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A Revenue Neutral Global Carbon Tax to Solve the Global Warming Problem

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ABSTRACT

In this paper we want to make a limitation of global warming as it was agreed on the Copenhagen summit. Here we propose a revenue neutral global carbon tax as a possible solution. We will show that a carbon tax is superior to a cap and trade mechanism and that there are some chances that the majority of all countries would accept the proposal. It will become clear that it is easy to introduce such a carbon tax.
Keywords: Global warming, carbon tax, cap and trade

1. INTRODUCTION

Even that we observe the global warming problem, the disastrous results of the Copenhagen summit in December 2009 made clear that the existing negotiations do not work to stop or to limit global warming at the international level.[1] The only compromise of the Copenhagen summit was that the average global temperature increase must not exceed 2 degrees Celsius in 2050.

The justification for the 2 degree Celsius increase is based on the consideration that for example South-Pacific islands like Fiji, Tuvalu, Kiribati and coastal areas around the world will not be flooded by the sea. Given the 2 degree temperature increase until 2050, Meinshausen et al. (2009) have calculated that the worldwide amount of CO2 emissions must not exceed 700 billion tons of CO2 until 2050. It should be noted, if we restrict the CO2 emissions to 700 billion tons of CO2 in the period 2010-50, the probability that the temperature will not exceed the limit of 2 degrees is 75 per cent. Naturally, it would be better to emit less than 700 billion tons of CO2 in these 40 years. However, we have to take into account that we were allowed to emit 1000 billion tons of CO2[2] in the period 2000-2050, but until now the world has emitted just around 300 billion tons of CO2 in the first ten years of the period. The remaining 700 billion tons must be distributed over a period from 2010 to 2050. Consequently, we have to reduce the actual yearly emissions of just around 30 billion tons of CO2 to 18 billion tons of CO2 worldwide on average yearly. Or to say it in other words the average yearly emissions of a human must be reduced from 4.1 tons of CO2 per year today to just around 2.5 tons of CO2 per year in the next 40 years, where we only take into account the 6.9 billion living humans today. If the world population will grow the reduction of CO2 emissions per capita must be more ambiguous. That means in principle the average human has to reduce its CO2 emissions by just

[1] For more details see Stauvermann (2010).
[2] It should be noted that the amount of GHG gases would be then 1500 billion tons of GHG gases. However, from practical reasons it is sufficient to concentrate only on the CO2 emissions. (see Meinshausen et al. (2009)).

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around 50 per cent immediately or much more in the next few years if population growth is zero. For someone who is living in a developed country the reduction must be just around 80% per year. The longer we will wait to change our lifestyles the more difficult it will become to reach the goal. For example, if we will not change our behaviour, in just around 20 years we must reduce our emissions to zero in the 20 years after the first 20 years to meet the accepted temperature goal.

However, why does the Copenhagen summit fail to find an international agreement how to reduce the emissions? One reason was that a few governments were convinced that their countries are allowed to emit more than 2.5 tons per capita in a year and others wanted to get financial support to fulfil their obligations. The strategies of individual countries what to do and when to do, are very different and this makes it complicate to compare the different measures of the governments. Additionally, the governments argued only from national perspective taking only into account the aggregate emissions of countries not the emissions per capita. For example India is emitting 5.3 per cent of the global emissions, which is a lot, but the emissions per capita are only 1.3 tons of CO2 in India. In the end, the results of the Copenhagen summit were like the outcome of a prisoner's dilemma game with just around 185 players.

In this paper we want to give a welfare-based reasoning why a revenue-neutral global carbon tax[3] could be a way out of this situation and why it is superior to a cap and trade system. In the next section we will investigate into the advantages and disadvantages of a carbon tax and a cap and trade mechanism. In the third section we will explain the global revenue-neutral carbon tax system. In the fourth section we will investigate into the question what the necessary tax rate should be. In the fifth section we think about the chances for the introduction of a global carbon tax and in the last section we will summarise our results.

2. Justification of a Revenue-Neutral Global Carbon Tax

At first we have to note that global warming problem is mainly caused by the combustion of fossil resources like oil, coal, timber and gas. The combustion process creates a negative externality, which results in an increase of CO2 content in the atmosphere. Without going into the details, mostly all experts in climate research assume that increase of the CO2 content will cause an increase of the average global temperature and as a consequence an increase of the sea level. Both effects, the sea level rise and temperature increase will harm a lot of regions in the world, for example low islands in the South Pacific will vanish and a lot of coastal areas are threatened by flooding, other regions are threatened by long periods of drought. The problem which we have to solve is in principle nothing else then to solve a tragedy of commons. This means the atmosphere regarding to absorb CO2 is a rival and non-excludable good. If it would be a national environmental problem, the government could solve the problem by distributing property rights, taxation or command and control policies. However, because of the global dimension of global warming, the main problem is that we do not have a global government who could enforce property rights or taxes. On earth are more than 200

[3] A carbon tax is equivalent to a CO2 tax, if the carbon tax rate is 44/12 times higher than the CO2 tax. The simple reason is that the weight relation between CO2 and carbon is 44/12. So it plays no role if we use the term CO2 tax or carbon tax.

countries, which have to find an agreement how the emissions of CO2 can be limited. In some sense we observe a prisoner's dilemma with more than 200 hundred prisoners, who have partly different interests and preferences. We have to state that until now all environmental agreements to limit the emissions of CO2 failed. If we will not realize an agreement to reduce the CO2 emissions by just around 50 per cent worldwide, the average global temperature will increase by more than 2 degrees Celsius. If we will emit like we have done it in the past, the average global temperature will be probably 7 degree Celsius higher than today.[4]

One main problem to find an agreement is the non-homogeneity of the involved countries. More or less all production processes use fossil fuels as a resource. In the very short run a reduction of CO2 emissions means a reduction of the production and hence a reduction of monetary wealth. Until now the governments of the countries bargain about how much every country has to reduce its CO2 emissions independently of the population size of the countries. For example at the Copenhagen summit the USA (20.23% of the global emissions in 2006)[5] wanted only to reduce its emissions, if India (5.3%) and China (21.7%) also would agree to reduce their emissions. At the first look the condition of the USA seems to be plausible, but if we look at the average emissions per capita the impression will change. The average US citizen emitted 18.99 tons of CO2 in 2006, the average Chinese 4.62 tons and the average Indian only 1.31 tons. The remaining question is then why shall the average Indian reduce his CO2 emissions, because it is just around 50 percent of the acceptable level of CO2 emissions. Consequently, the negotiations should not be based on the aggregate emissions of countries; it should be based on the emissions per capita in countries. Of course that has strong consequences for the national emission targets. Assuming that 2.5 tons of CO2 emissions per capita is the acceptable level of emissions, the USA has to reduce its yearly emissions by 86 per cent, China by 45 per cent and India could increase them by 94 per cent. Consequently, there exists no rational reason why India should reduce its CO2 emissions. Believing, that all humans are equal and should have the same equal rights, why shall then India reduce its emissions? It is a question of justice, which is answered by philosophers, independently of their ideological background. For example, John Rawls (1971, p.60) argues; 'First: each person is to have an equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others.'[6] It is obvious, if someone is emitting more than 2.5 tons of CO2 per year, he is violating the rights of others; in the extreme the most important human right; to survive. Or the philosopher Kant (1785, pp. 30) required in his categorical imperative; 'Act only according to that maxim whereby you can at the same time will that it should become a universal law.' Once again, to emit more than 2.5 tons of CO2 per year and capita cannot be a universal law. Or as it was laid down in the Universal Declaration of Human Rights (General Assembly of the United Nations 1948) article 1: 'All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.' and article 3; 'Everyone has the right to life, liberty and security of person.' However, if the US citizens do not reduce their emissions then they are threatening the life and the security of millions

[4] See for example the estimations of Meinshausen et al. (2009).

[5] All numbers regarding CO2 emissions are based on the data of the Carbon Dioxide Information Analysis Center (CDIAC) from 2006 and own calculations. The author will send the excel files on request.

[6] See also Abplanalp (2010).

of people who live on islands and in coastal areas. Anyway, there exists no moral or ethical reason why it should be allowed that an US citizen emits so much that other people will be harmed. In so far we assume that the emissions per capita shall count.

A second problem is why shall we prefer a global environmental tax instead of national taxes and why not introduce an emission trading system?

To answer this question, we should discuss at first the advantages and disadvantages of carbon tax and a cap and trade system. What are the characteristics of a global revenue-neutral carbon tax?

1. A carbon tax is a Pigouvian tax which internalizes the negative externalities caused by the emissions of CO2.[7] In so far a carbon tax will not create market distortions, it will reduce market distortions. A carbon tax can be administrated in a revenue-neutral way; this means that the tax revenue generated by the carbon tax will be redistributed to the consumers. The redistribution of the tax revenue can be managed in two ways; to redistribute it by a lump sum transfer or to reduce tax rates of other distorting taxes. The consequence would be a reduction of dead weight losses created by the distorting taxes. Without a specific proof, it should be clear that redistribution to reduce tax rates is Pareto-superior to redistribution with the help of lump sum transfers (see for example Goulder (1994)). The redistribution with the help of lump sum transfers works as follows; each consumer will receive a fixed amount of money, which equals the tax revenue divided by the number of taxpayers. Of course people who emit relatively less CO2 will gain and people who emit relatively much CO2 will lose. It should be noted that a lump sum transfer will not influence decisions at the margin and the behaviour of people.

2. A revenue-neutral carbon tax generates a double dividend; the first dividend is the reduction of CO2 emissions and the second is generated by the reduction of distortionary tax rates. (See for example; Pearce (1991), Repetto (2001), or Jaeger (2003).). A reduction of distortionary taxes, will lead in general to an increase of national income and the creation of new working places.

3. A carbon taxes makes energy prices relatively predictable. Because of the fact that the carbon tax is fixed to a specific amount per unit only the price changes on the resource markets of oil, gas, coal and so on influence prices of goods and services.

4. The introduction of a carbon tax can be easily administrated and this can be organized in a relatively short time period. The costs of administrating the carbon tax are low; the tax administration has only to know the consumption of the national oil, gas, coal and net timber production and the imports and exports of these resources. In general these numbers are well-known by the statistical offices.

5. A Carbon tax addresses emissions from all sectors of the economy.

6. The influence of lobbying and interest groups to exonerate some industries or goods from the carbon taxation seems to be very low.

[7] Please note 1 kg of carbon (C) approximately equals 3.667 kg of carbon dioxide (CO2).

7. A carbon tax is easily to understand for all members of the society.

8. The carbon tax creates continuously incentives for firms to invest in cleaner technologies and invest money in the research and development of cleaner technologies and for citizens to behave more environmentally friendly, for example to reduce the temperature of the heating. For example, in Germany a reduction of the temperature of heating of one degree Celsius would lead to a reduction of six per cent of the CO2 emissions of heating.

9. A carbon tax is very flexible with respect to new information. It is simple and cheap to change the tax rate with respect to the transaction cost. Of course the industries have to bear the menu cost of a tax rate change.

10. The disadvantage of a carbon tax is that the optimal tax rate is unknown. This will lead to a try and error behaviour to find it out. Of course the experiences from the past can be used to estimate a nearly optimal carbon tax rate.

The tax incidence of carbon tax is not clear a priori and some adversaries of a carbon tax argue that a carbon tax is a regressive tax. However, as long as the carbon tax is revenue neutral it seems to be unlikely that a carbon tax is regressive. However, if the carbon tax is regressive or not depends on the mechanism how the tax revenue is redistributed. A carbon tax can be regressive but it is not necessarily regressive.

We see a carbon tax has a lot of advantages and only one relevant disadvantage and that is to determine the optimal tax rate. Now we come to the advantages and disadvantages of the so called cap and trade mechanism (CTM). A CTM consists of three steps; at first to introduce a cap, secondly to distribute emissions rights and thirdly to institutionalize a market for emission rights. The idea of a CTM is that producers for whom it is cheaper to buy emission rights than to reduce emissions, will buy emission rights; and producers for whom it is cheaper to reduce emissions then to use up the emission rights will sell emission rights. Theoretically, the CTM leads to cost efficiency.

1. The cap is easy to determine; in our case it would be 700 billion tons of CO2 or 191 billion tons of carbon for the period 2010 to 2050 per year.

2. There are two ways how the emission rights can be distributed in the introductory phase. The emission rights or certificates can be auctioneered or can be grand-fathered. When all certificates are distributed an exchange for emission certificates must be institutionalized. However, at first we have to decide who shall trade with emission rights. The easiest way would be that only the firms and consumers who buy fossil fuels should trade with emission rights. That means and firms have to buy emission rights as a by-product of fossil fuels. It should be stated that this seems to be a very bureaucratic mechanism. Additionally, we have to think about how imports and exports should be handled. To avoid the problems of exports and imports we need an international emission trading market. If the emissions rights will be grandfathered, we will observe a huge redistribution of wealth, because the product prices of energy goods like heating oil, gasoline and so on will increase, because from a view of the firms who got the emission rights, these rights are wealth of the firm. Consequently, they will raise the prices. This price increase will change the world economy dramatically, and at least the consumers are

worse off. Especially the poor consumers will suffer. An additional problem is how the certificates should the grand-fathered, shall everyone get the same amount of certificates, or shall the certificates distributed like the emissions were distributed at a reference date or maybe in just another way?

If the emission rights will be auctioneered, then the revenue of the auction can be distributed to the citizens. However, it is not clear if the result of the auction will be efficient. The efficiency of an auction hinges on the number of bidders and how far it is possible for them to collude and how correct the expectations of the bidders about the future prices of emission rights will be. For example in the end of the nineties most European countries auctioneered off licenses for UMTS (mobile phone frequencies). In Germany the mobile network operators were very optimistic about the future of the market and the realized prices for the licenses were too high, so that not all operators could realize profits in the long-run. The revenue of the auction was just around 50 billion EUR. As a consequence, two network operators went bankrupt and the estimated loss was 15 billion EUR. In other European countries the price of UMTS licences was partly lower and partly higher than in Germany, even that the market conditions were relatively identical. For example, the expenditures per citizen for UMTS licenses were 100 EUR in Austria, 160 EUR in the Netherlands, 200 EUR in Italy, 620 EUR in Germany and 650 EUR in Great Britain. What we learn from this anecdote is that auctions will not necessarily deliver efficient market outcomes in reality. It cannot be excluded that something similar would happen if emission rights will be auctioneered. A further critical point will be the emission trading exchange market; it must be assumed that the market price will be very volatile. For example, the price for an emission certificate of one ton of CO2 at the exchange in Leipzig laid in the range of 11.49 EUR and 29.95 EUR in the period 09.03.2005-17.05.2006. Such huge price fluctuations make a long-run planning of firms very complicate if not impossible. Especially investments in environmental-friendly technologies will become risky investments. Additionally, the introduction of an emission trading system is time consuming. The administrative costs are relatively high in comparison to a carbon tax.

If we compare the carbon tax with a CTM, we must conclude that the carbon tax has much more advantages than an emission trading system.

Now we come to the question why shall we prefer a global carbon tax instead of different national carbon taxes?

Let us take a look at the following table, where we will see the carbon tax rates of different countries and the tax revenue per year. What we see is a kind of patchwork of carbon taxes. In Sweden the tax rate is US-$ 104.83 per ton of CO2, and in California (BAAQMD) it is only US-$ 0.045 per ton of CO2. Additionally the taxed sectors also differs from region to region, for example the BAAQMD taxes the whole primary sector except the fuel for traffic and in Boulder, Colorado only the electricity production is taxed.[8] Of course such differences open the opportunity for tax arbitrage, which is not desirable. Additionally, the tax revenue is used differently in the regions. For example, in Norway the tax revenue is part of the government budget and in Boulder it is invested in climate mitigation

[8] See Sumner, Bird & Smith (2009).

programs.[9] From the view of tax neutrality it seems to be desirable that carbon tax is a global one.

Carbon tax rates and revenues in different countries		
Country	Carbon tax per ton of CO2 in US-$	Tax revenue per year (billion US-$)
Finland	30	0.75
Netherlands	20	4.819
Norway	15.93-61.76	0.9
Sweden	104.83	3.665
Denmark	16.41	0.905
United Kingdom	Depends of resource	1.191
Bolder (USA)	13	0.00085
Quebec (Canada)	3.2	0.191
British Columbia (Canada)	9.55	0.292
BAAQMD (USA)[10]	0.045	0.001
France	24.74	4.499
CARB (USA)[11]	0.155 (2010/11) & 0.09 (from 2014)	0.063 (2010-13) & 0.036 (from 2014)

Table 1 (data from Sumner, Bird & Smith 2009)

From this section we can conclude that a revenue-neutral global carbon tax is preferable in relation to national carbon taxes and a cap and trade system.

3. THE GLOBAL CARBON TAX SYSTEM

In this section we want introduce our idea of a revenue-neutral global carbon tax system. Especially, we want to answer; what shall be taxed, and what shall happen with the tax revenue?

It seems to be rational to tax all kind of fossil fuels especially coal, gas, oil and net timber at best at the place of production (oil springs, gas sources, coal mines, forests). We define net timber as the difference between the quantity of timber used in production and consumption minus the quantity of new timber created by reforestation. Of course, we also could tax all goods and services differently, but then we need much more information than is available. For example, the CO2 life-cycles of all good and services must be known. Alternatively, to tax only fossil fuels is much easier than to tax end products differently, and it is relative easy to calculate the carbon contents of oil from a specific oil spring or coal from a specific coal mine. Of course the prices of all products and services which need fossil fuels in the production process or where some parts of the products and services are produced out of fossil fuels will become more expensive. Consequently, this could have strong consequences for the economic structure of the world economy. For example, it can

[9] See Sumner, Bird & Smith (2009).

[10] Bay area air quality management district

[11] California Air Resources Board

become profitable to shell crabs, caught in the Northern Sea in Germany. At the moment the crabs are transported by airplane to Morocco and Algeria to be shelled and then transported back to Germany. The reason for these transports is the relative low wage rates in the North-African countries and that kerosene is not taxed. It is also probable that highly durable goods of a high quality will become relative cheaper in relation to short-lived substitutes. However, this could lead to an increasing demand for repair services, because it will become relative cheaper to let repair high quality goods instead of throwing away a damaged good and to buy a new one. In general, it can be assumed that the worldwide production will become more labor intensive. In the view of the high worldwide unemployment rates this can be considered as a positive effect. Of course, some adversaries will argue that a global carbon tax is bad, because it increases the transportation costs and consequently reduces the volume of international and inter-regional trade. Of course, export led countries, who are exporting cheap products of low quality like China will be harmed. Otherwise, China's high trade balance surplus is mostly only based on the low wage rates in China, low environmental standards, low industrial law standards and the fact that the Chinese Yuan is undervalued in relation to the US-$ and the EUR (Tianyu, et al., ?).

The next important question is; what should be done with the tax revenue? As discussed before, it seems to be necessary to redistribute the tax revenue. We know in principle there are two ways how to do it. It can be managed by a lump sum transfer or to reduce the tax rates of other distorting tax. Because of the fact that the tax systems worldwide are very different, the tax revenue should be redistributed in a lump sum manner to the national governments and they should decide how to redistribute their national carbon tax revenue. Of course that is in some sense a weak point, because how can it be avoided that some policy-makers will use the carbon tax revenue only in their own interest? However, this problem is beyond the scope of the paper.[12] As noted above, it is difficult to determine the optimal tax rate. Here we make the proposal that the average emissions of a world citizen should be a reference point. If someone is emitting more than the average world citizen he has to make a net payment and if someone is emitting less than the average world citizen[13], he should implicitly receive a net payment.
Given this we can write down the net tax revenue for country *i*;

$$T_i = -\left(\tau X_i - \frac{\tau X}{N} N_i\right). \quad (2)$$

The negative sign of the RHS of equation (2) ensures that the national carbon tax revenue is positive if a country receives a positive payment and negative if it has to pay taxes. The variables are defined as follows;

T_i: The net tax revenue of country *i*, which can be positive, negative or zero;
τ : the tax rate in US-$ per ton of CO2 emission;
X_i: the amount of CO2 emissions of country *i* measured in tons;

[12] Maybe it is necessary to introduce an institutional organization to control the distribution of the carbon tax revenue to avoid corruptive behavior of national governments.

[13] In principle it would desirable if the term , which was 4.1 tons of CO2 per head in 2006, could be substituted by the desirable level of CO2 emissions per head of 2.5 tons of C02. However, if this would be done, the majority of countries and citizens of the world would reject the introduction of the carbon tax.

$X = \sum_{i=1}^{n} X_i$: the aggregated worldwide emissions of CO2;

n : the number of countries;

N_i : number of inhabitants in country *i*;

$N = \sum_{i=1}^{n} N_i$: the world population.

Maybe some readers are confused that X_i represents the amount of CO2 emissions in country *i*. Of course this variable is not known explicitly, because the carbon taxes are paid at the location of the production of coal, oil, gas and net timber. This means the carbon tax is a part of the price of all products which contain substances produced on fossil fuel basis or where fossil fuels are used in the production process of these products. In so far in reality this variable must be estimated with the help of price changes, caused by the carbon tax. However, this information is not necessary to know explicitly to introduce the tax easily.

One last question remains, how to handle population growth? Population growth is the root of all environmental problems, in so far population growth should be taken negatively into account. One advantage is that countries have no chance to fraud by faking the number of their inhabitants. Countries with high fertility rates, which are typically poor countries, would have an incentive to reduce the population growth and to give families financial incentives to reduce the number of children.

An adjustment of the population size regarding to calculate the tax should only take place if in some regions are a huge amount of refugees, which have been compelled to leave their home country.

The individual carbon tax revenue t_i of a citizen in country *i* is described by the formula;

(3) $$t_i = \frac{T_i}{N_i} = -\left(\frac{\tau X_i}{N_i} - \frac{\tau X}{N}\right) = -\tau\left(\frac{X_i}{N_i} - \frac{X}{N}\right).$$

In principle formula (3) tells us that the difference between average emissions per capita in country *i* minus the average emissions per capita worldwide will determine if the average inhabitant in country *i* will gain or lose something. However, maybe some readers would like to know if the individual will have incentive to save the fossil fuels. Of course, if for example someone reduces his emissions to zero he has to pay no carbon taxes and he will get explicitly (if the government distributes the tax revenue lump sum in cash) or implicitly (by reducing other distorting taxes, or investments in mitigation programs) approximately the amount of US-$ $\frac{\tau X}{N}$. In general, equation (3) can be reformulated such that a world citizen *j* has to pay a carbon tax on his personal CO2 emissions and that he will get the tax revenue divided by the world population;

(4) $$t_j = -\left(\tau x_j - \frac{\tau X}{N}\right) = -\tau\left(x_j - \frac{X}{N}\right).$$

Of course, in how far this incentive mechanism will work depends on the national government how it will redistribute the transfers of the carbon tax administration. Probably, it would be the most preferable incentive mechanism, if the government would make a non-marginal cash payment to its citizens. However, this problem of national redistribution of the carbon tax revenue is beyond the scope of the paper. Here we will always assume that a payment in any form can be expected by people who emit less than the average worldwide CO2 emissions per capita. It seems to be plausible that the tax morality of such a carbon tax is relatively huge, because the mechanism is easy to understand for everybody. In the next section we will investigate in the question how huge the tax rate per ton of CO2 shall be.

4. THE TAX RATE

As mentioned above the only critical point of a carbon tax is that the global carbon tax administration does not know how high or low the tax rate should be. Some studies were done in this field; in table 2 we will see the results of different studies.

	Carbon tax and results				
Study	Carbon tax US-$ per ton	CO2 tax US-$ per ton	Increase of the oil price %	Reduction of CO2 %	Region
Nordhaus (1990)	3 27	0.82 7.36	2 23	9 in 2050 28 in 2050	World World
Manne & Richels (1990)	250	68.18	158	75 in 2100	World
Cline (1989)	158	43.09	100	40 in 2050	World
Edmonds & Reilly (1983)	123	33.55	78	40 in 2050	World
Howarth et al. (1989)	623	169.91	103	26 in 2050	World
Whalley & Wigle (1990)	460	125.45	300	50 off trend emissions	World
Manne & Richels (1989)	300	81.82	190	85 in 2100	USA
Chandler & Nicholls (1990)	82	22.36	53	20 in baseline	USA
CBO (1991)	28 113	7.64 30.82	18 72	Stabilize 1990 10-20 of 1990	USA
Nordhaus & Yohe (1983)	20 100 200 300	5.45 27.27 54.54 81.82	13 65 130 195	6.7 27 43 54 below baseline	USA
Williams (1989)	160 250	43.64 68.18	104 162	63 74 below	Sweden

				baseline	
Kram & Okken (1989)	40	10.91	26	28 below baseline	Netherlands

Table 2 (data from Pearce 1991 and own calculations)

What we see is, that the results differ a lot; as noted above the real complicate question regarding a carbon tax is; "What is the necessary and sufficient tax rate to limit the temperature increase to 2 degrees Celsius until 2050?" If we look at the results in table 2 and taking into account that the worldwide target is to reduce the actual CO2 emissions by 50% worldwide, we should take into account the results of Manne & Richels (1990) with a carbon tax of US-$ 250, Cline (1989) with US-$ 158 Edmonds & Reilly (1983) with US-$ 123, Manne & Richels (1989) with US-$ 300, Whalley & Wigle (1990) with US-$ 460. Taking the inflation rates between the date of publishing and today into account, the carbon tax today would lie in the range between US-$ 269 and US-$ 808. Assuming that the results of the studies with respect to CO2 emissions would be similar today, the carbon tax should be something around US-$ 400-600 per ton of carbon. This would imply that a tax on one ton of CO2 would be in the range of approximately US-$ 110-164. For simplicity we will take two different tax rates into account US-$ 100 per ton of CO2 and US-$ 200 per ton of CO2. Expressed as carbon taxes it would mean a tax rate of US-$ 366 per ton of carbon and US-$ 733 per ton of carbon. To get a rough insight what it means for energy prices we use the CO2 calculator of the Bavarian Environment Agency (2007).[14]

Energy	**1 ton of CO2 is generated by**	**Unit**	**price increase per unit in US-$ in 2006**	
			$ 100 tax	$ 200 tax
Electricity	1610	KWh	0.06	0.12
heating oil	321	Liter	0.31	0.62
natural gas	402	cubic meter	0.25	0.50
liquid gas	525	Liter	0.19	0.38
Diesel	320	Liter	0.31	0.63
Petrol	343	Liter	0.29	0.58
timber pellets	15200	Kg	0.01	0.01

Table 3[15]

The price increase in per cent can be very different, for example if the CO2 tax of US-$ 100 per ton of CO2 would be introduced, the price increase of petrol in the USA would be just around 42% and in Germany only 16%. The obvious reason is that the price per gallon in Germany is 1.5 times higher than in the USA today. This means even if the carbon tax of US-$ 200 per ton of CO2 would be introduced in the USA, the price of petrol including the carbon tax would only be equal to the actual average price of petrol in Europe. In principle such a price increase can be named acceptable. However, it also interesting to compare the effects of a global carbon tax in different countries. Let us take a look at table 4.

[14] Please note all direct and indirect CO2 emissions are taken into account and we have assumed that the consumer will bear the whole tax incidence of the price increase.

[15] The numbers are based on the CO2 calculator of the Bavarian Environment Agency and own calculations.

country 2006	% of global emissions	Tons of CO2 per capita	Per capita net tax effect of 100 $ per ton in US-$	Per capita net tax effect of 200 $ per ton in US-$	national net tax effect of 100 $ per ton in billion $	national net tax effect of 200 $ per ton in billion $
China	21.467	4.62	-46.76	-93.52	-62.19	-124.39
Germany	2.832	9.74	-566.37	-1132.75	-46.60	-93.20
India	5.312	1.31	283.36	566.71	332.41	664.81
Italy	1.668	8.06	-404.13	-808.25	-23.48	-46.95
Korea, Republic of	1.672	9.89	-564.97	-1129.94	-27.48	-54.96
Qatar	0.162	56.24	-5087.06	-10174.13	-4.27	-8.55
Russian Federation	5.503	10.92	-710.41	-1420.82	-99.02	-198.05
Somalia	0.001	0.02	410.40	820.80	4.15	8.30
United States	20.232	18.99	-1442.10	-2884.20	-447.38	-894.76

Table 4 (data from CDIAC and own calculations)

If we look at the table in the last column we have positive and negative numbers, a negative number means a loss generated by the carbon tax system and a positive number means a gain. Let us look at the values of China and the USA who are emitting just around the same amount of CO2, even that China has more than 4 times inhabitants then the USA. That is why both countries have to make different payments; the loss of the USA is roughly 9 times higher than the loss of China. If we look at the countries with the highest and lowest CO2 emissions per capita, which are Qatar and Somalia, we also recognize that the gain of Somalia equals approximately the loss of Qatar. Especially, the low developed countries will receive net benefits, where the developed countries have to finance these benefit payments. On the one hand the payments seem to be very huge; on the other hand, we did not take into account either changes of the consumer preferences or changes of the production. To avoid too strong economic frictions, the best strategy would be to begin with a relative low CO2 tax rate, maybe with US-$ 10 per ton of CO2 and to increase it progressively from year to year. This would have the advantage that consumers and producers are able to make efficient plans, to adjust existing plans and to develop strategies how to reduce their CO2 emissions. For example, the consumer can buy a car which consumes less fuel than the old one.[16] Or the consumer can exchange the old heating against a more environmental friendly one or the heat insulation of the house can be improved. There are a lot of possibilities how to reduce the emissions of CO2. Maybe some people would argue that it is too expensive to introduce such a carbon tax

[16] For example, instead of buying a Citroen DS 3 VTI 120 Automatic which emits 160 g CO2/km a Citroen DS 3 HDI 90 FAP 99g air dreams can be bought, which emits only 99 g CO2/km. The first one has only a more powerful engine, but the price is 200 EUR higher. The CO2 reduction would be 61% and the buyer saves 200 EUR directly. Similar examples can be found for mostly all brand name car producers.

scheme. However, such a tax scheme would also solve a lot of other environmental problems of today, for example congestion of roads, noise pollution caused by cars, and the problem that the quantity of fossil fuels is limited. Additionally, the high amount of fine dust concentration in the air of urban areas can be reduced. As long it will become clear that the money the government receives will be invested in environmental technologies especially in poor countries can save a lot of money and overcome partly the underdevelopment problem. Of course the rich countries have to pay, following straight the polluter-pay-principle. However, also the individuals in rich countries would have an incentive to reduce CO2 emissions as long as the government will distribute the received money directly to them. As long as they emit less than 4.1 tons of CO2 yearly per capita (world average in 2006), they will gain from the revenue neutral carbon tax. Of course, it must be expected that the world average of CO2 emissions will decrease from year to year. Nevertheless, the incentive to emit less than the average will remain. The only real problem of the global revenue neutral carbon tax is how to administrate the distribution of the revenues so that no corrupt policymakers and no corrupt entrepreneurs have access to the money. And of course, that is a real serious problem.

5. IS THERE A CHANCE THAT A GLOBAL REVENUE-NEUTRAL CARBON TAX WILL BE INTRODUCED?

Assuming a democratic decision making process, we have to state if only countries represented by their governments would have the right to vote for or against the revenue neutral carbon tax, and assuming that governments vote for the introduction of the tax if its country will gain, the result would be; just around 38 percent of the countries would reject the introduction and just around 62 percent would vote in favour for the tax. If all citizens in the world could vote and assuming that all people who would gain would vote for the tax and all who will lose would vote against the tax, just around 42 per cent of the world population would reject the introduction and 58 per cent would vote in favour for the introduction.[17] However, what shall happen if countries like the USA, China and Russia would reject to participate in introducing the tax. The only mechanism to convince these countries beside the moral arguments to introduce the tax would be to introduce penalty taxes on products imported from not participating countries. For example, it would be no problem to tax the gas imports from Russia to the European Union, because all gas goes through a few pipelines.

On the other hand, they also have to pay the tax-induced higher world market prices. Additionally, these countries should not get any cent from the tax revenue as long as they will not sign the tax agreement. Maybe this alone could be an incentive for these countries to accept the tax agreement. Additionally, the political pressure should be strong to convince countries who would like to behave still as free-riders and to destroy the livelihood of others. It must be said that most European countries would accept the introduction of the tax, even that they have to make a net payment. If all countries, who will gain from the tax would cooperate; then they would have strong political and economic power to convince the remaining countries who reject the idea.

[17] The results are derived from CDIAC data and own calculations. In principle it is the extended table of table 4. In table 4 only India and Somalia would vote in favor for the introduction of the tax. All other countries would vote against the tax.

6. CONCLUSIONS

In this paper we proposed to introduce a global revenue-neutral carbon tax, because we think it is the most efficient way to manage the problem of global warming. The tax should be applied globally to eliminate the worries about the loss of national competitiveness. Secondly, we should introduce a tax instead of a cap and trade system. As Nordhaus (2009) has argued, 'To bet the world's climate system on the Kyoto approach is a reckless gamble. Taxation is a proven instrument. Taxes may unpopular, but they work.' Further on he argued; 'The CDM (Clean Development Mechanism, P.J.S.) produces highly opaque instruments which are climate equivalent of mortgage-backed securities and structured credit derivatives.' And now we know at least since 2007, if we want to become bankrupt these means are very efficient to do so. Also Michael Grubb (2009) agree with the introduction of a carbon tax, 'there is no doubt that governments will respond far better to climate change if they believe that there will be a substantial carbon tax in the future that everyone has to pay'.

Additionally, we can expect a double-dividend from this tax, the high revenue makes it possible to reduce other taxes, development aid can be abolished and the UN will have a strong mean to reduce violent conflicts by threatening not to pay out the money from the tax revenue. The overall effect of such a tax is of course unclear, however it is not excluded that the whole world will end up in a win-win situation. After introducing the tax the demand for environmental development and research activities will increase in all countries. It will be much easier for national policymakers to convince their citizens to buy environmental friendly household devices, cars, to prefer the extension of public transport and so on. At least, low-developed countries will have a chance to catch-up with the developed world. We have to have in mind; we have only one climate and not a second in our pocket.

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