Cost-effectiveness of greenhouse gas tax and CO2 tax

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Abstract

Current economic instruments aimed at mitigating climate change focus on CO_2 emissions, but the Kyoto Protocol refers to six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF6). Inclusion of non-CO_2 greenhouse gases in economic instruments can increase the cost-effectiveness of achieving the Kyoto target. The aim of this paper is to compare the cost-effectiveness of a CO_2 tax and a tax that covers the six Kyoto gases (GHG tax). Additionally, the distribution of the tax burden across product groups is compared regarding the two taxes. For this purpose we combined the reduction cost approach with input-output analysis and data about consumer expenditures. Our results show that a GHG tax can achieve the Dutch target for climate change in 2010 with a tax rate that is about 37 percent lower compared to a CO_2 tax. However, a GHG tax will also shift the tax burden from energy-related product groups to food-related product groups. These findings may contribute to the debate about the use of economic instruments in mitigating climate change.

Key-words: non-CO_2 greenhouse gases, CO_2 tax, cost-effectiveness

1. Introduction

Current economic instruments aimed at mitigating climate change focus on CO_2 emissions, but the Kyoto Protocol refers to six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF6). Inclusion of non-CO_2 greenhouse gases in economic instruments will increase the cost-effectiveness of achieving the Kyoto target (Reilly et al., 1999). Additionally, a shift in the tax burden across production sectors will occur since CO_2 and non-CO_2 GHG emissions are mainly emitted from different production activities. One can expect shifts in the distribution of the tax burden across product groups as well. However, it is still unknown to what extent a tax that covers the six Kyoto gases (GHG tax) will lead to different product prices as compared to a CO_2 tax. For consumers a shift in price effects can have major consequences, especially when the prices of essential products increase to a large extent. This paper compares a CO_2 tax and a GHG tax regarding cost-effectiveness and the distribution of the tax burden across product groups. This study focuses on the Netherlands.

2. Methods and data

To compare the cost-effectiveness of a CO_2 tax and a GHG tax we determined the tax rate of each tax that is needed to achieve the Dutch Kyoto target of 2010. The tax rates were determined with the reduction cost approach[1]. This method determines a tax rate by the intersection of a marginal abatement cost curve and a policy target. In this study, we used the abatement cost curve constructed by the Netherlands Energy Research Foundation (ECN) and the National Institute of Public Health and the Environment (RIVM) (ECN and RIVM, 1998). This abatement cost curve includes measures that aim at the reduction of the six greenhouse gases listed in the Kyoto Protocol. These measures were considered as applicable in the period 1998-2010. Furthermore, we used the Dutch policy target for climate change of 2010, which is 199 Mton CO_2 equivalents (VROM, 1999).

To get insight into the distribution of the tax burden across product groups, we linked the tax rates of a CO_2 tax and GHG tax to an input-output analysis (IOA) and data about consumer expenditures. We used the method of Nijdam et al. (2005) as a starting point. They calculated the environmental load of production sectors and households expenditure categories bought by Dutch consumers. In contrast to their study, we only consider greenhouse gases and assume that the technology matrix for foreign countries is similar to the Dutch technology matrix. The tax rates were linked to (multiplied with) the emission intensities of 365 product groups that cover the entire Dutch consumption. Finally, to get a clear picture of the price changes as perceived by Dutch consumers we calculated the price changes on the basis of product prices inclusive Value Added Tax and other product-related taxes. Eventually, we aggregated the 365 product groups to

[1] The reduction cost approach is also known as the abatement, avoidance, prevention, or control cost approach/ method (Davidson et al., 2005).

72 product groups. As a result we obtained the increase in the prices of 72 aggregate product groups caused by a CO_2 tax and GHG tax.

3. Results

3.1. Cost-effectiveness

Figure 1 illustrates how we obtained the tax rates of a CO_2 tax and GHG tax. For the GHG tax we found a tax rate of 0.057 euro per kg CO_2 equivalents. To determine a tax rate for the CO_2 tax we supposed that the Dutch policy target for climate change is achieved by the reduction of CO_2 emissions only. Next, we constructed an abatement cost curve for CO_2 emissions on the basis of the same data as the cost curve for GHG emissions; however, the emission reduction measures aimed at non-CO_2 GHG were removed from the cost curve. Figure 1 shows that the abatement cost curve of CO_2 emissions increases more rapidly than the abatement cost curve that includes the six Kyoto gases. We arrived at a tax rate of 0.091 euro per kg CO_2 equivalents for the CO_2 tax. According to the results, a GHG tax can achieve the Dutch policy target with a tax rate that is about 37 percent lower as compared to the tax rate of a CO_2 tax.

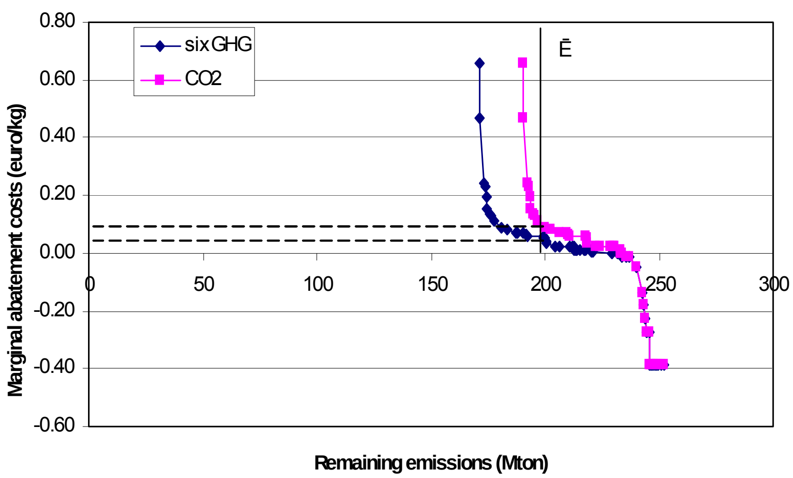

Figure 1. The intersection of the abatement cost curves with the Dutch target for climate change results in the tax rate of a CO_2 tax and a GHG tax.

3.2. Distribution of tax burden

Table 1 and table 2 show the top ten of product groups that experience the highest price increase after CO_2 taxation and GHG taxation, respectively.

Table 1. Top ten of product groups that experience the highest price increase after CO_2 taxation in the Netherlands in 2010.

	Product group	**Price increase (%)**
1	other costs heating and lighting	101.5
2	electricity	49.4
3	gas incl. solid and liquid fuels	35.4
4	gasoline and oil	28.3
5	fish	11.4
6	garden and flowers	6.8
7	vegetables	5.6
8	holidays, camp, weekend recreation	5.4
9	toys	5.4
10	butter, cheese and eggs	5.2

Table 2. Top ten of product groups that experience the highest price increase after GHG taxation in the Netherlands in 2010.

	Product group	**Price increase (%)**
1	other costs heating and lighting	64.6
2	electricity	31.6
3	gas incl. solid and liquid fuels	23.3
4	gasoline and oil	18.1
5	butter, cheese and eggs	10.5
6	milk and dairy products	10.1
7	potatoes	9.6
8	fish	7.7
9	chocolate	6.5
10	game	6.4

From the tables we can observe that the prices of the product groups 'other costs for heating and lighting[2]', 'electricity', 'gas inclusive solid and liquid fuels' and 'gasoline and oil' increase to the highest extent independently of which kind of tax is used. However, in the case of a GHG tax these four product groups experience lower price increases than in the case of a CO_2 tax. This can be attributed to the lower tax rate that a GHG tax needs to achieve the Kyoto target of the Netherlands.

The other product groups that are presented in table 1 and table 2 differ in ranking due to the ratio of CO_2 and non-CO_2 GHG emissions of the specific product group. For example, the product group 'butter, cheese and eggs' is ranked at place 10 in table 1 and is ranked at place 5 in table 2. The total GHG emissions of the product group 'butter, cheese and eggs' consist mainly of non-CO_2 emissions. The production of butter and cheese leads to high emissions of methane due to enteric fermentation by cows. Therefore, the CO_2/GHG emission ratio of 'butter, cheese and eggs' is 0.31. This implies that 31 percent of the GHG emissions consist of CO_2 emissions and 69 percent consists of non-CO_2 GHG emissions. When only CO_2 emissions are taxed (table 1) the price increase will be lower than when the six Kyoto gases are taxed (table 2), even though the tax rate of a GHG tax is lower than the tax rate of a CO_2 tax. Another example is the product group 'fish'. 'Fish' is ranked at place 5 in table 1 and at place 8 in table 2. The greenhouse gases caused by 'fish' consist largely of CO_2 emissions due to the boats used for fishing. The CO_2/GHG emission ratio of 'fish' is 0.93. When only CO_2 emissions are taxed (table 1) the price increase will be higher than when the six Kyoto gases are taxed (table 2), because the tax rate of a CO_2 tax is higher than the tax rate of a GHG tax. So, from table 1 and table 2 it appears that a CO_2 tax and GHG tax lead to a different distribution of the tax burden across product groups.

Figure 3 presents an overview of the price effects of 72 product groups at the aggregation level of five aggregate product groups and at the level of one aggregate product group (total). When focusing on the average price increase of all product groups together (total), we can observe that a GHG tax and a CO_2 tax will lead to an average price increase of 4 percent and 5.3 percent, respectively. So, a GHG tax can achieve the Kyoto target with an average price increase that is 1.4 percent lower as compared to a CO_2 tax. At the level of five aggregate product groups, the price increase of the product group 'house' will be reduced by 2.5 percent and the price increase of the product group 'development, leisure and traffic' will be reduced by 1.7 percent when

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[2] The product group 'other costs heating and lighting' includes candles, matches, costs for collective central heating and costs for energy in rent not mentioned somewhere else.

shifting from a CO_2 tax to a GHG tax. However, the price increase of the product group 'food' will become 0.8 percent higher when shifting from a CO_2 tax to a GHG tax. In general, a shift from a CO_2 tax to a GHG tax will lead to a shift in the tax burden from energy-related product groups to food-related product groups.

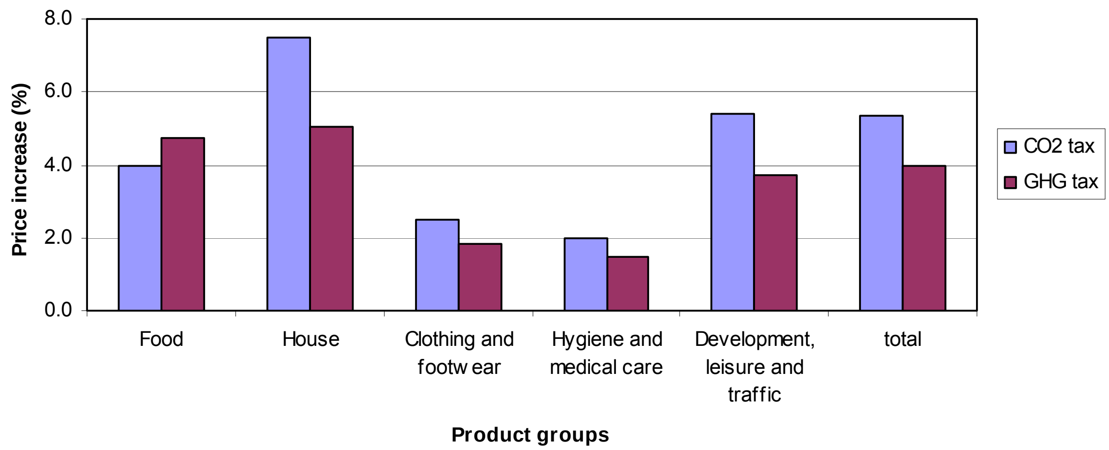

Figure 3. Price effects after CO_2 and GHG taxation at the level of five aggregate product groups and one aggregate product group.

4. Discussion and conclusions

By means of the reduction cost approach and input-output analysis we compared a CO_2 tax and a GHG tax regarding cost-effectiveness and the distribution of the tax burden across product groups. The results provide interesting insights into both kinds of taxes; however, we recognise that the used methodology has some limitations. Firstly, the input-output method follows financial flows instead of material flows. In the case of heterogeneous sectors this may lead to unfair allocation of emissions. On a highly aggregate level the effects of financial allocation will level out, however, on a detailed level the effects may be significant (Nijdam et al., 2005). Therefore, we aggregated the results of the 365 product groups to 72 product groups. Secondly, input-output analysis is restricted to fixed input-output coefficients and to exogenously-determined final demand, while it is expected that producers and consumers adjust their behaviour to the price changes. Therefore, the price effects should be considered as a short-term approximation. Consequently, the price effects may have been overestimated. Finally, we would like to mention that our study did not consider the practical feasibility of a GHG tax in comparison to a CO_2 tax.

The results of our study indicate that economic instruments that address the six Kyoto gases can achieve the Dutch target for climate change in 2010 with a cost reduction of 37 percent as compared to a CO_2 only reduction strategy for the same target. Our result corresponds largely with the findings of other studies (Reilly et al., 1999; Godal and Holtsmark, 2001; Van Vuuren et al., 2006). However, it should be realised that economic instruments that cover the six Kyoto gases will also shift costs for consumers from energy-related product groups to food-related product groups as compared to a CO_2 only strategy.

Over the last years, a number of countries have implemented economic instruments to help mitigating climate change. These instruments focus on CO_2 emissions only. Considering the results of our study, countries can mitigate climate change more cost-effectively when they implement economic instruments that include non-CO_2 GHG. However, when governments intent to include non-CO_2 GHG in economic instruments, they should realise that the prices of food products, like dairy products, will increase while the prices of energy-related products will decrease. This shift in tax burden may raise questions about the social adverse effects of a tax that covers the six Kyoto gases. The findings of this study may contribute to the debate about the possibilities of economic instruments in mitigating potential climate change.

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