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Does Fiscal Policy influence per capita CO2 emission? A cross country empirical analysis

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Sacchidananda Mukherjee[1*] and **Debashis Chakraborty**[2]

Abstract

Countries disburse subsidies with various motivations, e.g. to promote industrial development, facilitate innovation, support national champions, ensure redistribution. The devolution of subsidies may however also encourage economic activities leading to climate change related concerns, reflected through higher greenhouse gases (GHGs) emissions, if economic activities are conducted beyond sustainable point. Through a cross-country empirical analysis involving 131 countries over 1990-2010, the present analysis observes that higher proportional devolution of budgetary subsidies lead to higher CO_2 emissions. The countries with higher CO_2 emissions are also characterized by higher per capita GDP, greater share of manufacturing sector in their GDP and higher level of urbanization. The results further demonstrate that structure of economy is a crucial determinant for per capita CO_2 emission, as countries having higher share in agriculture and services in GDP are characterized by lower per capita CO_2 emission. In addition, the empirical findings underline the importance of the type of government subsidy devolution on CO_2 emissions. It is also observed that countries having high tax-GDP ratio are marked by lower per capita CO_2 emission, implying government budgetary subsidy is detrimental for environment whereas tax is conducive for sustainability. The analysis concludes by noting the importance of limiting provision of subsidies both in developed and developing countries.

Keywords: Government Budgetary Subsidy, Tax-GDP ratio, Per Capita CO_2 Emission, Government Policy, Environmental Kuznets Curve, Panel Data Analysis.

JEL Classification: H20, Q56, Q58

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1. Introduction

Providing subsidies to local players is a time-tested policy instrument, which can be applied for responding to various motives, e.g., countering domestic distortions (Bhagwati and Ramaswami, 1963), for granting 'infant-industry' protection (Melitz, 2005), for facilitating innovation, supporting national champions, ensuring redistribution, etc. (WTO, 2006). A country may extend subsidies to their primary, manufacturing and service sectors through various channels, e.g., through input subsidies (e.g. per unit fuel subsidy), output subsidies (e.g. per unit price support) and 'regulatory reliefs' in terms of maintaining weaker environmental regulatory standards and tax reliefs (Barde and Honkatukia, 2004; Heutel and Kelly, 2013; Fisher-Vanden and Ho, 2007).

Existence of subsidies *per se* does not necessarily lead to adverse environmental consequences. For instance, carefully crafted subsidy policies can contribute significantly for ensuring environmental protection in an economy (e.g. subsidies for promoting organic farming or other forms of environment-friendly agriculture, technology upgradation support to industry for securing lower emissions). Nevertheless, the adverse environmental implication of subsidies are well documented in existing literature. On one hand, several environmental implications of input subsidies have been underlined (Heutel and Kelly, 2013). First, demand for any subsidized input is expected to witness an increase due to substitution of other non-subsidized inputs. Second, firms enjoying the benefits of the subsidized inputs tend to produce more due to the fall in per unit production expenses, which increases their demand for all inputs in general. As a result of the consequent change in input usage patterns, the sectors benefiting from input subsidies generally grows in size and their expanded scale of operation might lead to overproduction and in turn overexploitation of resources. On the other hand, if the government provides output subsidies by offering higher price per unit of output produced to the producers, the chain of events again may potentially result in over-use of inputs, over-exploitation of resources, over-production and consequent environmental degradation (van Beers and van den Bergh, 2001). The existing literature supports this contention by underlining that subsidies generally encourage overuse of dirty inputs and enable the environmentally inefficient producers to continue in the market (Barde and Honkatukia, 2004). Conversely reduction of subsidies enhance environmental sustainability by lowering pollution-causing capital accumulation, shifting of capital and labor to less pollution intensive firms and enhancing the output of more productive firms (Bajona and Kelly, 2012).[1]

In addition to the existing theoretical and empirical literature, the subsidy-environment linkage has received considerable attention in the regulatory forum as well. For instance, the adverse environmental implication of subsidies in general, and energy subsidies, which encourage greater use of fossil fuel in particular, is well recognized in the UN discussion forums. It is estimated that world emissions of CO_2 and Green House Gases (GHGs) can be reduced by

[1] A comprehensive review of definitions of subsidies and their measurement issues has been undertaken in Jones and Steenblik (2010).

13 and 10 percent respectively by 2050 with the removal of fossil fuels and electricity subsidies in 20 non-OECD countries (Burniaux et al., 2009). One major objective of the Kyoto Protocol negotiations has been to secure reduction of subsidies, which lead to GHGs emissions (UNEP, 2003). The same spirit has been echoed in the Rio+20 Conference declaration as well, "We remain focused on achieving progress in addressing a set of important issues, such as, *inter alia*, trade-distorting subsidies and trade in environmental goods and services" (UNCSD, 2012). However, the UN initiatives for reduction of fuel subsidies have till date achieved limited success so far (Keen, 2012; IMF, 2013).

In addition to the United Nations Environment Programme (UNEP) initiatives, the multilateral trade forums under the wings of World Trade Organization (WTO) have also attempted to curb adoption of subsidies, although from a different standpoint. Subsidies are considered to be detrimental to the fair trade principle, which is cornerstone of the WTO architecture. Therefore the objective of the ongoing negotiations under the Agreement on Subsidies and Countervailing Measures (ASCM) is to bring about better discipline on both direct financial transfers as well as revenue foregone (e.g. interest payment on loan restructuring, tax breaks). One major objective of the ASCM negotiations is to classify the existing subsidies in Member countries under two broad categories, namely, actionable (i.e. subsidies which are directly linked with production and hence trade-distorting) and non-actionable (i.e. subsidies which are not directly linked with production and hence are less trade-distorting).

While the major focus of the WTO negotiations revolve around the question of trade-distortion, greater discipline on subsidies are also associated with tangible environmental benefits. For instance, elimination of subsidies by China in its bid to join the WTO were more fruitful in reducing emissions as compared to tariff reforms (Bajona and Kelly, 2012). Along similar lines, currently ASCM and other subsidy related negotiations under WTO (e.g. fisheries subsides, amber box subsidies in agriculture) are geared for lowering the provision of actionable subsidies by the Member countries, which in addition to being trade-distorting subsidies might also potentially be environmentally damaging ones (Chakraborty et al., 2011; Mukherjee et al., 2014). Nevertheless, the subsidy reforms under WTO have achieved limited results so far, given the slow progress of the Doha Round negotiations (Anderson et al., 2008; Morgan, 2010), which is a matter of grave concern.

The less than desired pace of subsidy reforms across countries and the growing concerns over climate change, as reflected through GHGs emissions, calls for a deeper analysis to identify whether there exists any linkage between the two. In this context, the current analysis intends to explore the statistical relationship between devolution of budgetary subsidies and transfers and per capita CO_2 emissions for 131 countries over 1990-2010. The current analysis is restricted only to the per capita CO_2 emission as an indicator of climate change owing to limited availability of long time series data on other GHGs for a large number of countries.

The present analysis intends to contribute to the existing pool of literature on subsidy-climate change nexus in two ways. First, a large body of studies in the theoretical as well as empirical literature have adopted general equilibrium framework, data envelopment analysis (DEA) modelling technique etc. to analyze the impacts of subsidy on environment and climate change (Bajona and Kelly, 2012; Heutel and Kelly, 2013; Managi, 2010, Yagi and Managi, 2011).

However, empirically explaining the relationship between government budgetary subsidies and per capita CO_2 emissions in a cross country panel data framework is a relatively less researched area. The current paper bridges this gap by testing the statistical relationship between the two series. In addition, the present analysis particularly contributes to the literature by attempting to understand the influences of various government subsidy reporting standards on CO_2 emission patterns.

Second, the existing theoretical and empirical literature explains the climate change related repercussions of international trade flows with help of three effects (WTO-UNEP, 2009; Zhang, 2012; Chakraborty and Mukherjee, 2014). First, through *scale effect* the growing output and exports of the polluting sectors may adversely influence environment, as that may cause additional energy use and exploitation of natural resources (Cole and Elliott, 2003). As subsidies are often provided for enhancing exports (Afonso and Silva, 2012; Bailey, 2002; Defever and Riaño, 2012; Girma*et al.*, 2009; Mansor and Karim, 2012), this effect may lead to serious climate change concerns. Secondly, trade can lead to change in industry structure and output composition resulting from *composition effect*, which may or may not always be adverse in nature (Honma and Yoshida, 2011). If output from the polluting manufacturing sectors rise, then the potential for emissions of pollutants also goes up. Clearly, if the subsidy (in the form of input, output or fuel subsidy) creates a bias in favour of a polluting sector, this effect might dominate. Finally, with rise in income level, environmental governance is expected to improve in an economy - through adoption of better pollution abatement technologies, formulation and enforcement of stricter regulatory policies etc. In other words, the growing income may create a demand for lower emissions and the associated reforms will be determined by the *technique effect* (Cole and Elliott, 2003). If the allocated subsidies are earmarked for adoption of greener production methods and secures access to technology upgradation, this effect is likely to overshadow the former two effects. Since a considerable proportion of subsidies until the recent period has been provided in the countries with certain underlying trade objectives (WTO, 2006), the empirical analysis intends to capture how their influence is reflected on these three effects.

The present analysis is arranged along the following lines. First, the existing literature on subsides and their potential implications on climate change concerns are briefly discussed. Second, selection of the empirical model and the data sources for the analysis are explained, followed by an account of the macro trends observed in the principal variables. A panel data empirical analysis is conducted in the following section for identifying the influence of budgetary subsidies on per capita CO_2 emissions. Finally, based on the empirical results, a few policy conclusions are drawn.

2. Subsidy and Climate Change Concerns: Evidence from Literature

One major effect of subsidies is to insulate market prices of natural resources from the full social costs of production. The consequent reduction in per unit cost aided by subsidies often influence choice of production techniques resulting in over-production and thereby facilitating overexploitation of natural resources and/ or uses of energy, and subsequently deepening of climate change concerns (Porter, 1997; van Beers and van den Bergh, 2001). Similar subsidy-led adverse environmental impacts are often rampant in several resource-intensive sectors, namely, primary sector (e.g. agriculture, fisheries), transport, energy and water sector etc. (van Beers et al., 2007; Myers and Kent, 2001; Maddison et al., 1997; Myers, 1998; WTO, 1999, 2009).

Support extended to the local agriculture sector through input subsidies (e.g., irrigation, electricity/fuel, fertilizer and pesticide subsidy) often leads to over-production and consequent over exploitation of natural resources (e.g., groundwater) and biodiversity loss, as the support incentivizes their overuse by lowering per unit variable costs for the farmers (Heutel and Kelly, 2013). Evidences on interrelationship between fertilizer usage in OECD countries and their CO_2 emission levels deserves mention here (Atici, 2009). Such fertilizer subsidies are particularly helpful for the bigger farmers, given their scale advantage, which may bear further environmental repercussions (Abimanyu, 2000). Similarly, provision of electricity subsidy reduces per unit cost of irrigation and facilitates cultivation of water-intensive crops, which are by nature also fertilizer and pesticide intensive (Mukherjee, 2010). Such subsidies often leads to groundwater overexploitation on one hand (Sidhu, 2002) and large scale leaching of nitrates and pesticides into aquifers on the other (Mukherjee, 2012; Kushwaha, 2008). Fuel subsidies provided to fishing trawlers and other vessels for capturing marine fisheries similarly lead to overuse of mineral fuels, harmful discharge in seas and over-fishing (Sharp and Sumaila, 2009; Sumaila *et al*., 2008).

Output subsidies result into higher than market price for domestic farmers through price support measures and other similar policies, thereby creating a push for greater cropping intensity and volume of agricultural production (Pasour and Rucker, 2005). Intensive cropping pattern leads to environmental concerns like groundwater depletion and soil pollution (Scherr, 2003); conversion of forests, rainforests, and wetlands into cultivable lands (OECD, 2003; WTO, 1999) and diversion of water resources (Myers and Kent, 2001). Similarly, the fisheries subsidies in the form of price support results in increasing fishing intensity, causing overexploitation of the fish stocks (Porter, 2000). In other words, both input and output subsidies lead to serious environmental as well as climate change related concerns.

Along similar lines, subsidies offered to the manufacturing and energy sector often result in equally harmful environmental consequences (UNCSD, 2012). For instance, fossil fuel subsidies contribute particularly to air pollution, emissions of GHGs and loss of biodiversity, as they reduce the operational cost of recipient industries and leads to higher volume of fossil fuel burning. Such energy-related and other form of subsidies have emerged as major problems in developed countries (Victor, 2009), emerging economies (UNEP, 2008; WTO, 2006) and leading Asian economies like China (Chow, 2007; Haley, 2008; Heutel and Kelly, 2013) and South Korea (Kang, 2012).

While budgetary subsidies play a crucial role in influencing the climate change concerns, the role of implicit subsidies (e.g., income foregone) are no less important. As compared to budgetary subsidies which are generally reported in Government Budgets, implicit subsidies are difficult to identify but their magnitude could often surpass the budgetary subsidy by many times and create strong *composition effects* (Srivastava and Rao, 2002). Evidence from the literature reveals that final consumption subsidies (direct and/or indirect) provide perverse incentives to households for overconsumption and results in environmental damage – e.g. Eastern Europe and Central Asian countries provide direct energy subsidies to energy providers to keep the household tariff below the actual cost of production (Laderchi et al., 2013). Moreover, implicit subsidies provided to Mexican industries in terms of below market price for petroleum fuels resulted in 5.7 percent increase in energy intensity between 1970 and 1990, as compared to decrease in energy intensity by 35.3 percent in OECD industry (Kate, 1993). However, subsidies provided for purchasing environmentally friendly goods is also available in some countries (Toshimitsu, 2010). It has been reported that subsidized crop insurance policies result in expansion of agriculture in marginal quality (economically inferior and environmentally vulnerable) land, which is environmentally detrimental (LaFrance *et al*., 2001). Another manifestation of this phenomenon is that as China provides capital subsidy by offering interest on borrowed capital below the market rate, the flat carbon tax system fails in protecting welfare by reducing emissions (Fisher-Vanden and Ho, 2007). A system of progressive carbon tax regime instead is desirable in an economy, which receives subsidies. Moreover, adoption of weaker environmental standards on pollution abatement functions as implicit cost subsidies to producers eventually leading to environmental degradation (Templet, 2003; Kelly, 2009; Barde and Honkatukia, 2004). Weaker pollution monitoring for Chinese state owned enterprises has been reported in the literature (Dasgupta et al., 2001b), that functions as an implicit subsidy for the operating units. While estimated values of sector-specific input subsidies is available for select countries for certain years, one major challenge is however to obtain actual / estimated data on implicit subsidies at country level on a regular basis.[2]

Given the data limitation on implicit subsidies, the primary objective of the present analysis is to analyze the nexus between government budgetary subsidies and climate change concerns as reflected through per capita CO_2 emissions. However, the per capita CO_2 emissions at country level may also be influenced by variables other than budgetary subsidies. To account for their influences a few control variables have been included in the present analysis in line with the existing literature on environmental sustainability, namely: past values of the per capita CO_2 emissions, Per Capita GDP(PCGDP in current US $), share of agricultural, manufacturing and service sectors in GDP, and level of urbanization in an economy. The income level of a country is generally positively related with its environmental sustainability (Bruvoll and Medin, 2003; de Bruyn et al., 1998; Mukherjee and Kathuria, 2006; Copeland and Taylor, 2004), since growing income level leads to a demand for cleaner environment. However, the Environmental Kuznets Curve Hypothesis (EKCH) notes that as an economy moves from primary to secondary sector, with rise in industrial activities higher emissions are observed. In addition, with further rise in development level, the contribution of the services sector rises in an economy and environmental sustainability improves (Shafik, 1994; Selden and Song, 1994; Grossman and Krueger, 1995; Mukherjee and Chakraborty, 2009). Hence, in addition to the PCGDP, the square term of it has also been incorporated in the model for understanding the effect of the higher order terms. Next, given the fact that the manufacturing sector is one of the major contributors of GHGs, the share of the manufacturing sector in GDP has been considered as one of the control variables. The effect of the other two sectors, namely, agriculture and services are also used as control variables in the regression analysis. Finally, level of urbanization (proxied through percentage of urban population in total population) has been included in the model as a control variable as growth divergence may bear interesting climate change repercussions (Maiti and Agrawal, 2005; Sahibzada, 1993). A robustness check has also been undertaken for the analysis.

[2] Fisheries sector is a case in point, which is a major recipient of implicit subsidies (Chakraborty and Kumar, 2010).

3. Empirical Model

The following panel data regression model is estimated here for 131 countries over 1990-2010 for analyzing the effect of budgetary subsidies on per capita CO_2 emission:

$$log(CO_{2it}) = \alpha + \beta_1 log\ (SUB_{it}) + \beta_2\ log\ (SUB_{i(t-1)}) + \beta_3\ log\ (CO_{2i(t-1)}) + \beta_4\ log\ (PCGDP_{it}) + \beta_5\ log\ (PCGDP_{it})^2 + \beta_6\ log\ (AGRIGDP_{it}) + \beta_7 log\ (MFGGDP_{it}) + \beta_8\ log\ (SERVGDP_{it}) + \beta_9\ log(TAXREV_{it}) + \beta_{10}\ log(URB_{it}) + C_{it} + GOV_{it} + T_t + \varepsilon_{it} \quad \text{.........(1)}$$

where,

log or prefix l	represents the logarithmic transformation of the variables
α	represents the constant term
βs	*are coefficients*
CO_{2it}	represents Per Capita CO_2 emission (in tonne per annum) of country *i* for year *t*
$CO_{2i(t-1)}$	represents Per Capita CO_2 emission (in tonne per annum) of country *i* for year *t - 1*
SUB_{it}	represents budgetary subsidy (as percentage of GDP) provided by country *i* for year *t*
$SUB_{i(t-1)}$	represents budgetary subsidy (as percentage of GDP)provided by country *i* for year *t-1*
$PCGDP_{it}$	represents per capita GDP (current US $) of country *i* for year *t*
$AGRIGDP_{it}$	represents agriculture value added (expressed as percentage of GDP) of country *i* for year *t*
$MFGGDP_{it}$	represents manufacturing value added (expressed as percentage of GDP) of country *i* for year *t*
$SERVGDP_{it}$	represents services, etc. value added (expressed as percentage of GDP) of country *i* for year *t*
$TAXREV_{it}$	represents tax revenue (as percentage of GDP) of country *i* for year *t*
URB_{it}	represents the level of urbanization (urban population expressed as percentage of Total population) in country *i* in year *t*
C_{it}	represents the Cash dummy in country *i* in year *t* (takes the value of 1 if the country follows cash accounting method, and 0 if the country follows accrual accounting system)
GOV_{it}	is a government financing dummy in country *i* in year *t* [takes the value of 1 if the subsidy corresponds to General Government (GG), and 0 for Budgetary Central Government (BCG)or Central Government (CG)]
PCGNIit	represents per capita nominal Gross National Income (US Dollars at current prices and current exchange rates) of country *i* for year *t*-
LIC	represents the low income country (PCGNI: US$1,035 or less) dummy, which has a value of 1 for the corresponding countries and 0 otherwise
LMIC	represents the lower-middle income country (PCGNI: U$1,035 - 4,085) dummy, which has a value of 1 for the corresponding countries and 0 otherwise

	UMIC	represents the upper-middle income country (PCGNI: US$4,085 - 12,615) dummy, which has a value of 1 for the corresponding countries and 0 otherwise
	HIC	represents the high income country (PCGNI: US$12,616 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 2000 and 0 otherwise)
ε_{it}		represents the disturbance term

The advantage of using the log-linear model in the current context is that the estimated coefficients can be interpreted as the elasticity between budgetary subsidy and per capita CO_2 emission and other variables.

The independent variables included in the proposed empirical model are in line with the existing empirical literature, especially in terms of measuring the aforesaid three effects. First, the literature notes that higher volume of output might be associated with higher emission of pollutants owing to factors like additional energy use, exploitation of natural resources etc. Hence $PCGDP_{it}$ has been considered here as the proxy of the *scale effect*. Second, as per predictions of the EKCH in the early stages of development a country moves from primary to secondary (i.e. manufacturing) sector, leading to increase in emissions level. Given the EKCH empirical evidence and the fact that the manufacturing sector is one of the major contributors of GHGs, $MFGGDP_{it}$ has been considered as the proxy of the *composition effect* in the present context. Thirdly, the EKCH also notes that further development may be associated with greater sustainability with rise in contribution of relatively less polluting services sector, higher citizen demand for cleaner environment, adoption of better environmental governance through stricter enforcement of sustainable practices etc. Therefore, $PCGDP^2_{it}$, $SERVGDP_{it}$ and URB_{it} have been included in the present model as the proxies of the *technique effect*.

4. Data Sources and Macro Trends

The present analysis obtains the data on budgetary subsidies from Government Finance Statistics (GFS).[3] It is observed that GFS compiles the government subsidy figures for countries from different government sources as per their reporting practice. Three types of government reporting have been observed in the GFS data for which the required data on subsidy is available. First, the *General Government* (GG) includes all the Central Government (CG) transfers plus budgetary expenses of all the Central Ministries / Departments and the same for the State Governments (SG) (including provincial or regional) and Local Governments. The *Central Government* (CG) transfers on the other hand represent the consolidated transfers of the Central Government (including transfers of Central Ministries / departments). Finally, subsidies reported under *Budgetary Central Government* (BCG) covers "Any central government entity that is fully covered by the central government budget" (IMF, 2005). In addition, the GFS generally reports the budgetary statistics for countries adopting cash accounting method, but for several countries accrual (non-cash) accounting method has been reported. When data is available for a country for different level of government, preference is given to GG over CG and similarly CG over BCG.

[3] Available online at: http://elibrary-data.imf.org/QueryBuilder.aspx?key=19784658&s=322 (last accessed on 11 July 2014)

IMF provides the data on subsidy under the broad head of 'Government and Public Sector Finance' as per the guidelines of *Government Finance Statistics Manual 2001*.[4] Under the specified accounting method (cash and non-cash or accrual), for a particular level of government the data on subsidies and transfers to public corporations and private enterprises is available under the heading 'Expenses by Economic Type' and sub-heading 'Expense'. The present analysis considers the data on subsidies as percentage of GDP of respective countries and the process scale out the size of the economy (as measured by their respective GDP). As per *GFS Manual 2001*, the IMF reported data on subsidies are, "..current transfers that government units pay to enterprises either on the basis of the levels of their production activities or on the basis of the quantities or values of the goods or services that they produce, sell, or import. Included are transfers to public corporations and other enterprises that are intended to compensate for operating losses" (IMF, 2005). In order to understand the differential effects of the data reporting differences in methods of accounting and the level of government, two dummy variables, namely, C_{it} and GOV_{it}, have been included in the empirical models.

The subsidies considered in the current analysis include only direct budgetary subsidies provided by general government, central government or budgetary central government of a country. The indirect or implicit subsidies (i.e., income foregone in terms of tax rebate/ exemptions etc.) are not covered due to non-availability of consistent cross-country data on that front. The effect of subsidies is estimated by considering per capita annual emission of CO_2 (in metric tonne) as an indicator of climate change impact in a country. The per capita CO_2 data is obtained from World Development Indicators database (World Bank, 2013).

For the control variables, the data on per capita GDP, share of agriculture, manufacturing and services sectors in GDP, level of urbanization and tax revenue (as percentage of GDP) have been taken from World Development Indicators database. The data on TAXREV is obtained from WDI. The dummy variables have been generated from the obtained data series as per the defined specifications.

The emerging trends in the major series considered in the regression analysis, namely – budgetary subsidies, per capita CO_2 emissions, per capita GDP, share of the three sectors in GDP, tax revenue as a percentage of GDP, level of urbanization etc. are illustrated with their descriptive statistics summarized in Table 1. First, it is observed that while a fluctuating trend is being noticed for both the average budgetary subsidies expressed as percent of GDP and per capita CO_2 emission, a rise has been noted in the former series. Similarly, average share of agriculture and manufacturing sectors have declined over the period, while the same for the services sector is showing a rising trend. A rise in tax revenue as a percentage of GDP and level of urbanization has also been noticed.

[4] Available online at http://elibrary-data.imf.org/QueryBuilder.aspx?s=322&key=1445284 (last accessed on 25 April 2014).

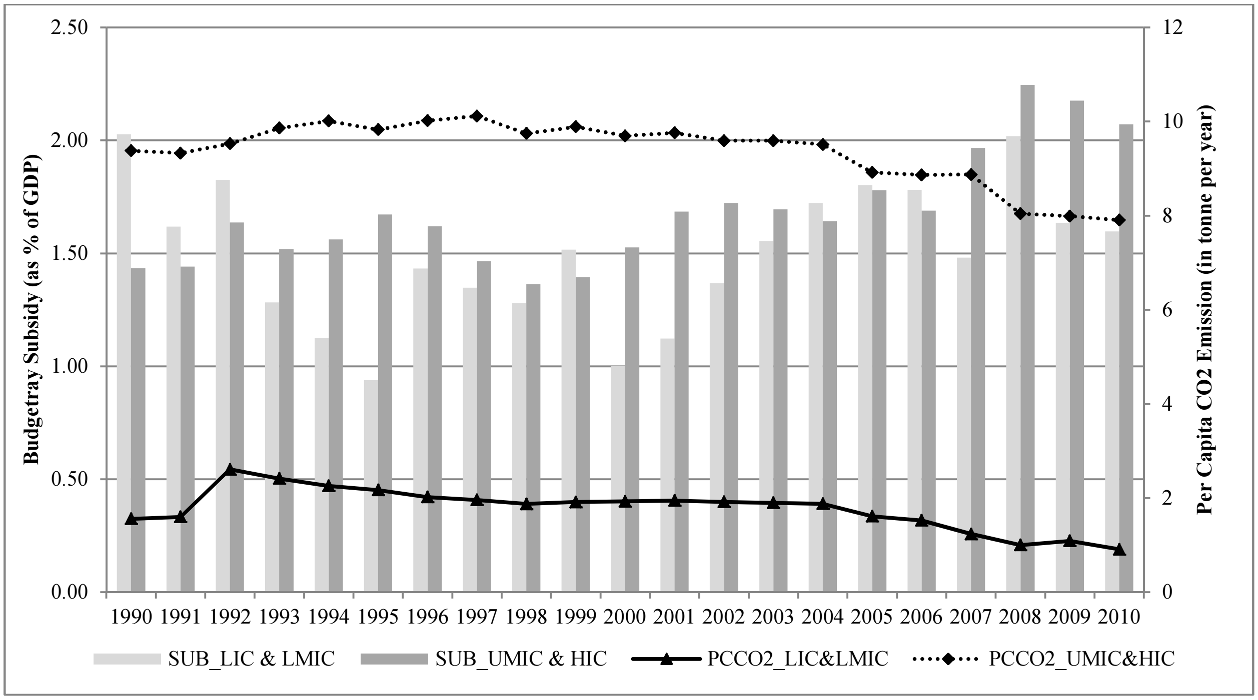
Table 1: Descriptive Statistics for the Key variables included in the Regression Model for Selected Countries

	Average Per Capita CO2 Emission (in Tonne)	Average Budgetary Subsidy (% of GDP)	Average Per Capita GDP (current US $)	Average Share of Agriculture in GDP (%)	Average Share of Manufacturing in GDP (%)	Average Share of Services in GDP (%)	Tax Revenue (as % of GDP)	Urban Population (as % of Total Population)
1990	3.96 ± 5.45	1.76 ± 2.32	5426 ± 8045	18.88 ± 14.82	17.23 ± 8.34	49.3 ± 13.66	14.54 ± 7.83	51.5 ± 23.65
	(0.02 - 26.2)	(0.01 - 14.38)	(161 - 36337)	(0.62 - 61.55)	(2.93 - 39.17)	(15.9 - 81.04)	(1.55 - 39.6)	(6.27 - 99.76)
1991	4.01 ± 5.7	1.55 ± 1.32	5538 ± 8276	18.51 ± 14.96	17.38 ± 9.1	50.3 ± 14.43	14.55 ± 7.62	51.81 ± 23.61
	(0.05 - 36.43)	(0 - 6.11)	(168 - 36310)	(0 - 64.07)	(1.72 - 45.28)	(18.01 - 79.79)	(0.26 - 41.68)	(6.46 - 99.79)
1992	4.55 ± 6.48	1.75 ± 2.15	5830 ± 8830	18.47 ± 15.54	17.42 ± 9	50.69 ± 14.77	14.94 ± 7.58	52.11 ± 23.57
	(0.04 - 54.74)	(0.01 - 11.79)	(110 - 39230)	(0 - 68.88)	(1.68 - 43.54)	(17.58 - 80.85)	(0.09 - 42.88)	(6.65 - 99.82)
1993	4.55 ± 6.98	1.37 ± 1.35	5569 ± 8386	18.48 ± 15.87	16.58 ± 8.01	51.66 ± 14.73	15.53 ± 8.22	52.42 ± 23.54
	(0.04 - 62.44)	(0.01 - 5.99)	(80 - 39721)	(0 - 65.12)	(1.6 - 36.14)	(19.43 - 82.86)	(1.09 - 46.6)	(6.84 - 99.85)
1994	4.48 ± 6.83	1.31 ± 1.21	5913 ± 9007	18.07 ± 15.47	16.49 ± 7.69	52.05 ± 14.35	15.37 ± 7.98	52.72 ± 23.52
	(0.04 - 61.04)	(0.01 - 5.26)	(65 - 43555)	(0 - 65.86)	(2.27 - 39.03)	(18.15 - 84.03)	(1.42 - 47.33)	(7.02 - 99.9)
1995	4.67 ± 7.18	1.3 ± 1.16	6773 ± 10293	18.04 ± 16.09	16.25 ± 7.37	52.59 ± 14.69	17.25 ± 8.87	53.03 ± 23.5
	(0.04 - 61.51)	(0.01 - 5.84)	(65 - 50593)	(0 - 81.82)	(2.31 - 39.06)	(12.91 - 85.3)	(1.15 - 57.8)	(7.21 - 100)
1996	4.74 ± 7.17	1.52 ± 1.31	6956 ± 10292	17.78 ± 15.9	16 ± 7.24	52.65 ± 15	17.03 ± 8.69	53.29 ± 23.46
	(0.05 - 62.1)	(0 - 6.08)	(73 - 49681)	(0 - 93.98)	(2.2 - 37.83)	(4.14 - 85.84)	(0.97 - 55.8)	(7.42 - 100)
1997	4.77 ± 7.54	1.41 ± 1.3	6802 ± 9715	17 ± 15.19	15.77 ± 7.26	53.27 ± 14.68	16.85 ± 8.72	53.55 ± 23.42
	(0.05 - 68.53)	(0.01 - 8.03)	(125 - 44140)	(0 - 76.95)	(2.22 - 39.46)	(8.24 - 85.73)	(1.17 - 53.58)	(7.63 - 100)
1998	4.7 ± 6.89	1.32 ± 1.35	6783 ± 9742	16.73 ± 15.12	15.65 ± 7.21	54.44 ± 14.14	16.43 ± 8.6	53.82 ± 23.39
	(0.05 - 58.87)	(0 - 7.39)	(129 - 45565)	(0 - 78.64)	(2.24 - 39.34)	(11.84 - 84.49)	(1.49 - 59.37)	(7.83 - 100)
1999	4.66 ± 6.63	1.46 ± 1.33	7107 ± 10238	16.01 ± 14.89	15.39 ± 7.48	54.51 ± 14.75	16.61 ± 7.52	54.08 ± 23.37
2000	4.72 ± 6.85	1.28 ± 1.1	7130 ± 10073	14.88 ± 14.3	15.13 ± 7.76	54.98 ± 15.44	16.84 ± 7.51	54.34 ± 23.35
	(0.04 - 58.5)	(0 - 6.95)	(92 - 46453)	(0 - 76.07)	(1.44 - 38.67)	(3.35 - 87.54)	(1.63 - 39.32)	(8.25 - 100)
2001	4.7 ± 6.2	1.41 ± 1.47	7029 ± 9881	14.63 ± 14.17	15.03 ± 7.51	56.06 ± 15.02	16.37 ± 7.54	54.65 ± 23.31
	(0.03 - 49.63)	(0 - 8.42)	(97 - 45743)	(0 - 77.42)	(2.02 - 39.68)	(4.26 - 88.33)	(1.04 - 40.46)	(8.47 - 100)
2002	4.67 ± 6.02	1.54 ± 1.66	7461 ± 10606	14.64 ± 14.27	14.8 ± 7.44	56.13 ± 15.15	16.05 ± 7.11	54.95 ± 23.28
	(0.02 - 45.23)	(0 - 9.22)	(111 - 50583)	(0 - 80.07)	(2.06 - 39.19)	(4.92 - 89.07)	(1.18 - 41.15)	(8.7 - 100)
2003	4.92 ± 6.69	1.63 ± 1.65	8735 ± 12631	14.36 ± 13.99	14.91 ± 7.48	56.36 ± 15.24	16.66 ± 8.06	55.25 ± 23.26
	(0.02 - 54.76)	(0.01 - 9.08)	(108 - 64532)	(0 - 73.48)	(2.14 - 39.88)	(5.31 - 89.86)	(1.32 - 56.54)	(8.92 - 100)
2004	5.04 ± 7.12	1.68 ± 1.65	10023 ± 14455	13.77 ± 13.19	15.04 ± 7.44	56.65 ± 15.14	16.8 ± 8.44	55.55 ± 23.24
	(0.03 - 61.62)	(0.02 - 8.21)	(122 - 74389)	(0 - 66.12)	(2.09 - 39.56)	(3.81 - 90.51)	(0.23 - 60.41)	(9.15 - 100)
2005	5.04 ± 7.2	1.79 ± 1.7	10934 ± 15608	13.27 ± 13.23	14.65 ± 7.24	56.97 ± 15.21	17.39 ± 8.56	55.85 ± 23.23
	(0.02 - 63.18)	(0 - 8.16)	(133 - 80925)	(0 - 67.01)	(2.01 - 38.93)	(2.96 - 91.26)	(0.18 - 60.77)	(9.38 - 100)
2006	5.1 ± 6.96	1.73 ± 1.69	11871 ± 16805	12.98 ± 12.93	14.61 ± 7.43	57.34 ± 14.48	18.15 ± 9.47	56.17 ± 23.19
	(0.02 - 58.64)	(0 - 9.51)	(158 - 90016)	(0 - 63.82)	(0 - 41.35)	(20.54 - 91.72)	(0.12 - 63.52)	(9.63 - 100)
2007	5.19 ± 7.2	1.77 ± 1.86	13594 ± 19136	12.64 ± 12.73	14.72 ± 7.29	57.92 ± 14.47	18.45 ± 9.45	56.49 ± 23.16
	(0 - 58.35)	(0 - 9.46)	(163 - 106920)	(0 - 65.6)	(1.85 - 41.72)	(22.43 - 92.76)	(0.2 - 65.9)	(9.88 - 100)
2008	5.07 ± 6.66	2.17 ± 2.2	14980 ± 20658	12.44 ± 12.94	14.49 ± 7.33	58.35 ± 14.36	18.27 ± 8.45	56.81 ± 23.13
	(0.01 - 50.03)	(0 - 10.33)	(187 - 112029)	(0 - 67.26)	(1.73 - 42.23)	(18.91 - 92.69)	(0.28 - 58.69)	(10.14 - 100)
2009	4.84 ± 6.25	1.97 ± 2.14	12931 ± 17628	12.47 ± 13.08	13.73 ± 7.08	59.77 ± 14.25	16.95 ± 6.24	57.13 ± 23.11
	(0.01 - 42.27)	(0 - 9.63)	(185 - 100541)	(0 - 58.19)	(1.47 - 42.27)	(24.38 - 92.83)	(0.97 - 34.91)	(10.39 - 100)
2010	5 ± 6.44	1.91 ± 2.04	13716 ± 18555	11.69 ± 12.01	13.44 ± 6.87	59.98 ± 14.23	17.01 ± 6.08	57.45 ± 23.09
	(0.01 - 40.31)	(0 - 9.57)	(211 - 103574)	(0 - 57.3)	(0.87 - 35.62)	(20.79 - 92.84)	(0.94 - 34.28)	(10.64 - 100)

Notes: Figures in the parenthesis show the range for the corresponding average value, figure after ± is the Standard Deviation.

The observation from Table 1 calls for having a closer look at the subsidy-emission patterns prevalent at the countries at different levels of development. To analyze that, the sample countries are classified into four broad groups based on their Per Capita Gross National Income (PCGNI), as defined earlier.[5] In order to understand the subsidy-climate change concerns across country groups, first the two data series are simultaneously considered in Figure 1. For the ease of presentation, the LIC and LMIC countries are grouped together whereas UMIC and HIC countries are considered as separate group. It is revealed from the figure that the higher income countries are characterized by both high degree of budgetary subsidies and per capita CO_2 emissions.

Figure 1: Temporal Variations of Average Budgetary Subsidy (as percentage of GDP) and Average Per Capita CO_2 Emission (in tonne per year) across Country Groups



Note: Figure is based on average values of the variables across sample countries
Source: Constructed by the authors

With the help of Figure 2 the devolution of budgetary subsidy patterns (as % of GDP) across the four groups of countries is analyzed next. A fluctuating trend is noticed across all the groups, barring the exception of the UMIC. Fluctuations have understandably been more pronounced both for the LIC owing to their limited fiscal space. Interestingly in the post-2001 period, the average budgetary subsidy devolution as percentage of GDP for LMIC countries are found to be higher than the same for the HIC countries. However, in the post-2007 period the figure has sharply increased for the HIC and UMIC as compared to their LMIC counterparts, underlining the provision of budgetary subsidies there in the post-recession period.

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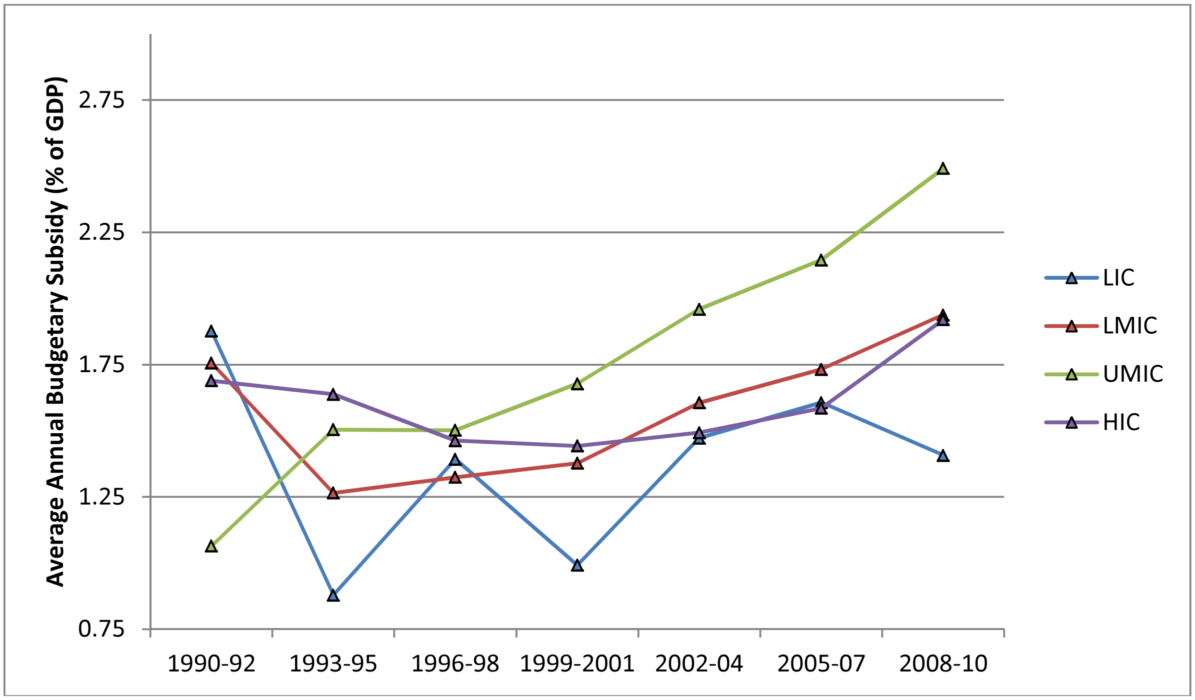
[5] This is in line with World Bank classification of countries based on per capita Gross National Income (GNI) (Source: http://data.worldbank.org/about/country-classifications - last accessed on 24 April 2014).

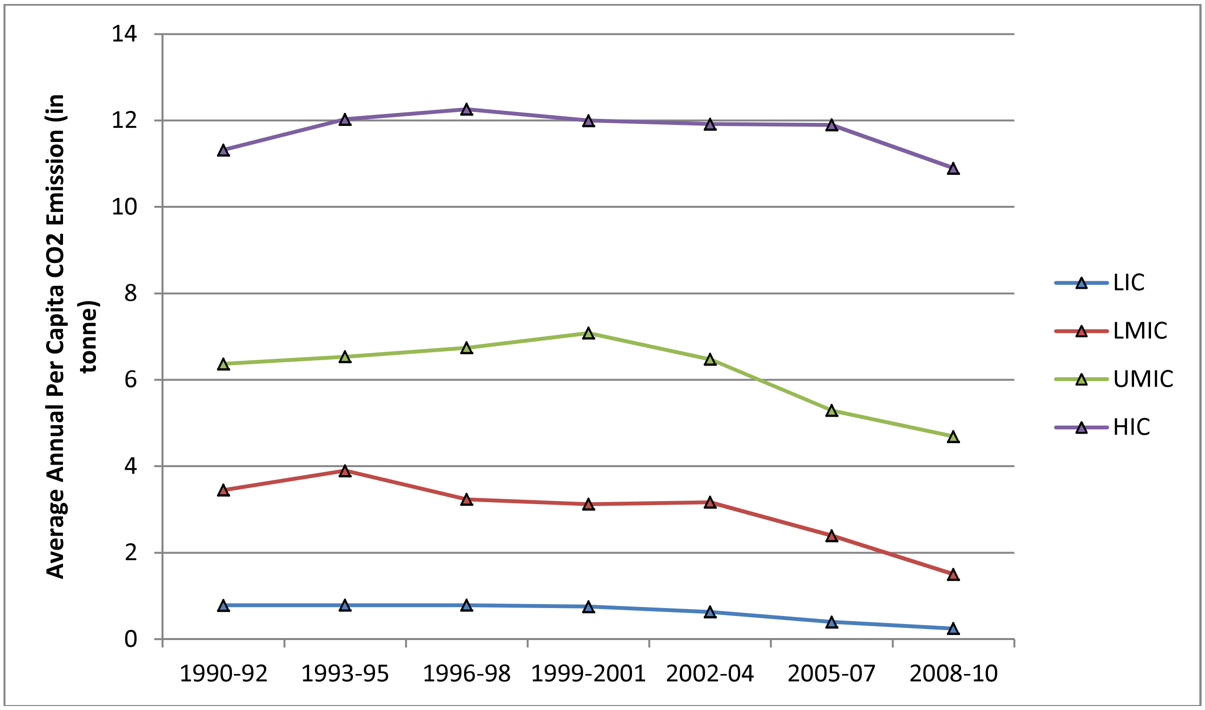
Figure 2: Average Annual Budgetary Subsidy (% of GDP) across Development Groups



Source: Constructed by the authors from GFS data

Figure 3 finally shows the average annual per capita CO_2 emissions pattern across the four groups of countries. The development-led divergence becomes all the more obvious from the trends observed in the figure, which illustrates that average emissions have been considerably higher in richer economies as compared to their lower income counterparts. Moreover, the figure shows that for developed countries average per capita CO_2 emission has fallen down over 2005-2009 (as compared to the 2000-2004 period), which can be explained due to the reduction commitments under Kyoto Protocol (w.e.f. 2005).

Figure 3: Average Annual Per Capita CO_2 Emission (in tonne per annum) across Development Groups



Source: Constructed by the authors from WDI data

Lastly, Table 2 illustrates the data availability for the present analysis as per the IMF GFS data obtained through the online platform. The first two rows segregate the total observations as per the cash and non-cash (accrual) reporting practices. While the first three columns report data availability by the type of government, the last three columns summarize the average subsidy scenario as per the income level of the country groupings. The bottom three rows analyze the data availability scenario with respect to level of government providing subsidy, i.e., GG and others (BCG and CG) in terms of income levels of the selected countries. Certain interesting observations emerge from the table. Firstly, it is observed that most of the countries where GFS reports data for either CG or BCG, follows cash accounting method. Conversely, the countries where data for GG is available, are practicing non-cash (accrual) method of accounting. Secondly, majority of lower income (LIC and LMIC) and higher income (UMIC and HIC) countries have adopted cash and non-cash accounting method respectively. Finally, for majority of lower income (LIC and LMIC) countries GFS reports data for either CG or BCG. The wide variation in data reporting practices across the selected countries justifies the inclusion of the C_{it} and GOV_{it} dummies in the empirical model for capturing the fixed effects corresponding to accounting method and level of government.

Table 2: Distribution of Budgetary Subsidy Data Availability based on Level of Development, Reporting Practices and Accounting Standards: 1990-2010

		Data Reporting Practice			Subsidy	Level of Development		
		Govt. - GG	Govt. - Others	Total		LIC & LMIC	UMIC & HIC	Total
Accounting Standards	Cash	248	1152	1400	1400	820	580	1400
	Non-cash	600	128	728	728	151	577	728
	Total	848	1280	2128	2128	971	1157	2128
	Subsidy	848	1280	2128		971	1157	2128
Data Reporting Practice	Govt. - GG					196	652	848
	Govt. - Others					775	505	1280
	Total					971	1157	2128

Source: Computed by authors based on IMF GFS Database

5. Empirical Results

The panel data regression analysis has been undertaken with help of the STATA software (version 13.1). To understand the working of the model for the proposed relationship in equation (1),[6] Hausman specification test is first conducted. It is observed that the Chi-square test statistic of 313.19 (Prob.: 0.0000) is statistically insignificant. The Hausman test suggests the presence of an underlying fixed effect model. For detecting the presence of first order autocorrelation in the model, the Wooldridge test is then performed. The F - test statistic of 26.016 (Prob.: 0.0000) indicates the presence of first order autocorrelation. To check the existence of heteroskedasticity in the estimated model, the Breusch-Pagan / Cook-Weisberg test has been conducted. The Chi-square test statistic of 106.29 (Prob.: 0.0000) indicates the presence of heteroskedasticity. Estimated mean variance inflation factor (VIF) is 11.56, 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. Based on these diagnostic tests, the present analysis adopts Feasible General Least Square (FGLS) method with time specific fixed effects. The estimated models make correction for the presence of heteroskedasticity and first order panel specific autocorrelation [PSAR(1)] within unbalanced panel data framework.

The estimation results for various specifications of equations (1) are summarized in Table 3, from which the following conclusions can be drawn. First and foremost, the estimation results strongly underline the adverse influence of government subsidies on Per Capita CO_2 emissions ($lpcco_2$) in the sample countries, as reflected from the positive and highly significant coefficients. The relationship is found to be robust for all the model specifications of the budgetary subsidies term, namely *lsub and lsub(-1)*. The empirical results in elasticity terms underline that with proportional increase in the budgetary subsidy level in a country, the rate of per capita emission of CO_2 also rises significantly. Interestingly in Models 3 and 4 the coefficient of *lsub(-1)* is found to be higher vis-à-vis the corresponding coefficients for *lsub*, which demonstrates the importance of the lagged effects of budgetary subsidies on per capita CO_2 emissions in the selected sample.

[6] In equation 1, We drop *lsubi(t-1)* from the list of regressors to carry out diagnostic tests for selection of appropriate specification of the regression model.

Secondly, among the control variables, the coefficient of *$lpcco_2(-1)$* has been found to be positive and significant, implying that a country characterized by historically high level of CO_2 emissions is expected to continue along the trend line, and vice versa. Thirdly, sign of the coefficients with respect to per capita income indicates that for one percentage point increase in *lpcgdp*, *$lpcco_2$* emission generally increases by a higher proportion, barring the exception in the robustness check Models 5, 6 and 9. Fourthly, the higher order terms of income ($lpcgdp^2$) are associated with a negative sign in all the estimated models. Fifthly, the contribution of manufacturing sector in GDP is found to be positively influencing the dependent variable, while the reverse is noted in case of primary and service sectors. In other words, growth in composition of manufacturing sector in an economy results in growth of CO_2 emissions, while the rise in primary and service sectors contribute in curbing the same. The PCGDP and economic composition results provide a strong support to the existence of the EKCH phenomenon. Sixthly, the *lurb* variable is found to be positive in most of the selected model specifications, signifying the negative repercussions of urbanization. Seventhly, Model 10 indicates a negative relationship between TAXREV and $PCCO_2$, which implies that higher the tax revenue (as % of GDP) lower the per capita CO_2 emission. Finally, the cash and government dummies are found to be significant, implying the importance of the underlying accounting method and level of government data reporting practices in influencing the subsidy-climate change nexus. The result indicates that adoption of accrual accounting across the countries is desirable.

In Models 5 and 6, the difference in share of subsidies in GDP and its difference with the past year's value has been considered as an independent variable and the estimated coefficient is found to be positive and significant. In other words, rising difference between past and present values of subsidies lead to higher CO_2 emissions. Moreover, the estimated result of a regression model could be specific to functional form. Therefore, to check the robustness of our estimated result, we have estimated Model 9 where first differences of all continuous variables are taken. Neither the sign nor the significance level of key policy variables changes in this model. In addition, by splicing the sample countries into two groups, namely LIC & LMIC and UMIC & HIC as per the relevant income definitions, the robustness of the proposed relationship has been checked through Models 7 and 8. The coefficient of *lsub* is found to be positive in both models, but the coefficient for the lower income countries are found to be larger vis-à-vis the same for their higher income counterparts. The observation can be explained by the fact that provision of subsidies in the lower income countries may potentially lead to greater CO_2 emissions given the possibility of natural resource base erosion.

A couple of interesting conclusions on the influence of subsidies on CO_2 emissions can be drawn by summarizing the regression results. First, the coefficient of *lsub* for the lower and higher income countries are 0.019 and 0.012 respectively, signifying greater emission growth in the former group in response to percentage increase in budgetary devolutions. In addition, the coefficient of *lpcgdp* for the lower and higher income countries are 1.065 and 1.399 respectively. The observation indicates that per capita income growth in developed countries potentially leads to higher CO_2 emissions, vis-à-vis the corresponding figures for their lower income counterparts. The difference in CO_2 emissions pattern across the two income groups can be explained by existing higher level of output in the richer economies which is in line with the predictions of the *scale effect*, as discussed earlier. However, growth in devolution of subsidies may harm the sustainability of the lower income countries more severely.

Secondly, the coefficients of *lmfggdp* for the lower and higher income countries are found to be 0.295 and 0.151 respectively. In other words, the growth in manufacturing sector output in lower income countries potentially leads to higher CO_2 emissions growth, vis-à-vis the corresponding figures for their higher income counterparts. The result underlines the current scenario in several UMIC and HIC countries, who are experiencing relatively steeper decline in per capita CO_2 emissions in recent period (Figure 3). It is evident that the rise in manufacturing sector output, if not associated with adequate compliance mechanism, may add to sustainability challenges. The positive and negative signs of the coefficient for *lmfggdp* and *lagrigdp* respectively also indicate the presence of a strong *composition effect* in both set of economies.

Finally, the negative coefficient of $lpcgdp^2$ both in lower as well as higher income countries indicates the decline in the per capita CO_2 emissions with further rise in income. The estimated results signifies the presence of an EKCH type relationship with reference to emission of per capita CO_2. Nevertheless, the coefficient for lower income countries (-0.037) is found to be smaller than the corresponding figure for the higher income countries (-0.057), indicating a sharper fall in the latter set of economies. The notion of development difference receives further support from the difference in the magnitude of the coefficient for the *lurb* variable for the two set of countries. While the coefficient is found to be 0.154 for the higher income countries, the same for the lower income countries is 0.996. In other words, the growth in urban population and consequent deepening of economic activities leads to far greater per capita CO_2 emissions growth in lower income countries. The result underlines the existence of a rising demand for cleaner environment and better environmental governance in higher income economies, which is in line with the predictions of *technique effect* and EKCH.

Table 3: Estimation Results on the Relationship between Budgetary Subsidy and CO_2 Emissions

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7 LIC & LMIC	Model 8 UMIC & HIC	Model 9 Difference#	Model 10
lpcco2(-1)					0.977*** (0.003)	0.977*** (0.003)				
lsub	0.018*** (0.004)	0.018*** (0.004)	0.021*** (0.004)	0.015*** (0.004)			0.019*** (0.005)	0.012** (0.005)	0.005*** (0.001)	0.017*** (0.004)
lsub(-1)			0.026*** (0.004)	0.019*** (0.004)						
lsub-lsub(-1)					0.004*** (0.001)	0.004*** (0.001)				
lpcgdp	1.154*** (0.081)	1.225*** (0.083)	1.269*** (0.075)	1.378*** (0.077)	0.110*** (0.013)	0.092*** (0.013)	1.065*** (0.201)	1.399*** (0.215)	0.275*** (0.058)	1.101*** (0.09)
lpcgdp2	-0.042*** (0.005)	-0.048*** (0.005)	-0.051*** (0.004)	-0.054*** (0.004)	-0.006*** (0.001)	-0.005*** (0.001)	-0.037*** (0.014)	-0.057*** (0.011)	-0.006* (0.003)	-0.04*** (0.005)
lagrigdpn	-0.137*** (0.019)	-0.17*** (0.018)	-0.252*** (0.016)	-0.158*** (0.019)	-0.002 (0.002)	0.000 (0.002)	-0.151*** (0.031)	-0.048** (0.02)	0.055*** (0.013)	-0.155*** (0.021)
lmfggdpn	0.2*** (0.021)			0.208*** (0.021)		0.004 (0.003)	0.295*** (0.022)	0.151*** (0.025)	0.089*** (0.019)	0.258*** (0.023)
lservgdpn		-0.222*** (0.048)	-0.291*** (0.054)		-0.034*** (0.01)					
ltaxrev										-0.063*** (0.023)
Lurban	1.049*** (0.048)	1.174*** (0.05)	0.939*** (0.042)	0.816*** (0.051)	-0.023*** (0.005)	-0.023*** (0.005)	0.996*** (0.048)	0.154** (0.073)	1.054*** (0.202)	1.082*** (0.056)
Cash	0.061*** (0.017)	0.079*** (0.018)	0.047*** (0.017)	0.047*** (0.017)	0.016*** (0.004)	0.018*** (0.004)	0.109*** (0.034)	0.064*** (0.019)	0.016*** (0.004)	0.146*** (0.025)
Gov	-0.027* (0.016)	-0.035** (0.016)	-0.038** (0.015)	-0.016 (0.015)	-0.018*** (0.004)	-0.02*** (0.005)	-0.104*** (0.032)	-0.032* (0.017)	-0.003 (0.004)	-0.049*** (0.019)
Constant	Omitted	Omitted	-8.284***	-9.951***	Omitted	-0.306***	-10.195***	Omitted	0.005	Omitted

			(0.311)	(0.326)		(0.059)	(0.664)		(0.009)	
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1661	1736	1549	1491	1548	1490	824	831	1472	1330
Number of groups	131	134	131	129	131	129	90	70	129	124
Wald chi2	14855.66	12468.86	8516.87	7132.02	2625470	1772387	5420.11	15994.62	592.89	14584.1
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: #- first difference of all continuous variables
Figure in the parenthesis shows the heteroskedasticity [*Panel(hetero)*] and Panel Specific First Order Autocorrelation [*PSAR(1)*] corrected standard error of the estimated coefficient
***, ** and * implies estimated coefficient is significant at 0.01, 0.05 and 0.10 level respectively.

6. Policy Observations

Supporting domestic players through subsidies for fulfilling both short term and long term objectives is a time-tested policy instrument across countries. The negotiations both at the multilateral trade forum (e.g., WTO) as well as the multilateral environment-related forums (e.g., United Nations Conference on Sustainable Development (UNCSD), United Nations Framework Convention on Climate Change (UNFCCC)) are presently geared towards containing the adverse environmental influences of subsidies which facilitate over-production, incentivize input overuse (including fossil fuel subsidy) beyond the actionable level, reduction of the GHGs emissions and protection of biodiversity etc. among other goal. The modest achievements of both the forums in curbing environmentally-harmful subsidies however remains an area of serious concern.

The conclusions of the current analysis need to be viewed in this wider context. First, the positive and significant relationship between subsidy-GDP ratio and per capita CO_2 emission is in line with the theoretical predictions, as the budgetary support to certain economic activities may lead to over-use of environmentally harmful inputs (e.g. fuels) and cause over-production, resulting in climate change concerns. Secondly, the empirical results relating to PCGDP and GDP composition are in line with the EKCH predictions that as the importance of the manufacturing sector gradually increases, it worsens emissions scenario. On the other hand, prominence of primary and service sectors in GDP are associated with decline in CO_2 emissions. The interesting dynamics in the divergence in values of the estimated coefficients across LIC-LMIC and UMIC-HIC groups however clearly indicates how subsidies influence climate change concerns across different countries differently depending on the relative strengths of the *scale*, *composition* and the *technique* effects. Last but not the least, the climate change concern seems imminent for both set of countries. While for UMIC-HIC, the presence of a higher *technique effect* might conceal part of the adverse effect of budgetary devolutions, adverse *scale* and *composition effects* are clearly witnessed for these economies as well from Table 3. Figure 1 clearly indicates that the budgetary subsidies expressed as percentage of GDP as well as the per capita CO_2 emissions are relatively higher for richer countries as compared to their lower income counterparts. However, developing countries also need to urgently pay heed to the adverse influence of budgetary subsidies on per capita CO_2 emissions, as the presence of a weaker *technique effect* is apparent in these economies from regression results. The observation underlines the need for an early conclusion of the UNFCCC forums negotiations to secure GHGs reduction commitments from countries across all development spectrum.

The current empirical analysis suffers from two limitations owing to the availability of subsidies data at present. First, a consistent cross-country long time series data on indirect/ implicit subsidies through revenue foregone (i.e., income foregone in terms of tax rebate/ exemptions etc.), which can affect CO_2 emissions significantly, is presently not available. The present analysis is therefore based entirely on direct subsidies, which involves budgetary devolutions (i.e. transfer of financial resources). Second, the underreporting of subsidies data is an acknowledged problem in trade literature (WTO, 2006). In future, development of a comprehensive database by multilateral bodies capturing all forms of subsidies provided by countries would facilitate further policy analysis on this front.

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