# Negative Influence of Fiscal Subsidies on Environment: Empirical Evidence from Cross-Country Estimation

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## Abstract

It has been observed that a number of developed as well as developing countries provide subsidies to their resource-intensive sectors like agriculture, fisheries, manufacturing etc. However, overproduction and consequent pollution as well as overexploitation of natural resources resulting from the provision of input and output subsidies have been a serious threat to environmental sustainability. An area of concern is that subsidies with potentially harmful environmental impacts are not declining in the recent period, despite the ongoing negotiations through the WTO framework and the UN forums. The present analysis attempts to understand the role of government budgetary subsidies on the overall environmental performance through panel data model estimation for a set of seventy four countries over an eleven year period (2000-2010). The empirical findings confirm that a positive relationship between subsidies and environmental degradation exists in a cross-country framework. The analysis notes that the failure to contain provision of subsidies through timely conclusion of the Doha Round negotiations is also posing a serious threat to the global climate change related concerns.

**Keywords:** *budgetary subsidy; environmental performance index, environmental sustainability; per capita $CO_2$ emission; human development; urbanization; government policy.

**JEL Classification:** H23, Q 53, Q56, Q58

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## Introduction

Over the last decade, the growth concerns in several countries have turned sensitive towards the quest for sustainable development. The World Commission on Environment and Development (1987) defined sustainable development as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). The principle has been reiterated in all the major multilateral forums for discussing environmental concerns. In particular, the Earth Summit at Rio de Janeiro (1992) declared that:

- "To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies. (Principle 8)
- States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health. (Principle 14)." (IISD, undated).

The aforesaid principles in essence indicated the need to curb unwanted subsidies which might lead to environmental degradation (e.g., deforestation and generation of higher pollution load). Along similar lines, the climate change related discussions led to Copenhagen Accord (2009), which stressed the need to reduce emissions from deforestation and forest degradation (UNFCCC, 2009). Similar concerns in the subsequent period have been reiterated by UNCSD (2012) in their declaration at the Rio+20 Conference released on 24 July 2012, "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." - Para 281; UNCSD (2012). However, government budgetary support and subsidies in several resource-intensive sectors, namely primary sector (e.g., agriculture, fisheries), transport, energy, water etc. is still rampant with enormous environmental ramifications (van Beers et al., 2004).

The tradition of providing subsidies by national governments for supporting domestic business vis-à-vis their foreign counterparts is in practice for a long time (Giuliani et al., 2011). The motivation behind the subsidies is often guided by the infant-industry argument as proposed by the international trade literature (Chang, 2001). Subsides can either be provided to the domestic players for boosting domestic production (domestic subsidy) or for promoting competitiveness and exports (export subsidy), or both. The subsidies extended to the local players by the government can either be direct transfer of resources (per unit production subsidy) or indirect support (e.g., in terms of revenue foregone by offering tax concessions etc.). The support can also be extended through concessional credit lines, monopoly rights or lax environmental standard (i.e., 'race-to-the-bottom' phenomenon) etc., among other means (Kelly, 2009). The existing trade literature has noted the adverse impact of the subsidies on trade flows on several

occasions which could manifest itself in terms of export dumping and price crash (Anderson et al., 2006; Oxfam, undated).

The realization on the long term adverse implications of subsidies on trade front has motivated inclusion of the 'Agreement on Subsidies and Countervailing Measures' (ASCM) under the wings of WTO since its inception in 1995. This has been in continuation of the GATT negotiations being held earlier since Tokyo Round in seventies. The ASCM considers not only the direct financial transfers, but also the revenue foregone (e.g., interest payment on loan restructuring) as subsidies (WTO, 1994). The WTO discussion aims at classifying the subsidies 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 with minimal impact on trade). At present, the focus of the negotiation by WTO Member countries revolves around the need to contain the actionable subsidies being provided by the Member countries (Chakraborty et al., 2011).

When market prices of natural resources do not reflect the full social costs of production, distortions in trade and/or environmental degradation are bound to happen (Porter, 1997). In addition to the more obvious trade-distorting effects, both domestic or export subsidies are potentially associated with over-production, resource over-exploitation and the consequent irreversible environmental damage. Notably, the subsidies being provided in the area of agricultural sector and the fisheries deserve special mention in this regard. Overproduction in both these sectors, aided by subsidies, may have serious adverse implications for the environment apart from their trade consequences. In addition, subsidies provided to the manufacturing sector, especially through fuel subsidies (i.e., allowing higher volume of fossil fuel burning) may lead to air pollution and emissions of greenhouse gases and ultimately to environmental degradation and loss of biodiversity. Apart from direct subsidies and/or tax exemptions (concessions) to producers, not adopting strict environmental rules and regulations and by not having institutional and infrastructural facilitates to monitor pollution abatement practices, a government provides implicit cost subsidies to producers who eventually externalize the environmental costs of production to the society in terms of environmental degradation (e.g., water and air pollution, land degradation) and/ or depletion of natural resources (e.g., falling groundwater level) (Templet, 2001).

The present analysis intends to explore the relationship between government financial transfers (i.e., budgetary subsidies) and environmental sustainability in a cross-country framework. The paper is arranged along the following lines. First, a brief discussion on the subsidies being provided to the agriculture, fishery and the manufacturing sectors by selected countries and their potential implications on environment are noted. A cross-country empirical analysis is conducted next for understanding the influence of subsidies on environmental quality. Finally on the basis of the findings, a few policy conclusions are drawn.

**Subsidies: Evidence from the Literature and the Implications**

Subsidization is witnessed across the globe, both developed and developing countries attempt to support their domestic players through this route. However, the extent of subsidization is considerably higher in the north. For instance, it is observed from *Table 1* that OECD countries during nineties have been a major recipient of subsidies in most of the reported categories.

**Table 1:** Estimates of World Subsidies – 1994-98 ($ billion)

| Criteria | OECD | Non-OECD | World | OECD as % of World |
|---|---|---|---|---|
| Natural resources sectors: | | | | |
| Agriculture | 335 | 65 | 400 | 84 |
| Water | 15 | 45 | 60 | 25 |
| Forestry | 5 | 30 | 35 | 4 |
| Fisheries | 10 | 10 | 20 | 50 |
| Mining | 25 | 2 | 30 | 83 |
| Energy and industry sectors: | | | | |
| Energy | 80 | 160 | 240 | 33 |
| Road transport | 200 | 25 | 225 | 89 |
| Manufacturing | 55 | negligible | 55 | 100 |
| **Total** | **725** | **340** | **1065** | **68** |
| Total as % of GDP | 3.4 | 6.3 | 4.0 | |

***Source***: van Beers and de Moor (2001)

It has been observed that the global agricultural production and government support is marked by a fundamental difference between two set of countries. On one hand, the developed countries characterized by capital-intensive production structure provides considerable subsidy to the local farmers in crops like rice, wheat, maze, corn, dairy products etc., which are of considerable export interest of the developing countries (WTO, 2010, 2011). The support provided by developed countries to their farmers covers both the field of input and output subsidies. On the other hand, the labor - intensive agricultural system in developing countries generally relies on input subsidies (Chand and Philip, 2001).

Looking at the implications of the difference between the two forms of subsidies, it is observed that the input subsidy (e.g., fuel, fertilizer and pesticide subsidy) can lead to lower per unit variable costs and hence motivates over-production. Steenblik (1998) noted that input subsidies are more prone to input overuse and consequent biodiversity loss. Atici (2009) reports the link between fertilizer usage in OECD countries and their $CO_2$ emission levels. Similarly, the output linked production subsidy (e.g., price support linked with volume of agricultural output) motivates the producer to go beyond the level of economic production (UIC-CMDA, 2003). For instance, Robin et al. (2003) have noted water and soil pollution (Scherr, 2003); conversion of forests, rainforests, and wetlands into cultivable lands (OECD, 2003) and diversion of water (Myers and Kent, 2001) as a result of intensive cropping across countries. In addition, lowering costs of operation by subsidies (e.g., due to free or partially free electricity supply) might make farmers' choice biased in favour of water intensive crops (which also fetch higher return on investment), resulting in indiscriminant extraction of groundwater (Sidhu, 2002). The water intensive crops are by nature fertilizer and pesticide intensive (Mukherjee, 2008; 2010). As a result large scale leaching of nitrogen and pesticides into aquifers is reported from intensively cultivated areas of India in the post-Green revolution period, leading to environmental challenges (Mukherjee, 2012; Kushwaha, 2008). Clearly, both forms of support to the agricultural sector may bear adverse consequences for the environment. Shi and Chen (2004) argue that as an alternative to subsidy, increasing off-farm employment

opportunity may encourage Chinese households to reduce cultivation in slope fields of the loess plateau which are prone to erosion.

Keeping generally the trade-related concerns in mind, a limit on the subsidy to be provided by the Member countries within the WTO Agreement on Agriculture has been defined in the following manner. The subsidies are classified under three boxes: Amber Box (production-linked subsidies, which are most trade distorting), Blue Box (subsidies linked with farm size, hard size etc. rather than absolute level of production, with relatively smaller effect on trade) and Green Box (subsidies linked to R & D and other activities, which are either not trade-distorting or least trade-distorting). The developed countries are supposed to keep the value of their Amber Box support measures within 5 percent of the value of their agricultural production, while the corresponding figure for their developing counterparts is 10 percent. However, it has been noticed that all support measures are not subject to discipline (Gulati and Narayanan, 2003).

There has been certain reform in EU and US agricultural policies over the years since the initiation of the Doha Round of WTO in 2001 (WTO, 2001), but the actual level of reform is subject to question (Anderson et al., 2008). For instance, the level of actual EU Common Agricultural Policy (CAP) reform to decouple the subsidies from production (i.e., to convert into Blue Box measures) has been challenged by Oxfam (2005). Similarly, the reforms proposed by the Farm Bill 2008 in the US have been criticized by other countries (Morgan, 2010). Substantial environmental externalities in the US through the hidden subsidies have widely been reported in literature (Myers and Kent, 2001). Maddison et al. (1997) estimate the size of environmentally damaging subsidies in UK and they conclude that the users of transport infrastructure are the single largest beneficiary of more than $20 billion subsidy. Myers (1998) estimates that globally environmentally perverse subsidies in five sectors - agriculture, fossil fuels and nuclear energy, road transport, water and fisheries - total $1.1 trillion per year. The problem is further compounded by underreporting of subsidies by WTO Member countries (WTO, 2006).

*Table 2* shows the 5-year annual average Producer Support Estimate (PSE) in agriculture for a few selected countries, as reported by the OECD database. It is observed from the table that the average agricultural support in all the countries have not declined uniformly since the initiation of the Uruguay Round discussions of General Agreements on Tariffs and Trade (GATT) in 1986. On the contrary, the average subsidy level has increased in Australia, EU, Japan and South Korea in early nineties. Similarly, the average subsidy level has increased in case of US after inception of WTO in 1995. In more recent period, the economic recession since 2009 has caused an increase in trade protectionism (Chaisse et al., 2011) and in particular, agricultural subsidies has also increased in several countries. The slow progress of the Doha Round negotiations makes the possibility of a speedy resolution on the reform of agricultural subsidies unlikely (Chakraborty and Khan, 2008). The downward rigidity in the level of agricultural subsidies in major developed countries (WTO, 2010, 2011) as well as in several developing countries (Anderson and Martin, 2009) raises a consequent question on the environmental sustainability as well. The government subsidy programmes to boost primary sector activities often directly led to environmental disasters. For instance, in late 1980s Brazil provided ‘tax concessions and subsidies to farmers and ranchers, to clear the forests in the Amazon’ (WTO, 1999).

**Table 2:** Annual Average Producer Support Estimate in Selected Countries

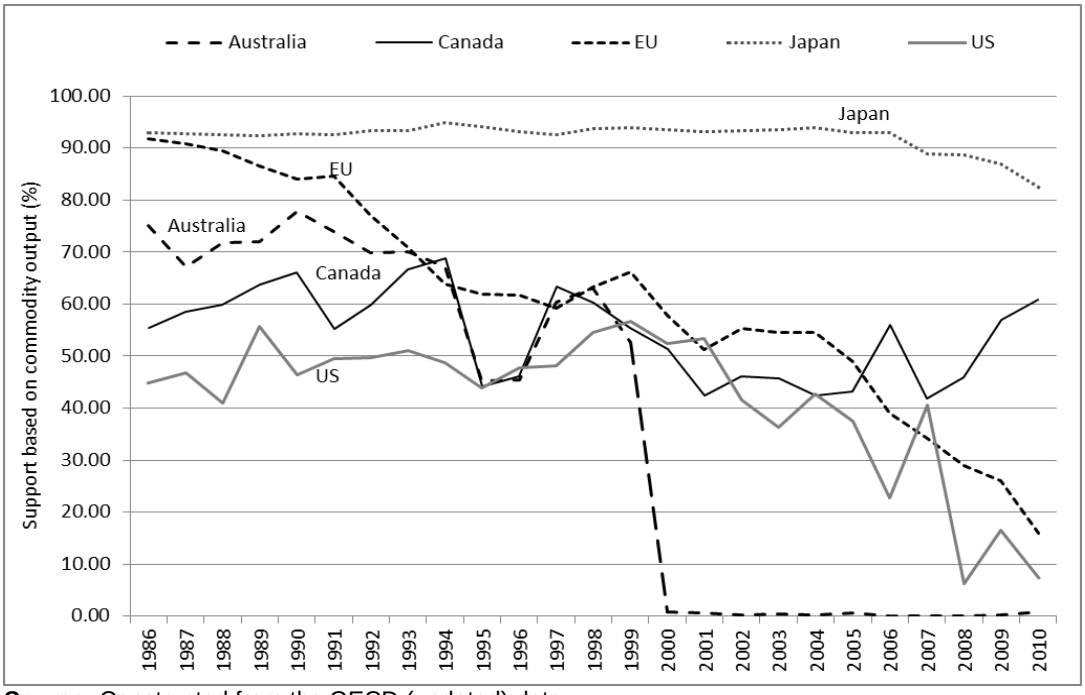
(US $ Billions)

| Period | Australia | Canada | EU | Japan | South Korea | US |
|---|---|---|---|---|---|---|
| 1986-90 | 1.42 | 5.87 | 95.39 | 47.92 | 14.76 | 35.83 |
| 1991-95 | 1.55 | 4.91 | 113.24 | 60.23 | 21.29 | 29.48 |
| 1996-2000 | 0.97 | 3.54 | 106.25 | 51.11 | 18.75 | 42.79 |
| 2001-05 | 0.92 | 5.23 | 108.77 | 45.50 | 17.84 | 42.28 |
| 2006-10 | 1.34 | 6.52 | 120.33 | 42.95 | 19.58 | 30.22 |

***Source***: OECD Database (OECD, undated)

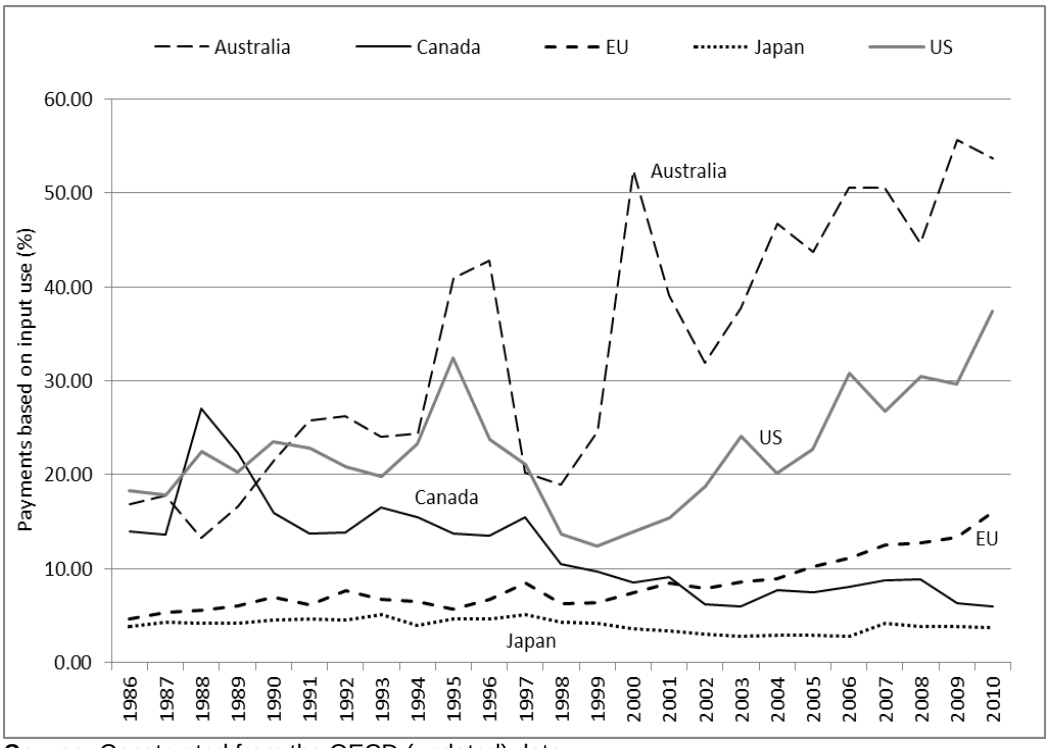
The evolving relative importance of output-based and input-based support measures for agriculture in OECD countries has been reported in Figures 1 and 2 respectively. Oskam and Meester (2006) have noted that output-based support is one of the major components of the aggregate agricultural support measures. It is observed from Figure 1 that the proportional importance of output-based support in case of Australia, EU and US has declined considerably over the years. This indicates that several 'Amber Box' subsides in the EU are getting converted into 'Blue Box' categories (Atici, 2009). On the other hand, these measures are still quite large in case of Canada and Japan. Conversely, the proportional importance of the input-based subsidy programmes is on the rise in Australia and the US (Figure 2). However, Canada and Japan are yet to switch towards the input-based support measures.

**Figure 1:** PSE Payments based on Commodity Output (%)




***Source:*** Constructed from the OECD (undated) data

**Figure 2:** PSE Payments based on Input use (%)




***Source:*** Constructed from the OECD (undated) data

The environmental implications of subsidies, especially reflected through loss of biodiversity, are particularly evident in case of marine fisheries. Huge devolution of funds to domestic players can lead to fishing with over-capacity, which may in turn result in overexploitation of the fish stocks owing to increased fishing intensity (Porter, 2000; WWF, undated). One additional problem is that in presence of subsidies, the economic signals of overcapacity and overexploitation (e.g. reduced productivity, lower catches) might go unnoticed (Chakraborty and Kumar, 2010). Moreover, subsidies through price support measures may increase the number of players, which compounds the problem of resource overexploitation. WTO (1999) estimated the annual volume of trade-distorting fishing subsidies at around US $54 billion, and reported overcapitalization and overfishing as a consequence. A decade later, persistence of the problem led WTO Director-General Pascal Lamy to caution that:

> "[T]oday, we run the risk that over-fishing will so deplete fish stocks in our oceans that many species will disappear forever. . . . It is bad news for the world's 43.5 million full time fishers. Governments have contributed to this problem by providing nearly $16 billion annually in subsidies to the fisheries sector. This support keeps more boats on the water and fewer fish in the sea…" - WTO (2009).

Like the case of agriculture, the WTO ASCM attempts to limit the extent of actionable subsidies to the *de minimis* level (within *ad valorem* 5 percent) in case of manufacturing products as well. However, the use of subsidies in international trade and associated disputes are quite frequent (Chakraborty et al., 2011). Industrial subsidies are quite high in several developed and developing countries (WTO, 2006). Subsidies to the operational cost deserve special mention in this regard. For instance, extension of fuel subsidies to various manufacturing activities is considerably high in several countries, which significantly harm environmental sustainability. Estimation of the value of annual global energy subsidy is however a critical question due to underreporting. It has been noted that annual global energy subsidy level is greater than US $300 billion (Victor, 2009). Although developed countries are among the major providers of energy subsidy, the developing countries are also coming up in recent period on this front. On one hand, Templet (2001) has reported presence of huge volume of energy, pollution and tax subsidies across US states. On the other, UNEP (2008) has noted that:

> ".. the twenty largest non-OECD countries amount to around US$220 billion based on 2005 data, of which subsidies to fossil fuels account for around $170 billion…Russia has the largest subsidies in dollar terms, amounting to about $40 billion, most of which go to natural gas... Iran's energy subsidies are almost as large, at an estimated $37 billion. Six other countries – China, Saudi Arabia, India, Indonesia, Ukraine and Egypt – each have subsidies in excess of $10 billion per year."

Conversely, subsidies provided to mining and the energy sector may also lead to resource overexploitations. For instance, the existence of coal subsidies in Poland and Russia can be mentioned here (WTO, 2006).

The continuation of the energy subsidies has forced UNCSD (2012) to note in the Rio+20 declarations that, "Countries reaffirm the commitments they have made to phase out harmful and inefficient fossil fuel subsidies that encourage wasteful consumption and undermine sustainable development" (Para 225, UNCSD, 2012). However, the negotiations on emission cut commitments by the countries from fossil fuel burning have hit a roadblock, which is an area of serious concern (EEPSPL, 2009). In particular, the use of various subsidy programmes in China and other Asian economies towards the environmentally sensitive sectors has come to light repeatedly over the last decade. NCTO (undated) has reported that China is helping the textile producers through a number of export incentive programmes. Haley (2008) noted that the energy subsides declined in China during 2002-03 after its entry into WTO in 2001 but has increased considerably in the subsequent period. Price et al. (2007) observed that more than US $ 52 billion has been spent in subsidies given to Chinese steel producers, which included preferential loan, credit, land-use discount etc. Chow (2007) has observed an interrelationship between use of energy from exhaustible resources in China and environmental degradation there. Kang (2012) estimated that emission of 58.86 million tonne of $CO_2$ can be reduced by reforming environmentally harmful subsidies prevalent in Korea. In short, the energy subsidies in both developed and developing countries are presently associated with adverse environmental implications.

**Data and Methodology**

The present analysis attempts to understand the role of subsidy provided by the General Government or Central Government (or Budgetary Central Government) on the overall environmental performance for a set of developed and developing countries through a cross-sectional time series analysis for the period over 2000-2010. In accordance with the availability of the latest data, 2000-2010 has been taken as the period of our analysis. A total of 74 countries, for which data on subsidy, environmental performance, per capita income and human development are available consistently over the last decade have been considered here for the analysis. The analysis deals with the direct subsidy, which is reported in government expenditure side of budget and reported in International Finance Statistics of IMF (2011). Unless or otherwise mentioned, by 'subsidy' the present discussion imply the budgetary support provided by the general government of the concerned country (as percentage of GDP). For few countries, in absence of direct subsidy provided by the general government, the analysis has instead considered the direct subsidy provided by the central government. Obtaining data from IMF sources helps the analysis to overcome the definitional differences associated with collecting the subsidy statistics from individual countries (WTO, 2006).

It has generally been observed in the literature that a composite environmental index properly summarizes the environmental condition of a country, and is more meaningful than individual pollution indicators (Adriaanse, 1993; Adriaanse et al., 1995; Blanc et al., 2008; Esty et al., 2005; Jones et al., 2002; Rogers et al., 1997). Following this discourse, the current study considers Environmental Performance Index (EPI) of a country as the representative scenario of the environmental quality within its territory (Emerson et al., 2012). A higher EPI score for a country implies better environmental sustainability.

Apart from composite index of environmental sustainability, we have also considered per capita emission of the major Greenhouse Gas (GHG) $CO_2$ as an indicator of climate change impact of a country. A few control variables have been considered in the present analysis: e.g. share of urban population in total population, and Per Capita Income (as measured by GDP per capita, PPP (current international $)). The data on per capita $CO_2$ emission, per Capita GDP have been taken from World Development Indicators database (World Bank, 2012).The data on the other control variable, Hybrid Human Development Index (HHDI), for 2000-2010 has been obtained from UNDP (undated). The data on level of urbanization (urban population as percentage of total population) is also taken from World Development Indicators database (World Bank, 2012).

The following panel data model involving environmental scenario of seventy four countries over eleven years (2000-2010) is used here for estimating the effect of subsidies on their environmental performance:

$$EPI_{it} = \alpha + \beta_1 SUB_{it} + \beta_2 PCGDP_{it} + \beta_3 URB_{it} + \beta_4 HHDI_{it} + \beta_5 GOV_{it} + T_t + \varepsilon_{it} \quad \ldots\ldots\ldots(1)$$

$$CO_{2it} = \alpha + \beta_1 SUB_{it} + \beta_2 PCGDP_{it} + \beta_3 URB_{it} + \beta_4 HHDI_{it} + \beta_5 GOV_{it} + T_t + \varepsilon_{it} \ldots\ldots\ldots(2)$$

In order to understand the relationship between the logarithmic transformations of the dependent variables and the independent variables as proposed under equations

(1) and (2), equations (3) and (4) as noted are estimated next. The expression 'log' in the following represents the natural logarithm.

$$log(EPI_{it}) = \alpha + \beta_1 log(SUB_{it}) + \beta_2 log(PCGDP_{it}) + \beta_3 log(URB_{it}) + \beta_4 log(HHDI_{it}) + \beta_5 log(GOV_{it}) + T_t + \varepsilon_{it} \quad \ldots\ldots\ldots(3)$$

$$log(CO_{2it}) = \alpha + \beta_1 log(SUB_{it}) + \beta_2 log(PCGDP_{it}) + \beta_3 log(URB_{it}) + \beta_4 log(HHDI_{it}) + \beta_5 log(GOV_{it}) + T_t + \varepsilon_{it} \quad \ldots\ldots\ldots(4)$$

where,

| | |
|---|---|
| α | represents the constant term |
| *βs* | *are coefficients* |
| $EPI_{it}$ | represents the Environmental Performance Index score of country *i*in year *t* |
| $CO_{2it}$ | represents the $CO_2$ emission level (metric tons per capita)of country *i*in year *t* |
| $SUBSIDY_{it}$ | represents the Share of Subsidy in GDP (in %) by country *i*in year *t* |
| $SUBSIDY_{i(t-1)}$ | represents the Share of Subsidy in GDP (in %) by country *i*in year *t-1* |
| $PCGDP_{it}$ | represents GDP per capita, PPP (current international $)in country *i*in year *t* |
| $PCGDP_{i(t-1)}$ | represents GDP per capita, PPP (current international $)in country *i*in year *t-1* |
| $URB_{it}$ | represents the level of urbanization proxied by urban population (% of total) in country *i*in year *t* |
| $HHDI_{it}$ | represents the Hybrid HDI Scores in country *i*in year *t* |
| $GOV_{it}$ | is a dummy which represents the subsidy corresponding to Budgetary Central Government or General Government in country *i*in year *t* (General Government=0, otherwise 1) |
| log or l | Natural logarithm form of the variable |
| $T_t$ | represents the time dummies (e.g., $t_1$=1 for 2000 and 0 otherwise) |
| $\varepsilon_{it}$ | represents the disturbance term |

*Equations (1)* and *(2)* specify a linear relationship among the variables and provide approximate description of the underlying behaviors. Equations (3) and (4) specify a linear relationship among log-transformed variables. When variables are measured in different units, considering a log-linear model is more appropriate as compared linear relationship. The parameters of log-log model (equation 2) provide elasticities. The impacts of some of the independent variables are not instantaneous

(specifically macroeconomic variables like per capita GDP, subsidy) and therefore we have introduced lags of those variables in both linear and log-linear models. To avoid multicollinearity problem we have introduced level and lagged variable in our regression models once at a time.

The panel data regression analysis has been undertaken with 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 35.52(0.0000) is statistically significant. The Hausman test suggests the presence of a fixed effect model. 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 8.27 (0.0040) indicates that the error term is heteroskedastic. For detecting the presence of autocorrelation in the model, the Wooldridge test is then performed. The F - test statistic of 61.771(0.0000) indicates the presence of serial autocorrelation among the selected variables. Estimated mean variance inflation factor (VIF) is 2.33(<10) (Kutner et al., 2004) implies that level of multicollinearity is within tolerance limit. On the basis of the diagnostic statistics, the present analysis estimates Feasible Generalized Least Square (FGLS) regressions with time effects and reports results for equation (1) and (3) with heteroskedasticity and panel-specific autocorrelation [AR(1)] corrected coefficients and standard errors.

To understand the working of the model for the proposed relationship in equation (2), Hausman specification test is first conducted. It is observed that the Chi-square test statistic of 21.31(0.0001) is statistically significant. The Hausman test suggests the presence of a fixed effect model. 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 92.59 (0.0000) indicates that the error term is heteroskedastic. For detecting the presence of autocorrelation in the model, the Wooldridge test is then performed. The F - test statistic of 12.502(0.0008) indicates the presence of serial autocorrelation among the selected variables. Estimated mean variance inflation factor (VIF) is 2.67 (<10) (Kutner et al., 2004) implies that level of multicollinearity is within tolerance limit. On the basis of the diagnostic statistics, the present analysis estimates Feasible Generalized Least Square (FGLS) regressions with time effects and reports results for equation (2) and (4) with heteroskedasticity and panel-specific autocorrelation [AR(1)] corrected coefficients and standard errors.

To check the robustness of the results, we have sliced the dataset of seventy four countries into two subsets - developing and developed countries. The set of developing countries consists of lower income countries (LIC) and lower middle income countries (LMIC), while developed countries include upper middle income countries (UMIC) and high income countries (HIC).[1] The models not only slice the entire data set into two set of countries but also slice a country depending on the status of Per Capita GNI. A country is defined as an LIC if its Gross National Income (GNI) per capita, Atlas method (current US$) is found to be US$1,005 or less; LMIC: US$ 1,006 - 3,975; UMIC: US$3,976-12,275 and HIC: US$12,276 or more. To capture the temporal aspects of the causal relationship, we have taken one year lag of the independent variables (e.g., Per Capita GDP, Subsidy) and introduced them instead of their level variable to tackle the problem of multicollinearity.

[1] This is in line with World Bank classification as provided in http://wdronline.worldbank.org/worldbank/a/incomelevel (last accessed on November 20, 2012).

Based on the diagnostic statistics as reported earlier, FGLS models are estimated and the heteroskedasticity and panel-specific autocorrelation [AR(1)] corrected coefficients has been reported in Table 4. Depending on availability of data for dependent as well as independent variables, different models consider different set of countries out of total seventy four countries.

**Empirical Results**

The estimation results reported in Table 3 clearly supports the hypothesis on the adverse influence of government subsidies on the environmental sustainability. It is observed that the dependent variable EPI is negatively influenced by the independent variable SUBSIDY, while $CO_2$ bear a positive influence with the same. In other words, with increase in the subsidy level in a country the environmental performance is worsened, while the level of $CO_2$ emission increases. Both PCGDP and HHDI exhibit positive relationship with the dependent variables. GOV is negatively related to both EPI and $CO_2$. The reported coefficients of the time dummies are also found to be significant in the analysis.

The relationship between EPI score and PCGDP is positive and significant for linear models, which implies that with the growing PCGDP, environmental performance improves for set of countries included in our analysis. Even, one year lag of PCGDP influences EPI score positively (even for log-linear model). There is an inverse relationship between budgetary subsidy (as percentage of GDP) and environmental performance. The relationship is stronger for one year lag of budgetary subsidy. The relationship also holds for log-linear models. There is an inverse relationship between level of urbanization and environmental performance. There is a positive and significant relationship between achievement in human development and environmental performance.

The relationship between PCGDP and per capita $CO_2$ emission is positive and significant. The relationship holds with one year lag of PCGDP and log-linear models. As budgetary subsidy increases (as percentage of GDP), per capita $CO_2$ emission also increases and the elaticity is positive and significant and magnitude of elasticity increases for one year of lag of subsidy variable. Hybrid HDI score significantly and positively influences per capita emission of $CO_2$. Literature also supports this finding (Costa et al., 2011).

It is observed that like the case of regressions reported at level, in the logarithmic transformations also the subsidies are directly related to $CO_2$ emission levels and negatively related to EPI score. In other words, the negative influence of subsidies on the environmental quality is confirmed by both set of regressions.

For better understanding of the relationships, we have estimated the regression models separately for developing (consisting of LIC and LMIC) and developed (consisting of UMIC and HIC). The results reported in Table 5 show that there is inverse relationship between PCGDP and environmental performance for developing countries and the opposite is true for developed countries. These findings support the EKC hypothesis. However, the relationship between PCGDP and per capita $CO_2$ emission is positive and significant for all countries. This implies that for set of countries included in our analysis,

improvement in per capita income costs higher per capita emission of $CO_2$. Budgetary subsidies are detrimental for environment and the results hold for both EPI and per capita $CO_2$ emission. With rising level of urbanization per capita $CO_2$ emission increases for developing countries whereas opposite is true for developed countries. For developing countries urbanization is detrimental for environmental performance. Human development facilitates better environmental performance but also increases per capita $CO_2$ emission, with intensification of economic activities.

**Table 3:** Estimation Results on the Relationship between Subsidy and Environmental Quality - Environmental Performance Index Score

| **Dependent Variable** | **EPI Score** | **EPI Score** | **EPI Score** | **Dependent Variable** | **Log(EPI Score )** | **Log(EPI Score )** | **Log(EPI Score )** |
|---|---|---|---|---|---|---|---|
| **Independent Variables** | **Coefficient** | **Coefficient** | **Coefficient** | **Independent Variables** | **Coefficient** | **Coefficient** | **Coefficient** |
| Constant | 27.647 *** | 28.653 *** | 29.114 *** | Constant | 4.332 *** | 4.275 *** | 4.107 *** |
| | (1.987) | (1.675) | (1.665) | | (0.133) | (0.121) | (0.118) |
| Per Capita GDP | 9.3E-05 *** | 9.9E-05 *** | | Log(Per Capita GDP) | -4.7E-04 | 3.8E-03 | |
| (pcgdp) | (1.4E-05) | (1.4E-05) | | (lpcgdp) | (8.8E-03) | (8.3E-03) | |
| Per Capita GDP(-1) | | | 1.1E-04 *** | Log[Per Capita GDP)(-1)] | | | 1.7E-02 ** |
| [pcgdp(-1)] | | | (1.4E-05) | [lpcgdp(-1)] | | | (8.2E-03) |
| Budgetary Subsidy | -0.047 * | | | Log(Budgetary Subsidy) | -0.001 ** | | |
| (subsidy) | (0.027) | | | (lsubsidy) | (0.001) | | |
| Budgetary Subsidy(-1) | | -0.119 *** | -0.103 *** | Log[Budgetary Subsidy)(-1)] | | -0.002 *** | -0.002 *** |
| [subsidy(-1)] | | (0.033) | (0.031) | [lsubsidy(-1)] | | (0.001) | (0.001) |
| Level of Urbanisation | -0.027 *** | -0.032 *** | -0.032 *** | Log(Level of Urbanisation) | -0.030 ** | -0.026 * | -0.021 |
| (urban) | (0.009) | (0.009) | (0.009) | (lurban) | (0.015) | (0.014) | (0.014) |
| Hybrid HDI Score | 38.915 *** | 36.675 *** | 36.027 *** | Log(Hybrid HDI Score) | 0.667 *** | 0.632 *** | 0.554 *** |
| (hhdi) | (2.453) | (2.304) | (2.288) | (lhhdi) | (0.053) | (0.052) | (0.052) |
| Level of Government | -1.161 ** | -1.394 *** | -1.287 *** | Level of Government | -0.036 *** | -0.039 *** | -0.035 *** |
| (gov) | (0.515) | (0.412) | (0.416) | (gov) | (0.008) | (0.007) | (0.007) |
| Time Fixed Effects | Yes | Yes | Yes | Time Fixed Effects | Yes | Yes | Yes |
| No. of Observations | 538 | 503 | 503 | No. of Obs. | 519 | 484 | 484 |
| No. of Groups | 62 | 62 | 62 | No. of Groups | 59 | 59 | 59 |
| Wald Chi2 | 7650.00 | 4445.41 | 4554.31 | Wald Chi2 | 4150.94 | 3473.73 | 2955.14 |
| Prob(Wald Chi2) | 0.000 | 0.000 | 0.000 | Prob(Wald Chi2) | 0.000 | 0.000 | 0.000 |

***Notes:*** Figure in the parenthesis shows the heteroskedastic and panel-specific 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.

**Table 4:** Estimation Results on the Relationship between Subsidy and Environmental Quality – Per Capita $CO_2$ Emission

| **Dependent Variable** | **Per Capita $CO_2$ Emission** | **Per Capita $CO_2$ Emission** | **Per Capita $CO_2$ Emission** | **Dependent Variable** | **Log(Per Capita $CO_2$ Emission)** | **Log(Per Capita $CO_2$ Emission)** | **Log(Per Capita $CO_2$ Emission)** |
|---|---|---|---|---|---|---|---|
| **Independent Variables** | **Coefficient** | **Coefficient** | **Coefficient** | **Independent Variables** | **Coefficient** | **Coefficient** | **Coefficient** |
| Constant | | -1.071 *** (0.351) | -1.495 *** (0.326) | Constant | -1.671 *** (0.431) | -0.706 ** (0.344) | -0.110 (0.275) |
| Per Capita GDP (pcgdp) | 1.8E-04 *** (8.9E-06) | 1.7E-04 *** (1.0E-05) | | Log(Per Capita GDP) (lpcgdp) | 4.1E-01 *** (3.1E-02) | 3.4E-01 *** (2.5E-02) | |
| Per Capita GDP(-1) [pcgdp(-1)] | | | 1.7E-04 *** (1.1E-05) | Log[Per Capita GDP)(-1)] [lpcgdp(-1)] | | | 2.5E-01 *** (1.7E-02) |
| Budgetary Subsidy (subsidy) | 0.034 * (0.018) | | | Log(Budgetary Subsidy) (lsubsidy) | 0.009 *** (0.001) | | |
| Budgetary Subsidy(-1) [subsidy(-1)] | | 0.017 (0.018) | 0.031 * (0.017) | Log[Budgetary Subsidy)(-1)] [lsubsidy(-1)] | | 0.010 *** (0.001) | 0.010 *** (0.001) |
| Level of Urbanisation (urban) | 0.001 (0.004) | 0.004 (0.004) | 0.003 (0.004) | Log(Level of Urbanisation) (lurban) | 0.070 (0.052) | -0.007 (0.060) | 0.069 (0.042) |
| Hybrid HDI Score (hhdi) | 6.661 *** (0.614) | 6.820 *** (0.706) | 7.220 *** (0.660) | Log(Hybrid HDI Score) (lhhdi) | 3.163 *** (0.163) | 3.418 *** (0.115) | 3.574 *** (0.085) |
| Level of Government (gov) | -1.262 *** (0.141) | -1.455 *** (0.145) | -1.459 *** (0.144) | Level of Government (gov) | -0.039 (0.026) | -0.178 *** (0.036) | -0.271 *** (0.036) |
| Time Fixed Effects | Yes | Yes | Yes | Time Fixed Effects | Yes | Yes | Yes |
| No. of Observations | 482 | 424 | 424 | No. of Obs. | 456 | 403 | 403 |
| No. of Groups | 66 | 65 | 65 | No. of Groups | 63 | 63 | 63 |
| Wald Chi2 | 18274.89 | 9034.55 | 7071.03 | Wald Chi2 | 35777.61 | 137403.94 | 630175.88 |
| Prob(Wald Chi2) | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 |

***Notes:*** Figure in the parenthesis shows the heteroskedastic and panel-specific 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.

**Table 5:** Estimation Results on the Relationship between Subsidy and Environmental Quality– Country Groups

| Sample | LIC & LMIC | UMIC & HIC | LIC & LMIC | UMIC & HIC | Sample | LIC & LMIC | UMIC & HIC | LIC & LMIC | UMIC & HIC |
|---|---|---|---|---|---|---|---|---|---|
| **Dependent Variable** | **EPI Score** | **EPI Score** | **Per Capita $CO_2$ Emission** | **Per Capita $CO_2$ Emission** | **Dependent Variable** | **Log(EPI Score )** | **Log(EPI Score )** | **Log(Per Capita $CO_2$ Emission)** | **Log(Per Capita $CO_2$ Emission)** |
| Constant | 41.264 *** | 16.794 *** | -2.218 *** | 0.826 | Constant | 4.139 *** | 3.583 *** | -12.182 *** | -0.874 |
| | (2.753) | (4.186) | (0.374) | (2.082) | | (0.194) | (0.203) | (1.318) | (0.798) |
| Per Capita GDP(-1) | -8.9E-04 *** | 1.2E-04 *** | 4.8E-04 *** | 1.3E-04 *** | Log[Per Capita GDP)(-1)] | -0.060 *** | 0.035 *** | 1.348 *** | 0.584 *** |
| [pcgdp(-1)] | (2.1E-04) | (1.7E-05) | (5.7E-05) | (2.1E-05) | [lpcgdp(-1)] | (0.019) | (0.012) | (0.170) | (0.066) |
| Budgetary Subsidy(-1) | -0.123 *** | -0.121 ** | 0.080 *** | 0.054 ** | Log[Budgetary Subsidy) (-1)] | -0.008 *** | -0.003 *** | 0.024 ** | 0.016 *** |
| [subsidy(-1)] | (0.046) | (0.059) | (0.012) | (0.026) | [lsubsidy(-1)] | (0.001) | (0.001) | (0.011) | (0.002) |
| Level of Urbanisation | 0.061 | -0.005 | 0.021 *** | -0.004 | Log(Level of Urbanisation) | 0.127 *** | 0.055 | 0.521 *** | -0.654 *** |
| (urban) | (0.042) | (0.022) | (0.003) | (0.005) | (lurban) | (0.028) | (0.037) | (0.121) | (0.070) |
| Hybrid HDI Score | 20.931 *** | 47.788 *** | 1.747 *** | 6.344 ** | Log(Hybrid HDI Score) | 0.342 *** | 0.621 *** | 1.092 *** | -0.696 |
| (hhdi) | (4.384) | (4.588) | (0.511) | (2.759) | (lhhdi) | (0.084) | (0.094) | (0.266) | (0.449) |
| Level of Government | -6.006 *** | 0.892 | 0.599 *** | -2.122 *** | Level of Government | -0.180 *** | 0.033 *** | 0.665 *** | -0.390 *** |
| (gov) | (0.594) | (0.709) | (0.212) | (0.129) | (gov) | (0.012) | (0.010) | (0.089) | (0.023) |
| Time Fixed Effects | Yes | Yes | Yes | Yes | Time Fixed Effects | Yes | Yes | Yes | Yes |
| No. of Observations | 114 | 386 | 116 | 305 | No. of Obs. | 97 | 383 | 97 | 302 |
| No. of Groups | 21 | 45 | 24 | 45 | No. of Grs. | 18 | 44 | 22 | 44 |
| Wald Chi2 | 261.81 | 607.63 | 645.80 | 1216.64 | Wald Chi2 | 388.39 | 454.32 | 5445.90 | 3787.13 |
| Prob(Wald Chi2) | 0.000 | 0.000 | 0.000 | 0.000 | Prob(Wald Chi2) | 0.000 | 0.000 | 0.000 | 0.000 |

***Notes***: Figure in the parenthesis shows the heteroskedastic and panel-specific 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.

**Future Concerns**

The adverse effect of global warming is a widely discussed area in the recent period and the need to reduce carbon emissions and other harmful pollutants is increasingly being felt by the countries. Overexploitation of natural resources and overproduction, aided by subsidies on various fronts including energy subsidy and various types of production subsidies (input and output subsidies), is however a serious threat against achieving that goal. In addition, a major challenge for the countries would be to bridge the conflict between 'the needs of the present' and the 'future generations', before reaching the path of sustainable development. As the discussions under the current analysis indicates, often the countries operate from a selfish standpoint, and in order to provide an edge to the local producers vis-à-vis foreign players, adopt an active policy of subsidization with less considerations for the environmental concerns. The driving motivation behind the support measures may vary from country-to-country from the domestic infant-industry protection argument to explicit export subsidization schemes for displacing foreign competitors. In addition, indirect support measures for the local producers could also be extended through the prevalence of relatively lax environmental standards in a country or lenient approach in regulation and monitoring of pollution abatement, which would provide lower variable cost for them (i.e., lower pollution abatement expenses). The empirical evidence on 'Pollution Haven Hypothesis' provides instances of this type of indirect support (Chakraborty, 2012; Cole et al., 2008; He, 2006; Merican et al., 2007; Wagner and Timmins, 2008).

Several UN led international forums have attempted to contain the adverse impacts of the subsidization programmes through multilateral negotiations. Among the leading UNEP / UNFCCC discussion forums which directly or indirectly focus on the reduction of subsidies, Rio Declaration, Kyoto Protocol, Johannesburg Plan of Implementation, Copenhagen Accord etc. deserve special mention. The recently concluded Rio+20 discussions have also explicitly dealt with the adverse environmental implications of the subsidies, and concluded by encouraging the WTO Member countries to, "..redouble their efforts to achieve an ambitious, balanced and development-oriented conclusion to the Doha Development Agenda" (Para 282, UNCSD, 2012). However, the actual progress on this front so far has been limited owing to various reasons. For instance, Lassa (2006) notes the reasons behind weaker outcome of the discussions under Kyoto Protocol.

Besides the limitations faced by the UN bodies, the progress under the WTO Doha Development Agenda Negotiations has also resulted fewer reasons to cheer. As per the WTO commitments, the Member countries are expected to reduce their actionable agricultural subsidies (Shah, 2012). In line with this principle, the Doha declaration (2001) underlined the need to phase out the trade-distorting agricultural support measures as well as all forms of export subsidies (WTO, 2001). However, the developed countries have always been guarded during the negotiations, resulting to the stalemate at the Doha Round (Chakraborty and Khan, 2008; Chakraborty and Singh, 2006). Ratna et al. (2011) noted that the carve-outs would lead to box-shifting rather than actual reform. Therefore, a speedy resolution of the disagreements among countries and the conclusion of the Doha Round are not expected very soon. However, the delay in conclusion of trade deal implies continuation of the agricultural subsidies. The experience of the cotton subsidies in the US is a case in point (Baffes, 2011).

The discussions and empirical analysis undertaken in the current study clearly indicates that despite the efforts of reducing subsidies through the WTO framework on one hand and the UN forums on the other, limited success has been observed till date. The positive relationship observed between subsidies and environmental sustainability in leading economies, who also happen to be key WTO Member countries is a worrying trend in this background. The failure to contain provision of subsidies through timely conclusion of the Doha Round negotiations is therefore posing a serious threat to the global climate change related concerns as well.

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