On the Relationship between Co2 Emissions and Economic Growth: The Mauritian Experience

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Abstract

This paper analyses the relationship between GDP and carbon dioxide emissions for Mauritius and vice-versa in a historical perspective. Using rigorous econometrics analysis, our results suggest that the carbon dioxide emission trajectory is closely related to the GDP time path. We show that emissions elasticity on income has been increasing over time. By estimating the EKC for the period 1975-2009, we were unable to prove the existence of a reasonable turning point and thus no EKC "U" shape was obtained. Our results suggest that Mauritius could not curb its carbon dioxide emissions in the last three decades. Thus, as hypothesized, the cost of degradation associated with GDP grows over time and it suggests that the economic and human activities are having increasingly negative environmental impacts on the country as cpmpared to their economic prosperity.

Key words: Environment Kuznets Curve, carbon dioxide emissions, GDP

Introduction

Carbon dioxide emissions have grown dramatically in the past century because of human activities, mainly by the use of fossil fuels as well as changes in land use that are directly linked with economic growth and development. The causal relationship between economic development and different indicators of environmental quality has been extensively explored in the recent years by the Environmental Kuznets Curve (EKC) models globally, regionally or country wise by several authors. In 1991, the EKC hypothesis was first introduced by Grossman and Krueger for different environmental indicators, including the carbon dioxide emissions as well. The EKC hypothesis stated an inverted *U*-shape relation between various indicators of environmental quality and per capita income. Under this hypothesis, carbon dioxide emission was usually explained by linear, quadratic or cubic polynomial functions of income per capita.

Research in this area has been attracted only recently and even then it has overwhelmingly focused on developed country cases (see De Bruyn et a (1998) and Dijkgraaf and Vollebergh (2001) with empirical evidences on developing countries, particularly African economies, being very scarce. Moreover existing literature has often ignored or inadequately treated the issues of dynamics and endogeniety in modeling the hypothesized link. This paper thus attempts to supplement the literature by bringing new evidences for the case of Mauritius as since independence in 1968, Mauritius has developed from a low-income, agrian based economy to a middle income diversified economy with growing industrial, financial, and tourist sectors. An economic growth rate averaging 5-6% yearly for the past few decades has enhanced the wellbeing of citizens of Mauritius, as captured by its high Human Development Index of 0.804 (2005). Rising standards of living have been accompanied by an increased demand for energy resources. Mauritius has developed a strong reliance on imported fossil fuels for its energy needs close to 82%, and this dependency is increasing. The carbon dioxide emissions associated with the burning of fossil fuels are also on the rise, and Mauritius has a per capita carbon dioxide emission is around 2.52 tonnes (CSO, 2006). Therefore, the proper use of the environment has become a divisive topic in economics. The huge potential for economic growth through the abuse of the environment is undeniable. Vital resources have forever been and continue to be an essential component of economic growth. But the environment also performs the vital function of supporting life. Needless to say, if humans impair the earth's ability to sustain life, the consequences would be dire. And unfortunately, the very same exploitation that provides us with crucial economic inputs can also be the instrument by which we impair the earth's ability to support life. As Mauritius is highly dependent on fossil fuels, the reduction of carbon dioxide emissions represents a serious environmental challenge for the Mauritian's economy.

This work thus attempts to examine the relationship between gross domestic product (GDP) and carbon dioxide emissions and vice-versa for the year 1975-2009. It attempts to take into account dynamic and feedback effects together with the endogeneous properties of growth modeling by using recent rigorous dynamic econometric time series analysis namely Vector Autoregressive model. We subsequently further investigates and consolidates our findings by focusing on the determinants of CO2 emissions, particularly with respect to growth and attempts to shed some lights on Environmental Kuznets Curve (EKC) in relation to Mauritius.

The rest of the paper is organized as follows namely section 2 reviews the theoretical underpinnings and the empirical literature, section 3 discusses the trends between carbon dioxide emissions and economic growth in Mauritius, section 4 lays out the methodology, discusses the results from the analysis and the last section concludes.

Literature Review

It is well known that higher level of pollution emission (carbon dioxide emission) might lead to the reduction of the productive capacity of a country and also to climatic change. On the other hand it is also a fact economic growth necessitate higher amount of energy consumption and thus carbon

dioxide and other pollution emission. In fact it has been argued that an inverted-U-shaped relationship between economic growth and measured pollution indicators (environmental quality) exist and this known as the EKC. Thus the EKC hypothesis is intended to represent a long term relationship between environmental impact and economic growth. As economic development accelerates with the intensification of agriculture and other resource extraction, the rate of resource depletion begins to exceed the rate of resource regeneration, and waste generation increases in quantity and toxicity. At higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, results in leveling off and gradual decline of environmental degradation. As income moves beyond the EKC turning point, it is assumed that transition to improving environmental quality starts. Thus, it could be a depiction of the natural process of economic development from a clean agrarian economy to a polluting industrial economy, and, finally, to a clean service economy (Arrow et al., 1995).

The EKC hypothesis actually summarizes an essentially dynamic process of change; as income of an economy grows over time, emission level grows first, reaches a peak and then starts declining after a threshold level of income has been crossed. However, the statement of the hypothesis makes no explicit reference to time. The EKC is a long run phenomenon; it is a development trajectory for a single economy that grows through different stages over time. Empirically, this development trajectory can be observed in cross-country cross-sectional data, which represents the countries with different income groups corresponding to their emission levels. Assuming all countries follow one EKC, and then at any cross-section of time, it should be observed that some countries are poor shaping the initial stage of EKC, some are developing countries approaching towards peak or start to decline and other are rich produce falling stage of EKC. Evidently, thus, under the null hypothesis of EKC and under the assumption of invariance of the income–emission relationship, for a given set of cross-country cross-sectional data on income and emission, the emission on income regression line should be an inverted-U-shaped empirical EKC.

Related Literature

The early sets of EKC studies relates to a study of the environmental impacts of NAFTA (Grossman and Krueger, 1991), the World Bank's 1992 World Development Report (Shafik and Bandyopadhyay, 1992) and Panayotou, 1993. Grossman and Krueger (1993) first pointed out an inverted-U relationship between pollutants (SO_2 and smoke) and income per capita. However, Panayotou (1993) first coined it as the Environmental Kuznets Curve or EKC [4]. However, De Bruyn *et al*. (1998) believe that the inverted U shape does not hold in the long run as it would be only an initial stage of the relationship between economic growth and environmental degradation. Above a certain income level, there would be a new turning point that would lead to N shaped curve, meaning that the environmental degradation would come back in high growth levels [44].

There have been subsequently a number of studies addressing the hypothesized link and these are also summarized in the table below

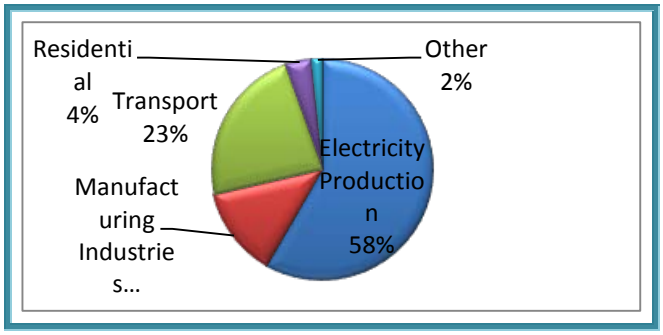
Table1 : Past studies on different EKC hypothesis

Authors	Region	Period	Dependent variable	Type of data	Conclusion
Moomaw and Unhruh (1997)	*16 countries*	1950-1992	CO_2emissions	Panel data	None EKC relationships are obtained.
Cole *et al.* (1997)	7 regions along the world	1960-1991	CO_2emissions	Panel data	The findings demonstrate that the global impact of CO2 emissions has provided little incentive for countries implement unilateral actions for these emissions.
De Bruyn *et al.* (1998)	countries (Netherlands, United Kingdom, USA, Germany)	1960-1993	CO_2, $NO_x$and SO_2 emissions	Panel data	An inverted U shaped curve was not found.
Agras and Chapman (1999)	34 countries	1971-1989	CO_2emissions and energy	Panel data	Inverted U shaped curve between income and energy and between income and CO2 emissions.
Dijkgraaf and Vollebergh (2001)	OCDE countries	1960-1997	CO_2 emissions	Panel data	The fact of that many countries do not reflect EKC pattern becomes mostly unlikely the existence of an inverted U shaped curve.
Lucena (2005)	Brazil	Brazil	CO_2 emissions	Time series	Evidences for an EKC in the case of CO2 emissions.
Arraes *et al.* (2006)	countries (sample size is not defined)	1980, 1985, 1990, 1995, 2000	CO_2 emissions and other indicators of development	Panel data	An inverted U shaped curve was found.

More recent studies are also found from Paul and Bhattacharya (2004) who found bidirectional causality between energy consumption and economic growth in India. Wolde- Rufael (2005) investigates the long-run and causal relationship between real. Using cointegration analysis, Wietze and Van Montfort (2007) show that energy consumption and GDP are co-integrated in Turkey over the period 1970–2003 and found a unidirectional causality running from GDP to energy consumption indicating that energy saving would not harm economic growth in Turkey. Ang, (2007 and 2008) found similar results for the Tunisian Economy.

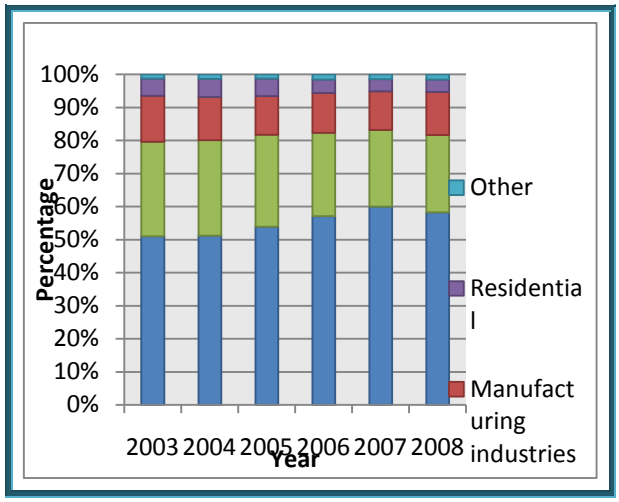
Carbon dioxide emissions and economic growth Mauritius: Facts

Indeed, Mauritius has a reliance on imported fossil fuels for its energy needs close to 82%, and this dependency is increasing. The carbon dioxide emissions associated with the burning of fossil fuels are on the rise, and Mauritius has a per capita carbon dioxide emission ~2.52 tonnes (2006). Virtually all energy is consumed in the form of electricity or as liquid fuels in transportation. The combination of electricity use and transportation accounts for 81% of total carbon dioxide emissions.



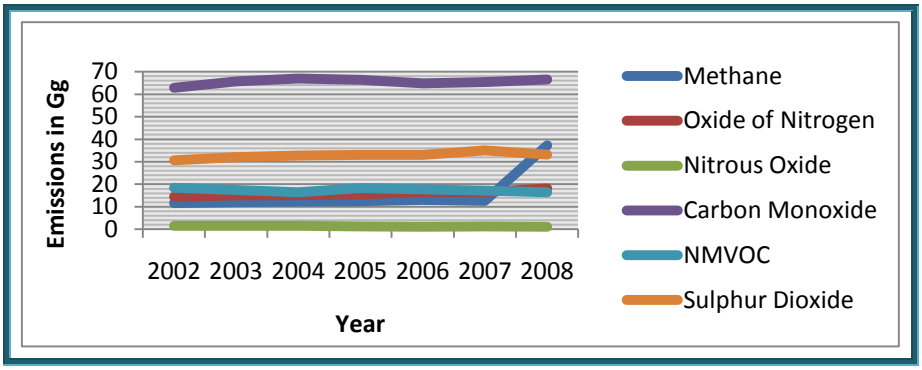
Sectoral Emission of GHGs in 2008 Source: CSO, Port Louis [1]

The relative contributions of the main sectoral carbon dioxide emissions from 2003 to 2008 are presented in the Figure below. The electricity sector is the main producer of GHG emissions contributing 51% of the 2003 national carbon dioxide -equivalent emissions to 58% in 2008.



Sectoral CO_2 Emissions (2003 – 2008) Source: CSO, Port Louis [1]

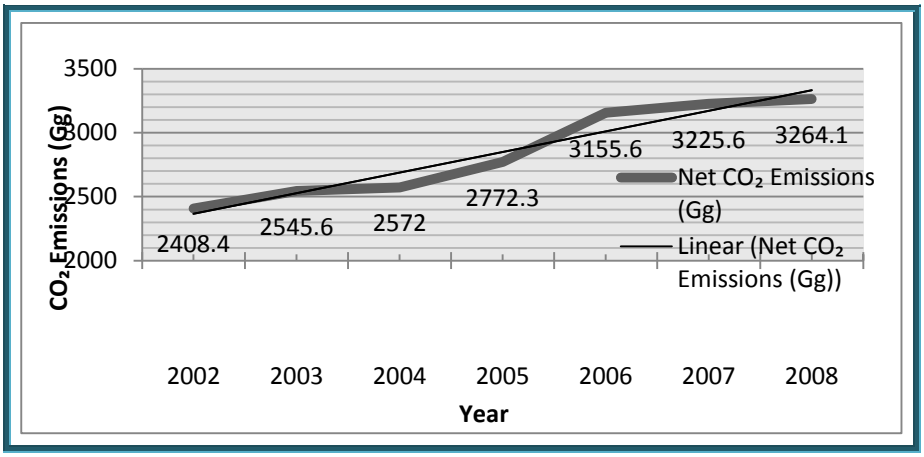
Mauritius emissions of GHGs other then carbon dioxide in 2008 are shown below. Carbon monoxide and sulphur dioxide is the most common non- carbon dioxide GHGs and totaled 94.4 thousand tones.



Non-CO_2 Emissions (2002-2008) Source: CSO, Port Louis [14]

Carbon Dioxide Emissions Profile In Mauritius

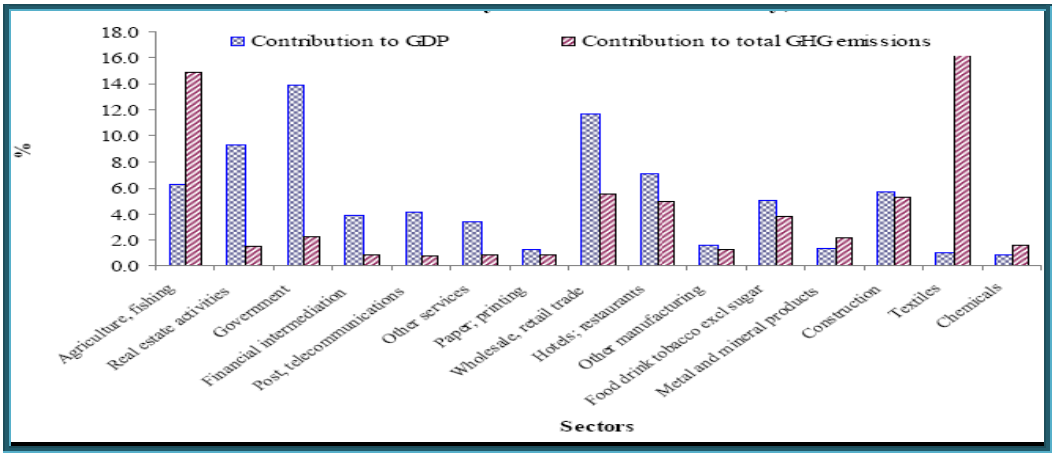
Figure below shows the net emissions of carbon dioxide from 2002 to 2008. The data indicate an increase in net carbon dioxide emissions from 3,226 thousand tonnes in 2007 to 3,264 thousand tonnes in 2008, representing a rise of 1.2%.



Net Emissions of carbon dioxide (Source: CSO, Port Louis) [14]

The greenhouse gas emissions accounts shows that 82% of the main gases emissions, in terms of 100-year global warming potential, are in the form of carbon dioxide, with nitrous oxide accounting for 11% and methane 7%. The figure below illustrates GHG emissions of the main sectors compared to their shares in GDP.

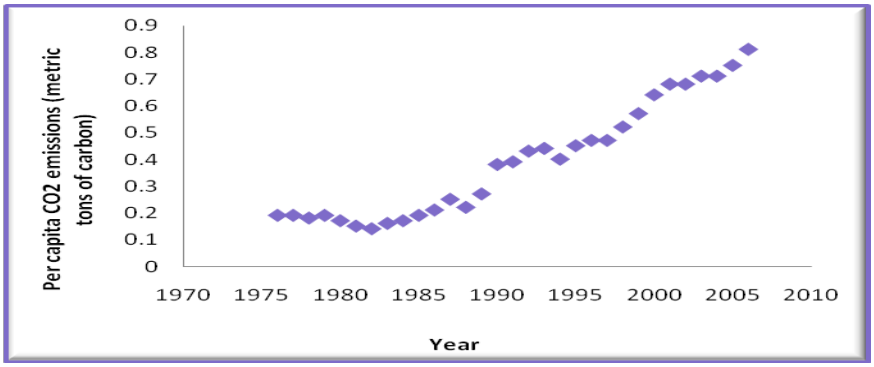
According to the data obtained from CSO, The GHG efficiency indicates the level of the impact, in terms of the emissions per unit of economic output has been calculated for the key sectors . Agriculture is positioned as relatively intensive in terms of environmental impact while the 'Other services, which includes the waste and refuse collection sector, is ranked most intensive in terms of greenhouse gas emissions relative to production (CSO, Port Louis).



GHG emissions of the main sectors compared to their shares in GDP (CSO)

Since Mauritius, forming an integral part of SIDS is particularly vulnerable to climate change and this will affect the climate system in the following ways:

- An increase the intensity of tropical cyclones
- The climb in global temperatures will have an effect on seawater temperatures and ocean circulation.
- Alterations in ocean circulation will affect migratory paths of pelagic fish, disrupting the fishing industry.
- Rise in temperature will cause variability in rainfall and will have rigorous social and economic consequences.
- Sea level rise due to global warming will affect freshwater resources due to saline intrusion and more erosion of beaches and damage to coral reefs.
- Higher sea-level, storm surges and higher tides will cause extensive coastal flooding and harm to coastal infrastructure on which tourism, transport and communications rely on such as sea ports, bridges and roads [60].



Carbon dioxide emissions in Mauritius, 1976-2010

Refering to figure above, a first insight in the development of carbon dioxide emissions in Mauritius can be gained by describing the time series of carbon dioxide emissions for the period of 1976 to 2006. As illustrated in the figure, Mauritius has experienced an overall increase in carbon dioxide emissions, with two slight falls in 1988 and 1994. From 1995 until 2006, we notice a continuous or even accelerating growth in the carbon dioxide emissions. This could be the result of an increase use of fossil fuels in various sectors in Mauritius. However, deforestation and land use changes is not included in this model because it is not apparent that emissions from deforestation are factored into the calculation of carbon emissions by the CDIAC. According to a description of the data, production of carbon dioxide from non-energy sources is not included in the estimation of carbon dioxide emissions (Factors, 2004). Thus, deforestation and land use would not have an impact on emissions in this study.

It is an undeniable fact that the world is plagued by the dominant use of fossil fuels and it is almost impossible to eradicate their widespread use completely. Fossil fuels have become an indispensable part of the society and economy. Emissions from electricity production accounts for about one-third of the total global emissions from fossil fuels combustion, although the contribution of each

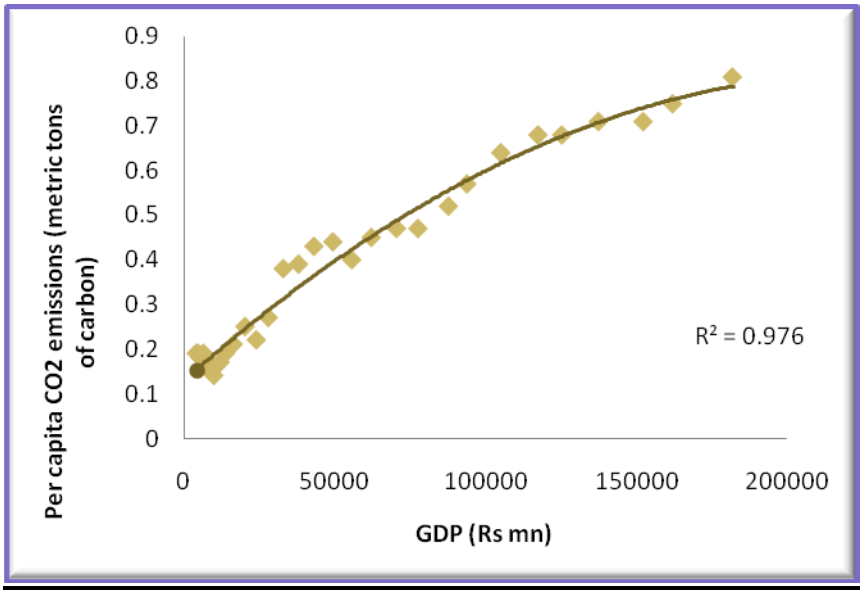
country varies according to the type of fuel sources it uses to generate its electricity. Mauritius has a heavy reliance on imported fossil fuels to support its energy needs and its carbon dioxide emissions are on rise since its early economic development. It imports a million tonnes of oil each year, of which 240,000 tonnes are used for electricity production, contributing 51% of the 2003 national carbon dioxide -equivalent emissions to 58% in 2008. For instance, France which generates most of its electricity using nuclear energy contributes only 5% of carbon dioxide emissions whereas Australia, Denmark and Poland are responsible for about 50% of the carbon dioxide emissions.

Co2 and GDP

CO_2 emissions and GDP for the period of 1976 -2006 (CDIAC [62] and CSO)

Year	Per capita CO_2 emissions (metric tons of carbon)	GDP (Rs mn)
1976	0.19	4165
1980	0.17	7389
1984	0.17	12050
1988	0.22	24061
1992	0.43	43215
1996	0.47	70597
2000	0.64	105206
2006	0.81	182009

As GDP increases, the carbon dioxide emissions rise. Developing countries, essentially all countries that experience economic growth also report rising carbon dioxide emissions. The countries, listed in the literature review by Karlsson *et al* in 2002, have experienced significant growth in emissions over the past thirty years, including Mauritius. It should also be observed that carbon dioxide emissions have grown in line or faster than GDP in India and Brazil over the past 30 years as shown in Figure below and carbon dioxide emissions in China have dropped in absolute terms as well over the past couple of years.



Carbon dioxide emissions and GDP in Mauritius, 1976-2006

Methodology and Analysis

The effect of carbon dioxide emissions on growth

To model the effect of carbon dioxide on growth we follow the standard literature (Ross and Levine (1996), Levine and Zervos (1998), Neusser and Kugler (1998), Wachtel (1998, 2001), Barro, 1991) in specifying a Solow Growth function pertaining to the economic model below with period 1976 to 2009. The following economic model is judged to best explain growth in Mauritius, given our relatively limited number of observation.

$$y = f\,(IVTGDP, XMGDP, SER, EMP, CO2)$$

Where,

- IVTGDP is the country's investment divided by its Gross Domestic Product (investment ratio);
- XMGDP is total of export and imports divided by the GDP of the country and are measure of openness;
- SER is the secondary enrolment ratio and proxies for the quality of human capital;
- EMP is the employment level;
- $C0_2$ is the per capita carbon dioxide emissions;
- y is the GDP of the country and reflects the economic development;

The above explanatory variables have been carefully selected from the standard literature from both a theoretical and empirical point of view and would contribute positively or negatively to the economic growth of the country.

Of interest to us a more significant explanation lies in the fact that carbon dioxide emissions may be highly correlated with economic growth since they are by-products of industrial processes, electricity consumption, and automobile use. As a matter of fact, the environment is a major factor of production in many underdeveloped countries that heavily rely on natural resources as a source of output. Therefore, environmental degradation in these countries is likely to reduce their capacity to produce and hence to grow. Moreover, several studies point out that high pollution levels may reduce worker productivity and thus economic output.

The main sources of our independent variables are from the World Bank's the IMF's 'International Financial Statistics'(IFS) except for the case of SER, where the country's Central Statistical Office's biannual digest of Statistics has been consulted. The dependent variable output was proxied by the real Gross Domestic Product per capita at constant price *(Y)* and was generated from the IFS. The time period of the study is over the years. Data on per capita carbon dioxide emissions, stemming from fossil fuels burning, cement manufacture, and gas flaring, is from the CDIAC.

The Econometric Model

Recalling model 1 above and taking logs on both sides of the equation (for more meaningful interpretation in terms of rate of change) and denoting the lowercase variables as the natural log of the respective uppercase variable results in the following:

$$y = \beta_0 + \beta_1 ivtgdp + \beta_2 xmgdp + \beta_3 ser + \beta_4 emp + \beta_5 CO2 + \varepsilon$$

The disturbance term **ε** is a deviation from the above relationship**.**

Before considering the appropriate framework of the econometric model, it is important to investigate the univariate properties of all data series and to determine the degree to which they are integrated. Both the augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) unit-roots tests have been employed for that purpose and the variables were found to be I(1). Subsequently a Johansen Cointegration test could not revealed a cointegrated relationship.

For our analysis, it is believed that a VAR model would be best appropriate. VAR has been proven to be especially useful for describing the dynamic behavior of economic time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model. Thus by adopting a Vector Autogressive Model in its difference form, we can also correctly analyse the effect of growth and development on environment and emissions

of carbon dioxide. In fact the VAR resembles a series of equation where each determinant comes as the explained variable in a system and the system is solved simultaneously.

Given that the variables are stationary only in first difference and not cointegrated , we estimated a VAR in the first difference and table below shows the results.

Estimates of DVAR

Variables	***Δy***	***Δco2***
Constant	4.37*	-1.57
Δy_{t-1}	0.33*	0.81**
Δivt_{t-1}	0.46**	1.27***
$\Delta open_{t-1}$	0.27*	0.51*
Δedu_{t-1}	0.16**	-0.22**
Δemp_{t-1}	0.14**	0.33**
$\Delta co2_{t-1}$	-0.096*	-0.21
R^2	0.71	0.62
D W statistic	1.88	2.11

Note: *, **, * indicate 10%, 5% and 1% significance level respectively**

Carbon dioxide is confirmed to be an important element in economic growth even in the short run. The lower coefficient in the short run might indicate that such might take some time to have its full effect on the economy. Thus a 1 percentage-point increase in the growth rate of carbon dioxide capital leads to a 0.1 percentage-point decrease in the growth rate of output after one year and this is an estimate of the direct effect. Investment and the levels of openness, employment, education, and employment also determined carbon dioxide emissions produced.

From table above we can notice that our results clearly illustrated that for every 1% increase in the secondary education ratio, the per capita carbon dioxide emissions decrease by 0.22% while for every 1% increase in the secondary education ratio is accompanied by an increase of 0.16% in the growth of GDP which shows the economic growth. These findings are in line with Tamazian *et al* (2009) studies conducted BRIC (Brazil, Russia, India and China) countries. Moreover, Talberth (2006) highlighted the fact that simple modifications to the venerable

Harrod–Domar (1957) model demonstrated how greater trade openness leads to both a positive level effect and positive growth effect on the value of GDP by increasing the relative prices of consumption goods in which a given economy has a comparative advantage . Likewise, open-economy modifications to the standard neoclassical model show how knowledge spillovers from abroad can positively influence both the level and growth rate of output.

Thus, from the results, we observe a bi-causality between carbon dioxide emissions and GDP. This shows that a rise in the GDP would inevitably have a direct impact on the amount of carbon dioxide emissions produced while carbon dioxide emissions would negatively impair economic growth. Our results are in line to what Ferda (2008) who revealed in her study a bi-directional Granger causality between carbon dioxide emissions and income. Dinda and Coondoo (2006) re-examine the evidence using more modern time series econometric techniques the existence of causal relationships between income and carbon emissions using cross country panel data. Surprisingly, they reject the null hypothesis of a long run cointegrating relationship for the North America, South America, Asia and Oceania country groupings while evidences strongly points to the existence of bidirectional causality in Africa and Asia is observed.

However, Soytas et al (2007) found no evidence of causality between either income and carbon emissions, or income and energy use. By refining their comings, Soytas and Sari (2007) discover that carbon emissions Granger cause energy use in Turkey. As the authors themselves remark, this result appears to be counter intuitive. The same study suggests that neither carbon emissions nor energy use Granger cause income. The assumption that carbon emissions cause economic growth is thus hardly borne out by the limited facts available.

Our results confirm the fact that trade leads to increase in size of the economy and which in turn increases pollution. However, many economists, Birdsall and Wheeler (1993), Lee and Roland-Holst (1997), Jones and Rodolfo (1995), have lengthy argued that trade is not the root cause of environmental degradation, whereby, trade can also improve the environment through composition effect or abatement effect, such as when income rises through trade, environmental regulation is tightened thus, enhancing pollution reducing innovations. Moreover a WTO reported that trade as such is rarely the root cause of environmental degradation, except for the pollution associated with transportation of goods.

It is noteworthy that in Mauritius the level of secondary education Granger causes carbon dioxide emissions but negatively as depicted in tables 7 and 8. German Advisory Council on Global Change (1995) published report in 1995 , to highlight the fact that raising awareness is not sufficient to actually change behaviour — this has been demonstrated often enough in the past. Environmentally relevant behaviour is shaped by a whole series of different factors; measures relating to education and the upbringing of children must take a wide variety of forms and be variable in their application if they are to have any real impact on behaviour

Effect of Growth on CO2

Now we consider model 2 to analyse the effects of different determinants on the carbon dioxide emissions in Mauritius. In this analysis, the OLS method is used to estimation. We estimate two specifications, linear and quadratic, to find the appropriate model with parameter t-values and coefficient as guidance. The variables in the model was selected following empirical studies and also in the given specificity of the island

CO_2 = *f* (IVTGDP, GDP, SER WTO, POP, VEHICLES) ---------- model 2

Where IVTGDP is the investment ratio, GDP is a measure of the output level, SER is the education level, POP is the population level, WTO is the regulation variable and vehicles is the number of vehicles on road

Statistically significant probabilities have an asterisk "*" next to them. An explanatory variable associated with a statistically significant coefficient is important to the regression model if theory supports a valid relationship with the dependent variable, if the relationship being modeled is primarily linear, and if the variable is not redundant to any other explanatory variables in the model.

OLS estimation

Variables	coefficient	t-ratios
Constance	*1.36***	***2.32***
Ivt	*0.33****	***4.16***
Gdp	*0.56****	***3.21***
Ser	*-0.22***	***-2.26***
Wto	*-0.36**	***-2.12***
pop	*0.57***	***2.26***
vehicles	***0.623*****	***2.57***

Note: *, **, * indicate 10%, 5% and 1% significance level respectively**

From the results in table above, we can demarcate clearly the relationship that each dependent variable has on the carbon dioxide emissions. Investment, GDP, population and the number of vehicles contribute in a way or another to an increase in the carbon dioxide emissions level in

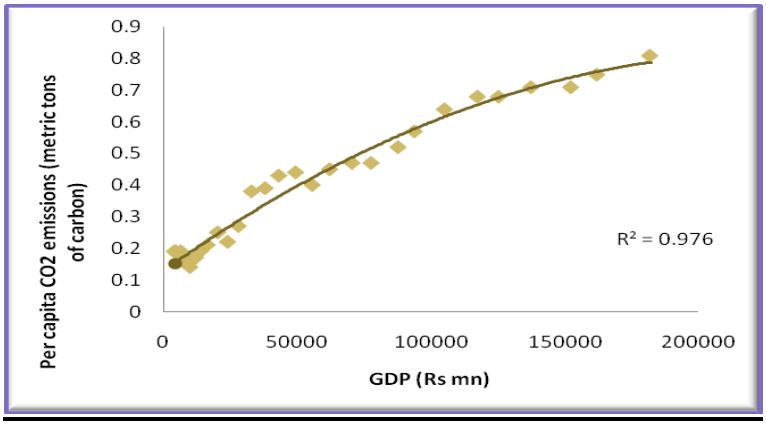
Mauritius at different significant level. The level of secondary education enrolment can help to lessen the level of emissions through awareness and sensitization programmes. However the data obtained could not be used to assess whether or not carbon dioxide emissions are statistically significant in Mauritius. Managi (2004) for example, included economic growth in a model of emissions and found highly significant positive correlation.

Environment Kuznets Curve for Mauritius

EKC preliminary results

According to our results, nevertheless, it seems to us that the typical inverted "U" form of EKC is not confirmed yet with our data set for Mauritius, though the time period covered is over 30 years. Even if we use a long time series, from figure 15, it can be seen that the emission of carbon dioxide per capita has not yet reached its maximum level. Cialani (2007), Getzner et al (2002) confirmed the same trend in Italy and Western countries and Austria where rapid economic growth has taken place mainly after the Second World War.

The graphical presentation of the relation between GDP and carbon dioxide emissions in figure 15 shows that an inverted "U" shape of the EKC might be unrealistic since emissions rather have an upward trend. However, from figure 15, we can notice that carbon dioxide emissions are not the only variables that are resulted due to a rise in GDP. There seems to have other factors which come into play that could result in the EKC model. Thus to confirm whether an EKC holds for Mauritius, the series of econometrics analyses were used to test and verify the hypotheses.



Carbon dioxide emissions and GDP in Mauritius, 1976-2008

We test the EKC hypothesis, by estimating a standard polynomial relationship between carbon dioxide emissions and GDP for Mauritius. We model the relationship as follows:

The inclusion of the squared GDP in the model 3 has the objective to support if there is an inverted U shaped curve between income and carbon dioxide emissions per capita. The theoretical expectation is that the coefficient that accompanies this variable is negative and significant. According to Stern et al. (1996) and Panayotou (1993), at high levels of economic

growth structural changes toward information intensive industries, as well as a greater social conscience and environmental regulation, lead to a gradual decline of environmental degradation.

$$CO_2 = f\ (IVTGDP, GDP, GDP^2, SER, WTO, POP, VEHICLES)$$ ----------*Model 3*

The Table shows the regression results for the period 1975-2009. We clearly reject the existence of an inverted "U" relationship, since the estimated t-ratios of the GDP quadratic term is not significant at any significance level tested. Thus, according to the results, it seems that the typical inverted "U" shape of the EKC is not confirmed yet with our data set for Mauritius. From the figure , it can be seen that the emissions of carbon dioxide per capita has not yet reached its maximum level as Mauritius still prevails in a rapid economic growth phase. This means that based on the yearly data over the period 1975–2009, the carbon dioxide emissions per capita have been linearly increasing in the level of GDP and there is no EKC in carbon dioxide emissions for Mauritius. Hence, so far there is no decoupling of carbon emissions and economic growth in Mauritius. This result is in line with the conclusion from the decomposition analysis that GDP growth (scale effect) is the main determinant of increase in carbon dioxide emissions in Mauritius over the period 1975–2006. Similarly, Cialani (2007), Huang *et al* (2008) found an increasing trend. Thus, further research is required in order to confirm that emissions will indeed decrease as predicted by the EKC hypothesis .Moreover, Saleh *et al*, results indicated that there no EKC was formed in Iran as it is expected to be formed in theory. In other words, economic growth in Iran is not effective enough to decrease environmental pollutants.

Environment Kuznet Curve for Mauritian's carbon dioxide emissions

Variables	***coefficient***	***t-ratios***
Constance	1.32**	2.11
Ivt	0.17***	4.16
Gdp	0.34***	3.27
Gdp2	0.17	1.27
Ser	-0.22**	-2.22
Wto	-0.37*	-2.12
pop	0.56**	2.27

vehicles	0.53***	2.37

From the EKC model study also found that GDP per capita or squared GDP did not contribute significantly to explain carbon dioxide emission per capita. Removing GDP per capita and its square, the model becomes simply a time trend model, which implies that we did not have any limiting point for carbon dioxide emission with respect to the increase for GDP per capita for Mauritius rather carbon dioxide emission is a function of time which is not some manageable cause. Better interpretation of the model is that, possibly there might have some important variables that were not incorporated in the model.

In conclusion, all current single-country studies seem to suggest that the EKC need not hold for individual countries over time. Nevertheless, different studies reach conflicting results as to the effects of growth on the carbon dioxide emissions. Therefore, additional research is needed to comprehend the progression of environmental degradation relative to GDP in a single country over time. In particular, both Vincent (1997) and Carson et al. (1997) are cross-regional studies; therefore they are also subject to the critiques to the cross-country approach mentioned.

Conclusions

In this paper we have analysed the relationship between GDP and carbon dioxide emissions for Mauritius and vice-versa in a historical perspective. Using time series properties and econometrics analysis, our results suggest that the carbon dioxide emission trajectory is closely related to the GDP time path. We showed that emissions elasticity on income has been increasing over time. By estimating the EKC for the period 1975-2008, we were unable to prove the existence of a reasonable turning point and thus no EKC "U" shape was obtained. Our results suggest that Mauritius could not curb its carbon dioxide emissions in the last three decades. Thus as hypothesized the cost of degradation associated with GDP grows over time and it suggests that the economic and human activities are having increasingly negative environmental impacts on the country relative to their economic prosperity.

So to reduce the cumulative emissions of carbon dioxide in Mauritius, scientists and policy makers should take more care for clean or environment friendly energy production as well as appropriate technology and adapt some policies regarding the reduction of carbon dioxide emission rather to increase the GDP only.

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Carbon Dioxide Emissions by Economic Sector 2005 in developed and developing countries

Percent of Carbon Dioxide (CO2) Emissions by Sector							
Countries	**Total Carbon Dioxide Emissions (million metric tons)**	**Public Electricity & Heat Production**	**Other Energy Industries**	**Manufacturing Industries & Construction**	**Internal Transportation**	**Residential**	**Other Commercial, Public, and Agricultural Sectors**
Developed countries							
U.S	5,689.2	42.3	4.6	11.5	46.8	6.2	9.9
E.U	6,156.9	40.2	4.2	16.9	19.2	12.1	6.0
Sweden	48.3	15.4	3.6	22.1	45.0	6.0	7.3
Japan	1182.7	34.9	3.3	19.1	22.1	5.4	10.9
Developing countries							
India	1,046.1	53.0	2.5	21.1	12.0	7.7	0.6
China	3,167.3	44.6	4.5	2.3	7.4	6.9	5.6
Brazil	315.1	10.1	6.7	29.7	40.8	5.4	6.3

Source: International Energy Agency (IEA) [55]

Main socio-economic indicators, Republic of Mauritius, 1999 and 2008 (Environment Statistics and Environment-Economic -Accounts – 2008) (CSO)

Indicator	Units	1999	2008 [1]
1. Gross Domestic Product (GDP) at market prices	Rs mn	108,076	264,854
2. Sectoral contribution to GDP			
Agriculture	*%*	*6.1*	*4.3*
Manufacturing	*%*	*23.9*	*20.1*
Construction	*%*	*5.7*	*6.9*
Wholesale and retail trade	*%*	*13.1*	*12.3*
Hotels and restaurants	*%*	*6.9*	*8.6*
Transport and communications	*%*	*12.2*	*11.2*
Financial intermediation and business services	*%*	*8.4*	*10.9*
Other	*%*	*23.7*	*25.7*
3. GDP annual growth rate (basic prices)	*%*	*2.1*	*5.3*
4. Per capita GDP at market prices	Rs	91,945	208,570
5. Per capita GDP in US dollars	US$	3,656	7,354
6. Investment (GDFCF)	Rs mn	29,457	64,893
7. Exports (f.o.b) (include ship's stores and bunkers)	Rs mn	40,025	68,409
8. Imports (c.i.f)	Rs mn	56,629	132,564
9. Population (mid year)	000	1,175	1,269
10. Population annual growth rate	%	1.1	0.6
11. Population density (per kilometre square)	Number	597	644
12. Total labour force [2]	000	519.5	583.4
13. Total employment [2]	000	480.5	543.0
Agriculture (as a % of total)	*%*	*12.0*	*8.6*
Manufacturing (as a % of total)	*%*	*29.6*	*22.5*
14. Unemployment rate [2]	%	7.7	7.2
15. Inflation rate	%	6.9	9.7
16. Tourist arrivals	000	578.1	930.5

1 Provisional; 2 Labour force, employment and unemployment, 16 years and over.