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"Do Trade and Invesment Flows Lead to Higher CO2 Emissions? Some Panel Estimation Results"

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Do Trade and Investment Flows Lead to Higher CO_2 Emissions? Some Panel Estimation Results

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Abstract

Over the last decade cross-country trade and investment flows have increased considerably, which is often linked to climate change concerns. The present analysis attempts to understand the influence of trade and investment flows on CO_2 emissions through panel data model estimation for a set of 181 countries over 1990-2009. The empirical findings confirm that both in case of lower and higher income countries, higher merchandise trade growth in general and service and merchandise export growth in particular leads to the higher CO_2 emission growth in their territories. Both FDI inward and outward stock is found to be positively related to CO_2 emission, reflecting a complementary relationship between the two. The empirical results indicate that the composition, scale and technology effects significantly influence the trade-climate change interrelationship.

Keywords: environment and trade, foreign direct investment, climate change; democracy.

JEL Classification: F21, Q56

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Do Trade and Investment Flows Lead to Higher CO_2 Emissions? Some Panel Estimation Results

1. Introduction

Over the last decade cross-country trade and investment flows have increased considerably. The growing trade and investment is often linked to environmental degradation in general (Chakraborty and Mukherjee, 2013a) and emission of Green House Gases (GHGs) in particular (Meléndez-Ortiz *et al*., 2012; World Bank, 2012; WTO-UNEP, 2009). Therefore, there is growing literature on climate change impact of international trade and investment flows.

Environmental implications of international trade can be explained by a combination of three effects (WTO-UNEP, 2009; Zhang, 2012). First, through '*scale effect't* the growing output of the polluting sectors may adversely influence environment. Secondly, trade can lead to change in industry structure and output composition resulting from *composition effect*, which may not always be adverse in nature. Finally, the improvement in emission abatement standards in the economy with rise in trade orientation determines the *technique effect*.

The relative strength of the three effects is determined by the relevance of following environment related theories in a particular country in question. For instance, as per predictions of the Pollution Haven Hypothesis (PHH) prevalence of relatively lax environmental governance mechanism in a developing country / LDC may motivate firms from its developed counterparts to relocate dirtier part of their production chain in the former through FDI for enjoying associated advantages. The phenomenon in short-run may augment export flows from the recipient country, but in long-run lead to adverse environmental repercussions through *scale* and *composition effect*. On the other hand, exports may lead to higher levels of per capita income and human development, and the macroeconomic improvement in long run may fuel the demand for cleaner environment and introduction of strictly enforceable standards in line with the predictions of Environmental Kuznets Curve Hypothesis (EKCH). The overall relationship between pollution and income, as predicted by the EKCH, will therefore be non-linear in nature. In addition, the micro perspective proposed by Porter Hypothesis (PH) indicates that the firms may turn into environmentally efficient entities with lower carbon emissions.

WTO-UNEP report (2009) noted that open trade regimes may result in higher CO_2 emissions, as *scale effect* is more likely to outweigh the *technique* and *composition effects*. However, trade and climate change related discussions need to be viewed in wider context of development dimension. The literature notes that while enhanced trade leads to environmental degradation in lower income countries, the reverse may take place in their higher income counterparts. The outcome can be explained by the higher human development achievements in the developed countries and vice versa, which differentiates the local demand for cleaner environment across economies (Chakraborty and Mukherjee, 2013a). Presently, the developed countries happen to be the major contributors of CO_2 emissions globally, though advanced developing countries (e.g. China, Iran, South Africa) are witnessing higher emissions during the last decade (Olivier *et al*., 2012). It is imperative to see the impact of international trade and investment flows on emission of CO_2.

As a result this growing complexity, the United Nations Framework Convention on Climate Change (UNFCCC) forums has till date witnessed limited success in curbing the GHGs emissions. For instance, the declaration of the Durban climate conference (2011) proposed to reduce the aggregate emissions of GHGs for Annex I countries by at least 25 to 40 percent below 1990 levels by 2020. The developed countries like EU and Switzerland however offered to meet the target only if other developed countries 'commit for comparable emission reductions and that economically more advanced developing countries contribute adequately according to their responsibilities and respective capabilities' (UNFCCC, 2012). It was expected that the developing countries would commit on GHGs through the Kyoto Protocol discussions, once their developed counterparts achieve their target. However given the current scenario, the developing countries have so far shown reservations against quantifiable emission reductions commitment, fearing adverse implications in future (Grubb, 2003). The limited success of the WTO multilateral negotiations to curtail subsidies causing overproduction raises further concerns on environmental sustainability (Chakraborty and Mukherjee, 2013b).

In this context, the present analysis intends to explore the relationship between trade inclination and climate change concerns for a panel of 181 countries for the period 1980 to 2009. Non-availability of long time series data on other GHGs for a large number of countries has restricted us to consider only per capita CO_2 emission as an indicator of climate change. The paper is arranged along the following lines. First, a brief literature survey on the implications of trade and investment on climate change is presented, followed by the discussion on selection of the empirical model and data sources. A cross-country empirical analysis is undertaken next for understanding the influence of trade and investment on per capita CO_2 emission. Finally on the basis of the empirical results, a few policy conclusions are drawn.

2. Evidence from Literature

2.1 Trade and Climate Change

There exist a rich literature on the relationship between trade openness and environment, but the empirical evidence is ambiguous. While a section of the literature argues that trade leads to environmental degradation and climate change concerns, the notion has been rejected by another segment for lack of conclusive evidence (Chakraborty and Mukherjee, 2013a).

A number of cross-country studies have so far concluded that outward orientation leads to adverse environmental repercussions. It has been observed that increased trade openness leads to higher carbon emissions and adversely affects sustainability (Managi and Kumar, 2009; Talberth and Bohara, 2006). The climate change concerns has been explained by the fact that with trade liberalization energy use increases, thereby leading to higher carbon emissions (Ang, 2009; Honma and Yoshida, 2011; Lee and Zhang, 2009).

A number of country specific studies have recently attempted to trace the relationship between trade and climate change. The GHGs emissions from enhanced agricultural production and export, due to agri-related fuel emissions, fertilizer production etc., have been reported in the literature (Drabo, 2011; Garnett, 2011; Zaman *et al*., 2012). Similarly, emission of methane and other GHGs due to large volume of trade in livestock products, has been noted in Austria (Gavrilova *et al*., 2010), OECD countries (Kim and Koo, 2011), South Asia (Laborde, 2011) and the US (Kim and Pang, 2011). Trade openness and growing merchandise exports has led to increasing magnitude of CO_2 emissions in several developing countries, e.g. China (Ang, 2009; Zhang, 2012), Tunisia (Chebbi *et al*., 2010). Apart from direct influence of trade, growing emissions from the enhanced international freight transport in line with the merchandise trade growth has also increased considerably over the years (Cristea *et al*., 2010; Teehankee *et al*., 2012).

However another branch of the literature has reported that the climate change consequences of trade may not always be negative. The positive relationship between trade and climate change has been observed in European countries which indicates innovation, technology spillover and presence of Porter Hypothesis (PH) phenomenon (Costantinia and Mazzanti, 2012; Naughton, 2010). While the analysis of Marin and Mazzanti (2013) observed adverse impact of Italy’s bilateral trade on its GHGs emissions, a reverse scenario has been witnessed with respect to the country’s trade with EU-15 countries. The findings have been explained with technology spillover effects and a positive 'race to the top' phenomenon rather than the 'race to the bottom' one among EU-15 trade partners. In addition, greater consciousness has been noted in developing countries like China (Xiao-jing, 2012) and India (Martin, 2011) in recent period for reducing carbon emission from trade-related activities. Finally it has been observed that within a Regional Trade Agreement (RTA) CO_2 emissions have converged to a lower level, which indicates that trade creation may lead to environmentally optimal outcomes (Baghdadi *et al*., 2012).

A section of the empirical literature has attempted to explain the observed difference between the two conflicting results by presence of various factors, e.g., variations relating to data type and coverage, estimation method employed for the analysis. In particular, income level plays an important role in the trade-climate change interrelationship. For instance, trade flows positively influence the environment in OECD countries, but the reverse is true for SO_2 and CO_2 emissions in non-OECD countries (Managi *et al*., 2009). Baek *et al*. (2009) have arrived at a similar conclusion with respect to SO_2 emissions. Similarly, trade openness is found to increase deforestation in non-OECD countries while slowing down the same in their OECD counterparts (Tsurumi and Managi, 2011). The present study contributes to the literature by attempting to test the linkage between trade and climate change concerns through a panel data analysis of 181 countries for the period 1980 to 2009. The empirical findings also enable one to identify the concerns for countries in different income plane separately.

2.2 Trade, PHH and Environment

Though there exists a rich literature on PHH, the empirical findings are ambiguous. One section of the literature notes shifting of plants in polluting industries / foreign investment in production of dirtier industries from countries with stringent environmental regulations to the countries characterized by lax policy framework (Low and Yeats, 1992; List and Co, 2000; Xing and Kolstad, 2002). The shift of such industries from OECD countries to the developing countries / LDCs led to acceleration of industrial pollution intensity and often processing of toxic wastes in the latter (Lucas et al., 1992). The existente of PHH has been observed in China (He, 2006) and ASEAN countries (Mukhopadhyay 2006; Merican *et al*., 2007). It has been observed that formation of a RTA may facilitate concentration of polluting activities in locations characterised by less stringent environmental regulations within the bloc, e.g. Mexican experience within NAFTA (Gallagher, 2004). The existence of PHH can also be established through the relationship between FDI outflows from 'North' in pollution-intensive segments to the 'South', e.g. outward investments from OECD countries (Aminu, 2005), Germany (Wagner and Timmins, 2008). Such investment flows may enhance the pollution-intensive exports from developing countries by creating a *composition effect*, thereby adversely affecting the environment (Qureshi, 2006). It has been noted that the Dutch economy is increasingly exporting cleaner products while importing dirtier products (in terms of GHGs), indicating existence of PHH in developing countries and emerging economies (Edensa *et al*., 2011).

The notion of PHH has however been rejected by the other branch of the literature, which noted that FDI is not necessarily guided by lax environmental regulations and creates significant pollution in recipient countries (Birdsall and Wheeler, 1993; Chakraborty, 2012; Cole and Elliott, 2005; Grossman and Krueger, 1993; Mani *et al*., 1997; Tole and Koop, 2008; Verbekea and De Clercqa, 2006; Walter, 1982). Several studies have noted that evidence in favour of PHH is weak and the environmental degradation may not necessarily be attributed to the higher investment inflows (Cole and Elliott, 2003; Cole *et al*., 2011; Ederington *et al*., 2005; Jaffe *et al*., 1995). It has been noted that the attraction of weak environmental standards in home country may motivate producers from foreign countries differently (Dean *et al*., 2009). It can be argued that given the deepening of international production networks (IPNs) in recent period, it is in the best interest of the investing foreign parent to ensure environmental sustainability in the developing country subsidiary, so as to enable import of the intermediate or semi-processed product in the long-run.

In line with the growing demand for 'cleaner' and 'greener' production process, the number of ISO 14000 certifications across developing countries has gradually increased over the last decade (Boys and Grant, 2010).

The notion on negative environmental effect of the RTAs has also been questioned by a section of the literature. Stern (2007) reported that while Mexico witnessed certain increase in pollution in post-NAFTA period, the same was followed by an improvement in environmental quality afterwards. Eskeland Harrison (2003) explained the observation by noting that while US FDI outflows has focused on industries characterized by high costs of pollution abatement, the US plants in foreign location also adopt superior technology, use cleaner types of energy and are significantly more energy efficient vis-à-vis local firms. Similarly, looking at the experience of DR-CAFTA, Cunha and Mani (2011) have noted major environmental degradation in terms of depletion of forests and water resources in the post-bloc period in El Salvador, but rejected the PHH arguing that the positive *scale effects* dominate the *composition effects*. Given the ambiguity reported in the empirical results, the present analysis have tested the hypotheses with respect to both FDI inward and outward stock and per capita CO_2 emission.

2.3 Influence of Socio-economic and Governance factors on Climate Change

In addition to merchandise exports and total trade, climate change concerns in a country can also get influenced by several economic and governance related factors, e.g., the per capita income of the countries (measures the *scale effect*), sectoral composition of the economy, and political freedom, which needs to be included in a cross-country analysis as control variables. The existing literature notes the presence of a non-linear relationship between income level of a country and its CO_2 emissions, which can be explained with the EKCH (Agras and Chapman, 1999; de Bruyn *et al*., 1998; Schmalensee *et al*., 1998). It is further noted that trade in services can significantly influence CO_2 emissions (Papathanasopoulou, 2007).

Hence, per capita income of selected countries and services trade inclination has been considered as control variables in the present analysis.

It is observed that the major industrial sectors like iron and steel, machinery and equipment etc. are among the major users of petroleum and other mineral fuels. Hence these sectors contribute significantly in emission of GHGs (EPA, 2008; IEA, 2012). Finally, political freedom in a country generally leads to economic efficiency and growth, which in turn may enhance exports and emission patterns in the country (Congleton, 1992; Liebenberg, 2012). While presence of democracy in general may facilitate better governance and environmental resource management (Morrison, 2009), through occurrence of deforestation is reported to be relatively higher in democratic LDCs (Larjavaara, 2012). The result can be explained by the fact that political freedom also increases income and might influence emissions through *scale* and *composition effects*. Therefore, contribution of industrial sectors in GDP of a country and indicators of political freedom has been included as control variables in the current analysis.

3. Empirical Model

The following panel data regression model involving 181 countries over 1980-2009 is estimated to understand the effect of trade-investment orientation on CO_2 emissions. The advantage of using the log-linear model in the current context is that the estimated coefficients can be interpreted as the elasticity between trade and climate change concerns.

$$LCO_{2it}= \alpha+ \beta_1 LPCGDP_{it}+\beta_2 LPCGDP_{it}^{2}+ \beta_3 LMERX_{it}+ \beta_4 LMERT_{it} +\beta_5 LSERT_{it} +\beta_6 LGDPIND_{it}+ \beta_7 LFDIIN_{it}+ \beta_8 LFDIOUT_{it}+ \beta_9 LFHIPR_{it}+ DEV_{it} + T_t+\varepsilon_{it} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

α	represents the constant term
βs	*are coefficients*

LCO_{2it} represents log of Per Capita CO_2 emission (in tonne per annum) of country *i* for year *t*

$LPCGDP_{it}$ represents log of Per Capita Gross Domestic Product (PPP, current international $) of country *i* for year *t*

$LMERX_{it}$ represents log of Merchandise Export (expressed as percentage of GDP) of country *i* for year *t*

$LMERT_{it}$ represents the log of Merchandise Trade (Export +Import) (expressed as percentage of GDP) of country *i* for year *t*

$LSERT_{it}$ represents log of Commercial Services Trade [1] (expressed as percentage of GDP) of country *i* for year *t*

$LGDPIND_{it}$ represents the log of share of industry in GDP[2] (expressed as percentage of GDP) of country *i* for year *t*

$LFDIIN_{it}$ represents the log of inward stock of Foreign Direct Investment (expressed as percentage of GDP) of country *i* for year *t*

$LFDIOUT_{it}$ represents the log of outward stock of Foreign Direct Investment (expressed as percentage of GDP) of country *i* for year *t*

$LFHIPR_{it}$ represents the log of Freedom House Index of Political Rights of country *i* for year *t*

DEVit represents Development Dummy of country *i* for year *t*, where DEV_{it} is constructed as follows:

$PCGNI_{it}$ represents Per Capita Gross National Income (GNI) (atlas method, current US$) of country *i* for year *t*

LIE represents the low income country (*PCGNI*: US$1,005 or less)[3] dummy, which has a value of 1 for the corresponding countries and 0 otherwise.

1 to understand Includes all service categories (transport, travel, communications, construction, insurance, financial services, computer and information services, royalties and license fees, other business services, personal, cultural and recreational services) except government services (UNCTAD Database)

2 Includes mining and quarrying, manufacturing, electricity, gas and water supply, and construction (UNCTAD Database)

3 Income brackets are in line with the World Bank classification. For details, see **http://wdronline.worldbank.org/worldbank/a/incomelevel** (last accessed on April 19, 2013)

LMIE represents the lower-middle income country (*PCGNI*: US$1,006 - 3,975) dummy, which has a value of 1 for the corresponding countries and 0 otherwise

UMIE represents the upper-middle income country (*PCGNI*: US$3,976-12,275) dummy, which has a value of 1 for the corresponding countries and 0 otherwise

HIE represents the high income country (*PCGNI*: US$12,276 or more) dummy, which has a value of 1 for the corresponding countries and 0 otherwise

T_t represents the time dummies (i.e., T_1=1 for 1980 and 0 otherwise)

ε_{it} represents the error term

In order to understand the effects of merchandise exports and overall merchandise trade on per capita CO_2 emissions separately, MERX and MERT have not been included simultaneously in the regression models. Also, to explore whether the effects of FDI inward and outward movements influence emission patterns in a country differently, the current analysis includes them in alternate regression models. Finally the model drops the lower middle income economies (LMIE) dummy from the analysis to avoid the problem of multicollinearity.

3. Data and Macro Trends

The data on the dependent variable included in the empirical analysis– Annual Per Capita CO_2 emission (in tonne) and Per Capita Gross National Income (PCGNI) are obtained from World Development Indicators database of the World Bank.[4]For other independent variables, namely - Per Capita GDP (US Dollars at current prices and current exchange rates), Merchandise exports, Merchandise trade (exports plus imports) and Commercial Services

4 World Bank (2013), World Development Indicators, Available at: http://databank.worldbank.org/databank/download/WDIandGDF_excel.zip (last accessed on May 22, 2013).

5 The data can be accessed from UNCTAD Statistics at http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx (last accessed on May 4, 2013).

trade in a country expressed as percentage of its GDP, where the data of GDP (US Dollars at current prices and current exchange rates in millions and the share of industrial sector in GDP of a country are all obtained from UNCTAD database.[5]

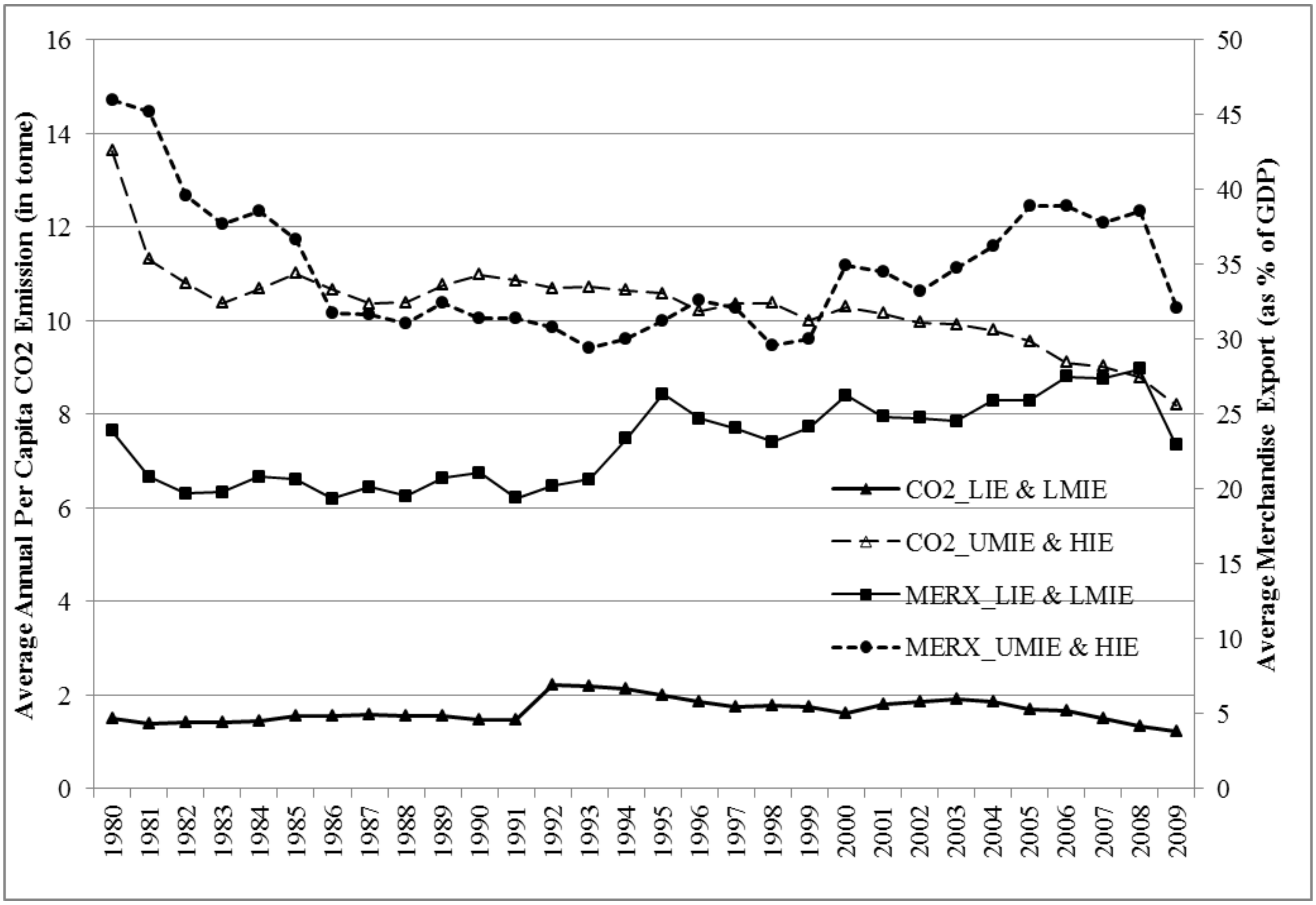
The data for FDI inward stock and outward stock (expressed as percentage of GDP) is also accessed from UNCTAD Database. The present analysis includes FDI inward and outward stock data instead of investment flows, as the existing literature points several problems of using flow data (Dick and Jorgenson, 2011; Grimes and Kentor, 2003; Jorgenson, 2007; Perkins and Neumayer, 2009). The data on political freedom is obtained from Freedom House, where the country scores range over 1 to 7 (where1 represents the highest and 7 the lowest level of freedom respectively).[6]

The time trend in the three key series considered in the current analysis, namely – Per Capita CO_2 emissions and merchandise exports and trade are illustrated with the help of figures 1-2. It is observed from the figures that since nineties onwards the annual per capita CO_2 emission is declining both in higher income countries (HIE and UMIE) and their relatively poorer counterparts (LIE and LMIE). Figure 1reveals the average merchandise export scenario (expressed as percentage of GDP) for the two groups of countries. The exports have fluctuated during the recession years, but have shown a general increasing trend. The increase has been sharper for the higher income countries. Along similar lines, figure 2reveals that proportional importance of merchandise trade has increased for both group of countries, but the increase has been sharper for LIE and LMIEs during the recent period. The proportional importance of both merchandise exports and trade in GDP and per capita CO_2 emissions has been higher in UMIE and HIEs as compared to their LIE and LMIE counterparts throughout the entire study period.

[5] The data can be accessed from UNCTAD Statistics at http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx(last accessed on May 4, 2013).

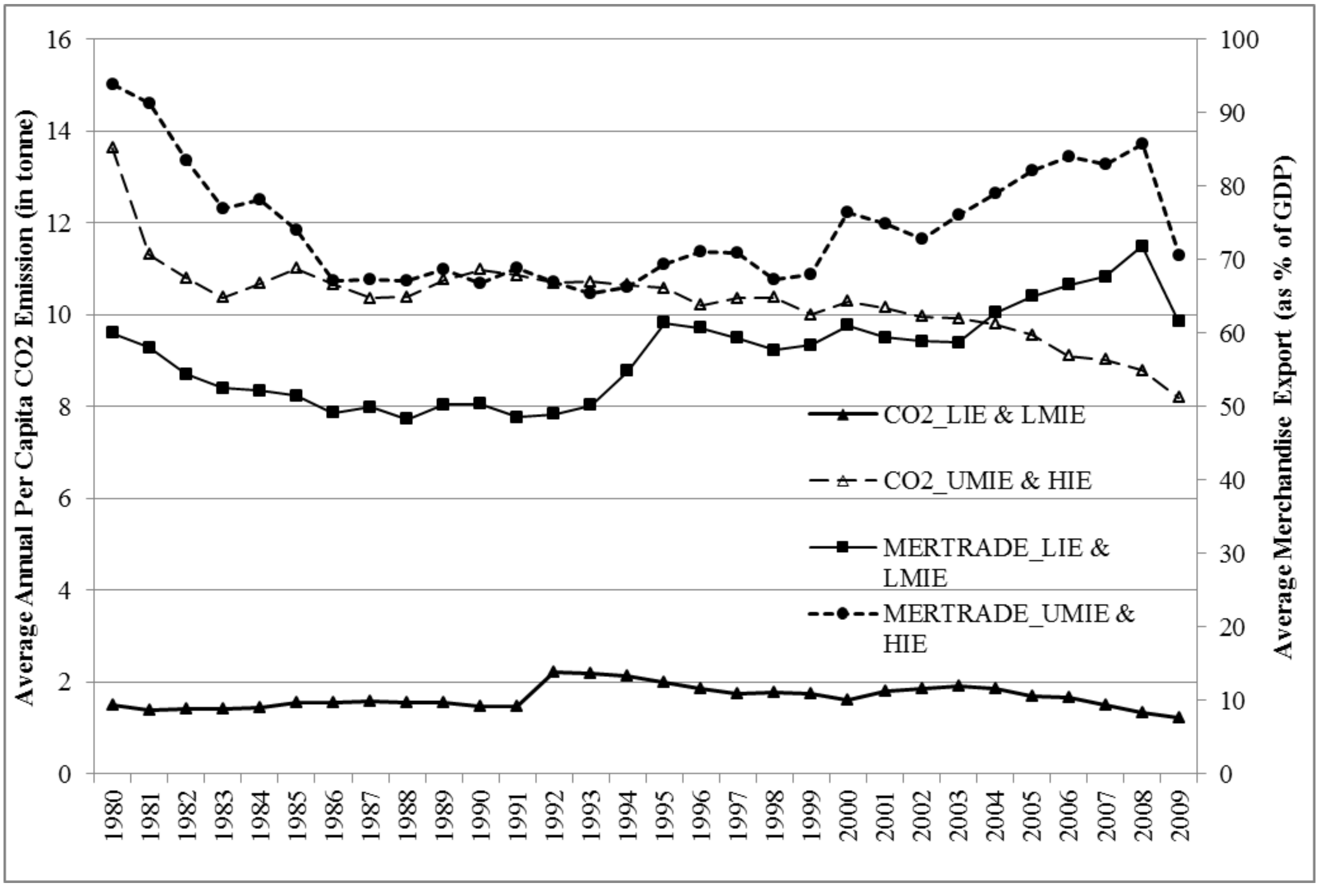
[6] The country scores on 'Index of Democracy' can be accessed at http://www.freedomhouse.org/sites/default/files/FIW%20All%20Scores%2C%20Countries%2C%201973-2012%20%28FINAL%29.xls (last accessed on May 4, 2013).

Figure 1: CO2 Emission and Merchandise Exports Scenario for Countries belonging to Different Income Groups:-



Source: Constructed by authors

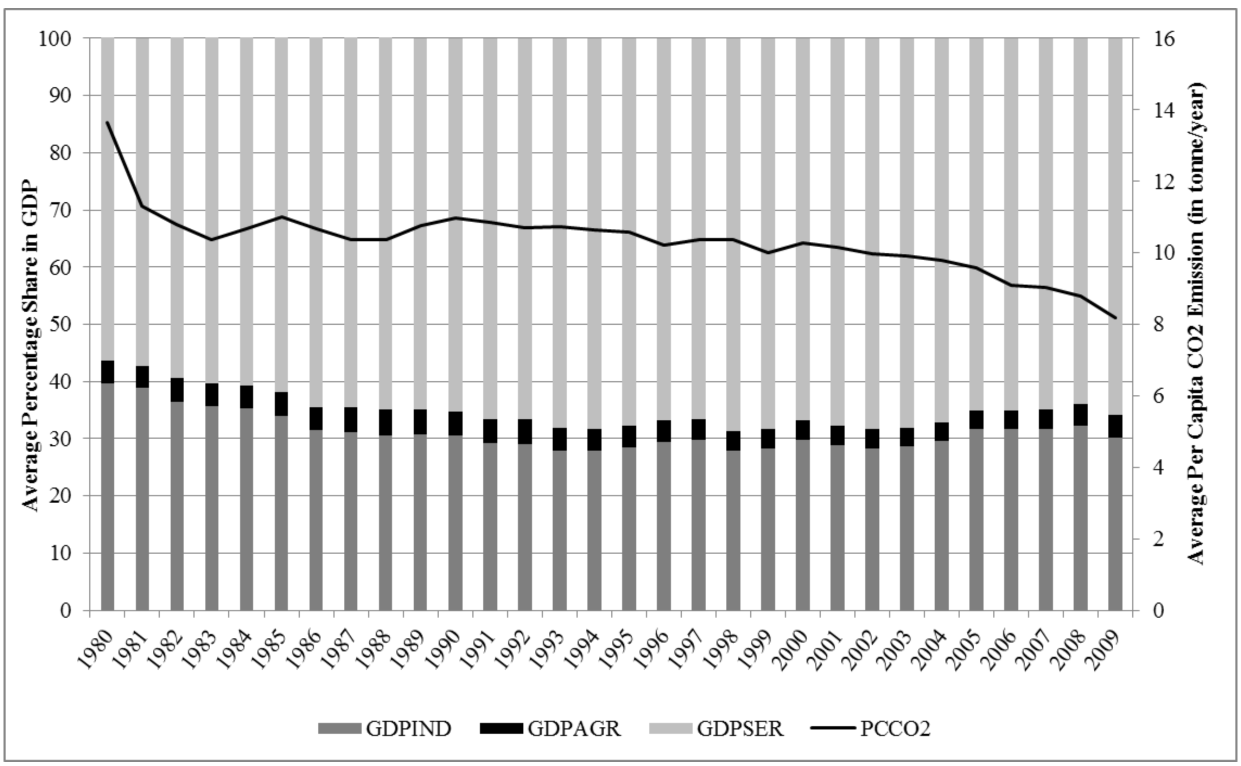
Figure 2: CO2 Emission and Merchandise Trade Scenario for Countries belonging to Different Income Groups



Source: Constructed by authors

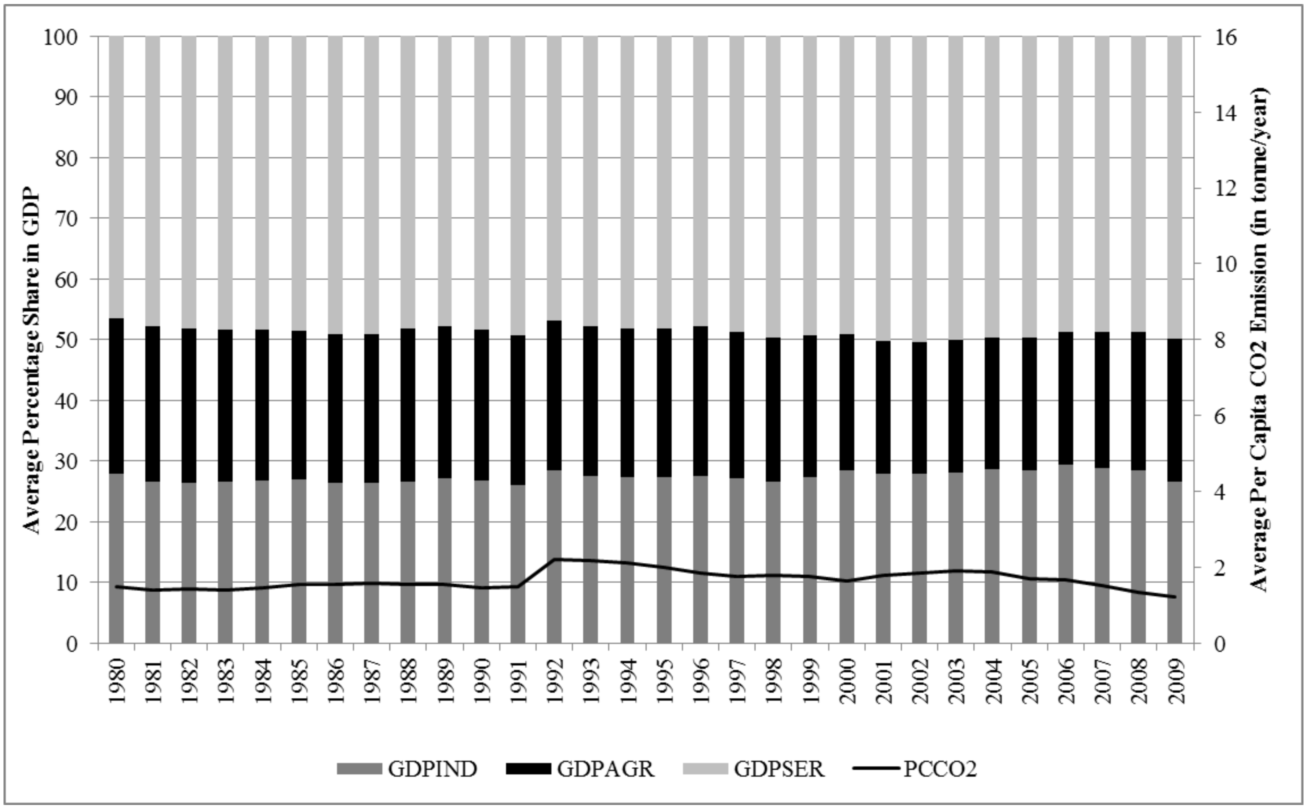
The *scale effect* reflected through the difference in per capita income between higher (UMIE & HIE) and lower income countries (LIE & LMIE) is one of the main factors behind differences in per capita annual CO_2 emission (Figures 3(a) and 3(b)). The high correlation (0.48) between combined average share of industry and agriculture in GDP and per capita CO_2 emission for higher income countries shows that the *composition effect* is stronger for these countries as compared to lower income countries (0.06). Since the structural composition of lower income countries has already shifted towards services sector (average percentage share of services in GDP is 48.3), further shift in services sector is expected to reduce per capita CO_2 emission from the existing level. While the higher income countries have fared poorly in lowering per capita CO_2 emission, despite having high share of services in their GDP (average percentage share is 64.2), there is enormous scope for lower income countries to do so provided they adopt right technology.

Figure 3(a): Composition Effect of Per Capita CO2 Emission: UMIE & HIE



Source: Constructed by authors

Figure 3(b): Composition Effect of Per Capita CO_2 Emission: LIE & LMIE



Source: Constructed by authors

6. Results

A panel data regression analysis has been undertaken with the help of the STATA software (version 10.1). To understand the working of the model for the proposed relationship in equation (1), Hausman specification test is first conducted. It is observed that the Chi-square test statistic of 671.42(0.0000) is statistically significant. The Hausman test suggests the presence of a fixed effect model. Next we have conducted Wooldridge test for first order autocorrelation in panel data and the test statistics is 51.793 (0.0000), which implies the presence of autocorrelation. Breusch-Pagan / Cook-Weisberg test is conducted next and the test statistics is 215.50 (0.0000), which implies the presence of heteroskedasticity. The test for detecting presence of multicollinearity in the model reveals a mean Variation Inflation factor (VIF) score of 18.80, which results from the inclusion of both Log (PCGDP) and its square term in the model. For other variables, the values of VIF are within the tolerance limit of multicollinearity.

The estimation results clearly indicate that merchandise exports and trade significantly influence CO_2 emissions for the selected countries (Table 1). It is observed that for the reported regression models, the coefficient of merchandise export is found to be positive and significant. The results indicate that both in case of lower and higher income countries, higher merchandise export growth rate leads to the higher carbon emission growth in their territories. Similarly, merchandise trade also has a positive and highly significant coefficient, which implies that higher merchandise trade growth leads to higher CO_2 emission growth. In other words, apart from exports, the import volume may also add to the emissions in a country, especially if the same is further processed in the importing country. The positive and significant relationship between contribution of industrial sector in GDP and CO_2 emissions adds further support to this contention. Hence greater presence of industrial sector (i.e., generation of greater volume of manufacturing output), both geared for domestic consumption and exports as well as processing of the imported merchandise products, may lead to higher emission scenario owing to the *composition effect*. Commercial services trade is also found to be positively related to the dependent variable, which can be explained by the emission potential from services related to tourism, medical tourism and transportation etc.

Outward inclination viewed through the prism of FDI movements reveals that the coefficient of FDIIN bears a positive sign with the dependent variable. The result indicates that higher incoming FDI enhances emissions in the recipient countries, owing to their contribution in the productive activities (including manufacturing) undertaken locally. The empirical results lend supports to the PHH predictions. On the other hand, FDIOUT is also found to be positively related to CO2 emissions in the selected countries. The sign of the coefficient can be explained by the fact that most of the high income countries are the source of FDI. Such FDI from these ‘North’ economies to the ‘South’ may deepen their association with integrated production networks with trade partners, leading to higher import of raw material and semi-processed inputs, and enhancing final exports. In other words, the FDIOUT effect supplements the FDIIN effect.

Among the control variables, log of per capita GDP of a country is found to be positively related with the dependent variable, while the coefficient of the square term is found to be negative and significant. The result implies that the growth rate of PCGDP is associated with greater emission growth, but the rate of emission declines with higher income level. The result clearly underlines the *scale effect* and signifies the presence of the inverted U-shaped non-linear relationship between the two variables, in line with the EKCH predictions. In this context, the sign of the country group coefficients however indicate an interesting dynamics. While the sign of the coefficient for the LIE dummy is negative like the constant term, the UMIE and HIE dummies included in the regression models are all found to be positive and significant. The result implies that other things remaining unchanged, the higher income countries are characterized by higher per capita CO_2 emission levels. The contention is supported by the fact that the coefficient for the HIE dummy is higher vis-à-vis the corresponding UMIE figure. In addition, the sign and the magnitude of the country group coefficients also indicate the importance of the *technology effect*.

Conclusion

The steady growth of international trade and investment flows during the last decade has deepened the cross-country production integrations. However, greater energy use from enhanced activities has led to higher level of trade-led emissions, irrespective of the income level of the countries. Although the causal effects are well-reported in the literature, the remedies are yet to be reached. In recent times the UNFCCC negotiations has become a prisoner of sequencing problem, i.e., several countries have promised to undertake reform commitments only when countries belonging to other groups, developed or emerging agrees to similar commitments. Such 'Chicken-and-Egg' problem is contributing little in rectifying the emission pattern and the associated climate change concerns. In recent times, the likes of the EU proposal on border tax adjustments to tackle climate change concerns can be considered as a response to this stalemate.

The empirical results of the present analysis need to be viewed in light of this wider context. It is clearly observed that the three effects, namely, *composition*, *scale* and *technology* effects significantly influence the trade-climate change interrelationship. While the countries growing faster generally witness higher CO_2 emissions, the composition of the economy might play a crucial role in determining the extent of GHG emissions from its territories. In addition, the ability to adopt the green technology both in the merchandise and service sectors can significantly contribute in curbing the harmful emissions. The role of FDI from abroad is also crucial in this respect. While FDI inflow in general and in manufacturing sectors in particular can fuel climate change concerns, they may also bring in cleaner technology (Popp, 2011). The climate change concerns in a country can however be strongly influenced by its political structures, institutions of environmental governance and resource management policies.

The present scenario strongly indicates that solving the climate change concerns by relying entirely on market mechanisms may not lead to optimal outcome. In order to contain the problem, first and foremost, an effective agreement on emission commitment needs to be implemented through UNFCCC forums. Softening of standpoint on the part of HIEs is of utmost importance in this context as these economies continue to be the major emitters of GHGs. It will not be possible to secure commitments from the UMIEs and subsequently the LMIEs, unless HIEs first agree to curb emissions within their territories.

Second, there is a need to avoid misplaced focus on polluting sector activities in several relatively poorer economies, which attracts PHH-led FDI on one hand and contribute to harmful emissions on the other. Containing the problem through strengthening of political institutions and governance pattern will contribute significantly in this regard. However, locally perceived rather than externally imposed solutions stands a better probability of success in this context. For instance, a punishment mechanism in line of border tax adjustment or carbon tariff may create political sensitivity in the targeted country and be less effective in achieving the core objective of emission reduction. Also the conformity of such measures with multilateral trade rules under WTO is debated (Bartels, 2012). The proposed "Carbon Conditional Measures" (CCMs), which are product-specific, as compared to the country-specific carbon tariffs, have instead gathered greater support as a policy instrument (Messerlin, 2010). Nevertheless, internally arrived decision by a developing country to opt for Low-carbon Foreign Investment (LFI) is likely to win higher acceptance domestically and thereby would ensure superior implementation performance.

Finally, while the LFI option may ensure shift to low-carbon technologies, processes and products for MNC operations, ensuring transfer of technologies for the domestic players in general is of equal importance. Though enhanced international trade and investments is expected to facilitate transfer of environmentally friendly and low carbon technologies to developing countries, in practice import of such technologies have remained a bone of contention between many developed and developing countries at the UNFCCC discussions (Martin and Mazzanti, 2013; Ockwell *et al*., 2010). Therefore, ensuring smoother transfer of these technologies from 'North' to 'South' would contribute in lowering emissions in short run, which would pave the way further for greater acceptance on climate change related commitments in long run.

Regression Results on Relationship between Merchandise Export, Trade and Climate Change

Independent variables	Dependent Variable: log of Per Capita CO_2 emission (in tonne per annum)					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Constant	-7.3445 *** (0.2755)	-8.8336 *** (0.2744)	-9.0328 *** (0.3467)	-9.4303 *** (0.2773)	-9.4721 *** (0.3495)	-9.4303 *** (0.2773)
Log(Per Capita GDP)	1.2441 *** (0.0661)	1.1763 *** (0.0648)	1.3474 *** (0.0801)	1.2658 *** (0.0651)	1.4102 *** (0.0807)	1.2658 *** (0.0651)
[Log(Per Capita GDP)]^2	-0.0347 *** (0.004)	-0.0298 *** (0.004)	-0.0437 *** (0.0047)	-0.0349 *** (0.004)	-0.0472 *** (0.0048)	-0.0349 *** (0.004)
Log (Merchandise Exports)	0.1864 *** (0.0098)					
Log (Merchandise Trade)		0.2791 *** (0.0145)	0.2759 *** (0.0177)	0.2362 *** (0.0171)	0.2240 *** (0.0207)	0.2362 *** (0.0171)
Log (Commercial Services Trade)				0.0687 *** (0.0132)	0.0601 *** (0.0157)	0.0687 *** (0.0132)
Log (Share of Industrial Sector in GDP)		0.3442 *** (0.0232)	0.3347 *** (0.0296)	0.4002 *** (0.0252)	0.3921 *** (0.0315)	0.4002 *** (0.0252)
Log (FDI Inward Stock)	0.0459 *** (0.0062)	0.0361 *** (0.0061)		0.0308 *** (0.0064)		0.0308 *** (0.0064)
Log (FDI Outward Stock)			0.0275 *** (0.0042)		0.0267 *** (0.0043)	
Log (Political Rights)	-0.0186 * (0.0108)	-0.0176 * (0.0106)	-0.0256 ** (0.0118)	-0.0200 * (0.0107)	-0.0256 ** (0.0116)	-0.0200 * (0.0107)
LIC Dummy	-0.0553 *** (0.0144)	-0.0588 *** (0.0137)	-0.0551 *** (0.0175)	-0.0505 *** (0.0139)	-0.0457 *** (0.0174)	-0.0505 *** (0.0139)
UMIC Dummy	0.0521 *** (0.0139)	0.0553 *** (0.0137)	0.0397 *** (0.014)	0.0547 *** (0.0139)	0.0385 *** (0.0139)	0.0547 *** (0.0139)
HIC Dummy	0.0591 *** (0.02)	0.0623 *** (0.0198)	0.0472 ** (0.0191)	0.0609 *** (0.02)	0.0443 ** (0.0189)	0.0609 *** (0.02)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	4739	4738	3316	4381	3213	4381
No. of Groups	181	181	146	178	146	178
Wald Chi Square	7741.22	9384	5949.97	9875.32	6186.68	9875.32
Prob>Chi Square	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure in the parenthesis shows the heteroskedasticity and first order autocorrelation [AR(1)] corrected standard error of the estimated coefficient
***, ** and * implies estimated coefficient is significant at 0.01, 0.05 and 0.10 level respectively.

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