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International Trade and Consumption-Based CO_2 Emission: A Cross Country Analysis

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Abstract

This study analyzes the effect of a recently developed consumption-based carbon emissions database to investigate the impact of renewable energy consumption and global trade on consumption-based emissions of CO_2 for the period covering 1995-2019 for emerging economies E7 (India, Brazil, China, Indonesia, Russia, Turkey, and Mexico) and G7 (Canada, Japan, US, Germany, UK, France, and Italy) country groups. To find the short and long-run association between dependent variable i-e consumption-based CO2 emissions and Production based CO2 with exports, imports, GDP, industry value added and renewable energy consumption, cross-sectionally augmented ARDL is applied. Interestingly the results in the long run and short are identical for G7 and E7 in case of consumption based carbon emission where exports and renewable energy consumption negatively and significantly affects the consumption based CO2 in both long run and short run whereas imports, GDP and industry value positively and significantly affects the consumptions based CO2 emissions. Whereas in case of production based CO2 emissions the results obtained from the study are identical to the above-mentioned results both in long run and short run except for E7 imports which negatively affects the production based carbon emissions both in long and short run.

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Finally, the results the of DH granger causality test for E7 economies show that any policy to target exports, imports, GDP, and industry value added significantly changes CO_2 emissions. The findings recommend focus on importing environment-friendly production machinery by imposing tax on carbon intensive imports. Furthermore, one of the best possible solutions for reducing carbon emissions is to shift towards renewable energy.

Key words: Carbon dioxide, Emissions, international trade, Energy, Renewable energy

1. Introduction

As global economy is majorly based on international trade. Doubling its value in less than three decades, the contribution of trade constitutes third part of the gross domestic product of the world (Hanson, 2017; Head et al. 2017).Whereas, on the flip side, it has serious ecological consequences (Liu *et al*., 2018). Global trade contributes to ecological degradation, as through trade the exchange of good and services is promoted among countries encouraging the pollution intensive industries. Additionally, trade increases the earning level of the countries which might be utilized to decrease the degradation of ecological system in later stages (Grossman et al., 1991).

Emissions incorporated in trade are the emissions that take place during the production of traded services and goods (Wiebe et al., 2016). Therefore, the contribution of global trade cannot be overlooked in the explanation of CO2 emissions (Gozgor et al., 2016; Liu et al., 2018; Nathaniel et al., 2019). Carbon dioxide is a key heat-trapping greenhouse gas, that is released through activities of humans like burning of fossil fuels and cutting of forests, also processes of nature like volcanic eruptions and respiration are also the main reason of global warming[1]. The reason behind the high rate of global

[1]As per the Annual Global Analysis of NASA, the "record-warm" year since 1880 was 2016-2017. This ascending trend of global warming is primarily due to activity of humans and to its consequent greenhouse gas outflow, mainly carbon dioxide (IPCC, Climate Change 2014).

emissions since 2000 is the unforeseen increase in the intensity of energy per unit of GDP as well as the carbon intensity of energy along with the rapid increase in population and GDP per capita energy (Le Quere*et al.,* 2009; Raupach*et al.,* 2007)[2].

According to the Stern Review (Stern, 2007), North America and Europe are responsible for generating a major share of 70% of CO_2 emissions resulting from production of energy since 1850. To deal with global warming and environmental anomalies, numerous long-run got developed for instance, the 2015 Paris Climate Agreement (PCA) and 1997 Kyoto Protocol in 1997. But unfortunately, the major focus in these agreements has been on the fundamental statistical measure; the production based emissions which accounted those emissions produce within a country's national territory. Whereas emissions on national level fails to provide a valid depiction of a country's actual carbon emissions since some of their production share is transferred to foreign through exports whereas a part of its total demand is gratified by imports (Davis, et al., 2010). So, there is need to focus on consumption based CO_2 emissions along with production based in these agreements. These reduction efforts are boosted through eco-friendly technological modernization, growing part of renewable energy in total consumption of energy and prices of energy. According to Kaya (1990), supply of renewable energy has a significant role in the reduction of CO_2 emissions.

Effective supply of renewable energy will reduce the carbon and energy intensity. According to the prediction of the International Energy Agency (IEA) for the next five years' renewable energy will continue as fastest growing electricity source, with their

[2]Almost 75% greenhouse gases account for carbon dioxide, which becomes the foremost cause of climate change and extreme weather event heat waves, floods, droughts, and heavy rainfall often seen in the past years. As per the most recent data, the worldwide discharge of CO_2 has come to 36.15 giga tones in 2017 which involve China being the leading emitter whose 2017 carbon dioxide release attained 9.84 giga tones i.e., 27.21% of the global threshold (Li *et al*., 2019).

rising share from 23% to 28% in 2015 to 2021 respectively. Renewable energy provide solution to the problem of carbon emissions and maintain consumption of energy. The International Energy Agency (IEA, 2009b) proposed that tendencies these days in supply of energy and consumption are still unsustainable ecologically, socially, and economically. Moreover, advanced economies are responsible for less than one quarter of cumulative emissions, whereas is it anticipated that because of high population and growth of GDP, the current underdeveloped economies will create the major portion of three quarters of the future emissions. So, consumers demand in advanced economies are satisfied by a substantial segment of growth in these struggling economies (Guan *et al.,* (2009). The emissions produced because of exports from developing markets to advanced economies strengthen existing huge international disparity in per capita emissions as well as the regional efforts incompleteness to decarbonize is revealed. As, according to the World Bank (2018), the contribution highly advanced G7 countries to the global emissions of CO_2 was 95 billion tons (27.3%) in 2018.

Additionally, the trade figures connected to G7 economies is noteworthy[3.] G7 contribute more than 60% of the global net wealth and 50% of the global GDP. In future there will be a shift in the power economically in the far future i.e., by 2030 with the rise of powerful E7 countries challenging the monopoly of G7 countries (The World in 2030).

The E7(Emerging seven is the 07 countries, India, China, Mexico, Brazil, Indonesia, Turkey, and Russia)that are clubbed together due to their significant emerging economies. The emerging markets of China, Russia, and India highly export carbon due to which the prevalence of coal, a carbon-intensive fuel, and the exports of

[3]Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) G7 also known as the Group of Seven, includes seven countries that are currently the world's biggest, highly developed, and well-advanced economies. They came into existence in 1975 and have around 50 years of well-stocked history. The principal motive of the G7 is to give opportunity to the global leaders of the seven most dominant and considerably great industrialized countries to gather to encourage change world-wide. G7 economies rank high in the emissions of CO_2 and consumption of energy. The economic growth because of globalization highly pressurizes gas emissions specially in G7.

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the lower value of intensive energy are reflected. On the contrary, Japan and Western Europe consume high per unit of energy to produce goods for exports, and low carbon technology generates a higher share of the required energy. The developing countries have higher carbon intensity of exports than the advanced US economy. However, Western Europe has far less carbon intensity of exports than the US economy. Nevertheless, the carbon intensity of exports is much higher than their imports to India, China, and the Middle East (Davis *et al.*, 2010). Therefore, the policies related to climate proposed by these economies as well their actions are highly emphasized for transitioning to a low carbon economy.

The facts and figures discussed above making it necessary to examine the correlation of consumption based carbon emissions associated with international trade. Along with studying consumption CO2 emissions this study also analyzes the effect of renewable energy consumption and global trade on consumption based emissions of CO_2 for the period covering 1995-2019 for E7 and G7.Further, focusing primarily on consumption based CO_2 emissions, this study tries to provide an insight to the actual situation of consumption based CO_2 emissions relating to renewable energy consumption. This study is different from preceding studies not only in terms of its period covered (1995-2019) but also in terms of explanatory variables incorporated in the study and the area of study. The base for the selection of E7 and G7 group of countries as study area is the possession of their favorable characteristics.

2.1. Literature Review

Shafik, (1994); Grossman and Krueger, (1991) identified the true relationship between environment and trade. Almost 13% the total carbon dioxide emissions of the economies are due to the manufacturing goods imports Kulionis, (2014). Further, Munksgaard and Pedersen, (2001) stated that foreign demand is the reason behind increase in emissions because of which it is difficult to reach the national target of CO_2

emissions. Stahls*et al.* (2011) results stated that all the emissions in forest industry is due to the production for exports. Andersson, (2018) estimated that the emission of the rest of world increases because of importing commodities from China, instead of producing the same quantity and type of commodities locally.

As, per world bank study, pollution intensive production rate is low if countries follow open trade policies. On the contrary, the findings of Rock, (1996) reveal that open trade policies are more emissions intensive. Next Ahmad and Wyckoff, (2003) reveal that national consumption are greatly involve in emissions as compared to the local production.In Europe and East Asia, the significant and inverse relation of carbon dioxide emissions with trade confirmed by the results of Copeland and Taylor, (2004). In contrast the findings of Jalil and Mahmud, (2009) and Omri, (2013) confirms that carbon dioxide emissions are insignificantly associated with international trade.

According to Managi*et al*. (2009)and Jorgenson and Clark, (2012) the impact of trade is different in advanced and underdeveloped; as trade result in high emissions in underdeveloped countries whereas the emission level of advanced economies reduces but it appears somewhere else in form of carbon leakage because they meet their excess consumption through importing from other countries (Hertwich Peters, 2009; Davis and Caldeira, 2010). Dong *et al*. (2016) and Steinberger *et al*., (2013) concluded that carbon emission based on consumption does not get support from Environmental Kuznets Curve as it is seen that this curve is direct and increasing for emission based on consumption. Furthermore, Bosupeng, (2016) concluded that countries should consider economic growth, exports market demand and energy consumption in their efforts to decrease emissions of carbon dioxide. As per the results of some studies, renewable energy consumption increases due to carbon emissions (Omri*et al*., 2015). Although, some found the opposing effect of the emissions (Ackah and Kizys, 2015; Marques, 2012). According to Marques *et al*., (2010) CO_2 emissions and sources of non-renewable energy held back the deployment of renewable energy. Rafiq and Alam, (2010) replicated Sadorsky, (2009) and concluded that CO_2 emissions and income have significant and encouraging effects on consumption of renewable energy. Shahbaz, *et al.* (2018) the empirical outcomes suggested that reduction in CO_2 emissions and improvement in the overall health of the environment occurs because of investment in technologies innovation. Khan *et al*. (2020) concluded that carbon emission from consumption perspective is negatively associated with exports, innovative technology, and consumption of renewable energy. Managi*et al*. (2009) categorizes the emissions embodied in trade into scale, composition, and technical effect. The scale and composition effect lead to higher trade embodied carbon emissions whereas the technical effect counterbalance to some extent.

Technological change brings efficiency, which is the prime factor in reducing carbon emissions, but the technological change has no substantial effect because of the rebound effect of carbon emissions. Which means that technical change only decreases carbon concentration by encouraging the optimization and upgradation of industrial structure. Vlčková*et al*. (2015) confirms that in Visegrad economies changing the industrial structure played a vigorous role in reducing carbon emissions. Khan *et al*. (2020) work on new emerging phenomena of emissions based on consumption. The important variable which researchers focused on these studies are export, GDP, and imports. Still the role of consumption of renewable energy and its effect on emissions based on consumption are not covered.

3. Research Methodology

This study is design to scrutinize the impact of international trade on carbon dioxide emissions based on consumption for G7 and E7 economies. The contribution of renewable energy usage and openness of trade (imports and exports) in carbon emissions based on consumption context is ascertained in this study. Study period

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started from 1995 till 2019 (annual) for the selected group of countries E7 and G7. Study models also comprise of additional control variables that may impact carbon dioxide emissions based on consumption, GDP, and net output of industrial sector (Mrabet *et al.*, 2019). To achieve the study objectives, the succeeding research pattern is adopted.

This study used Second Generation Approach instead of First-Generation estimation technique and traditional panel estimation techniques (such as the Fixed Effect, Random Effect, Dynamic Ordinary Least Squares, and Generalized Method of Moments) to acquire vigorous outcomes and make proper references. This is because these econometric methods neglect both the dependency among cross sections across borders, the problem of heterogeneity and structural breaks, which will yield misleading results. According to Alam*et al.* (2018) the assumption of homogenous slop coefficient led to the ambiguous estimates. So, this study employs Pesaran and Yamagata, (2008) slope homogeneity test, to scrutinize the presence of homogenous or heterogeneous slop coefficient. Therefore, prior to analyzing stationarity characteristics of all variables, this study is utilizing the cross section dependence test suggested by Pesaran, (2015).The existence of dependency among countries nullifies the use of panel unit root test from first generation (Jalil, 2014), so this study follows Pesaran, (2007) to cope up with the issues as discussed above.

Further, this study is based on co-integration technique of Westerlund, (2007). According to Kapetanios*et al.*, (2011) this test gives us significant results and robust when there is dependency among error terms of cross-sections. Dependency among cross sections, heterogeneity and dynamics are the basic characteristics of panel estimation and all these are jointly forecast by Cross Section Augmented ARDL. The estimates of conventional panel ARDL approach might be ambiguous in presence of cross section dependency. This is the reason why this study employs CSARDL approach. Finally, the causality test by Dumitrescu and Hurlin, (2012) is used in this

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analysis.This test is also applicable in situation where period (T) is greater than cross sections (N).

4. Results and Discussion

4.2.Slope Heterogeneity Test for G7 & E7 Economies

Pesaran& Yamagata, (2008) slop homogeneity test outcomes reject null hypothesis at 1%, 5% and 10% levels of significance correspondingly as shown in table 4.2. Which means that there is heterogeneity problem in the selected panel of G7 and E7 economies.The slope heterogeneity coefficient is mainly due to different economic structures, demographic, and socioeconomic factors for G7 & E7 group of countries. So, slope coefficients for these cross-sections vary with time and different for each cross-section.

Cross Sectional Dependence Test

The outcomes of Pesaran, (2015) test of cross section dependence (CD) test is presented in table 4.3. Test statistics reject null hypothesis which assume that cross sections are not dependent on one another for all the focused variables in the study at 1%, 5% and 10% significance levels correspondingly as represented in table 4.3 for G7 countries[4.] Whereas the outcomes of the dependency test by Pesaran, (2015) for emerging 7 economiesreject null hypotheses for all variables except exports (EXP) and imports (IMP) which reject alternative hypothesis for dependency among cross section

4.4. Panel Unit Root Test

The empirical findings of unit root test depict that all the relevant variables are integrated of order 1 which means that we can apply co integration test proposed by Westerlun, 2007[5].

[4]Results of cross sectional dependency tests for G7 and E7 are given in appendix table 4.3.

[5]Results of panel unit root test tests for G7 and E7 are given in appendix table 4.4.

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4.5. Panel Co-Integration Test

Next the empirical results show a steady long run relationship among variables presented in models for both groups of countries that is G7 and E7 as we reject null hypothesis of no co-integration at 1%, 5% and 10% level of significance[6].

4.6. Cross-Section Augmented ARDL Approach

According to test statistics the significant and negative coefficients of consumption of renewable energy and exports are both in long and short period indicate that emissions based on consumption decreases as result of increase in exports and renewable energy consumption in highly advance G7 countries at 1%, 5% and 10% level of significance. Whereas other variables such as industry value added, GDP, imports are positively related with emission based on consumption. According to coefficients 1% upsurge in imports result in 0.241% increase in CO_2 emissions based on consumption` in shorter period while 0.274% in longer period, which require an explanation. As majority of the imports of G7 economies are energy intensive products which ultimately increases consumption based CO_2 missions. Whereas in short and long run -0.459% and -0.482% diminution in CO_2 emissions based on consumption caused by exports.

These results are consistence with the findings of Managi*et al.* (2009) and Sadorsky, (2012).Next the coefficient of gross domestic product shows positive impact on carbon dioxide emission based on consumption. In both shorter and longer period 0.962% and 0.971% increase in emission based on consumption is due to gross domestic product respectively. With growing economic activities, energy demand is also increasing which eventually leads to rise in CO_2 emissions; hence, GDP and emission

[6]Results of panel cointegration test are given in appendix table 4.5.

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based on consumption are positively associated with one another. These results consistence with the findings of Zhang and Da, (2015); Destek and Sarkodie, (2019).

Table: 4.5 Cross-Section Augmented ARDL Approach for G7 and E7

Variables	CS-ARDL for G7				CS-ARDL for E7			
	Short run		Long run		Short run		Long run	
	Coefficient (Std. Error) DV: CCO_2 mt	Coefficient (Std. Error) DV: TCO_2 mt	Coefficient (Std. Error) DV: CCO_2 mt	Coefficient (Std. Error) DV: TCO_2 mt	Coefficient (Std. Error) DV: CCO_2 mt	Coefficient (Std. Error) DV: TCO_2 mt	Coefficient (Std. Error) DV: CCO_2 mt	Coefficient (Std. Error) DV: TCO_2 mt
ΔExports	-0.459* [0.2616]	-0.079*** [0.0241]	-0.482*** [0.1042]	-0.097*** [0.0163]	-0.179* [0.1057]	-0.09**** [0.0108]	-0.202*** [0.042]	-0.13*** [0.0204]
Δ **Imports**	0.241*** [0.0562]	0.0246*** [0.0077]	0.274*** [0.0724]	0.0291*** [0.00721]	0.108*** [0.0235]	-0.055*** [0.01351]	0.1921*** [0.0249]	-0.06*** [0.0160]
Δ **GDP**	0.962* [0.5271]	0.694** [0.3441]	0.971*** [0.2032]	0.701*** [0.1072]	0.519*** [0.1617]	0.5720** [0.2627]	0.739** [0.2965]	0.6499** [0.3063]
Δ **REC**	-0.048*** [0.0126]	-0.141* [0.0772]	-0.052*** [0.0162]	-0.163*** [0.0264]	-0.2675* [0.1461]	-0.2894* [0.1577]	-0.335** [0.1613]	-0.365** [0.1826]
Δ **IVA**	0.162*** [0.0241]	0.231*** [0.0872]	0.281*** [0.0715]	0.271*** [0.0612]	0.120*** [0.0163]	0.1882*** [0.0264]	0.172*** [0.0352]	0.191*** [0.0374]
ECM (-1)	-0.872*** [0.1254]	-0.814*** [0.1542]			-0.918*** [0.12422]	-0.851*** [0.07645]		

*Note: *** is for 1%, ** for 5% and *10% statistical significance level.*

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According to the empirical outcomes in long and short run utilization of renewable energy cause 0.0521% and 0.048% decrease in carbon emissions based on consumption respectively. These outcomes are consistent with the findings of Panwar *et al*. (2011); David and Venkatachalam, (2018). Since, the sources of renewable energy are cleaner, environment friendly and pure that are sustained and satisfy the needs of present and future generation with safe environment; that is why, it is the source of subsiding emission based on consumption. Next 0.281% and 0.162% upsurge in CO_2 emissions based on consumption is trigger by industry value added respectively. These outcomes are in line with the findings of Liddle, (2018). On the other hand, the impact of export and utilization of renewable energy are negative for production based CO_2 emissions which gives the idea that one percent increase in exports and renewable energy utilization result in -0.079% and -0.141% decrease in territory based emissions in long and short term correspondingly.Moreover, the variables such as GDP, imports and IVA are positively associated with territory based emissions both in short and long run and its respective coefficients indicate that 0.694%, 0.246% and 0.231% upsurge in territory based CO_2 emissions are triggered by GDP, imports and IVA correspondingly in shorter period. Whereas in long run with one percent increase in GDP, imports and IVA leads to 0.701%, 0.0291% and 0.271% increase in territory based CO2 emissions.

According to test outcomes of E7 countries exports and renewable energy consumption negatively and significantly associated with consumption based CO2 emissions. Coefficients of export in short and long run shows -0.17% and -0.202% decrease in consumption based carbon emissions respectively. Whereas on the opposite side, imports, industry value added, and gross domestic production have positive impact on emission based on consumption and their respective coefficients in short and long run are 0.108%, 0.1204%, 0.5187%, and 0.1921%, 0.172%, 0.739%, respectively.The outcomes of co-integration are supported by the following studies like Hasanov *et al*.

2018; Liddle, 2018; Peters *et al*. 2012; Wiebe &Yamano, 2016; Shahbaz *et al*. (2020).Whereas exports, imports and renewable energy consumption negatively and significantly associated with production based emissions in both long and short run. Positive coefficient of Industry value added,and GDP shows an increase in production based carbon dioxide emissions in short as well as long run.

4.7 Pairwise DumitrescuHurlin Panel Causality Tests (G7)

The concluding results of causality test for G7 shows that any policy to target exports, imports, GDP, and IVA considerably changes CO_2 emissions based on consumption at 1%, 5% and 10% level of significance. According to results, to significantly affect consumption based carbon emissions one's must focused on renewable energy utilization and vice versa. Furthermore, there is bidirectional causality running from export, import and REC towards territory based CO_2 emissions.

4.8 Pairwise DumitrescuHurlin Panel Causality Tests (E7)

Next the findings confirm the existence of two-way causal relationship of carbon emissions based on territory and consumption with imports, exports, gross domestic product, consumption of renewable energy and industry value added in group of seven emerging economies and these variables have predictive control over one another. According to statistics as shown in the table 4.8 that there is only one-way relation between renewable energy and territory based emissions. These finding are consistent with the earlier studies of Hu *et al*. (2018);Acaravci and Ozturk, (2010) and Arouri*et al*. (2012) and following are the results depicted in table 4.8 in appendix.

5. Conclusion and Recommendations

5.1. Conclusion

This study examines the effect of consumption of renewable energy and international trade on consumption based emissions of CO_2 for the period covering 1995-2019 for emerging economies E7 and G7 country groups. This research employs the panel estimation technique from second generation to empirically examine this relationship for the group of G7 and E7 economies from 1995-2019. Based on study outcomes import, GDP and industry value added increase consumption based CO2 emission and opposite are the result of exports. whereas is in case of renewable energy consumption it is inversely associated with both consumption and production based carbon emission in G7 and E7.

Finally, the results of DH granger causality test for E7 economies shows that there is two ways association among exports, imports, GDP, industry value added, renewable energy and consumption based carbon emissions. While the empirical findings of causality test for territory-based carbon emission shows that except renewable energy consumption all the remaining variables are bidirectionally associated with one another.In case of G7 the test statistics confirm that the only variable which has bidirectional causal relationship with consumption-based carbon emission is renewable energy consumption. In short, if countries around the globe wants to reduce the overall carbon emissions, they must switch towards renewable energy sources and focus on research and development for ecofriendly innovation.

5.2 Recommendation

This study recommends that countries should focus on importing less carbon intensive goods. By decreasing carbon intensive imports country's will be able to reduce the effect of imports on emissions. According to the empirical findings which shows that imports and GDP both increases consumption based emission. By controlling their domestic consumption country's will be able to reduce emission based on consumption. Further, the findings confirm that the advancement in industrial sector result in higher consumption based CO_2 emissions. So, to reduce carbon emissions there is need to encourage use of environment friendly technologies and promote research and development for ecofriendly innovation.Further empirical outcomes of this study reveal

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that increase in the consumption of renewable energy will decreases both production and consumption based carbon dioxide emissions. Which means that use of renewable energy is the best possible solution to environmental degradation. So, such policies should be designed to encourage the use of affordable and cleaner energy sources such as renewable energy instead of carbon intensive energy.

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Appendix

Table: 4.2 Slope Heterogeneity Test for G7 and E7

G7 Slope Heterogeneity test		
Variables	**Delta**	**Adjusted Delta**
CCO2	9.367(0.000)	11.359(0.000)
TCO2	8.778(0.000)	10.645(0.000)
E7 Slope Heterogeneity test		
Variables	**Delta**	**Adjusted Delta**
CCO2	3.681(0.000)	4.016(0.000)
TCO2	5.222(0.000)	5.839(0.000)

Table: 4.3 Cross-Sectional Dependency Test for G7 and E7

Variables	G7 test statistics P-value	E7 test statistics (P-value)
CCO_2	9.031(0.000) ***	19.767(0.000) ***
TCO_2	11.002 (0.000) ***	19.527(0.000) ***
EXP	8.134 (0.000) ***	1.336(0.182)
IMP	11.438(0.000) ***	-0.497(0.619)
REC	18.449(0.000) ***	13.292(0.000) ***
GDP	19.873(0.000) ***	21.879(0.000) ***
IVA	16.337(0.000) ***	7.978(0.000) ***

Table: 4. 4 Panel Unit Root Test G7 & E7

	Panel unit root test statistics for G7	**Panel unit root test statistics for G7**	Ord

Variables	Level		First difference		Level		First difference		er
	Constant	Const & Trend	Constant	Const & Trend	Constant	Const & Trend	Constant	Const & Trend	
CCO_2 mt	-1.276	-1.936	-5.18***	-5.29***	-1.713	-1.760	-4.51***	-4.71***	1(1)
TCO_2 mt	-1.917	-1.948	-5.07***	-5.08***	-1.927	-1.640	-4.04***	-4.14***	1(1)
EXP	-1.589	-1.665	-3.41***	-3.65***	-1.983	-2.620	-4.34***	-4.32***	1(1)
IMP	-1.846	-1.735	-4.27***	-4.26***	-1.891	-2.407	-4.52***	-4.49***	1(1)
GDP	-1.570	-1.776	-3.28***	-3.49***	-1.298	-1.637	-3.57***	-3.37***	1(1)
REC	-1.758	-1.211	-5.53***	-5.56***	-1.736	-2.615	-4.69***	-4.75***	1(1)
IVA	-1.281	-1.964	-4.62***	-5.01***	-1.958	-1.889	-4.51***	-4.66***	1(1)

*Note: *** is for 1%, ** for 5% and *10% statistical significance level.*

Table: 4.5 Panel co-integration test for G7 and E7

S. No	Panel co-integration test for G7				Panel co-integration test for E7			
	Group statistics		Panel statistics		Group statistics		Panel statistics	
	G_t	G_a	P_t	P_a	G_t	G_a	P_t	P_a

Model 1 CCO_2	-7.613 (0.000)	-24.652 (0.000)	-17.993 (0.000)	-25.656 (0.000)	-5.411 (0.000)	-16.593 (0.000)	-12.694 (0.000)	-18.991 (0.000)
Model 2 TCO_2	-6.168 (0.000)	-20.890 (0.000)	-16.659 (0.000)	-21.777 (0.000)	-2.511 (0.208)	-10.207 (0.700)	-8.107 (0.005)	-19.865 (0.000)

Table: 4.7 Pairwise DumitrescuHurlin Panel Causality Tests for G7

Pairwise DumitrescuHurlin panel causality tests CCO_2 G7				**Pairwise DumitrescuHurlin panel causality test TCO_2 G7**			
Null Hypo: does not change homogeneously	**W-Stat.**	**Zbar-Stat.**	**Prob.**	**Null Hypo: does notchange homogeneously**	**W-Stat.**	**Zbar-Stat.**	**Prob.**
EX → CCO_2MT	7.77***	5.730	0.000	EX↔TCO_2MT	5.65531***	3.53144	0.0004
CCO_2MT → EX	2.78	0.555	0.578	TCO_2MT↔EX	6.32034***	4.22109	2.E-05
IM →CCO_2MT	7.219***	5.1539	3.E-07	GDP→TCO_2 MT	3.29454	1.08323	0.2787
CCO_2 MT→ IM	2.27	0.0174	0.9861	TCO_2MT→GDP	2.39701	0.15245	0.8788
GDP→CCO_2MT	4.192**	2.0140	0.0440	IM ↔TCO_2MT	5.68210***	3.55922	0.0004

CCO_2MT →GDP	1.68	-0.5925	0.5535	TCO_2MT ↔IM	6.50057***	4.40800	1.E-05
IVA →CCO_2MT	4.255**	2.0796	0.0376	IVA→TCO_2MT	3.67072*	1.47334	0.1407
CCO2MT →IVA	1.686	-0.5847	0.5587	TCO_2MT→IVA	2.00524	-0.2538	0.7996
REC↔ CCO_2MT	9.002***	7.0025	3.E-12	REC↔TCO_2MT	10.6225***	8.68260	0.0000
CCO2MT→REC	6.072***	3.9639	7.E-05	TCO_2MT↔REC	6.75221***	4.66896	3.E-06

*Note: *** is for 1%, ** for 5% and 10% statistical significance level.*

Table: 4.8 Pairwise DumitrescuHurlin panel causality tests for E7

Pairwise DumitrescuHurlin panel causality test CCO_2 E7				**Pairwise DumitrescuHurlin panel causality test TCO_2 E7**			
Null Hypo: does not change homogeneously	**W-Stat.**	**Zbar-Stat.**	**Prob.**	**Null Hypo: does notchange homogeneously**	**W-Stat.**	**Zbar-Stat.**	**Prob.**
EX↔ CCO_2MT	3.92776*	1.73990	0.0819	EX ↔TCO_2MT	4.11560**	1.93469	0.0530
CCO_2MT ↔EX	10.5748***	8.63309	0.0000	TCO_2MT↔ EX	10.9603***	9.03291	0.0000
GDP↔CCO_2MT	6.58555***	4.49613	7.E-06	GDP↔TCO_2MT	8.03694***	6.00127	2.E-09
CCO_2MT↔GD	6.19145***	4.0874	4.E-05	TCO_2MT↔GD	5.02180**	2.8744	0.004

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IM ↔ CCO_2MT	4.15000**	1.97037	0.0488	IM↔ TCO_2MT	6.25493***	4.15326	3.E-05
CCO_2MT↔ IM	6.15289***	4.04744	5.E-05	TCO_2MT↔ IM	5.52727***	3.39865	0.0007
IVA↔CCO_2MT	3.96745*	1.78106	0.0749	IVA↔TCO_2MT	4.99810***	2.84988	0.0044
CCO_2MT↔IVA	7.62879***	5.57800	2.E-08	TCO_2MT↔IVA	5.54213***	3.41407	0.0006
REC↔CCO_2MT	7.04216***	4.96965	7.E-07	REC→TCO_2MT	5.22475**	3.08493	0.0020
CCO_2MT↔REC	3.65837*	1.46053	0.1441	TCO_2MT→REC	3.46623	1.26127	0.2072

*Note: *** is for 1%, ** for 5% and 10% statistical significance level*