINF}_{it} + \beta_7 \text{LINF}_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \quad (56)$$

$$\begin{aligned} \text{LDEMPCH}_{it} = & \beta_0 + \beta_1 \text{LDEMPCH}_{it-1} + \beta_2 \text{LDPROD}_{it} + \beta_3 \text{MIIT}_{it} + \beta_4 \text{MIIT}_{it-1} \\ & + \beta_5 \text{LINF}_{it} + \beta_6 \text{LINF}_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \quad (57)$$

For the individual-level survey data, we obtained the micro-data for labor-force statistics from the Turkish Statistical Institute by signing a contract. The data covers 2010 to 2020, fall under Group-B microdata, which can only be retrieved with approval from the Turkish Statistical Institute. The variable definitions for the individual-level data are detailed in Table 18.

Table 18 Description of individual-level data

Variable	Description
INDC (Industry Change)	It is classified as movers=1 and stayers=0. It represents the primary activity of the workplace, categorized by NACE Rev2, for workers who left their jobs in the last year.
Female	It is a binary variable, where '1' shows a female and '0' shows a male.
Age	It represents a participant's completed years at the time of the survey.
High Education	It is a binary variable with '1' indicating a university or higher degree and '0' otherwise.
Married	It is a binary dummy variable with '1' denoting a married worker.
Inflation	It is calculated using the industry-weighted GDP deflator (Statistical Region Level 2: 26 regions) based on current prices.

The industry level data is analyzed using Kripfganz (2019)'s `xtdpdgm` command which is a two-step System GMM Estimator. There is the problem of both endogeneity and omitted variables when the panel data has long N and short time-span. This novel command and methodology resolves the issues faced with Roodman (2009)'s `xtabond2` applications. Some of the issues were impacting reported degrees of freedom for tests of overidentifying restrictions. Thus, more accurate estimates can be obtained. The GMM estimator employs an initial weighting matrix from potential options. (Arellano & Bover, 1995), (Blundell & Bond, 1998), (Windmeijer, 2000) and also (Blundell et al., 2001). Most importantly, `Xtdpdgm` Stata command is also recommended by (Blundell & Bond, 2023, p. 109).

As for the individual data, we employed panel logit model. The model specification is as follows:

$$y_{it}^* = \alpha_i + \beta'x_{it} + u_{it}, \quad (58)$$

where ' $i=1, \dots, N$; $t=1, \dots, T$; and y_{it}^* is a random variable'.

$$y_{it} = \begin{cases} 1, & \text{if } y_{it}^* > 0 \\ 0, & \text{if } y_{it}^* \leq 0 \end{cases}$$

$$P(y_{it} = 1|x_{it}, \alpha_{it}) = F(\alpha_i + \beta'x_{it}) = \frac{e^{\alpha_i + \beta'x_{it}}}{1 + e^{\alpha_i + \beta'x_{it}}}$$

(59)

(Pesaran, 2015),

where:

y_{it} represents ‘industry change’ (IndC) for individual i at time t , where:

$y_{it} = 1$ if the individual i experienced an industry change (mover), and

$y_{it} = 0$ if the individual i stayed in the same industry (stayer).

$P(y_{it} = 1|x_{it}, \alpha_{it})$ is the conditional probability that individual i experienced an industry change (mover) at time t given that;

$x_{it} = [\text{Female}_{it}, \text{Age}_{it}, \text{HigherEducation}_{it}, \text{Married}_{it}, \text{Inflation}_{it}]$.

$F(\alpha_i + \beta'x_{it})$ is the logit function, which models the log-odds of experiencing an industry change as a linear combination of the individual-specific random effect, α_i , and the explanatory variables, (x_{it}) , mentioned above.

$e^{\alpha_i + \beta'x_{it}}$ is the exponential term in the logistic function.

β is the vector of coefficients to be estimated for the explanatory variables.

α_i shows individual-specific random effect for individual i .

4.5. Estimation Results

This section examines the relationship between employment changes and IIT/MIIT in Turkey. We provide industry-level data descriptive statistics, correlation matrix, and estimation results in subsection 4.5.1. Additionally, we employ a panel logit estimator with individual-level survey data, presenting corresponding statistics and results in subsection 4.5.2. All analyses use Stata 17.

4.5.1. Empirical Findings for Industry-Level Data

This section presents the estimation results for both models using various estimators. Specifically, the system GMM estimation results with industry-level data are reported as the primary analyses. Tables 19 and 20 provide the descriptive statistics and correlation matrix, respectively.

The correlation matrix reveals that employment changes positively correlate with LDAPCONS, LDPROD, and LTROPEN, indicating that higher consumption, productivity, or trade openness may lead to increased employment opportunities. However, LDEMPCH shows weak correlations with MIIT, IIT, IITLTROPEN, and LINF.

The correlation matrix also shows that apparent consumption (LDAPCONS) is positively correlated with all other variables except intra-industry trade (IIT), which has a weak and negative correlation. This suggests that increases in consumption are likely to coincide with increases in productivity, employment, and trade openness but are not associated with changes in intra-industry trade.

Productivity per labor (LDPROD) is positively correlated with all variables except inflation (LINF), which has a weak and negative correlation. This implies that higher productivity levels are associated with increases in consumption, employment, trade openness, and intra-industry trade but not with increases in inflation.

Trade openness (LTROPEN) is positively correlated with all variables, including the interaction terms $IIT*LTROPEN$ and $MIIT*LTROPEN$, which have a positive correlation with each other. This suggests that increases in trade openness are associated with higher levels of productivity, consumption, employment opportunities, and intra-industry trade and that the effect of trade openness on intra-industry trade is more substantial when there are higher levels of marginal intra-industry trade (MIIT).

Based on the results of the correlation analysis, we selected several key variables to include in our modelling approach, which aimed to test the validity of the Smooth Adjustment Hypothesis (SAH) in the context of Turkey. In particular, we

focused on the relationship between industrial employment changes (LDEMPCH), measured at the 4-digit level of the International Standard Classification Revision 4 (ISIC Rev4), and a range of explanatory variables, including intra-industry trade (IIT) and marginal intra-industry trade (MIIT). We included the IIT variable in the model in Table 21, and subsequently introduced the MIIT variable, presented in Table 22. Both models focus on the dependent variable "of industrial employment changes" (LDEMPCH). The unit of analysis is the absolute value of employment changes over one year, as suggested by (Brulhart & Thorpe, 2000, p. 730). We used Windmeijer-corrected standard errors to estimate both models robustly. To validate the Smooth Adjustment Hypothesis, the coefficient sign of either IIT (GL Index) or MIIT (A-Index) is expected to be negative and statistically significant. However, IIT coefficient is insignificant in any of the five models.

We have included multiple variables to improve the predictive power of our model. Expressly, we have incorporated inflation and its lag, as well as the lag of the MIIT variable. Moreover, we have introduced an interaction term between MIIT and trade openness, along with the lag of this interaction term. This enables us to capture any possible joint effects of these variables on the dependent variable of interest, as suggested by previous studies (Brülhart et al., 2006b, p. 528).

Labor productivity can significantly impact labor supply and demand. Higher productivity can lead to raise in wages and increase employment. However, it can also reduce labor demand due to substitution effect. In our model, productivity per labor (LDPROD) is expected to have a negative coefficient.

As for apparent consumption, with respect to LDEMPCH, a positive coefficient is expected. This can be explained with direct demand effect for a particular product, for instance a particular sub-industry. In this case, the production and employment in corresponding industry will increase, leading employees change jobs in the similar industry.

Table 19*Descriptive Statistics*

Variable	Observation	Mean	Median	Max	Min	Std Dev
DEMPCH	988	1,642.668	640	50,358	0.00	3,645.50
DAPCONS	964	503,000,000	163,000,000	17,400,000,000	92,390.26	1,310,000,000
DPROD	962	1,027.995	384.50	27,875	0.00	2,241.46
TROPEN	990	0.02	0.01	0.27	0.0002	0.03
MIIT	990	0.27	0.11	0.99	0.00	0.32
IIT	990	0.52	0.50	0.99	0.02	0.27
INF	987	11.03	9.06	55.60	-8.56	9.01
IIT*TROPEN	990	0.01	0.00	0.22	0.00	0.03
MIIT*TROPEN	990	0.01	0.00	0.14	0.00	0.02

Table 20 Correlation Matrix

	LDEMPCH	LDAPCONS	LDPROD	LTROPEN	MIIT	IIT	IIT* LTROPEN	MIIT* LTROPEN	LINF
LDEMPCH	1.00								
LDAPCONS	0.45	1.00							
LDPROD	0.60	0.40	1.00						
LTROPEN	0.45	0.59	0.38	1.00					
MIIT	0.11	0.04	0.05	0.08	1.00				
IIT	0.01	-0.03	0.02	0.04	0.22	1.00			
IIT*LTROPEN	0.23	0.33	0.18	0.49	-0.14	-0.81	1.00		
MIIT*LTROPEN	0.01	0.11	0.04	0.16	-0.93	-0.19	0.25	1.00	
LINF	-0.03	0.03	-0.09	0.06	-0.12	0.03	0.01	0.13	1.00

Table 21*System-GMM estimation results with IIT*

Variables	Model One	Model Two	Model Three	Model Four	Model Five
L.LDEMPCH	0.21** [2.20]	0.19** [2.51]	0.19** [2.45]	0.22*** [2.62]	0.18*** [2.61]
LDAPCONS	0.10 [1.51]	0.14* [1.89]	0.13* [1.77]	0.14* [1.76]	0.11 [1.56]
LDPROD	0.30** [2.06]	0.19 [1.06]	0.21 [0.81]	0.21 [0.99]	0.31** [1.64]
LTROPEN	0.20** [2.48]	0.21*** [2.60]	0.25 [0.43]	0.22 [0.49]	0.19** [1.99]
IIT	-0.57 [-0.31]	-1.84 [-0.71]	-1.90 [-0.47]	-8.36 [-0.61]	-0.81 [-0.76]
L.IIT		2.31 [0.87]	1.90 [0.52]	8.44 [0.58]	
IIT*LTROPEN			-0.03 [-0.03]	-1.19 [-0.50]	
L.(IIT*LTROPEN)				1.18 [0.47]	
LINF	-0.03 [-0.08]	0.04 [0.11]	0.02 [0.05]	-0.00 [-0.00]	0.37 [1.22]
L.LINF					-0.15** [-1.96]
Constant	3.19* [1.86]	2.51 [1.35]	2.97 [0.90]	2.73 [1.11]	2.69* [1.79]
Time Effects	Included	Included	Included	Included	Included
Observations	843	843	843	843	783
Number of Groups	90	90	90	90	90

Moment Conditions: Linear	26	27	28	29	34
Sargan-Hansen	(0.17)	(0.23)	(0.24)	(0.25)	(0.35)
AR(2)	(0.19)	(0.19)	(0.18)	(0.25)	(0.27)

Note(s): *, **, and *** represent significance at 10%, 5%, and 1%, respectively; t-statistics are presented in [] and p-values in ().

Table 22*System-GMM estimation results with MIIT*

Variables	Model One	Model Two	Model Three	Model Four	Model Five	Model Six
L.LDEMPCH	0.16** [2.29]	0.16** [2.25]	0.20***[3.57]	0.30***[3.91]	0.11** [2.20]	0.17** [2.51]
LDAPCONS	0.11* [1.66]	0.11* [1.65]	0.12** [2.23]	0.11* [1.86]	0.18*** [3.03]	
LDPROD	0.41*** [3.98]	0.40*** [3.86]	0.28** [2.53]	0.13** [2.24]	0.29*** [3.58]	0.60*** [5.11]
LTROPEN	0.12* [1.78]	0.13* [1.82]	0.23** [2.10]	0.47*** [3.41]	0.16** [2.13]	
MIIT	0.31** [2.18]	0.31** [2.13]	0.25 [0.19]	-3.74** [-2.03]	0.26*[1.91]	0.33** [2.51]
L.MIIT		-0.01 [-0.02]	-0.10 [-0.66]	0.36 [0.79]		0.04 [0.26]
MIIT*LTROPEN			-0.01 [-0.03]	-0.80** [-2.06]		
LINF	0.28 [1.45]	0.29 [1.42]		0.07 [0.83]	0.50 [0.024]	0.13** [2.05]
L.LINF				-0.08 [-1.24]	-0.17*** [-3.52]	-0.10* [-1.87]
Constant	1.29 [0.98]	1.33 [1.00]	2.86** [2.00]	4.19*** [3.01]	0.99 [0.79]	2.266142*** [3.91]
Time Effects	Included	Included	Included	Included	Included	Included
Observations	843	843	872	783	783	783
No of Groups	90	90	90	90	90	90
Moment Conditions: Linear	39	39	39	40	54	63

Sargan-Hansen	(0.28)	(0.23)	(0.47)	(0.40)	(0.80)	(0.39)
AR(2)	(0.21)	(0.22)	(0.10)	(0.13)	(0.62)	(0.14)

Note. *, **, *** denote significance at 10%, 5% and 1% respectively. [] are t-statistics and () represents p-values.

We estimated a total of 11 econometric models with various combinations of variables. The first five models incorporated the IIT variable, while the remaining six used the MIIT variable. Our analysis, detailed in Tables 21 and 22 indicate the varied relationship between industrial employment changes, labor productivity, trade openness, and other factors. We employed the system GMM estimator with the `xtdpdgm` code by (Kripfganz, 2019), using a dataset of 843 observations across 90 industries.

We anticipated a negative coefficient sign for either IIT or MIIT to validate the SAH. However, the IIT coefficient showed no significance across all five models. A similar lack of significance in the IIT coefficient was noted by (Erlat & Erlat, 2006, p. 15) in their study of SAH in Turkey. Additionally, (Azhar & Elliott, 2003b, p. 421) highlighted the limitations of the static IIT index, as it overlooks yearly variations and may not accurately capture adjustment effects and trade dynamics. (Brühlhart et al., 2006b, p. 540) also found nonsignificant results with IIT in their study. However, labor productivity and trade openness do positively and significantly affect employment changes in Models One and Five. Lagged inflation demonstrates a negative impact in Model Five.

Model Four in Table 22 highlights the significance of MIIT, also observing the consistent importance of lagged employment changes, labor productivity, and trade openness. The significance of Inflation appears mainly in Model Six. The negative coefficient of MIIT and MIIT*LTROPEN interaction underscore the linkage of employment changes to trade openness.

In Model Four, our analysis shows significant outcomes. The MIIT variable presents a robust negative and statistically significant coefficient at 5%, further consolidating the support for the validity of the SAH. Following this, the MIIT*LTROPEN interaction term also demonstrates a notable negative coefficient, shedding light on the profound connection between changes in employment and Turkey's openness to trade. Moreover, additional variables substantially influence employment shifts. Particularly noteworthy is the impactful role of labor productivity, for which a notable positive effect is evident. This is underscored by a coefficient of 0.13 (t-statistic=2.24), indicating that increased productivity contributes to more pronounced employment changes.

Trade openness significantly impacts employment changes, with a positive coefficient (0.47, t-statistic=3.41), indicating that open-trade policies drive substantial employment shifts.

Considering time effects, both the Sargan-Hansen and AR(2) tests confirm the model's validity. The Sargan-Hansen test yields a p-value of 0.40, affirming instrumental-variable credibility.

Model Four is optimal for exploring the SAH in Turkey's manufacturing sector. Factors such as historical employment trends, labor productivity, trade openness, and MIIT collectively contribute to employment shifts.

4.5.2. Empirical Findings for Individual Level Data

This section presents the estimation results panel logit estimator, based on individual-level data. In contrast to the earlier industry-level analysis, the focus here is on examining individual-level survey data to gain deeper insights into the factors in employment changes in Turkey. The utilization of individual-level data allows for a more diverse perspective, uncovering unique insights that may complement the industry-level analysis.

We analyzed 157,911 observations from 2010 to 2020. Frequencies and statistics for variables (gender, education, marital status, age, MIIT, and inflation via the gross domestic product (GDP) deflator) are presented in Tables 23, and 24. We focused on industry moves, following (Brülhart et al., 2006a, p. 536), as the survey lacked specific occupational information.

Table 23*Frequencies of individual-level data*

Variable	Choice	Frequency	Percent	Total Observations
Industry Change	0	144849	91.73	157911
	1	13062	8.27	
Female	0	90185	57.11	157911
	1	67726	42.89	
Higher Edu.	0	134527	85.19	157911
	1	23384	14.81	
Married	0	54072	34.24	157911
	1	103839	65.76	

Table 24*Descriptive statistics of individual-level data*

Variable	Observations	Mean	Std Dev	Min	Max
MIIT	157911	0.02	0.05	0	0.26
Age	157911	37.65	13.86	15	65
Inflation	157911	0.76	1.19	0.006	10.67

Table 25*Panel logit estimation results*

Variables	Fixed-Effects	Random-Effects	Marginal Effects	Odds Ratio
MIIT	-0.61*** [-2.70]	-0.48** [-2.25]	-0.48** [-2.25]	0.62** [-2.25]
Female	-0.62*** [-28.36]	-0.62*** [-30.78]	-0.62*** [-30.78]	0.54*** [-30.78]
Age	0.06*** [10.59]	0.05*** [0.05]	0.05*** [11.41]	1.06*** [11.41]
Age Square	-0.00*** [-15.97]	-0.00*** [-17.19]	-0.00*** [-17.19]	1.00*** [-17.19]
Higher Education	-0.34*** [-10.73]	-0.36*** [-12.29]	-0.36*** [-12.29]	0.70*** [-12.29]
Married	-0.30*** [-11.62]	-0.29*** [-12.25]	-0.29*** [-12.25]	0.75*** [-12.25]
Inflation	-0.07*** [-7.10]	-0.07*** [-7.78]	-0.07*** [-7.78]	0.93*** [-7.78]
Constant		-2.35*** [-28.93]		0.09*** [-28.93]
Observations	86172	157911		157911
No of Groups	8488	25178		25178
LR/Wald	$\chi^2_{72894.21} > 14.07$	$\chi^2_{72929.88} > 14.07$		$\chi^2_{72929.88} > 14.07$
ρ		0.02 (0.00)		0.016 (0.00)
σ_u		0.23 (0.03)		0.234 (0.03)
LR Test		11.51***		-43361.09***

Notes. [] refers to Z-statistics: *** and ** indicate significance at 1% level and 5%, respectively; () indicates std error.

To examine the Smooth Adjustment Hypothesis (SAH), we conducted a second estimation using a panel-logit estimator with individual-level data. The analysis focuses on whether labors changed industries and includes variables such as marginal intra-industry trade (MIIT), age, age squared, higher education, married status, and inflation. The data covers 157,911 households. The results are consistent with random effects as detailed in Table 25.

The inflation is available in the model for the survey data. The GDP deflator is used for inflation as it reflects the overall price trend in the economy and captures the inflation expectations of households and firms. As stated by (Church, 2016), the GDP price index and implicit price deflator assess price increases for locally produced goods and services, but not necessarily those that are imported, whereas the CPI monitors price changes for commodities and services that urban consumers frequently purchase. The GDP deflator may be a more appropriate measure for the survey data, as it reflects the overall price changes in the economy and captures the inflation expectations of households and firms.

The likelihood ratio test results show individual effects in the model. According to the panel logit model estimation, the Hausman test statistic, H_0 : Difference in coefficients not systematic,

$$\chi^2_6 8.34 < 12.592$$

we fail to reject the null hypothesis, suggesting that the random-effects model is the preferred model.

The estimation results show the impact of various factors on the likelihood of labors' changing industries. All parameters in the model are significant. MIIT, female, age square, higher education, married, and inflation variables have negative parameter signs, and only age has a positive sign.

The MIIT variable has a negative and statistically significant effect on the probability of labors' changing industries. A one-unit increase in the MIIT variable reduces the participant's probability to change the industry by 48%. The negative coefficient of -0.485 for the variable MIIT implies that higher levels of marginal intra-

industry trade are associated with a reduced probability of labor movement between industries.

Age and age square have reverse signs. An increment of one year in the survey participant's age is associated with a 5.5% increase in the probability of changing industries. However, age increases the probability of industry change; after a certain age, the likelihood of a worker moving to another sector decreases. Females' probability of changing industry is 86.05% lower than males. Survey respondents with an undergraduate degree or higher are 42.78% less likely to change industry than those with less educational attainment. Based on the survey data, almost 65.76% of the respondents are married, and they are 34.07% less likely to change industry than unmarried respondents. A 1% rise in inflation lowers the likelihood of workers changing industries by 7.13%.

In summary, the findings indicate that industry-specific characteristics, gender, age, educational attainment, marital status, and inflation rate all substantially impact a labors' likelihood of changing industries. Furthermore, the findings emphasize the importance of considering individual and contextual factors when researching job mobility and labor market dynamics.

5.1. Conclusion

We examined the SAH in Turkish manufacturing sectors by analyzing data from both industry-wide data and data from individual surveys spanning the years 2010 to 2020. Using the MIIT variable to understand IIT intensity, we initially applied a system GMM model. Furthermore, we conducted an assessment employing a panel logit model to measure its effect on the probability of workers' changing industries.

The results obtained from both models, namely, 'system GMM Model Four' and the panel logit models, consistently indicate that the MIIT variable exerts a negative and statistically significant influence on labor mobility between industries. These findings support the concept of smooth adjustment. This study suggests that when IIT has a substantial presence, companies are more likely to reshape their production frameworks while retaining their workforce within the same industry.

(Erlat & Erlat, 2006, p. 22)'s study did not yield evidence supporting SAH when the current value of MIIT was considered. However, SAH is supported when the lagged value of MIIT is taken into account. This study is the sole investigation conducted for Turkey on this matter.

In contrast, our examination did not reveal any substantial relationship between IIT and changes in employment, as discerned through various model analyses. This outcome is consistent with (Erlat & Erlat, 2006, p. 15) and (Brulhart & Thorpe, 2000, p. 731). However, a desirable development emerged as the interaction term of IIT and trade openness (LTROPEN), denoted as $IIT*LTROPEN$, yielded a significant and negative coefficient.

The panel logit model also sheds light on industry-change factors at the individual level. We discover that the likelihood of industry change is highly influenced by gender, education, and marital status. Specifically, our analysis underscores that employees who are married, having higher educational attainment, and are female tend to exhibit a lower inclination towards industry-switching.

Collectively, our study contributes substantial evidence that is consistent with the SAH, operating at both industry and individual levels. These findings carry significant implications for both policy framers and businesses, guiding the development of strategies aimed at fostering a resilient labor market through the promotion of IIT. Policymakers should ensure a conducive trade environment that facilitates IIT and avoids excessive protectionism. By promoting open-trade policies, reducing trade barriers, and participating in trade agreements, policymakers can support sectoral growth and increase opportunities for specialization, thereby reducing the requirement for labor movement between industries.

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APPENDIX A: ISIC CODES AND DEFINITIONS

ISIC Code	Manufacturing Industry
1040	Manufacture of vegetable and animal oils and fats
1050	Manufacture of dairy products
1061	Manufacture of grain mill products
1062	Manufacture of starches and starch products
1071	Manufacture of bakery and farinaceous products
1072	Manufacture of sugar
1073	Manufacture of cocoa, chocolate and sugar confectionery
1074	Manufacture of macaroni, noodles, couscous and similar farinaceous products
1079	Manufacture of other food products N.E.C.
1080	Manufacture of prepared animal feeds
1391	Manufacture of knitted and crocheted fabrics
1392	Manufacture of made-up textile articles, except apparel
1393	manufacture of carpets and rugs
1394	manufacture of cordage, rope, twine and netting
1399	Manufacture of other textiles N.E.C.
1410	Manufacture of wearing apparel, except fur apparel
1420	Manufacture of articles of fur
1430	Manufacture of knitted and crocheted apparel
1512	Manufacture of luggage, handbags and the like, saddlery and harness

1520	Manufacture of footwear
1621	Manufacture of veneer sheets and wood-based panels
1622	Manufacture of other builders' carpentry and joinery
1623	Manufacture of wooden containers
1629	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials
1701	Manufacture of pulp, paper and paperboard
1702	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
1709	Manufacture of other articles of paper and paperboard
2011	Manufacture of chemicals and chemical products
2012	Manufacture of fertilizers and nitrogen compounds
2013	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms
2021	Manufacture of pesticides and other agrochemical products
2022	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
2023	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
2029	Manufacture of other chemical products
2030	Manufacture of man-made fibers
2211	Manufacture of rubber tires and tubes; retreading and rebuilding of rubber tires
2219	Manufacture of other rubber products

2220	Manufacture of plastic products
2310	Manufacture of glass and glass products
2391	Manufacture of refractory products
2392	Manufacture of clay building materials
2393	Manufacture of other porcelain and ceramic products
2394	Manufacture of cement, lime and plaster
2395	Manufacture of articles of concrete, cement and plaster
2410	Manufacture of basic iron and steel and of ferro-alloys
2420	Manufacture of basic precious and other non-ferrous metals
2511	Manufacture of structural metal products
2512	Manufacture of tanks, reservoirs and containers of metal
2513	Manufacture of steam generators, except central heating hot water boilers
2520	Manufacture of weapons and ammunition
2593	Manufacture of cutlery, tools and general hardware
2599	Manufacture of other fabricated metal products
2610	Manufacture of electronic components and boards
2630	Manufacture of communication equipment
2651	Manufacture of instruments and appliances for measuring, testing and navigation
2660	Manufacture of irradiation, electromedical and electrotherapeutic equipment
2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus

2720	Manufacture of batteries and accumulators
2731	Manufacture of fiber optic cables
2732	Manufacture of other electronic and electric wires and cables
2733	Manufacture of wiring devices
2740	Manufacture of electric lighting equipment
2750	Manufacture of domestic appliances
2790	Manufacture of other electrical equipment
2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
2812	Manufacture of fluid power equipment
2813	Manufacture of other pumps and compressors
2814	Manufacture of bearings, gears, gearing and driving elements
2816	Manufacture of lifting and handling equipment
2819	Manufacture of other general-purpose machinery N.E.C.
2821	Manufacture of agricultural and forestry machinery
2822	Manufacture of metal forming machinery and machine tools
2823	Manufacture of machinery for metallurgy
2824	Manufacture of machinery for mining, quarrying and construction
2825	Manufacture of machinery for food, beverage and tobacco processing
2826	Manufacture of machinery for textile, apparel and leather production
2829	Manufacture of other special-purpose machinery N.E.C.
2910	Manufacture of motor vehicles

2920	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
2930	Manufacture of parts and accessories for motor vehicles
3030	Manufacture of air and spacecraft and related machinery
3091	Manufacture of motorcycles
3092	Manufacture of bicycles and invalid carriages
3100	Manufacture of furniture
3211	Manufacture of jewelry, bijouterie and related articles
3220	Manufacture of musical instruments
3230	Manufacture of sports goods
3240	Manufacture of games and toys
3250	Manufacture of medical and dental instruments and supplies
3290	Manufacturing N.E.C.
