Chapter 19
Comparing the Environmental Effects of Production and Consumption in a Region – A Tool for Policy

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Introduction

National environmental policies, in general, are directed to environmental quality, emission reduction and spatial planning of nature areas, all within the borders of a country. Despite the growth in GDP in the Netherlands in the past decades, Dutch environmental policy has led to a substantial decrease in the emissions of several substances (RIVM 2004a). However, nowadays, policy makers realize that there are still several persistent global environmental issues, such as climate change, the loss of biodiversity and the depletion of natural resources that cannot be tackled on a national scale (VROM 2001). Attempts to deal with these issues require an understanding of the relations between economy and the environment, both within and between countries.

For policy makers to develop policies that have an effect on the cross-border environment, they have to be provided with relevant information on economic activities and their ecological effects. Data on environmental pressure across national borders can be assigned in several ways to both production and consumption activities in a country and international trade. It is up to scientists to use the necessary cross-sections from this data to provide policy makers with the right information. Input-output (IO) analysis in combination with industrial ecology offers tools and methodologies for presenting the same data in different ways directed at specific policy questions concerning national or cross-border issues.

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This chapter investigates the environmental impact of a country or region using two approaches to gain a clear understanding of the producer–consumer relation and the shift of environmental pressure to other countries. In the first approach, the environmental pressure of production and consumption within the country's geographical borders is investigated, while in the second, the pressure of the country's inhabitants and related to their consumption patterns is explored. In an open economy such as the Netherlands, there will be a difference in outcome between the two approaches. This is due to high import and export quotes compared to less open economies. Dutch sectors deliver goods and services, both for domestic and foreign markets. On the other hand, the Netherlands imports goods and services for its own inhabitants. So, environmental pressure is partly due to production of goods for consumption abroad. On the other hand, consumption by Dutch households leads to environmental pressure abroad. For a larger region than the Netherlands, e.g. the European Union (EU), the role of imports and exports is less important. This can be shown in similar calculations carried out for a region roughly corresponding with the EU.

The environmental impacts for both approaches were calculated at sector level using an IO model. The model, described for the Netherlands in Chapter 16 (Nijdam et al.) in more detail, is based on the relationships between production and consumption in a region, and related imports and exports. Taking these activities as a starting-point, the model describes the use of natural resources and emissions to the environment in a region and abroad. Since climate change, as mentioned above, is one of the persisting environmental issues not tackled yet, the model is illustrated by calculating greenhouse gas emissions in the Netherlands and abroad for both approaches. For the EU region, calculations are carried out for CO_2 emissions. The discussion goes into the differences between the two approaches and the relevance these differences have for policy.

Background

The shift to other locations, e.g. countries, qualifies as one of the four types of environmental pressure shifting, as listed below (Bade et al. 2001):

- To other locations, both inside and outside a region or country
- To other environmental themes or compartments
- To other sustainability domains, viz. economy and social and
- To other, viz. future, generations

In the past decades, there was a growing interest in Dutch national policy documents for these types of shifting. The third National Environmental Policy Plan (VROM 1998) showed the trade-offs between environmental themes and compartments (air, soil and water), i.e. shifts that also played a role in product-oriented environmental policies (see Chapter 16 by Nijdam et al.). The document, Environment and Economy (in Dutch) (EZ 1997) focused on the area of tension between economic and environmental interests. Globalization of environmental issues has also occurred recently in Dutch policy. The fourth National Environmental Policy Plan (VROM 2001) pushed climate change, the prevention of damage to the global biodiversity and the exhaustion of natural resources onto the political environmental agenda, thereby directing attention in policy-making to the environmental impact of a nation's consumption on other countries. This policy plan introduced an integrated environmental policy, in which solutions for one problem would not lead to an increase of other problems, and in which the solutions of today would not be the problems of tomorrow.

Nowadays, the Dutch government is seeking sustainable economic development, in other words an absolute decoupling of economic growth and environmental pressure in the Netherlands. Such sustainable economic development should take place on condition that shifting environmental problems somewhere else or into the future is prevented (NSDO 2002; VROM 2004). Combining these implies a decoupling of what we might call the ecological footprint (based on the idea of Wackernagel and Rees 1996) and the socio-economic handshake (Ros and Poolman 2004), the last one especially with reference to developing countries. This form of decoupling is the leading concept of the international part of the action plan for sustainable development in the Netherlands.

Sustainable production and consumption patterns may help to tackle the persistent environmental issues previously mentioned. As already indicated, policy options are generally directed to the environmental pressure inside the borders of a country (first approach). In such a country approach, both the environmental pressures of exports and domestic final demand are influenced. However, national policies directed only to reducing environmental pressure in a country might not be optimal. For example, the worldwide reduction of greenhouse gas emissions, which is regulated under the Kyoto Protocol, departs from such a country approach. At a country level, policy options are mainly concerned with efficiency improvements by stimulating new technologies. Furthermore, the existence of some energy-intensive activities may be limited, which, for example, can lead to a shift to more imports of electricity from other countries. It is imaginable that production will be moved to other countries with less-efficient technologies, resulting in higher overall emissions (carbon leakage; see references in Hoekstra and Jansen 2002). This shift can be analyzed using IO analysis.

One option for the Netherlands is to contribute to emission reduction in other countries via the Kyoto mechanisms, Joint Implementation and the Clean Development Mechanism. This new type of trade or investment allows one to buy negative emissions. Of course, the emissions trading programme will be an important policy instrument in the coming years. Moreover, initiatives like 'trees for travel' fit in with the idea that a country might have an impact elsewhere. We will be the first to take these impacts into account if they are positive. However, policies directed at more sustainable consumption patterns (according to the second approach), including volume limitations, have been less often applied. These options not only influence a part of the environmental pressure inside a country, but also affect the environmental pressure abroad (although they do not influence production technologies in other countries).

There is a need for more transparency in production chains and the impact of consumption to facilitate policy making on sustainable production and consumption. Insights into production processes have provided conditions for a dialogue between stakeholders and market parties on the requirements for sustainable production and consumption (VROM 2004). The SER has underlined the importance of transparency in production chains for sustainable consumption too (SER 2003).

This type of analysis points to the question of responsibility. Pollution occurs in all stages of the life chain of products. Who is responsible for the emissions related to the production and distribution of a certain product? Is it the producer, who actually produces the emissions or is it the user/consumer, who purchases a good or service? The responsibility question comes up both at the national level in a country (producers versus consumers) and at the regional level (the shift between nations). The resulting question is who should pay for the pollution: the polluter or the user? The ‘polluter pays’ principle is based on direct emissions or pollution. In cases where the user has to pay, pollution during the whole life chain of products has to be considered. Steenge suggests a combination; both polluter and user have to pay a part (Steenge 1999). The policy measures taken should depend on who is responsible (Hoekstra and Jansen 2002).

There are different answers (depending on one’s values) to the question of what country is responsible for the environmental pressure in other countries (RIVM 2004c). From a market-oriented perceptive the choice between the economy and the environment is the responsibility of the exporting country. Trade is the consequence of a search for the most efficient production chains; and trade stimulates developing countries in their development. From the point of view of international solidarity it can be said that trade due to stiff competition has a negative consequence for nature and environment in developing countries. Rich countries should take their responsibility for this in the form of trade agreements, technology transfer, investments and development assistance. In this way, rich countries (partly) pay for reducing pollution in poor countries (Steenge 1999).

There are several scientific approaches in existence to support policy making on the issues mentioned above. A well-known approach concerning the environmental shift of one country to other countries is the ecological footprint concept (Wackernagel and Rees 1996). The ecological footprint approach is directed primarily to the shifting of land use on to other countries. However, the approach has also been used for investigating other environmental effects related to consumption (see Chapter 16 by Nijdam et al.). Related studies concern the calculation of the environmental impacts of imports as, for example, carried out for six OECD countries (Wyckoff and Roop 1994), and the USA (Suh et al. 2002). Some studies have been extended to allow comparison of the emissions related to imports and exports, resulting in an environmental balance of trade for a country. Such studies were carried out, for instance, for Japan and China (Gerilla et al. 2002), Poland (Przybylinski 2002) and the Netherlands (De Haan 2004). The two-system approach, which is discussed in this chapter, was applied by Wilting (1996), who compared energy use and CO_2 emissions in the Netherlands to energy use and emissions related to Dutch consumption. Ros and Wilting (2000) extended this approach to include acidification and land use. All studies, except that of Wackernagel and Rees, were carried out using IO methods.

Two Systems: A Region Versus the Inhabitants of the Region

The two approaches – distinguished in this chapter and defined below – have different system boundaries.

- System 1: the production-consumption system in a country or region. The physical borders of the country mark the first system, which concerns all production and consumption in the country. Environmental policies of national governments are directed mainly to the activities in the system, including all production in the country, both for domestic demand and exports. Furthermore, the system consists of all consumption-related activities in a country, including the activities of foreigners visiting the country. A part of the environmental pressure in a region can be seen as a shift of other regions to the region under consideration.
- System 2: consumption of the inhabitants of a country or region. Consumption patterns mark the second system directed to all production related to the consumption of the inhabitants of a certain country or region. These patterns include the indirect part of the production chain (partly abroad) and the activities of the inhabitants abroad (on holidays, for example). Collective services and public consumption are also included. So, System 2 concerns the shift of the region on to other regions. System 2 is related to a production chain approach such as the ecological footprint.

The two-systems approach does not include environmental pressure related to import required for exports. Figure 19.1 shows, as an example, the two-system approach for the Netherlands.

The overlap of Systems 1 and 2 consists of the economic activities within the region directly and indirectly related to the consumption of the inhabitants of that region. In the case of a small country like the Netherlands, different results can be expected per system because of the open character of the economy. The differences between the two systems show the environmental relevance of imports and exports. Differences show that the Dutch population (shortly referred to as the Dutch) has a 'footprint' abroad, but others as well have part of their 'footprint' in the Netherlands.

Methodology

IO analysis was used for the calculation of the environmental pressure for both systems. Although insights into total pressure per sector for System 1 can be obtained from monitoring data, IO analysis is required for dividing pressure over domestic

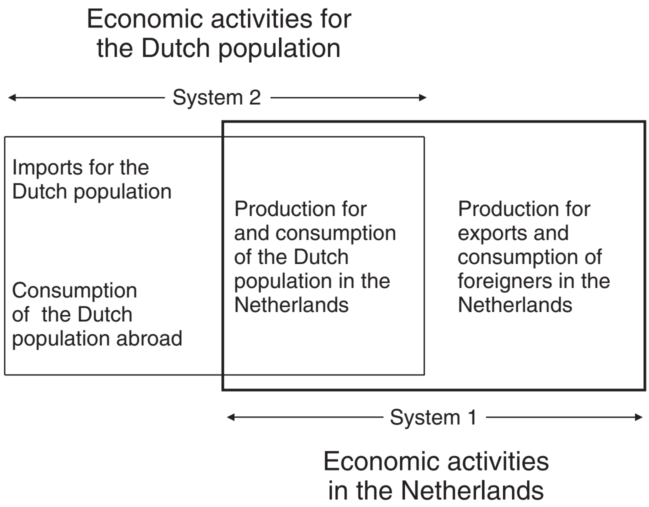

Fig. 19.1 Two Systems for Studying the Environmental Pressure Related to the Netherlands in the Netherlands and for the Dutch Population

demand and exports. The calculation follows a similar scheme for both systems. Starting-point is the determination of the final demand under consideration in the relevant system, such as household consumption or exports. After that, the required production per sector and region is calculated for the relevant final demand with the Leontief inverse matrix. Combining this production (also called production by origin) with direct environmental intensities results in the total environmental pressure per sector required for final demand. The calculation scheme for both systems is explained in more detail on the basis of the calculations concerning greenhouse gases for the Dutch situation.

System 1

System 1 concerns the production in the Netherlands divided over exports and domestic final demand. In order to assign all final demand in the Netherlands to one of the two final demand categories, investments were allocated to these categories on the basis of the production by origin per sector. So, consumption of the Dutch does not only consist of private consumption, but also of public consumption (e.g. government consumption, education and defense) and part of the new investments. Static Leontief inverse was used for both consumption and exports in order to calculate the production in Dutch sectors for these final deliveries. The calculation was carried out with a direct requirements matrix for the Dutch economy, excluding imports.

The calculated production by origin for both types of final demand was combined with intensities per sector for greenhouse gas emissions per unit of production. Some of the emissions from Dutch transport companies and fisheries occur abroad. Since these emissions do not belong to System 1, marked by the borders of the Netherlands, these emissions were excluded from the calculations (for System 1).

Direct emissions caused by consumption were added to complete the calculation of the greenhouse gas emissions in System 1. The direct environmental pressure of consumption concerns activities which take place in households, such as CO_2 emissions of combusting natural gas for heating and combusting fuels in passenger cars. Methane emissions of household waste at landfills were added too.

System 2

System 2 concerns the environmental pressure related to the consumption patterns of the inhabitants of the Netherlands. Direct pressure together with indirect environmental pressure (calculated by means of an IO analysis as described above) builds up total environmental pressure of Dutch consumption in the Netherlands. The data from the environmental pressure that takes place in the Netherlands is already calculated in System 1. In order to determine total environmental pressure of the Dutch, the part that takes place abroad has to be added.

The greenhouse gas emissions related to Dutch consumption are caused by a large amount of production processes in maybe all countries of the world. A pragmatic way to handle this, which is often applied, assumes that all imports are produced with technologies similar to those in the Netherlands. In general, however, production technologies differ across countries. To account for the differences in production technologies across countries, technologies were categorized into three world regions. So, in total, the model consists of four regions, the Netherlands, OECD-Europe, the other OECD countries and the non-OECD countries. Each foreign region produces directly or indirectly (via the Dutch production system) for Dutch consumption.

The requirements of imports for Dutch consumption were determined on the basis of the tables of competitive and non-competitive imports for the Netherlands. These imports consist of imports that are directly consumed by the Dutch population and those that are used in the Dutch production sectors for Dutch consumption. With the use of import statistics, total imports per sector were assigned to one of the three foreign regions as the place of origin. In this way, the deliveries for the Dutch production and consumption system were determined per region. Final demand of a foreign region concerns the exports to the Netherlands, both for production and consumption, and a small part of the investments; this allows maintenance of the production capacity for the Dutch. Finally, production by origin for the three regions was calculated. The Leontief inverse matrices for the three regions were derived from IO tables for the three regions at a 30-sector level. Total production by origin per region was combined with greenhouse gas intensities per sector and region in order to determine the greenhouse gas emissions related to Dutch consumption in other countries.

In fact, the method described is a simplification, since the trade flows between the three regions were not taken into account. The imports of a region were assumed to be produced in that region with the technology installed in that region. Since, for each region, imports are relatively small compared to total production, the errors that were introduced will be small too. The part of the model functioning outside the borders of the Netherlands does not cover the whole world (excluding the Netherlands), but only consists of the production in foreign countries that is ultimately, i.e. directly or indirectly, meant for the consumption by the Dutch.

Application of the Two-System Approach

The two-system approach was applied to two cases: (1) greenhouse gas emissions related to the Netherlands, and (2) CO_2 emissions related to the EU. The CO_2 emissions in the Netherlands taken over a time period were considered too.

Data

The cases required both economic data, especially IO tables, and data on emissions. For the Netherlands (NL) case, the technological matrix was derived from an IO table for the Netherlands geared to 105 sectors (CBS 1998). The IO data for the foreign regions and the EU were constructed by aggregating detailed economic data of individual countries and sub-regions from the GTAP database (McDougall et al. 1998).

For the NL case, the amount of imports was derived from national import statistics (Statistics Netherlands 1998). For the EU case, imports were derived from the GTAP database.

The intensities for Dutch industries were derived from both production per industry and total emissions per industry. The latter were obtained from the Dutch national emission inventory system (VROM 1997). Direct emissions of Dutch consumers were obtained from the same system (see also Chapter 16 of this handbook by Nijdam and Wilting). For the three foreign regions, data for greenhouse gas emissions per sector were collected from the EDGAR database (Olivier et al. 1996).

The NL Case

The first case concerns greenhouse gas emissions related to the Netherlands for the year 1995. This section presents both the outcomes of the calculations and a comparison of the outcomes. To illustrate the relevance of the economic structure

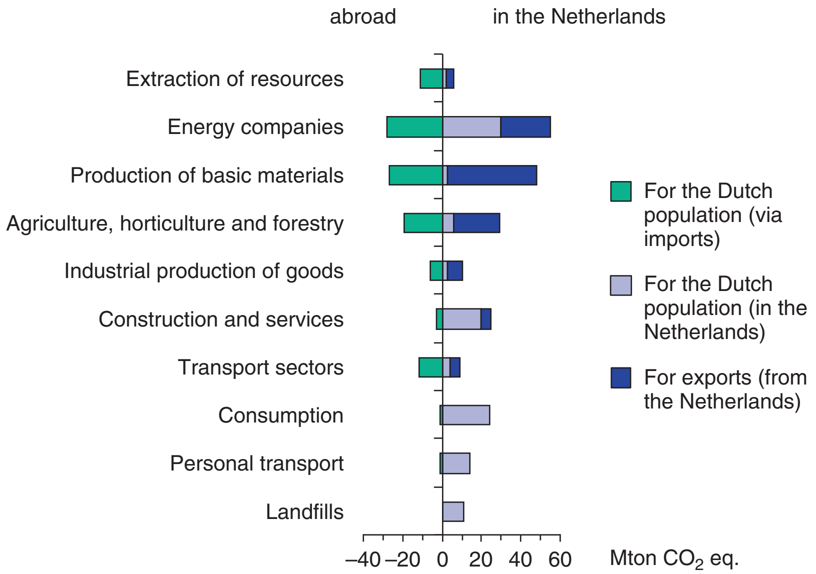

Fig. 19.2 Greenhouse Gas Emissions in the Netherlands (Both for the Dutch Population and Exports) and Abroad for the Dutch Population, 1995 (Extraction of Resources Includes Oil and Natural Gas; Energy Companies Include Refineries and Power Stations)

in the Netherlands for the environmental pressure in the country, the production-consumption chain was broken up into ten main parts. Figure 19.2 shows the greenhouse gas emissions for the two systems assigned to the ten parts of the production–consumption system. The greenhouse gases considered are CO_2, CH_4, N_2O and HCFCs. The amounts of all gases were expressed in CO_2 equivalents, using the so-called Global Warming Potentials, which describe the relative contribution of a gas to the greenhouse effect.

The right-hand side of the figure shows the greenhouse gas emissions in the Netherlands divided over exports (from the Netherlands) and domestic demand. Almost 50% of the greenhouse gas emissions in the Netherlands occur as a result of the exports of goods and services. Especially the energy-intensive sectors at the beginning of production chains, such as agriculture and horticulture, the energy sectors and the basic industries (chemicals, metals and paper), are responsible for a fair amount of greenhouse gas emissions related to the exports. An important explanation is the availability of cheap natural gas that led to a rapid expansion of basic industries in the Netherlands in the early 1970s.

Greenhouse gas emissions directly related to consumption occur mainly in the Netherlands. These emissions appear, for example, during the combustion of natural gas for heating or fuels for personal transport. The greenhouse gas emissions at landfills concern methane mainly. These emissions are assigned to all the inhabitants of the Netherlands, since by far the largest part of these emissions concerns waste from households. The left-hand side of Fig. 19.2 depicts the greenhouse gas emis-

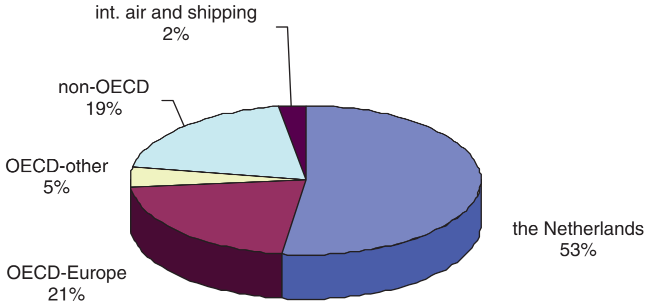

Fig. 19.3 Greenhouse Gas Emissions for the Dutch Population per Region, 1995

sions that occur to the advantage of the Dutch outside the borders of the Netherlands. They add up to 47% of the total greenhouse gas emissions related to the Dutch. The left-hand side of the figure also includes emissions from international shipping and air transport, which occur along the borders of the Netherlands but cannot be assigned to other countries either.

Figure 19.3 shows the emissions of greenhouse gases as related to the consumption of the Dutch population divided over the regions considered in the model. Most of the foreign emissions occur in OECD-Europe and the non-OECD countries. About 70% of the greenhouse gas emissions for the Dutch in foreign countries are regulated in the Kyoto Protocol. This protocol has the character of an agreement; there are no sanctions if the protocol is violated. So, 30% of the greenhouse gas emissions for the Dutch population are not included in the agreement. These emissions occur in countries that have not ratified the agreement, such as the USA, or in countries that have not signed the Kyoto agreements. Furthermore, these emissions concern activities that are not part of the climate agreement, like international air and sea transport (2% of the emissions related to Dutch consumption).

The IO calculations as described for System 2 depict the environmental pressure of the Dutch per sector and per region. Chapter 16 (Nijdam et al.) shows the environmental pressure of consumption at the level of consumption categories, an interesting illustration from the viewpoint of consumption patterns.

The EU Case

Since the Netherlands is characterized by high imports and exports compared to production in the country, the difference between the system approaches is substantial. This may be different for larger nations or regions with less international trade. A comparison for the world as a whole only shows the effects of international transport of which the emissions are not assigned to countries. In order to show how the two-system approach worked for a larger region, it was applied to a region consisting of the EU-15 extended with some Eastern-European countries. This newly

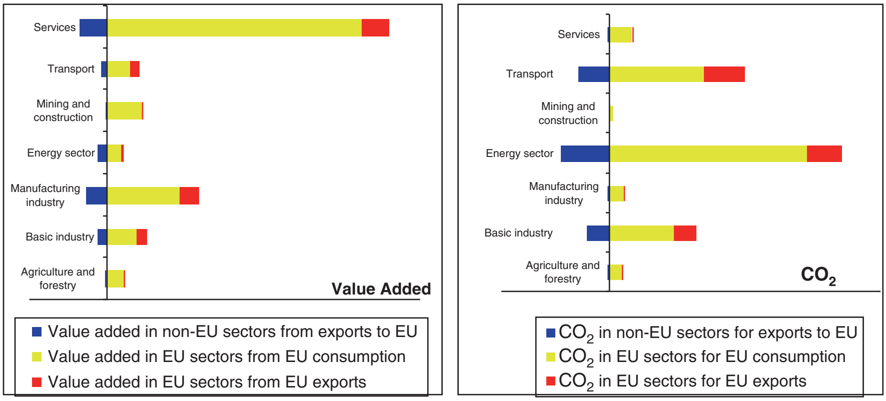

Fig. 19.4 CO_2 Emissions and Value Added for the Two Approaches in and for the EU, 1995

created region covers approximately the area occupied by the EU-25. Calculations were carried out for both CO_2 emissions and for value added.

Figure 19.4 shows a fairly closed EU; most of value added is generated in the EU for the EU. The same holds for CO_2 emissions. About 55% and 20% of value added are created in the service and manufacturing industries, respectively. These sectors contribute less than 10% to regional CO_2 emissions. However, they generate emissions related to transport and energy use in other sectors. The figures show that sectoral emissions take place mainly at the beginning of production chains and that value added is gained mainly at the end of production chains.

The EU's contribution to total global environmental pressure is decreasing, but the interaction with other parts of the world is increasing, for example, due to the lowering of trade barriers. Increasing trade has changed the distribution of pressures on the environment among countries and regions of the world. In the past 20 years, goods in which manufacturing exerts intensive pressure on the environment have been increasingly imported from newly industrial or developing countries. The share of imported resources in the total material requirement of the EU has increased (Schütz et al. 2004).

The NL Case Again

Considering the fourth National Environmental Policy Plan (VROM 2001), developments in the Netherlands should take place under the condition that total emissions for Dutch consumption do not increase. Figure 19.5 shows the developments in CO_2 emissions for both approaches for the 1990–2010 period. Total CO_2 emissions in the Netherlands were derived from monitoring data, but the division in domestic demand and exports was based on IO calculations for 1990, 1995 and 2000, and interpolation for 2010.

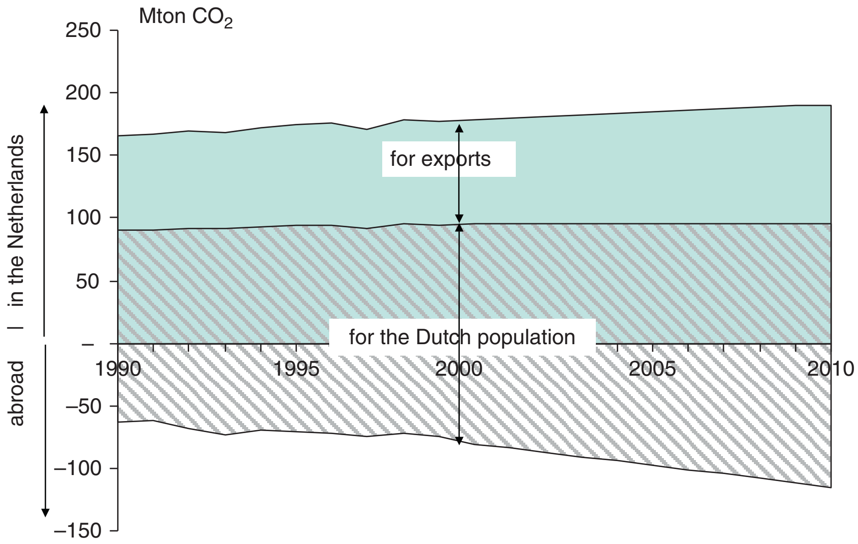

Fig. 19.5 CO_2 Emissions in The Netherlands and Abroad for the Dutch Population

Figure 19.5 shows an increase of 8% in CO_2 emissions in the Netherlands in the 1990–2000 period. In the first 5 years the increase was stronger than in the second 5 years. The weaker increase in the second 5 years is the result of an increase in the imports of electricity (Van den Wijngaart and Ybema 2002). The Netherlands Bureau for Economic Policy Analysis (CPB 2002) formulated two economic scenarios for 2000–2010: (1) a cautious and (2) an optimistic economic scenario. Van den Wijngaart and Ybema (2002) constructed the development in CO_2 emissions for the optimistic economic scenario for 2001–2010. According to the optimistic economic scenario, production for exports will increase faster than the production for domestic demand in the period up to 2010. The CO_2 emissions in the Netherlands for domestic consumption will stay at the same level.

From consumption models, CO_2 emissions related to consumption of the Dutch were derived that would increase further in the 2000–2010 period as a result of growing consumption. This increase in volume cannot be compensated by efficiency improvements in production and consumption. Since the possibilities for production for consumption in the Netherlands are limited, shift in production for Dutch consumption from the Netherlands to abroad will increase. And so CO_2 emissions abroad for Dutch consumption will increase too.

Summarizing, CO_2 emissions related to exports will increase in the Netherlands in the period up to 2010, but the emissions abroad for the Dutch consumption will increase even faster in the same period.

Discussion

This chapter has focused on the calculation of environmental pressure using IO analysis for a country or region seen from two perspectives. The advantage of using an IO analysis is the insight it provides into the spatial relationships between producers and consumers, and environmental pressure, which may help policy makers in their considerations on the responsibility issue, for example.

The figures used in this chapter had been presented previously in reports destined for the use by Dutch government departments and policy makers. The figures concerning the Dutch case were included in several documents meant for the Dutch government departments, Parliament and policy makers. They have been presented in the fifth Environmental Outlook (RIVM 2000). In fact, the fourth National Environmental Policy Plan (VROM 2001) reacted to this information by designating the problem. However, quantified policy goals for reducing the impact of consumption have not been set, although the figures were also used in the Environmental Balance 2002 (RIVM 2002). The EU figure was taken up in the EU environmental balance (RIVM 2004b). Dutch government has taken note that on the basis of the study presented in Chapter 16 of this handbook by Nijdam and Wilting most environmental pressure related to Dutch consumption takes place abroad. However, the government claims this pressure to be, in most cases, beyond the reach of environmental legislation and agreements with industries (Tweede Kamer 2004).

The environmental pressure related to exports has, to date, not received much attention in Dutch policy documents. Reduction of this environmental pressure forms part of the policy aimed at sectors for reduction of emissions. However, taking environmental pressure exerted by exports out of the total pressure 'picture' in the Netherlands will allow us to build up an ecological balance. How do environmental pressure of imports and exports relate to each other? And how do these pressures relate to the value flows of imports and exports?

This chapter has shown different ways to present the relations between domestic production, imports, exports, consumption, etc. by using the two-system approach. Both systems aim at the quantification of the environmental pressure of a country. From an equity perspective, in which each world citizen has the same claims on prosperity, the System 2 approach seems fairer. This approach enables a comparison between inhabitants of different countries or regions and their environmental profiles. In this connection, the approach can be used for revealing possible disproportionate pressure on the environment of the inhabitants of certain countries. Furthermore, System 2 also portrays emissions that are not included in the System 1 approach, such as the emissions of fisheries, and international shipping and aviation. The emissions related to international transport occur outside the borders of countries and are not included in national emission statistics. As a consequence, they are not included in national environmental policies either. Since climate policy includes several new forms of trade, it is a challenge to include them in IO analysis.

Country borders are based on historical events and are arbitrarily chosen from an environmental perspective. It is quite reasonable to expect differences between the systems per country or region. Considering the large international trade flows there will be no countries for which the systems completely overlap; in other words, no country is completely self-supporting. For historical reasons, and considering the size of the Netherlands and the open character of the economy, we can see that differences between the two systems do exist. The calculations show the total emissions of greenhouse gases in System 1 to be at the same level as those in System 2. However, the overlap between the two systems, i.e. the emissions for the Dutch population in the Netherlands, only accounts for about 50% of total emissions. This implies an enormous shift of greenhouse gas emissions from the Netherlands to abroad and vice versa. The second case study showed the difference between the two systems for the EU to be far lower than in the Dutch case. Although in the EU situation the two systems match far better than for the Netherlands, the question remaining is who should pay for the pollution.

In the Netherlands, CO_2 emissions for other countries are at about at the same level as CO_2 emissions in other countries caused by the Netherlands. However, there are differences in technologies and efficiencies per country and region. In some other countries, production is less efficient than in the Netherlands. However, the state of technologies and knowledge about technologies only partially explain the differences. Climate characteristics, soil properties, the available mix of energy carriers, population density and spatial relations are country-specific and have an impact on production efficiencies too. The multi-regional character of the IO model allowed us to estimate the differences as well. If other countries were to apply Dutch production technologies, the CO_2 emissions in other countries caused by Dutch consumption would drop by about 30%. Therefore, in the eyes of many stakeholders, the presence of large energy-intensive industries in the Netherlands is justified by the fact that some of the Dutch companies are among the best in the world and support technological optimization. As for Dutch companies not being on the top, policy goals have been set to get them there. The concept of benchmarking has been developed to stimulate economic sectors in such a way as to allow them to compete with sectors abroad for their efficiencies. Benchmarking is now one of the leading approaches in Dutch policy on industrial energy use.

One drawback of the aggregation over European countries in the EU case is that aggregation hides the differences in technologies and efficiencies between countries. So for sectors with a high environmental pressure, optimization on a European level may take place inside that sector. Agreements will have to be made at this level.

The cases dealing with the calculation of the environmental pressure in the two systems concerned climate change (CO_2 and greenhouse gas emissions). Of course, the methodology is applicable to other substances and environmental themes as well. Ros and Wilting (2000) calculated environmental pressure for both approaches related to acidification and land use. The model outcomes for intensities of environmental pressure, for example, can be used as inputs for other models. These translate the use of natural resources and emissions of substances related to the Dutch population into loss of biodiversity and public health. A further step may be the application to economic (e.g. value added in the EU case) and social aspects. In this way, the two-system approach can be used for sustainability assessments.

The differences and insights obtained from the chain approach of System 2 may be useful for optimizing production–consumption chains over country borders. A global optimization across countries might lead to more optimal results in environmental policy. Such an optimization, which requires an international approach, may involve a shift of foreign production to the Netherlands (and produce more efficiently), or may actively improve technology elsewhere. However, optimization has to be carried out with care, since optimization for greenhouse gases may lead to less optimal outcomes for other environmental themes, like acidification, land use or pesticides. These themes are specific for certain regions, unlike climate change, which is a global problem. And in some cases the use of land may have the same efficiency across countries, but the damage to nature may vary per country. From an ecological perspective, a shift to other countries may be justified if the production efficiencies in other countries are at least at the same level as in one's own country, so that overall environmental pressure and damage to nature will not increase. So, from an ecological perspective, for most cases, a shift to developing countries, with a high biodiversity, would not be preferable. Furthermore, optimizing on ecological aspects alone is too narrow from a sustainability perspective. Therefore economic and social aspects have also to be considered when optimizing across countries.

The case of the greenhouse gas emissions showed large differences in the efforts to deliver calculations for both the systems. The emissions in System 1 were obtained from environmental statistics based on emission monitoring. Only the division over exports and domestic demand required an IO analysis for the Netherlands. Determining the emissions in System 2 was much more labor-intensive. Besides the IO analysis of the Netherlands, this calculation required a large amount of data on trade flows and production technologies in other countries and regions. The fact that these calculations are based on more assumptions implies that the uncertainties in the outcomes for System 2 are higher.

Conclusions

IO economics offers opportunities to show the relations between production, consumption, international trade and environmental pressure in different ways. Different cross-sections of environmental pressure and economic activities may help policy makers in pursuing new policies.

This chapter has discussed two approaches using IO analysis for determining the environmental pressure of a country or region. The calculations have provided insights into the differences between the two approaches. Determining the environmental pressure in a country (System 1) is far easier and outcomes are less uncertain than for determining the environmental pressure of the inhabitants of a country (System 2). However, policies directed to reduce the environmental pressure related to the inhabitants of a country (System 2) seems to be fairer. Since both approaches have their specific pros and cons, they may complement each other. Especially the outcomes of the System 2 approach deserve more attention in environmental policies.

The results show greenhouse gas emissions in the Netherlands to be in contrast with those related to the inhabitants of the Netherlands. The Dutch show a shift to other countries and vice versa, a shift that will increase in the next decade. Optimization across countries may be useful to reduce the shift in greenhouse gas emissions. However, in optimizing, other environmental themes, and social and economic aspects have to be considered too.

The two system approach does not provide policy solutions for the problem of shifting environmental pressure to other locations. However, it does show where and to what extent shifting takes place. The two system approach can prove to be a useful instrument for dealing with choices and examining the most optimal solutions, and so may serve as a tool for weighing up policy options.

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