

# CO<sub>2</sub> accounts for open economies: producer or consumer responsibility?

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## Abstract

International negotiations of reducing CO<sub>2</sub> emissions address the question of how to account annual CO<sub>2</sub> emissions. For open economies like Denmark facing national CO<sub>2</sub> targets import and export of commodities influence the total accounted CO<sub>2</sub> emissions. In this article we demonstrate the consequences of using two basic accounting principles: a production versus a consumption principle. The distinction between the two principles is whether the producer or the consumer is responsible for the CO<sub>2</sub> emitted. By subtracting total emissions based on the two accounting principles we develop the concept of a “CO<sub>2</sub> trade balance”. Using Denmark as a case, we show that from 1989 to 1994 the CO<sub>2</sub> trade balance has changed dramatically turning into a deficit of 7 million tonnes from a surplus of 0.5 million tonnes in 1987. Consequently, it has become more difficult to reach the national CO<sub>2</sub> target as an increasing part of emissions from Danish territory is caused by foreign demand. © 2001 Elsevier Science Ltd. All rights reserved.

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## 1. Introduction

In Kyoto, December 1997, an international agreement has been reached on reducing global CO<sub>2</sub> emissions to the atmosphere. Most of the European countries including EU as a whole have agreed to cut back CO<sub>2</sub> emissions by 8% in the period 2008–2012 compared to the level in 1990,<sup>1</sup> cf. United Nations (1997).<sup>2</sup>

Besides the amount of reduction to be carried out and the choice of reference years much attention in international climate negotiations has been given to what means

to use in order to reach the national targets. Attention has also been given to questions of efficiency, i.e. joint implementation and tradeable permits. However, only very few have addressed the question: How to account national CO<sub>2</sub> emissions for open economies considering the embodiment of CO<sub>2</sub> in international trade?

International trade has an increasing influence on the ability to fulfil national CO<sub>2</sub> targets as a significant amount of CO<sub>2</sub> is embodied in goods traded internationally, cf. Wyckoff and Roop (1994). The issue of energy and CO<sub>2</sub> embodied in international trade has also been addressed in studies by e.g. Lenzen (1998) and Battjes *et al.* (1998).<sup>3</sup> Trade has an impact on national CO<sub>2</sub> emissions as the production of CO<sub>2</sub> intensive goods for export is charged to the national CO<sub>2</sub> account. Contrary to this the import of goods is charged to the CO<sub>2</sub> accounts in foreign producer countries. Open economies facing national CO<sub>2</sub> targets and having a big net export of CO<sub>2</sub> intensive goods therefore have to make an extra effort to reduce domestic CO<sub>2</sub> emissions.

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<sup>1</sup> Some countries like Iceland, Sweden and Norway have the permission to increase CO<sub>2</sub> emissions due to a low actual CO<sub>2</sub> emission level and to high abatement costs.

<sup>2</sup> In June 1998 the EU member states made an agreement on sharing the 8% CO<sub>2</sub> burden. Denmark has agreed to take the lion's share accepting a 21% CO<sub>2</sub> reduction in 2008–2012 compared with the 1990 level, cf. the Danish Energy Agency (1998). Also, in the national planning context Denmark has an ambitious CO<sub>2</sub> target. According to the energy act, *Energy 21*, Danish CO<sub>2</sub> emissions have to be reduced by 20% in the year 2005 compared with the 1988 level, cf. the Danish Energy Agency (1998).

<sup>3</sup> In a study made by the European Commission (1998) the pollution embodied in EU imports and exports has been analysed using sectoral pollution intensities for the US.

The embodiment of CO<sub>2</sub> in goods traded internationally points to the question of who is responsible for emitting CO<sub>2</sub> to the atmosphere and which accounting principle it is appropriate to use.

In this article we address the question: Who is responsible for emitting CO<sub>2</sub> to the atmosphere — the consumer or the producer? We develop two basic models for calculating national CO<sub>2</sub> emissions depending on whether the production or consumption approach is used. Based on these two models we develop the concept of a CO<sub>2</sub> trade balance showing the difference in CO<sub>2</sub> emissions embodied in total import and export. Further, we estimate the models and the CO<sub>2</sub> trade balance for an open economy exemplified by Denmark.

The methodologies developed in this article obviously have policy applications. Considering international CO<sub>2</sub> negotiations the methodologies stress the importance of using appropriate national CO<sub>2</sub> measures. Figures like annual CO<sub>2</sub> produced per unit of GDP or per capita could be misleading for open economies having a big net export of CO<sub>2</sub> intensive goods. This suggests the need to expand the accounting of CO<sub>2</sub> emissions to include CO<sub>2</sub> embodied in imported non-energy goods. In negotiating the burden sharing of future CO<sub>2</sub> reductions the methodologies can be used to eliminate the problems of choosing a fair base year level in which domestic CO<sub>2</sub> emissions are not too much affected by imbalances in foreign trade. Taking such imbalances in foreign trade into account might reduce the reluctance of some open economies having trade balance problems to accept such kinds of agreements.

Considering national policy means for CO<sub>2</sub> reduction the consumer CO<sub>2</sub> accounting principle gives additional information to decision makers about the CO<sub>2</sub> impact of consumer habits. Thereby “bad” consumer habits are highlighting pointing at introducing CO<sub>2</sub> reduction means which are directed towards the consumer, e.g. labelling and information campaigns.

The content of this article is as follows: Section 2 gives a brief description of the accounting principles to be analysed, i.e. the production approach, the consumption approach and the actual Danish approach. In Section 3 data and data sources are described. A model framework for empirical analysis based on input–output analysis is developed in Section 4. The results from using the model are shown in Section 5. The results consist of Danish CO<sub>2</sub> accounts for 1994 and a CO<sub>2</sub> trade balance for the period 1966–1994. Section 6 summarises the conclusions.

## 2. Accounting principles

We distinguish between two methodologically different accounting principles: The production principle versus the consumption principle. Further, we

look at the official Danish accounting principle actually used.

Whereas the Danish accounting principle is considered for pure empirical reasons, the distinction between the production and the consumption accounting principle is inspired by a distinction made by Proops *et al.* (1993) between “CO<sub>2</sub> emission” and “CO<sub>2</sub> responsibility” considering the treatment of export and import in input–output analyses.

According to the *production accounting principle* the producer is responsible for the CO<sub>2</sub> emissions from the production of energy, goods and services. In that way CO<sub>2</sub> emissions are all located to the processes actually emitting CO<sub>2</sub> to the atmosphere, i.e. industrial production, energy production and the use of fuels in households. The production accounting principle is the principle presumed in the Kyoto agreement. In practice the principle implies that a significant part of the CO<sub>2</sub> emissions is linked to the energy production sector (e.g. the power and district heating plants) though the energy production sector simply converts fuels to useful energy demanded by the industry, households, etc. Another drawback of the production principle is the lack of distinction between export and domestic consumption, i.e. CO<sub>2</sub> emissions from the production of goods exported to foreign countries are treated equivalent to domestic emissions thereby influencing the ability to fulfil the national CO<sub>2</sub> target.

According to the *consumption accounting principle* the consumer is responsible for CO<sub>2</sub> emissions from the production of energy, goods and services.<sup>4</sup> Using this principle CO<sub>2</sub> emissions are related to final use of goods and services even if they are imported from foreign countries. In this way the consumption accounting principle considers the global CO<sub>2</sub> impact of Danish consumption. A shortcoming of including foreign “imported” CO<sub>2</sub> emissions in the national account is that no direct influence can be expected by the importing country on the technologies and fuels used abroad.

The *Danish CO<sub>2</sub> accounting principle* involves the application of a modified version of the production principle.<sup>5</sup> Danish CO<sub>2</sub> emissions from production

<sup>4</sup> In a study by Munksgaard *et al.* (2000) it is analysed to what extent Danish consumers are responsible for the increase in global CO<sub>2</sub> emissions. The study is based on decomposition analysis using data for the years 1966–1992. In this study a distinction is made between direct and indirect CO<sub>2</sub> emissions from household consumption. Direct CO<sub>2</sub> emissions are generated by the use of energy, e.g. electricity, gas and gasoline, whereas indirect CO<sub>2</sub> emissions are generated by the production of goods and services, e.g. foods, furniture and newspapers, demanded by the consumers.

<sup>5</sup> In Denmark, actual as well as adjusted figures based on the production principle are estimated. Adjusted figures are used as a reference for the national CO<sub>2</sub> emission target in 2005, whereas actual figures are reported according to the international agreements.

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