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The CO_2 Equivalent Emissions and Total Economic Output

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1. Introduction

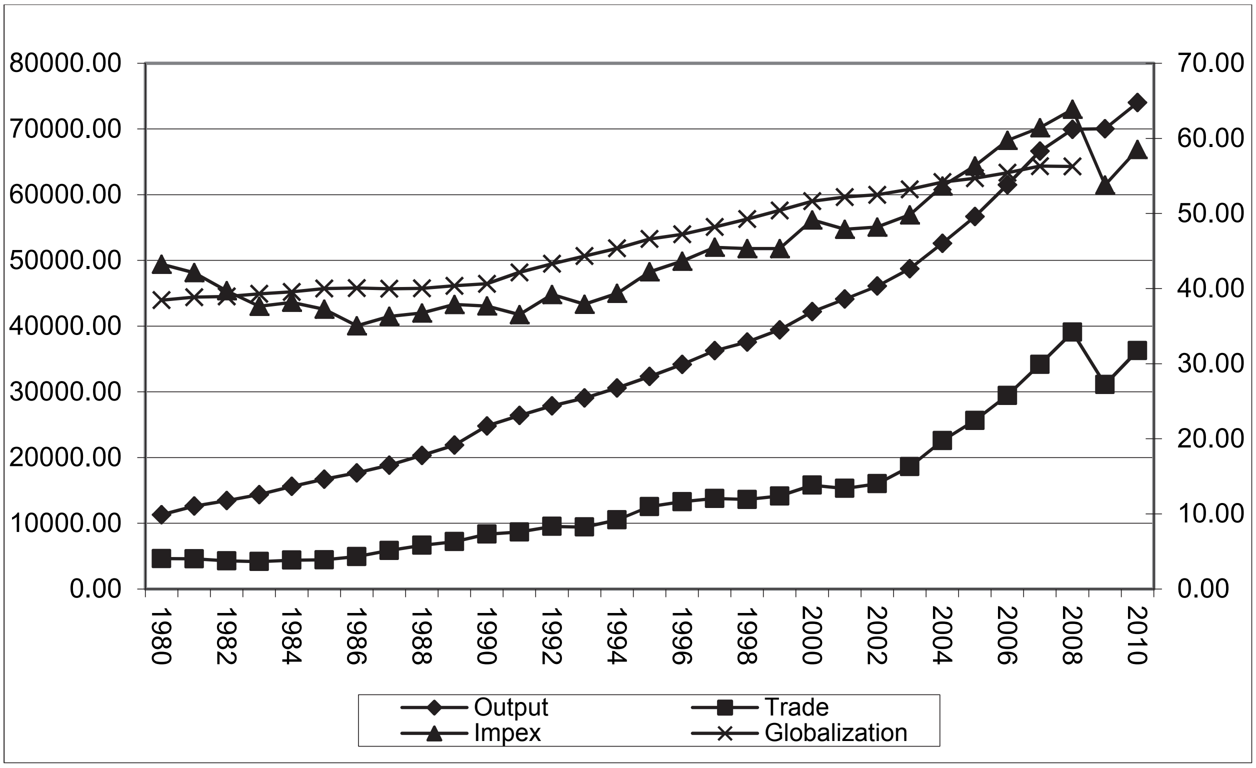
As the process of globalisation rolls on year in and year out, the states of the world become dependent upon each other. The interdependencies between countries – economically, environmentally and culturally – call for common policy-making, i.e. coordination of decision-making. The often heard call for global governance is only credible if it can deliver a theory about effective decision-making. However, often global meetings of governments result in little or nothing except sometimes non-binding recommendations.

This Marxian type contradiction between ONE global economy and environment on the one hand and some 200 states in need of policy coordination in response to the challenges of globalisation is extremely difficult to resolve. On the one hand, the representatives of each and every state will want to have a SAY in global decision-making – the unanimity principle. On the other hand, respecting the will of each of the 200 governments would lead to staggering transaction costs in negotiations. Is there a way out of the veto-transaction cost problematic that can save global reunions from coordination failures like the Copenhagen Summit on Climate Change?

2. Global Economic Interconnectedness: one market economy

The interconnectedness in the global economy has become so large that any major shock hurts almost all economies in the world. The amount of interaction in the global economy is typically measured with the IMPEX indicator, which divides imports plus exports with the GDP. Diagram 1 shows the constantly growing IMPEX scores for the global economy, which follow closely the expansive trend for global output and world trade.

The close match between the trends in Diagram 1 confirms the basic insight in market economics that only free trade can deliver affluence. Global trade and foreign direct investments remain the engine that power global economic expansion. Constantly increasing economic interactions between countries not only cement ONE global economy, but also push the GDP of most countries steadily higher. Growth in aggregate output means that it is easier to fight poverty, but it comes with a most important consequence, namely the increase in CO2 emissions.



Source:
Output = Gross domestic product based on purchasing-power-parity (PPP)
valuation of country GDP;
Current international dollar; Billions (left axis)
Trade = Imports and exports of goods and services; Current dollars;
Billions (left axis)
Impex = Trade / Gross domestic product, current prices; Current
dollars; Billions (right axis)
Globalization = Means for KOF index (Dreher 2006) for 174 constant
countries (right axis)
Sources: IMF (2010) World Economic Outlook Database; available via:
http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx
Dreher, Axel (2006): Does Globalization Affect Growth? Evidence from a new Index of Globalization, Applied Economics 38, 10: 1091-1110;data available via: http://globalization.kof.ethz.ch/

Diagram 1. Interconnectedness: IMPEX scores, trade and global GDP.

3. The three types of pollution

Among the cornucopians, it is believed that affluence reduces pollution. This was the classical policy stance of Julian Simon (2003) and Aaron Wildavsky (1997), rejecting the relevance of environmental policies that reduce CO2 emissions. However, they fail to distinguish between three very different forms of pollution when it comes to the effects of rising affluence, i.e. GDP. One must separate between visible and invisible pollution as well as between direct and indirect pollution. Thus, we have:

1. Littering or petty pollution: it occurs massively in poor third world countries, like e.g. India or Fiji;
2. Toxic waste, metals and sewage: they are to be found on a large scale in the emerging economies where high levels of growth are combined with weak environmental protection;

3. CO2 pollution: it takes place in industrial and post-industrial economies requiring massive input of energy in various forms: transportation, heating, cooling, etc.

Whereas rising affluence would tend to result in lower littering as well as toxic waste, especially if the additional resources that economic growth hand down are used in either public policies or in private efforts to clean up, it is definitely not the case that economic development or quick economic growth decreases CO2 emissions, as we shall see below.

It is absolutely essential to separate between these different forms of pollution. Soumyananda Dinda (2004) has shown in several articles that the relationship between per capita income and different pollutants is complex, varying between different sets of countries depending upon their per capita affluence. Thus, a so-called *environmental Kuznets curve* posits an inverted U-shaped relation between pollutants and country affluence per capita. Here we will only research CO2 equivalent emissions as one kind of pollutant. And we will not look into the nature and complexity of the environmental Kuznets curve, focussing here only upon total economic production or GDP.

Now, a cornucopian like Bjorn Lomborg (2001) argue first like Simon and Wildavsky that the link between CO2 emissions and climate change had not been scientifically established. But he later changed his view (Lomborg, 2007) stating that climate change, when true could not possibly be as dangerous as ecologists warn about. There are two hypotheses involve here in this debate between cornucopians and ecologists:

(H1) C02 emissions are not the major cause of global climate change. Or this assertion has yet to be proven by convincing evidence that is as yet lacking.

(H2) The role of CO2 emissions has been enormously exaggerated. As a matter of fact, this form of pollution is notoriously difficult to both measure and model.

Here, I will concentrate upon H2, as I believe it can be rejected through an analysis of the link between CO2 equivalent emissions and global economic output, as measured by the GDP indicator.

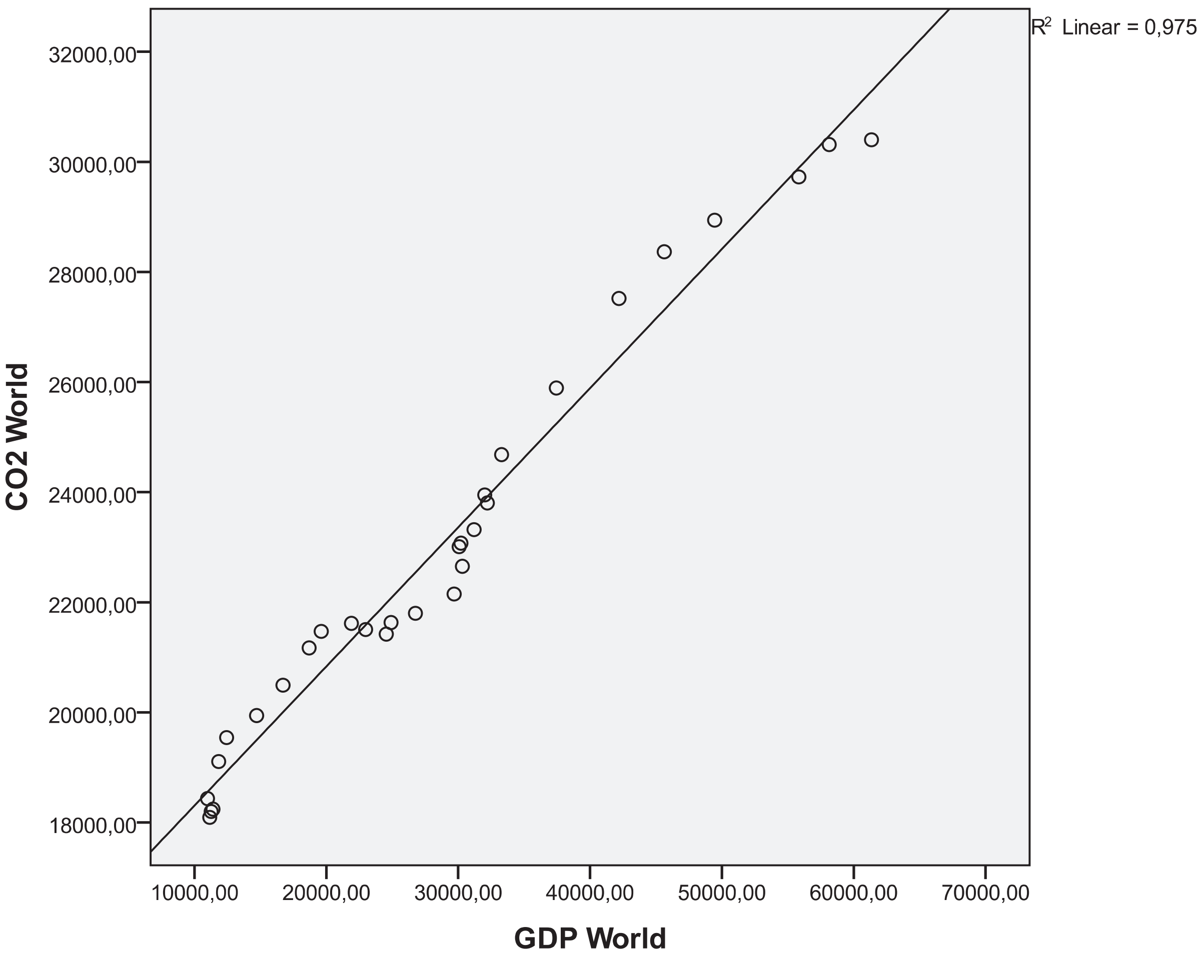
4. The increase in the CO_2 equivalent emissions 1970

The increase in CO2 equivalent emissions appears in Figure 1, where yearly totals are plotted against total output, or GDP. Total emissions per year have doubled over this thirty years period. Since these emissions have a very long life time, they build up in the atmosphere to huge cumulative amounts. As a matter fact, this process has been going on since the start of the industrial period, but typical of recent decades is the sharp yearly increases in emissions.

This type of pollution – CO2 equivalent emissions poisoning the atmosphere – increases as a function of economic activity. Economic output requires huge amounts of energy, which today is mainly coming from the burning of fossil fuels. This in turn results in the CO2 emissions. In Figure 1, the match between GDP increases and growth in emissions is perfect. On the basis of data over time, one may estimate an equation: Emissions = f (GDP) for 1980-2009. It gives the following parameter estimates (Table 1):

	Global emissions 1980-2009
GDP	
Constant	15 780
Coefficient (significance = .000)	.25
R2 = .975	

Table 1. The growth of C02 emissions and global economic output 1980-2008.



Source: CO2 emissions + Population: EIA (2011) International Energy Statistics; data available from: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm;
GDP data: World Bank (2011) World Development Indicators; data available from http://databank.worldbank.org/ddp/home.do

Fig. 1. Total emissions 1980-2008 against global economic output (Million tons and billions).

This finding implies that a further economic expansion globally at say 6 per cent economic growth during the next decade will lead to roughly a yearly increase of 1,5 per cent in CO2 emissions, i.e. one arrives at a level of pollution of about 40 000 thousand metric tons in 2020.

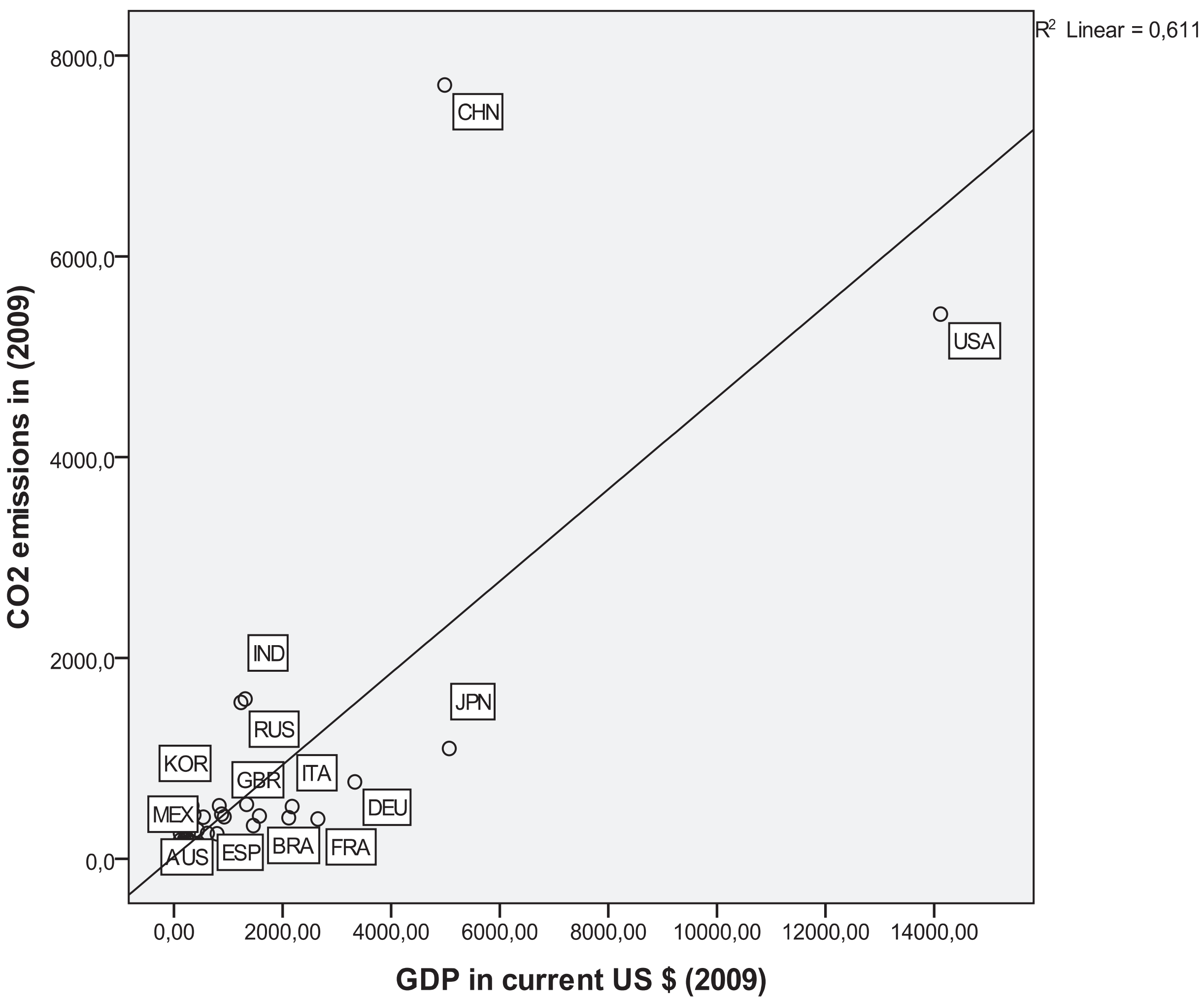
It could be even worse if many emerging countries developing quickly use more coal as substitutes for expensive oil and gas. The Fukushima tragedy makes nuclear power less attractive, again increasing the demand for dirty coal. Thus, the conversion factor between GDP and emissions may rise from 0.25, worsening the pollution of the atmosphere. However, the depletion of oil reserves will stimulate steps towards a green economy, lowering the conversion factor.

When total emissions reach 40 000 thousand metric tons on a yearly basis, then climatologists warn that climate change is not only unavoidable, but it also will be pretty violent. Be that as it may, here the focus is upon the link between economic development and emissions. As mankind is hardly going to settle down for zero growth one may expect that incentives push people to efforts resulting in higher output and thus income, especially when global population is still expected to increase. However, it will lead to huge increases in emissions, unless a green economy is embarked upon somehow, lowering the conversion mechanism between output and emissions.

Now, the global scene with the close link between GDP and emissions harbours considerable country variations, as countries not only differ in terms of output but it is also the case that some countries have much higher transmission factors than others.

5. Variations in the output-CO_2 equivalent emissions connection between economies

Generally speaking, a country economy delivers more CO2 emissions the more affluent it is and the larger its transmission factor between output and pollution. Consider Figure 2 that portrays the large country variations in the GDP-emissions space.



Source: CO2 emissions + Population: EIA (2011) International Energy Statistics; data available from: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm; GDP data: World Bank (2011) World Development Indicators; data available from http://databank.worldbank.org/ddp/home.do

Fig. 2. Country CO2 emissions against country GDP 2009.

Figure 2 confirms the general connection between economic output and total emissions. It also indicates that China is a so-called outlier, i.e. an exception to the trend because of its high conversion factor between GDP and emissions China is simply the most polluting country in the world although its total economic output is not even half of that of the US. One may employ the regression technique to estimate the same equation (E1) above but this time by means of cross-sectional data. Table 2 has the findings.

	Country emissions 2009
GDP	
Constant	20,632
Coefficient (significance = .000)	.457
R2 = .611	

Table 2. Regression analysis of GDP and CO2 emissions on a country basis in 2009.

Today, the conversion factor between economic output and CO2 emissions stand as high as .45, meaning that one unit of output results in almost 0.5 unit of emission. Since economic growth is unstoppable, one may safely predict that CO2 emissions will rise in the next decade. Economic growth is today strongest among the so-called emerging economies. They differ in how much emissions they have per unit of GDP.

6. Economies of scale in CO_2 equivalent emissions?

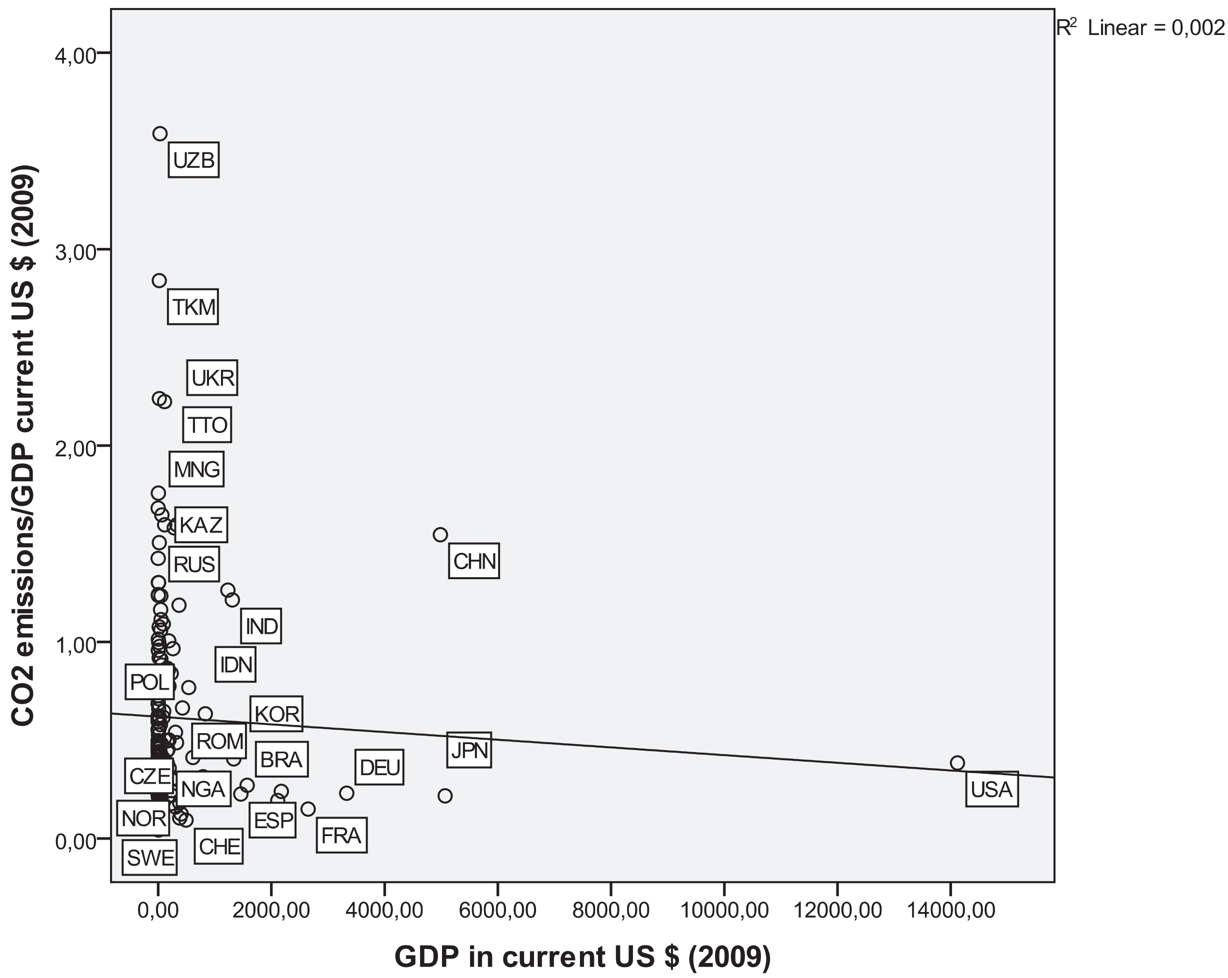
As we have seen, a higher GDP gives more CO2 emissions. But it could be the case that the amount of CO2 emissions per GDP unit decreases at the same time due to economies of scale in energy production and consumption. Figure 3 suggests such a mild tendency, emissions per GP falling the more affluent the county.

This economy of scale is not a strong one, but Figure 3 shows that several countries have emissions per GDP that are much higher than most other countries. It is a matter of not only of China and India, burning massive amounts of coal, but also of countries like Russia and the Khanates. When Chiba declares that it is only committed to holding its emissions per GDP constant until 2020, then this policy would not help reducing emissions increase at all. On the contrary, given the rapid economic development in China, its total emissions would skyrocket.

In general, the increase in emissions from GP growth is not offset by the reduction in emissions per GDP by growing affluence. Thus, total emissions can be predicted to grow to alarming levels, if the climate change hypothesis (H1) is correct, i.e. CO2 emissions drive a greenhouse gases effect.

7. Towards a global CO_2 emissions policy?

The most ambitious attempt to come up with a global emissions policy thus far is the Stern Review from 2007. It has been widely debated, receiving both praise and blame. It outlines a policy response to the rising CO2 emissions with a complex mixture of global measures involving price increases upon fossil fuels as well as compensation of Third World countries for these higher energy prises. Also China is suggested to receive compensation, if it lowers its massive use of coal.



Source: CO2 emissions + Population: EIA (2011) International Energy Statistics; data available from: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm; GDP data: World Bank (2011) World Development Indicators; data available from http://databank.worldbank.org/ddp/home.do

Fig. 3. CO2 emissions per GDP against total economic output (GDP).

We have found that economic development, which is unstoppable, is the main cause of one fo the major global pollutants, namely the CO2 equivalent emissions. There are other contributing factors, like for instance deforestation and desertification. One unit of output today results in almost half a unit of CO2 emission. Over time, economic expansion in the form of a GDP increase has led to a .3 increase in total emissions. Each country economy has its conversion factor, i.e. the link between GDP and CO2 emissions. Some countries have extremely high conversion factors, leading to massive pollution of the atmosphere.

The Stern recommendations do not appear viable, because they are simply too complicated. And they build upon the assumption that global agreements about reductions in emissions, carbon taxes or emissions trading as well as compensation claims can be enforced or even monitored. When one takes opportunism, free riding, ambiguity and myopia into account, then global environmental coordination, as conceived by Stern, is not feasible.

The rise in C02 emissions can only be stabilized when the rate of economic growth comes down in emerging economies or when the conversion factor between economic output and emissions is lowered significantly. This will not be possible through global coordination through the UN schemes where each country has one vote and decisions require unanimity.

Emissions will stabilise when the cost of energy has risen to such a level that the path to a green economy must begin to be trodden. From the perspective of the global environment and its protection, the ongoing sharp rise in energy prises is positive.

8. Conclusions

Total CO2 emissions, being one type of pollutant are closely linked with total economic output, or GDP. To stabilise the CO2 emissions, only two options are available: (a) reducing economic growth, or (b) moving to a green economy where energy consumption does not result in CO2 emissions. Realistically, only the second alternative is feasible, reducing the conversion factor between energy-output-CO2 emissions. It now stands at 0.45, which endangers the atmosphere of Mother Earth. It will go down when new sources of energy replace the fossil fuel dependency. Single countries may engage in various carbon tax schemes or carbon trading mechanisms, but on a global scale this is not feasible, at least not in the complicated formula suggested by the Stern Review, involving massive amounts of compensation and transfers between governments.

Many economists like for instance Bhagwati (2004) welcome the globalisation period that mankind has entered. However, there is a major problem, namely the enormous growth in CO2 equivalent emissions during the last decades. If they drive climate change to drastic levels involving a 4-6 % increase in average temperatures, then mankind will be in dire straits. Given the link between total economic output and CO2 equivalent emissions, global warming and climate change appears unstoppable.

9. Acknowledgements

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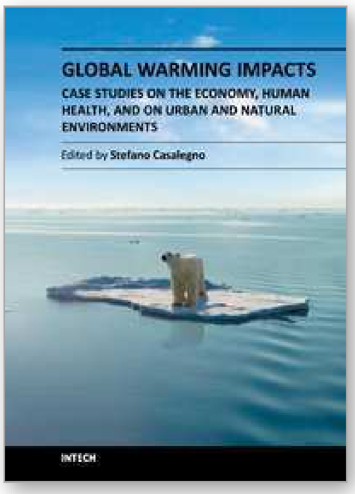

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This book addresses the theme of the impacts of global warming on different specific fields, ranging from the regional and global economy, to agriculture, human health, urban areas, land vegetation, marine areas and mangroves. Despite the volume of scientific work that has been undertaken in relation to each of each of these issues, the study of the impacts of global warming upon them is a relatively recent and unexplored topic. The chapters of this book offer a broad overview of potential applications of global warming science. As this science continues to evolve, confirm and reject study hypotheses, it is hoped that this book will stimulate further developments in relation to the impacts of changes in the global climate.