Environmental impact of indirect subsidies

Development and application of a policy oriented method

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Preface

The government uses all kinds of policy instruments to intervene in the economic process. The standard reason given for government intervention is market failure due to so-called external effects. If the external effects are *positive*, the market tends towards under-investment or underproduction compared with the social optimum. With *negative* external effects the result is precisely the opposite, namely over-investment or overproduction. For example, investment in R&D is characterised by knowledge 'leakage' to competitors who profit from it without having to pay for it. If the government wants to prevent under-investment in R&D, then it must provide subsidies to compensate for these 'leakage' effects. Looked at from the other direction, the theory of prosperity says that tax should be levied in the case of *negative* external effects.

This study shows that well-intentioned public policy can have unintended (and unnoticed) side effects on the environment. Scientists, policy-makers and the public at large seem insufficiently aware of this problem.

This report has been compiled in response to the request from the Minister of Housing, Spatial Planning and the Environment for a methodological study of the environmental effects of policy measures in the Netherlands. The study has produced a scientific method for charting first order environmental effects in a transparent, rapid and flexible way. Application of the method to a number of subsidies in the energy, agriculture, transport, and tourism sectors shows that there can be significant first order effects on the environment. In principle the method can be applied more broadly, e.g. for questions relating to the lack of a public policy. As long as it is applied responsibly the method is a useful aid for policymakers.

The following research team carried out the study:

- Dr. C.P. van Beers (project leader) on behalf of the Department of Economics of Innovation, Faculty of Technology, Policy and Management of Delft University of Technology;
- Prof. dr. J.C.J.M. van den Bergh and drs. F.H. Oosterhuis on behalf of the Institute for Environmental Studies at the Vrije Universiteit Amsterdam;
- Drs. A.P.G. de Moor on behalf of the National Institute for Public Health and the Environment.

The research was supervised by a committee under the chairmanship of drs. R.E. Weenink of the Strategy and Policy Directorate, Directorate-General for Environmental Protection, Ministry of Housing, Spatial Planning and the Environment. The final responsibility for the content of this report lies with the researchers.

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Summary

This study aims at *developing a transparent, integrated method to determine the environmental impact of indirect subsidies, with applications in the agriculture, energy, transport, and tourism sectors*. A clear theoretical and methodological framework for the analysis of indirect subsidies has so far been lacking in the economic and policy literature.

Various definitions of subsidies exist that can be applied for analytical or policy reasons. In this study, a common definition of subsidies has been chosen based on analytical considerations. Subsidies comprise all government measures that, directly or indirectly, keep consumer prices below or producer prices above the free market level, or that reduce costs for consumers and producers. The absence of active public policies aimed at internalising external environmental effects is not regarded as a subsidy. In principle, however, this study's method is suitable for analysing the impact of an absence of public policy as well.

A subsidy has a negative environmental impact if it leads to a manner of production or consumption that is, on balance, more harmful to the environment than would have been the case without the subsidy. In terms of their primary objectives, subsidies with negative environmental effects generate benefits as well. The valuation of these benefits is not included in this study. Subsidies aimed at the realisation of environmental objectives are also outside the scope of the present study.

The method that is developed and applied in this study analyses the chain of effects brought about by a subsidy. Initially, the size of the subsidy leads to a reaction in consumption or production behaviour (economic effects). In turn, these may lead to negative environmental effects. The method aims at mapping the relations between these effects systematically and in a scientifically responsible way. It consists of three parts. Firstly, the size of the subsidy has to be determined. Secondly, the resulting economic effects are assessed. Finally, the environmental effects associated with the economic effects are identified.

The method was developed so as to make it possible to analyse different types of subsidies in different economic situations. The point of application of the subsidy is one of the factors that determine the way in which the method should be applied. In this study, a distinction was made between consumers and producers. If the subsidy is applied to producers, information is needed on whether the subsidy is an input or an output subsidy. If it is applied to consumers, the final consumer price is important.

To quantify the first order economic and environmental impact, an approach was chosen based on standard economic theory of producer and consumer behaviour. Subsidies that are applied to affect producers' behaviour are mapped quantitatively through supply and demand relationships. Indirect subsidies applied to affect consumers' behaviour are analysed and quantified using a utility maximisation model.

After the economic effects have been determined, these are assessed for environmental effects. This is done by distinguishing between a number of relevant environmental

impacts and aggregating these into 'theme indicators' using the Environmental Performance Indicators (EPI) method. This study was restricted to the following environmental impacts: greenhouse effect, acidification, photochemical ozone creation, eutrophication, and land use. However, other environmental impacts can be added.

The method distinguishes between several situations and subsidy types and shows which parameters are needed to quantify the economic and environmental effects. The typology of subsidies chosen in this study is based on a classification of subsidy types according to form. The following types were identified: tax subsidies; public provision of goods and services below cost price; capital subsidies; price regulation; volume restrictions; and trade measures.

In the agriculture, energy, transport and tourism sectors a number of subsidies have been analysed to illustrate and test the method. In making the selection, attention was paid to the distribution among types of subsidies, their size, the expected impact on producing or consuming activities, and the relative environmental importance of the additional activity induced by the subsidy. Regarding agriculture, two producer subsidies were chosen (minimum prices for milk/dairy products, and the designation of land for agricultural purposes). One consumer subsidy was chosen (low rate of VAT on meat). In the energy sector, the exemption from Regulatory Energy Tax for large-scale users was selected as a producer subsidy. In the transport and tourism sectors, the exemption from excise duty for aviation fuels, the tax deduction for use of public transport in commuter traffic, the incomplete passing on of rail infrastructure costs, and the low return from the government's share in Schiphol Airport were analysed.

The applications show that sizeable indirect subsidies may bring about relatively large environmental impacts. This is particularly true for the subsidies provided through the energy tax, guaranteed minimum prices for milk and the designation of agricultural land. These subsidies interfere at an early stage in the production-consumption chain, allowing for a prolonged impact. The excise tax exemption for aviation fuels also has a substantial environmental impact. More limited environmental effects are reported for subsidies concerning tax deduction for use of public transport in commuter traffic, the passing on of rail infrastructure costs and the government's share in Schiphol Airport.

The cases show that the method has a number of advantages and disadvantages. The method's firm scientific basis, transparency and flexibility are advantages, as is the fact that it can be applied swiftly as an initial investigation of environmental impacts. The method is transparent because the influence of the different parameters is shown clearly and directly. It is also flexible because sensitivity analyses can be performed easily and refinements can be calculated to take into account specific circumstances. Thus, the method provides a useful framework for further policy analysis. If the consecutive steps are followed as set out in chapter 2, the method could in future be used by researchers or (inter-)departmental working groups in policy evaluations or in analyses of first order environmental effects of existing subsidy schemes, e.g. in an Interdepartmental Policy Analysis. Furthermore, the method could be used in *ex ante* policy evaluations to assess new forms of subsidy policy.

The method can be linked to equilibrium models, which reflect the impact of a subsidy on several markets and thus show the second order effects. It can also be linked to 'bottom up' models, which describe the possible reactions of producers and consumers to their choice between technical alternatives.

The limitations of the method relate mainly to the fact that it only generates first order environmental effects and that it is less suitable for the analysis of subsidies with environmental effects in a very complex policy context, such as in the case of the designation of agricultural land. This means that additional research is needed to further specify the environmental impact and to see whether the method can be further refined. In addition, the sensitivity of the results to the parameter values should be mentioned. This underlines the fact that careful and thorough research is needed to determine the parameter values accurately and within plausible boundaries. From this perspective, the establishment of a database is to be recommended with subsidies and elasticities that can be used in the policy process. Finally, it is recommended that policy priorities be assigned to subsidies according to their position in the chain and according to the level of the related elasticity of supply and demand.

1. Aim and scope

1.1 Introduction

Since the Earth Summit in Rio de Janeiro in 1992 it has become clear that the aim of sustainable development is not easy to achieve. This was also the conclusion of a Special Session of the General Assembly of the United Nations in 1997. In spite of agreements and principles such as those set down in Agenda 21, many governments do not make sufficient use of economic instruments in their environmental policy. Recent studies have even shown that existing public policy can be a significant obstacle to sustainable development.[1] This current policy covers measures in the areas of agriculture, traffic and transport, energy production and consumption, etc. It is difficult to determine what implications public policy in all of these areas has on the effectiveness of environmental policy. This problem is the point of departure for the present study.

The Dutch government is aware of the relevance of the problem. In 2000 it commissioned a study into the damage to the environment as a result of government subsidies in the Netherlands.[2] This study showed that, of the 550 *direct* subsidies granted by the State, 35 might be harmful to the environment. On the basis of eight cases it was concluded that the environmental impact of direct subsidies would be limited. The subsidies in question include individual rent subsidies, subsidies for regional road infrastructure and support for the building of new sea-going vessels. This earlier study focused in particular on direct subsidies, which can immediately be seen on the expenditure side of the government's budget. However, another study shows that the largest and most environmentally damaging subsidies are indirect.[3] The present study concentrates on the environmental impact of indirect subsidies in the Netherlands.

The aim of this study is to develop a method for determining the environmental impact of indirect subsidies. The point of departure is a typology of subsidies to cover the large number of different types. The large-scale subsidies will be considered first, on the assumption that these will often have extensive environmental effects. Then, the environmental effects in the Netherlands will be calculated. The restriction to the Netherlands means that no attention is given to the environmental consequences of abolishing subsidies.

An earlier study showed that the most extensive indirect subsidies at world and OECD level are mainly in the energy, agriculture and transport sectors.[4]

The method is tested by calculating the environmental effects of large-scale subsidies in these three sectors and in the tourism sector. This is in accordance with the request from the Minister of Housing, Spatial Planning and the Environment.

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1 See Van Beers and De Moor (2001).
2 Wit et al (2000).
3 De Moor and Calamai (1997).
4 See Van Beers and De Moor (2001).

To date no clear theoretical and methodological framework has been developed in economic and policy literature to analyse indirect subsidies. There are two reasons for this. First of all, it was only recently that the social relevance was recognised of government subsidies that have a negative environmental impact. Secondly, there are a large number of different types of subsidy. In order to give structure to our study, there is a discussion in the section below of what is meant by 'subsidies'. The types of subsidy are named in section 1.3 as the part of departure for our study. There is also a short discussion of the environmental impacts to be analysed. Section 1.4 deals with the definition of the energy, agriculture, transport and tourism sectors, which together serve as a methodological framework for the study.

1.2 Definitions

Subsidies can be divided into direct and indirect subsidies. Direct subsidies are visible on the expenditure side of the government's budget. Indirect subsidies, on the other hand, tend not to be recognised as subsidies at all. They comprise all kinds of government intervention: tax benefits for specific groups, minimum prices for agricultural products, financial guarantees such as export credit facilities, etc. There are various definitions that can be used in connection with analytical or policy considerations. A broad definition of a subsidy is normally used in the empirical literature (OECS, 1997; De Moor and Calamai, 1997):

Subsidies comprise all government measures that directly or indirectly keep consumer prices below or producer prices above free market level, or that reduce costs for consumers and producers.

We have chosen this broad definition for this study. This definition is consistent with the need to differentiate between producer and consumer subsidies and between subsidies that are and those that are not visible in budgets. The study focuses on the latter category, namely indirect subsidies.

When further defining the concept of a subsidy it is important to differentiate between policy failure and market failure. Policy failure refers to active intervention by government that interferes with the workings of the market mechanism and consequently leads to economic inefficiency. For example, exemption from energy tax for a specific group of producers leads to greater energy consumption than without the exemption. Market failure points to the absence of external costs in market prices. An active public policy is then necessary to internalise the external costs of, for example, negative environmental effects and to allow the market to generate prices that are in line with social demands.

In this study the lack of an active public policy to incorporate external effects is not classed as a subsidy. We therefore focus only on policy failure.[5]

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[5] If the lack of an active public policy is classed as a subsidy – as is usual when controlling imbalance in the transport sector – the results as regards subsidy effects and environmental effects will be significantly greater than those that are reported in this study. In that case, the results of this study might be classed as the lower bound of the actual extent of the subsidy and the related environmental effects.

For example, the fact that there is no tax on the use of space is not classed as a subsidy and the related environmental effects are not mapped. On the other hand, the total or partial exemption from energy tax for a particular group of producers or consumers or for particular types of energy consumption does qualify as a subsidy. Analytical considerations motivated the decision not to analyse the lack of active public policy to internalise external environmental effects. However, the method that is presented in this study is suitable for analysing the effects of a lack of the required active public policy.

Subsidies are used to achieve particular government aims. For example, keeping the family income of farmers at an acceptable level is an important aim of the European Union's agricultural subsidies. The achievement of this aim is a result or a benefit that is gained from the subsidies. Evaluation of the benefits falls outside the scope of this study. It is therefore not possible to entirely assess the positive or negative contribution of a subsidy to social prosperity and that is therefore not attempted in this study.

Subsidies aimed at achieving environmental aims are not considered either.

1.3 A typology of subsidies

Table 1.1 presents a classification of types of indirect subsidy that will be used in this study. The large number of different types of indirect subsidies is covered in this classification system, which can therefore be used as the point of departure for the development of a general method for analysing indirect subsidies. The typology will be applicable to any subsidy that is tested for the presence of substantial environmental effects. Differentiated tax systems, such as the Regulatory Energy Tax for small-scale but not for large-scale users or excise duty for road traffic but not for air traffic, are also classed as indirect subsidies.

Table 1.1 Taxonomy of indirect subsidies by type

Subsidy types	Examples
Tax subsidies	Subsidies in tax policy such as deductions, exemptions, special (zero) rates, preferential treatment, etc.
Public provision of goods and supplies below cost price	Infrastructure facilities and supplementary services
Capital subsidies	Preferential loans, loan guarantees, debt cancellation
Price regulation	Minimum and maximum prices
Volume restrictions	Regulations governing the minimum take-up of a particular product
Trade measures	Import regulations in the form of rules and quotas; export credit guarantees

Public provision of goods and supplies below cost price refers to goods and supplies that the government provides, e.g. a public road network, and that are actually provided below the cost price. For example, when new roads are built there is the question as to how far the cost of construction (including sunk costs) and of maintenance that are not passed on to the user lead to changed behaviour by the user that has an impact on the environment.

Capital subsidies are subsidies that result from policy aimed at offering loans that have an interest rate below market rate or that have generous repayment conditions. Debt cancellation is also a form of indirect subsidy. It is also classed as a subsidy when state enterprises or government investments are allowed to have a lower ROI (Return On Investment) than the market rate.

Subsidies can also be provided using the market mechanism, in which case there are no direct costs for the government. Such subsidies are in the form of minimum prices for agricultural goods (EU agriculture) that are paid by the consumer, or maximum prices that are achieved by price controls (e.g. on energy). Volume restrictions and preferential treatment for particular bidders in public calls for tender are also classed as subsidies. This category also covers government regulations that stipulate the use of a particular technology or of minimum volumes of a good or service in a production process. An example of this is the regulation that stipulates that German electricity companies have to use at least a certain volume of coal from German mines at a price that is above the (world) market price.

Volume restrictions and trade measures partly overlap. They are considered separately because trade measures can have a major impact on the functioning of a very open economy like the Dutch economy. In addition, trade measures such as import tariffs – which are classed in this framework as indirect subsidies to domestic producers – have been regularly discussed in recent years, especially in a GATT/WTO framework (see for example Van Beers and Van den Bergh, 1995). Furthermore, trade measures comprise not only import-related matters but also export credit guarantees.

1.4 Report structure

The report is structured as follows. Chapter 2 comprises the theory behind the study and discusses the relevant aspects of indirect subsidies that an analysis method must bring out. Simple formulae or rules are then presented for the different types of indirect subsidies. These formulae are presented in mathematical form in Appendix I.

Chapter 3 gives an overview of the existing subsidies in the four sectors considered: agriculture, energy, transport and tourism. The method is tested in chapters 4 to 11. The environmental effects of a number of indirect subsidies in the Netherlands are calculated for each of the four sectors mentioned.

The cases that are studied for the agricultural sector are minimum prices for milk, the low rate of VAT on meat and the designation of land for agricultural use. The case considered for the energy sector is exemption from Regulatory Energy Tax for large-scale users. The cases considered for the transport and tourism sectors are as follows: exemption from excise duty on aviation fuel, tax deduction for use of public transport in commuter traffic, passing on of rail infrastructure costs, and the low return from the government's share in Schiphol Airport. Subsidies in the tourism sector mainly concern tourist transport. That is why the transport and tourist sectors are considered together in the case studies.

In Chapter 12 there is a discussion of the results of the case studies and the suitability of the method.

2. Development of a method

2.1 Introduction

In this chapter a method is developed for determining the environmental effects of subsidies. Attention is given to conceptual, theoretical and modelling aspects. The scientific literature only pays sporadic attention to subsidy analysis, either in terms of the public economy (including economic analysis of public finances and public policy) or in terms of the environment (the most important themes being analysis of the environmental effects of economic activities, the choice of instruments in environmental policy and the financial representation of environmental impact).[6] All empirical studies into the consequences of subsidies are based on the relationships between changes in relative costs and profits on the one hand and production and consumption choices by the beneficiaries on the other. These relationships are hidden in all kinds of assumptions and laws of economics that are locked into the models that are used, particularly in OECD studies. There are few publications that provide the starting point for a more general theoretical presentation of the effect of subsidies on the environment. The following are exceptions: Van Beers and Van den Bergh (2001), Van Beers and De Moor (2001), Wolfson (1996) and OECD (1998, 1999).

The aim of this chapter is to develop a transparent integrated method for determining the environmental effects of indirect subsidies. The method proposed here is based on a classification of indirect subsidies as discussed in the previous chapter. The method encompasses everything: framework, scope of the analysis, quantification and presentation, as well as the relationship between these various elements. We have separated out the scope of the analysis and quantification using models or analysis techniques to provide clarity about the points of departure and possible interpretations of the applications in later chapters.

This chapter is structured as follows. In section 2.2 a conceptual framework is set out. Section 2.3 gives an economic analysis of subsidies, which breaks down into an overview of possible economic effects and the methods that are available for analysing those effects. The environmental impact analysis is set out in section 2.4, again broken down into effects and methods. This is used as the basis for presenting the choices in section 2.5 as regards integrated methods for an environmental impact analysis of indirect subsidies. Special attention is given to the need for and the availability of information.

There is then a discussion of a classification scheme that allows incorporation of both qualitative and quantitative (including calculated) indicators for each subsidy that is considered.

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6 For example, the standard textbook by Atkinson and Stiglitz (1980), in which the theoretical analysis of taxes is explained, hardly devotes any attention at all to subsidies. Although some subsidies can be seen as negative taxes, those are only some of all the possible subsidies (see Table 1.1).

2.2 Conceptual framework

The framework is based on a chain of effects that starts with a subsidy and ends with an environmental impact. A formal presentation of this chain can be found in Appendix I. It follows from the basic model that the environmental impact of a subsidy is determined by the level of the subsidy, the reaction to the subsidy in terms of producer and/or consumer behaviour, and the degree of pollution that comes from the sector concerned. However, there are all kinds of factors that make the basic model more complex, such as autonomous or externally induced changes in use of the means of production, technology, and autonomous economic changes (shift in demand). When analysing effects it is also essential to know the point of application of a subsidy. There are subsidies for producers where the point of application is on the supply side of the market, and subsidies for consumers where the point of application is on the demand side of the market (see also definition in Chapter 1).

When determining the environmental effects of subsidies, multidisciplinary or integral modelling of a chain of effects through the economy is required, starting with a subsidy and ending with an environmental impact. Figure 2.1 gives an overview of the steps to follow to take account of all types of subsidies and all economic and environmental effects.

These steps are:

Step 1: The very first step is to determine the type of subsidy, partly because the type of subsidy says something about how to quantify it. For example, indirect subsidies such as indirect tax measures directly affect prices, whilst volume restrictions primarily affect the volume of supply or demand. The typology of subsidies that is used is that given in chapter 1.

Step 2: The size of a subsidy is determined using a quantifiable indicator. This indicator can be an amount of money (prices or cost savings) or a volume of a product expressed as a functional unit or in physical terms (e.g. kg). If it is not possible to quantify the subsidy, this does not necessarily mean that the analysis of that subsidy will only provide qualitative information. This is particularly true of the discrete effects of subsidy choices. For example, if a production subsidy results in another production technique, then a comparison of the environmental effects of the different techniques will provide information about the environmental impact of the subsidy, even if this information is not quantified (or is only quantified as a 0-1 variable).

Step 3: The policy environment will have to be analysed if policy measures and the institutional context have a demonstrable effect on the environmental impact of the subsidy. One example from our study is the combination of quotas and guaranteed prices for milk in the agricultural sector.

Step 4: The economic effects of the subsidy are determined. An overview of the possible effects and methods is given in section 2.3.

Step 5: Relevant parameters are quantified. If these cannot be derived immediately from previous studies then further research is required. For example, price elasticities that incorporate effects on several markets might be determined using applied general equilibrium models that describe the interactions between the relevant markets.

Step 6: The (relevant) environmental effects are calculated. An overview of possible effects and methods is given in section 2.4.

Step 7: Finally, a sensitivity analysis will have to be performed in which another interpretation of the parameters will give insight into the reliability of the calculated effects.

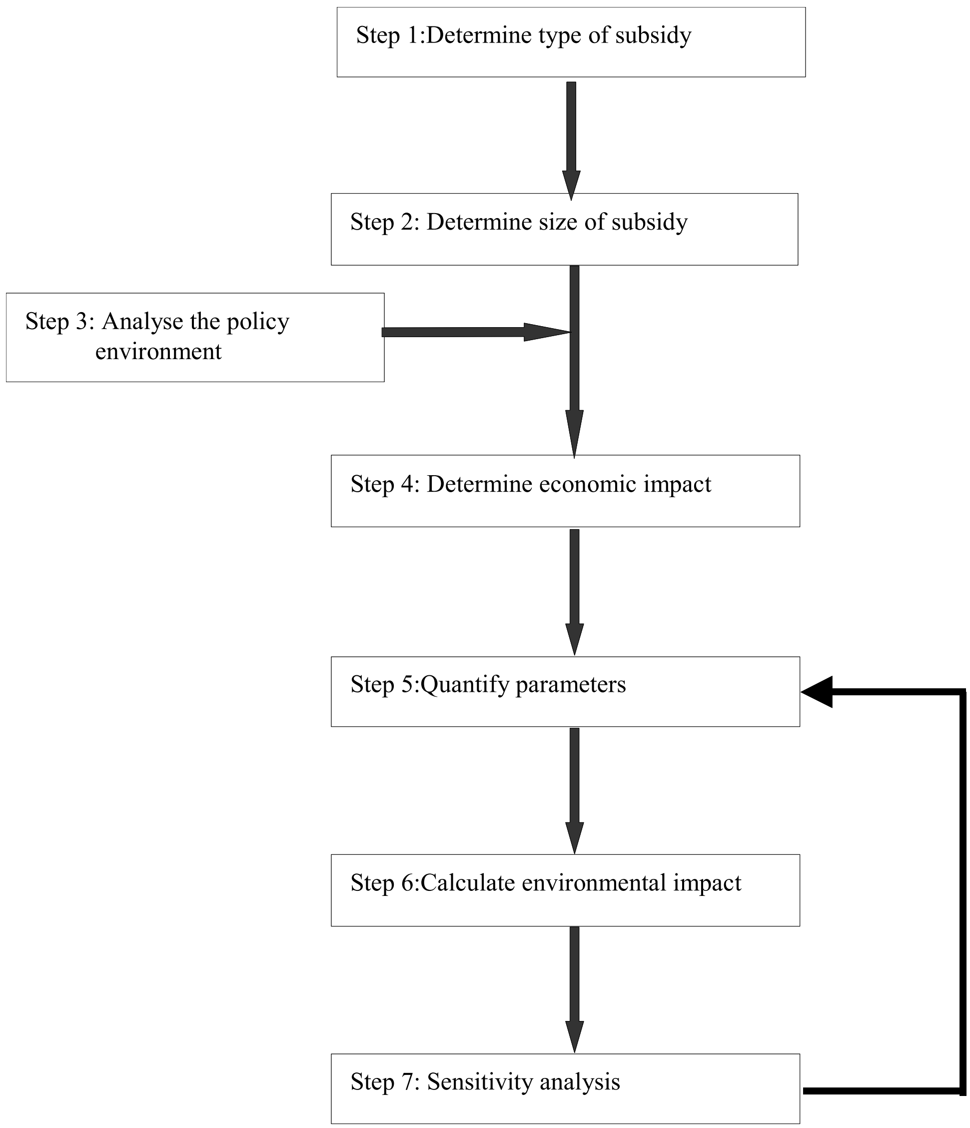

Figure 2.1 Framework for determining the environmental effects of indirect subsidies.

2.3 Determining the economic effects of subsidies

2.3.1 An overview of possible economic effects

This section considers the economic effects of a subsidy, with a specific focus on changes in economic variables that are directly related to environmental effects. These changes can be outputs, inputs or production techniques.

Subsidies can have various points of application: costs, proceeds, profit, inputs, outputs, demand, supply, prices or volumes, techniques, etc. This means that different approaches are required for an analysis.

In our study we have chosen to differentiate between indirect subsidies for producers and indirect subsidies for consumers. We will also look at the scope of the effects.

Indirect subsidies for producers

On the supply side, the first effect of a subsidy is reflected in the behaviour of the decision-makers in companies or within a sector. The main question is what the consequences are for inputs, technology and output (scale of production or volume). Technology is seen as being related to the production process within a company, particularly the process technology. The inputs that have an effect on the environment are energy, raw materials and equipment, as well as land and water (especially in the agricultural sector). A subsidy that affects the cost of using raw and auxiliary materials (or particular machines) can make one technique a better choice than another. Capital subsidies and R&D subsidies usually allow more freedom in terms of choice of techniques, but even they can impose one particular technique – explicitly or implicitly – which may have consequences for the environment per unit of produced output.

At company level it is possible to determine whether a specific subsidy affects the prices of inputs or outputs, costs or profit. Some subsidies have a direct effect on the prices of inputs or output, whilst others have an indirect effect on prices, for example through costs or volume restrictions. A subsidy on an input will have a relatively small effect on the output if the non-subsidised inputs are essential or irreplaceable (there are no substitutes) and the price elasticity of the demand for the end product is low, or if the input is only a small part of the overall marginal costs. Such a subsidy primarily affects profit. Where there is a substitute there will be a shift in the input mix from a non-subsidised input to the subsidised inputs. Depending on the price elasticity of the demand for the end product and the size of the subsidy in terms of its effect on the marginal costs, there can be a significant output effect.[7] If a subsidy on an input stimulates or imposes the use of a particular input and the effect on the prices of the end products of the company concerned is small, then the analysis should focus on the relevant factor market.

In addition to the substitution possibilities between and within input factors, the economic effect also depends on the type of output and input markets. For example, where there is a lot of competition on the sales market a capital subsidy via a soft loan or low return on investments might lead to lower output prices, a demand for greater volume and consequently to increased production. It will be very difficult to trace or quantify the effect of capital subsidies because it runs through the 'black box' of investment decisions – where uncertainties, coincidence, subjectivity and dynamic aspects dominate.

A capital subsidy, or a subsidy on a particular type of capital goods, is a subsidy on a company's fixed costs. These subsidies permeate slowly through the sector in question. Capital subsidies allow a lot of room for manoeuvre as regards the choice of production process, and are therefore not as harmful to the environment. Conversely, if these

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7 Sometimes this might even happen within a subset of production factors – take the energy input mix, for example. Such a substitution effect can have major environmental consequences, even if the sale of the end product is hardly affected by the subsidy.

subsidies are abolished the 'environmental benefits' are not felt until much later. In most cases where these subsidies harm the environment it is because they lead to new development work or are given to polluting industries that have a long technical life.

In contrast, subsidies on variable costs result in immediate consequences for production decisions. Such subsidies on energy, equipment and water immediately discourage the innovation that would lead to more economic consumption. This has far-reaching environmental consequences because it is precisely the extraction of raw materials and energy and the manufacture of equipment that are among the most polluting economic activities. Given that the use of certain raw and auxiliary materials often also means that only one or a small number of techniques can be used, subsidies on equipment, energy and water also lead to 'lock-in effects'. These cases can also be explained as subsidies on certain types of capital goods. In addition, there is also a category of subsidies on fixed costs that have a major environmental impact. These are subsidies without which an entire economic activity would not start or take place. A capital subsidy on new development work in the mining industry is one example.

In principle, it is possible to consider that almost all indirect subsidy effects take the form of price changes. In this regard the notion of a shadow price is relevant. A 'shadow price' is the change in costs that can be achieved in production by moving at a given level of production to an input other than the one to which an indirect subsidy is applied. In the case of a subsidy through volume regulation on a (domestic) input a producer is forced to use more of this domestically produced input than is economically efficient.[8] This will make the production costs higher than without the subsidy and this is the 'shadow price'. A tax exemption on an energy-intensive input for example is also the shadow price of that input. However, in the case of a tax exemption that has a general effect on profit it is less clear how the economic effect is reflected in price, especially when a company produces several products. In that case the effect depends on the producer's internal cost-distribution code.

This code is partly determined by competitive relationships on the input and output markets. For example, if the output market is very competitive, the producer will be quick to reflect the tax exemption in the prices of the end products.

A subsidy on the output price immediately affects the proceeds from the product, which has a significant impact on both the volume demanded and the volume supplied and thereby also on the volume of inputs that are required to meet the demand.

Guaranteeing a minimum price, e.g. for primary agricultural products in the EU, gives the producer a direct and strong (price) incentive to increase production in order to obtain maximum profit from the subsidy. Minimum prices have far-reaching economic consequences and invite a chain of subsidies. One direct consequence is that excess (supply) is created and new subsidies are required to transport and store this excess, which is then eliminated by selling it to domestic consumers or on export markets with yet more subsidies. Furthermore, a system of minimum prices can only be maintained if import barriers are raised to keep out cheaper products from foreign competition.

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[8] In this case mandatory regulations are required because substitution through import or other inputs would be cheaper (see the example of the coal mines in Germany).

Ultimately such output price subsidies can even lead to a change in the production structure and a 'lock-in' of subsidised activities (see below). A minimum price subsidy is often part of a more complex policy package, e.g. with volume regulation to avoid excess supply.

Indirect subsidies for consumers

Following on from the above overview of the impact of subsidies on producers, we now turn to subsidies for consumers or the demand side of the equation. This can be seen in particular in the 'transport' sector. In general, price effects on consumption can be investigated by looking at market prices, incomes or substitution effects.

In accordance with market forces, a subsidy in the form of a maximum price has an immediate effect on demand. The output price is lower and consumers will therefore increase demand. Subsidies via indirect taxes, such as no VAT on airline tickets or exemption from excise duty on kerosene, are also directly reflected in the end prices and therefore have a direct effect on the volume demanded.

Subsidies via income tax measures affect both income and the shadow price and therefore have a strong effect on demand. Tax exemption for a particular activity, such as the former flat rate allowance for commuting between home and work, leads not only to a high net income but also to a reduction in the costs of the activity in question. The shadow price therefore ends up lower and as a result there is a greater volume of commuter traffic (see below). In this specific example of the flat rate allowance for travel costs, the subsidy may even lead to people going (or continuing) to live further away from work, which is a form of 'lock-in' of subsidised activities (see below).

Subsidies via income tax also have another indirect effect, namely on distribution of income. Taxes are partly intended to affect the distribution of income, but subsidy measures can undo these envisaged effects and promote inequality of income. Subsidy measures in progressive tax systems in particular can have this effect. However, an analysis of this effect is beyond the scope of this study.

Scope of the effects of indirect subsidies

It is also necessary to look at the extent to which subsidies have partial and limited or significant consequences.

For example, the interim or ultimate demand for a product may be significantly affected as regards size or composition, or the sector structure may change (the 'technology' above company level). In such cases a partial analysis might not offer enough insight.

Some economic effects take time since a lot of changes come about through investments. A dynamic breakdown is necessary before aspects such as tax deduction for investment in capital, write-offs and interest payments can be adequately analysed.[9] Gradual discarding of obsolete technology, write-offs, future expectations, accumulation of capital, and long-term environmental effects then give the analysis a dynamic character.

If anything, the effect of a subsidy that leads to a 'lock-in' of activities is even more complex. The term 'lock-in' indicates that an unwanted or less than optimum technology

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9 See Atkinson and Stiglitz (1980, chapter 5) for more details.

or method of production dominates as a result of a historical process of self-organisation ('path dependence') based on coincidences ('historical accidents') and positive backward coupling. The latter is indicated by increasing proceeds and can be caused by processes on the demand and supply sides of the economy.[10] Subsidies can tip the balance in historical development to a 'lock-in' of an unwanted method of production by affecting or even strengthening specific increasing proceeds. For example, the price subsidies in agriculture have led to a gradual shift in the production structure. Specific capital subsidies that are accompanied by technological requirements have a stronger lock-in effect than generic capital subsidies, which reduce loan costs for example but leave companies free to use the resulting extra financial scope as they see fit. Significant lock-in effects also result from sunk costs. For example, if the government decides to build a (subsidised) coal-fired power station (or have one built) that station will be there for the next 40 or more years. As a result of the accompanying sunk costs it will remain cheaper throughout that period to continue to use the station than to transfer to a gas-fired power station or to another alternative.

Furthermore, a lock-in makes it very difficult to change the existing situation; modifications require not only 'correct prices', they also require additional policy. Although the lock-in effect is the most important long-term consequence of subsidies, it is very difficult to quantify. This is because it would have to be possible to repeat all of the historical complex technological changes and changes in sector structure without subsidies. A model would involve too many unverifiable assumptions. It might be possible to gain some insight in specific cases from a comparison between countries with different systems and development patterns.

However, this presumes an extensive *ceteris paribus* clause. A good point of departure may well be that quantifying the environmental effects of subsidies with lock-in effects will generally lead to a lower bound of the actual environmental effects, since the impact of the lock-in will be overwhelmingly to strengthen the change caused by the subsidy. This is because subsidising a polluting activity can lead to all kinds of investments and R&D being re-directed in favour of the activity concerned, as well as to so many consumers consuming the product that a positive external demand effect occurs – because of fashion, reputation, and network effects such as with (Internet) software or mobile phones. The specific environmental effects of the subsidy will in this case be greater with than without the lock-in, since the result is an increase in the volume of the product to which the environmental effects are related.

2.3.2 Methods for an economic effects analysis and their suitability

This section gives a brief overview of possible operational methods for analysing economic effects. It is essential with all the methods that they provide information about the change in output or specific inputs that is caused by a subsidy. The choice between

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[10] Examples are network externalities (telecommunication), imitation (fashion), information externalities (more users generate more awareness), mass production (lower production costs) and technological complementarities such as infrastructure and sub-technologies (e.g. petrol-driven cars, refineries, filling stations). See also David (1985) and Dosi et al (1988).

output, input(s) or a combination of the two depends on what the relevant environmental effects most directly relate to.

One significant limitation of economic effects analysis is that assumptions have to be made about producer behaviour. A description is required of how decisions are taken and how these choices would be different if there was no subsidy. The dominant model in economics is that from neo-classic theory, which assumes that producers maximise their profit given a known production function. Other points of departure are possible, but it is difficult to translate alternative behavioural hypotheses into quantifiable models and we will therefore not consider this further.[11]

General equilibrium models

There are a number of methods or approaches when performing an economic analysis of subsidies. In theory, a general equilibrium or macro-economic analysis is comprehensive. Such an analysis covers direct and indirect economic effects, both static and dynamic and with all possible forward and backward coupling. That means factors such as technology, sector structure, composition of the ultimate demand, long-term environmental effects and possibly also lock-in of activities, as described in the previous section. However, even a general equilibrium model has its flaws; there are limitations, which include those that result from extensive assumptions about behaviour, market equilibriums and 'model closure', as well as those that result from the use of ad hoc 'benchmark data' and the lack of a thorough econometric basis. The development and application of a general equilibrium model, therefore, is beyond the scope of the present study.

METR and an elasticity approach

Another method that is often used to analyse economic effects is the partial equilibrium analysis. One example is the so-called 'Marginal Effective Tax Rates' (METR) method.[12] METR closely follows the model set out in Appendix I, in other words a company seeking to make a profit whose decisions about inputs and level of production are affected by the prevailing tax and subsidy system. METR is the additional amount of tax to be paid on the last unit of taxable input or output. This is a marginal measurement scale that can be used to determine behavioural reactions. The METR approach can be used to investigate the combined effect of subsidies and taxes. In this method subsidies are treated as negative taxes.

An approach based on elasticities is close to an METR analysis. Appendix I presents a discussion of the technical aspects of such an approach, which can be based on relationships between the input prices of products and supply as a point of departure for determining an environmental effect of a subsidy. If the subsidy relates to output prices, information about inputs can be ignored. This implicitly assumes that the input mix is not affected by the subsidy. The approach proposed below is in keeping with the METR and elasticity approaches (see also Appendix I).

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11 See Van den Bergh et al (2000) for another approach. Its relevance has been shown in connection with energy savings made by companies; cf. De Groot et al (2001).

12 See for example McKenzie et al (1997 and 1998).

Neo-classic maximisation of utility

The theoretical point of departure in an analysis of demand, i.e. an analysis of the effect of indirect subsidies on consumer behaviour, is the neo-classic model of maximisation of utility. Empirical relationships are usually specified immediately at the level of relationships in demand, which are affected not only by the price of the product and prices of related products, but also by socio-economic factors such as family size and composition, family income, double-income households, education and type of job. Elasticities are available from earlier studies to summarise consumer behaviour.[13]

AETR

Another model is the 'Average Effective Tax Rates' (AETR) method. This method is based on the evaluation of cash flows, and more specifically on the total amount of taxes to be paid divided by the total value of the taxable input or output. This gives a scale for measuring the average burden of taxation, which is however less suitable, according to standard economic theory, for describing the behavioural reactions of producers. This is because marginal costs have a more direct relationship with the optimum production volume of separate companies than average costs, which affect a company's profitability. The marginal cost curve and with it the volume supplied in the short term are indeed affected by a subsidy on variable costs but not by a subsidy on fixed costs. A subsidy on fixed costs only reduces the average costs and will therefore only affect longer-term decisions.

Bottom-up models

Bottom-up models are based on a collection of technique or process descriptions grouped around the contributions that they make to satisfying a particular category of demand. Optimising methods are used to determine, within the given limiting conditions, the combination of techniques and processes that meet this demand at the lowest cost. The limiting conditions can include maximum emission volumes or technical and economic conditions such as the time required to realise the techniques and processes, and any rules that apply. These models can be used to check what effect a subsidy has on the choice of the techniques and thereby also on the environmental effects of those techniques. Such models need a lot of data about the techniques in question, which is why we have not used them in this study. However, the method used here would be suitable for use in combination with these bottom-up models.

Points of application

When developing an analysis method to determine the environmental effects of subsidies it is important to first determine the point of application of a specific subsidy in the chain of activities and markets. This also raises questions like what direction the dominant economic effect of the subsidy takes – down the chain or up the chain – and where the chain of economic effects ends, within an acceptable margin of error.

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[13] See Ferrer-i-Carbonell et al (2000) for a recent overview of elasticities for the energy and traffic & transport sectors.

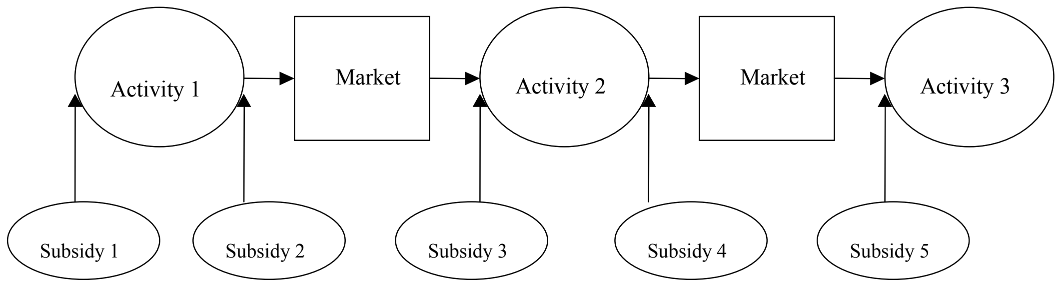

Figure 2.2 Possible points of application of subsidies in the economic chain of activities and markets

Figure 2.2 shows the chain of activities and markets. We have chosen a chain with three activities, as it offers a general framework that can be used to describe both intermediate deliveries between companies (Activities 1 and 2) and final products to consumers (Activities 2 and 3). Activity 1 might describe a process in which natural resources (e.g. natural gas) are used directly.

Communication between one activity and another is via a market, i.e. the markets are situated between the activities. The subsidies can therefore be applied in different places. They can be applied to each of the activities, as well as to the input or output side of a specific activity.

Both the inputs and the outputs can include production factors – some of which are directly related to environmental effects (e.g. fossil fuels) – or final goods and services. This relates to markets for production factors, intermediate products and final goods and services. Note that if Activity 3 refers to a consumer, the chain ends there and a subsidy is therefore only possible on the input for this final activity (consumer subsidy).

The points of application for subsidies as indicated in Figure 2.2 can be illustrated as follows:

- Subsidy 1: Special tax conditions for fuel and technology used in drilling for natural gas, designation of land for agricultural use within the framework of spatial planning;
- Subsidy 2: A minimum price or an export subsidy for natural gas (notional);
- Subsidy 3: Exemption from excise duty on kerosene, which is an input for airline companies; not charging NS for the use of rail infrastructure; low return on the government's share in Schiphol Airport; reduced rates of Regulatory Energy Tax on cultivation under glass (in this case A1 refers to production of natural gas, A2 to horticulture and A3 to consumers and export of horticultural products);
- Subsidy 4: Minimum prices for milk;
- Subsidy 5: Flat rate allowance for travel costs; reduced rate of VAT on meat.

Note that a relatively large number of subsidy types have a point of application as indicated for Subsidy 3, i.e. they are subsidies on an input to a production activity.

The above framework can then be used as the point of departure for an analysis that uses concrete quantity indicators. This relationship can be illustrated using the elasticity method. The information required is where the subsidy is applied, to what product of what activity, and on what market. The elasticity can be chosen to take account of the relevant end of the chain. In this connection it is important to understand that the extent and interpretation of an elasticity depend on the empirical database from which the elasticity is calculated. For example, if it is implicit that changes have been included further along the chain, then the extent of the elasticity will be greater than if this is not the case. By way of example: an elasticity can be calculated for determining the economic consequences of no excise duty on kerosene with or without the following being taken into account:

- The reaction of the kerosene suppliers;
- The reaction of the passengers to higher ticket prices;
- The effect that the higher travel costs have on the rates charged by travel agencies;
- The substitution between transport modes.

The more the data implicitly includes such processes, the more of the relevant chain will be covered by the resulting elasticity.

2.4 Determining the environmental effects of subsidies

2.4.1 Relevant environmental effects

In order to arrive at an estimate of the environmental effects of subsidies it is first necessary to consider the relationship between the economic effects as discussed above on the one hand and the relevant environmental effects on the other. The environmental effects can be coupled to the inputs or outputs. Where possible we will assume a fixed relationship between outputs and environmental effects. The environmental effects will be aggregated to form theme indicators.[14] The environmental effects that are relevant for this study are as follows:

1. Increased greenhouse effect: we will focus in particular on carbon dioxide (CO_2), as this is relevant for energy and transport. For the agricultural sector methane (CH_4) and nitrous oxide (N_2O) emissions are also relevant;
2. Acidification: NO_x and SO_2 emissions are particularly relevant for the energy and transport sectors; NH_3 emissions are particularly relevant for agriculture;
3. Photochemical creation of ozone: emissions of volatile organic compounds (VOC) and carbon monoxide (CO) occur in particular in transport. NO_x emissions are also important;

[14] These indicators are based on the Environmental Performance Indicators (EPI) method. See VNCI (2001).

4. Eutrophication: phosphates, nitrates, BOD and COD. The phosphates and nitrates in particular are relevant in the agricultural sector;
5. Land use: although land use is not an environmental impact indicator, its impact is important in the agricultural sector. It also plays a role in discussions about possible indicators for biodiversity.

In choosing the above effects for this study we are focussing on the most important environmental problems as indicated in the National Environmental Policy Plan 4 (NMP 4). The decision to limit this study to the effects on the most important environmental themes is motivated mainly by practical considerations; if the method works, more indicators can be added in a subsequent study, such as depletion of the ozone layer, human and ecological toxicity, soil water and groundwater pollution, noise pollution, odour nuisance, safety, waste, and groundwater pumping (see VNCI, 2001).

2.4.2 Methods for an environmental effects analysis and their suitability

The environmental effects analysis translates the economic effects – on inputs or outputs – into environmental effects. This is done using various previous studies and files, including those that are available at the National Institute for Public Health and the Environment (RIVM).

Aggregation to form theme indicators is done by using weighting factors as reported in VNCI (2001). It is then possible to calculate Environmental Performance Indicators (EPIs). EPIs are formulated in terms of potentials (such as global warming, acidification and eutrophication). This is done as follows. Each type of emission (in kg/year) in a particular category – e.g. CO_2 in the case of global warming potential – is multiplied by a (unique) weighting factor. The results for all types of emissions within each category are then added together, which gives the EPI for that category. This gives the following formula for calculating the environmental impact j if this is based on n(j) separate emission types (see also Appendix I):

$$EPI\ (j) = \sum_{i=1,\ldots,n(j)} (emission\ type\ j, i) \times (weighting\ \ factor\ \ j, i)$$

Note that it is possible, in principle, for the emission of a particular substance to contribute to several EPIs to which different weighting factors apply. Appendix II contains an overview of the weighting factors used.

Figure 2.3 summarises the economic and environmental effects of subsidies.

2.5 Description of the method

2.5.1 Decisive factors per subsidy type

In order to develop a more detailed view of the environmental effects of subsidies we will take as a starting point the subsidy types as determined in chapter 1 (see also Table 2.1). Tax subsidies change the prices of outputs or inputs, which generally leads to a reduction in price. Public supply of goods below cost price leads to reduced costs and therefore to changes in the relative prices of inputs. Capital subsidies result in more profit and possibly in more output or more investments for a private company. Price regulation results directly in different prices. Volume regulation results in a different input mix and different shadow prices. Trade measures in the form of import restrictions result in less overall supply such that there is relatively more demand for the domestic supply, i.e. the price will increase and with it the profit for the companies involved. Export subsidies increase profit for the domestic producers and may increase the overall supply or reduce domestic supply.

Appendix I contains a formal analysis of the environmental effect of different types of subsidies. These different cases are presented in more detail below, whereby the following are derived for each case:

- The determining variables for the environmental effects;
- The relationship between the variables, i.e. how the various data have to be combined to derive the environmental effect.

From this it also follows which data are required to apply specific methods and further develop the above. The availability of data is the main factor that determines whether more or fewer variables are analysed and which model must be used.

Table 2.1 indicates the determining factors per subsidy type, both with and without all data being available.

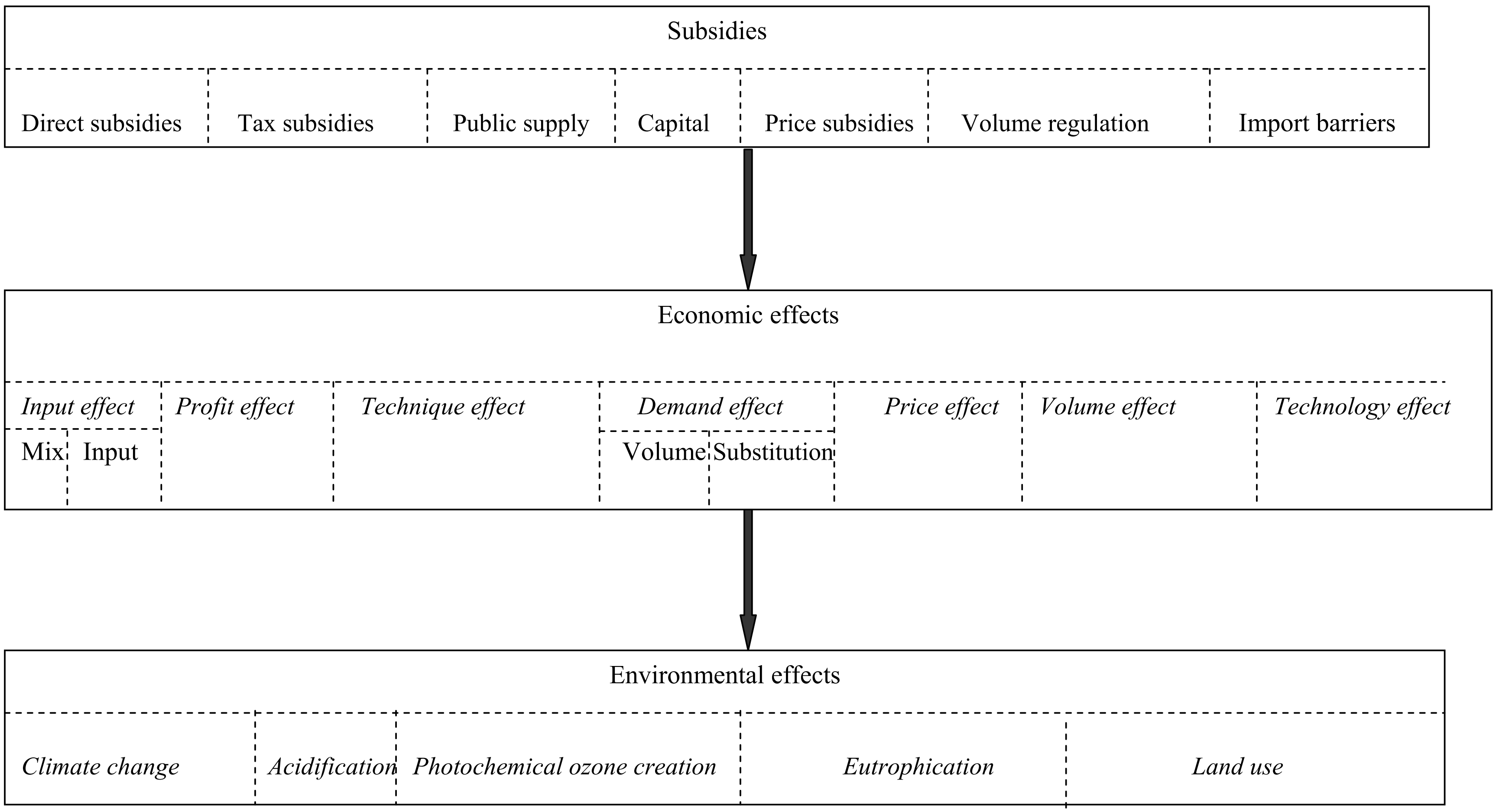

Figure 2.3 Overview of economic and environmental effects of subsidies.

Table 2.1 Factors that determine environmental effects, per subsidy type and according to availability of data

Type of subsidy	With all data available	With some data not available
1. Subsidy in the form of reduced input prices	Size of subsidy Parameters of production function Size of relevant input Output price and input prices Degree of pollution from production	
2. Subsidy on inputs in the form of tax measures (tax subsidies)	Size of subsidy Price reaction in demand Output price reaction in supply Input price reaction in supply Degree of pollution from production	
3. Subsidy on outputs in the form of tax measures (tax subsidies)	3.a. Production Size of subsidy Price reaction in demand Price reaction in supply Degree of pollution from production 3.b. Consumption Size of subsidy Demand effect of the subsidy Degree of pollution from consumption or production of consumed product	3.a. Production Size of subsidy Price reaction in equilibrium volume Degree of pollution from production
4. Public supply below cost price	Idem 1	
5. Capital subsidies	Formal analysis problematic	
6. Minimum prices	Currently supplied volume Demanded volume at free market price Degree of pollution from production	Currently supplied volume Demanded volume at world market price Degree of pollution from production
7. Volume regulation	Idem 6	
8a. Import barriers (trade measures)	Idem 7	
8b. Export credit guarantees (trade measures)	Formal analysis problematic	

A number of aspects summarised in the Table are presented in a little more detail below, and extensively in Appendix I. Note that all approaches are based on information about marginal costs. This is consistent with the fact that all the subsidy types in the Table affect the marginal costs of production or the marginal utility of consumption of a particular product.

1. Subsidy in the form of lower input prices – technology effect is dominant

If detailed information about production functions is available, such as with regard to energy and agriculture, the environmental effects of subsidies that are applied to the prices of input factors are determined by five variables:

1. The size of the subsidy
2. The parameters of the production function
3. The size of the relevant input
4. The output price and input prices
5. The effect of the relevant inputs and output on the environmental impact.

The formulae that play a role here are in equations (2), (3) and (16) to 23 in Appendix I. Sub-methods 2 or 3 should be used if effects on factor or product markets are relevant.

2. Subsidy on inputs in the form of tax measures – effect of factor market is dominant

In the case of tax exemption on an input factor in a production process the increased environmental impact depends on five variables:

1. The size of the subsidy
2. The price reaction of the demand (D_p)[15]
3. The output price reaction in the supply (S_p)
4. The input price reaction in the supply (S_{w*})
5. The degree of pollution from production (Z_q).

Equation (41) in Appendix 1 indicates the relationship between these variables.

3. Subsidy on outputs in the form of tax measures – effect of product market is dominant

3.a. Production

A tax exemption on the price of an output has an effect on the environmental impact of production according to four variables:

1. The size of the subsidy
2. The price reaction of the demand
3. The price reaction in the supply

[15] The following is meant by 'price reaction of the demand': the absolute change in the demanded volume that occurs in reaction to a given price change. The following is meant by 'price elasticity of the demanded volume': the relative change in the demanded volume as a result of a relative price change of 1%.

4. The degree of pollution from production.

Formula (34) indicates the relationship between these variables. If separate information is not available about supply and demand, the effect of the subsidy will depend on four variables (see formula 35):

1. The size of the subsidy
2. The price elasticity of the equilibrium volume
3. The equilibrium volume and price
4. The degree of pollution from production.

3.b. Effect of subsidies on consumer decisions (transport)

The extent to which tax affects the environmental impact depends on the following variables (see formula (53) in Appendix I):

1. The size of the subsidy
2. The effect of the subsidy on demand. This effect depends on the assumed functional specification of the utility function. It is also possible for a subsidy to produce cross-effects, in which case the effects must be added together. However, this will not be that relevant in practice since the cross-effects are relatively small compared with the 'own' effects;
3. The degree of pollution from the consumption or production of the consumed product to which the subsidy applies.

4. Public supply below cost price

This amounts to determining the effect of a reduction in the input price and involves using the approach indicated under point 2.

5. Capital subsidies

It is very difficult to quantify the economic effects, and consequently the environmental effects, of capital subsidies. This is because these subsidies change the conditions in which companies take decisions about investments. Since these decisions are taken against a background of uncertainty and generate dynamic effects, it is not possible to analyse corporate decision-making as pursued in the Appendices. The specific expertise and information on such effects may well be available in the field of corporate financing, but a more detailed analysis is outside the scope of this study. Only in specific cases is it possible to carry out an analysis using a different approach. For example, in the case of low return on the government share in Schiphol Airport (see chapter 11) the indirect subsidy is in the form of low airport charges, which makes it possible to carry out an analysis using approach 2 based on a tax on an input.

6. Minimum prices

The extent to which minimum prices affect the environmental impact depends on the following variables (see formula (54) in Appendix I):

1. Supply at a guaranteed price, or in the current situation.

2. Supply at the free market price. This requires a hypothetical situation, which, in some cases, can be based on the application of simple rules such as price change multiplied by elasticity, or on earlier studies (e.g. with CGE models). Note, where the world market price is not equal to the domestic free market price, that the supply at the world market price is relevant. It is very difficult to determine the free market price if there is no world market price or when a hypothetical national free market price applies.
3. The degree of pollution from production.

7. Volume regulation

Since volume regulation and minimum prices usually go together, the method as described under point 6 can be used here.

8. Trade measures

8a. Import barriers

The same applies here as under 7 since import barriers are a special type of volume regulation.

8b. Export credit guarantees

Export credit guarantees are a type of subsidy the effects of which are very difficult to quantify. As under 5, it is a question of the effect on behaviour in an uncertain situation. It is difficult to determine the result as regards additional polluting production or supply.

2.5.2 Classification of the results

The analysis of the environmental effects of subsidies in the following chapters is presented in a systematic way, as indicated in Table 2.2.

The first heading covers a number of qualitative facts as background information. For this purpose the most important characteristics of the studied subsidy are described: what is the activity in question, what environmental effects can occur and, where applicable, what policy has a significant effect on the relationship in question.

The second category covers quantitative facts that are to be reported, including the size of the subsidy in financial or physical terms, quantification of the parameters, calculation of the environmental effects and a sensitivity analysis. The method used is also briefly described. A sensitivity analysis is optional.

Finally, comments about limitations and relevant studies are included where necessary.

Note that under 1.2 (the directly stimulated activity) the economic sector that directly causes the relevant environmental effects does not necessarily have to be named. For example, an analysis of the Regulatory Energy Tax can focus in the first instance on the demand side since that is where the subsidy is applied.

Table 2.2 Structure for the presentation of applications

1. Qualitative information
   - 1.1 Description and type of subsidy
   - 1.2 Directly stimulated activity
   - 1.3 Environmental effects
   - 1.4 Policy context

2. Quantitative information
   - 2.1 Method
   - 2.2 Size of subsidy
   - 2.3 Quantification of parameters
   - 2.4 Calculation of environmental effects
   - 2.5 Sensitivity analysis

3. Comments

In that case, therefore, energy users such as glasshouse horticulturalists and energy-intensive industries are considered. Nevertheless, the direct originators of the environmental effects can be other players, e.g. the energy producers.

2.6 Conclusion

The aim of this study is to develop a transparent method for determining the environmental effects of indirect subsidies. In this chapter we have defined the range of choices as regards possible economic and environmental effects. In accordance with the aim and limitations of this study we have chosen a transparent, static and partial approach to quantify the subsidy effect chain. This approach can be used to analyse a wide range of subsidy types. The method to be developed answers the question as to what the first order effects are of different types of government subsidy. Since second order effects are usually significantly smaller than first order effects, a first order effect will generally give a good picture of both the mark and the magnitude of the overall effect. It is partly for this reason that there is little point in developing a comprehensive general equilibrium model here. Although it could be used to study all kinds of backward coupling, the development of such a complex model would go too far for this study. Furthermore, the partial approach proposed here is not necessarily inferior because a complex model relies on a large number of arbitrary assumptions and uncertainties as regards parameter values.

The decision to use a partial approach means that the models as presented in the two appendices can be used if the relevant data is available regarding the size of the subsidies, the size of the demand and the supply of inputs and outputs, price elasticities, production function coefficients and degrees of pollution.

3. Inventory of existing indirect subsidies

3.1 Introduction

The method developed in this study is tested on four sectors, namely agriculture, energy, transport and tourism. Earlier studies that focused on OECD countries showed that there is potential for a lot of subsidies to have an environmental impact in the first three of these sectors in particular (Van Beers and De Moor, 2001). Since it is the intention to test the method in the empirical analysis, we have not chosen any specific sub-sectors. For example, the subsidy on Regulatory Energy Tax for cultivation under glass is counted as belonging to the energy sector. This makes it possible to examine different types of subsidies, including those with the greatest environmental effects. The energy sector encompasses the extraction of primary energy and its conversion (e.g. oil refining and electricity generation). The subsidies given to large-scale users of energy such as the steel and aluminium industry are also significant. The agriculture sector only covers primary agriculture. Subsidies given to the agricultural processing industry are beyond the scope of this study. Transport covers traffic and land, air, rail and water-borne transport. The transport consumer is explicitly included. The environmental consequences of congestion are not included. Tourism covers the environmental effects of tourists coming to and staying in the Netherlands and the environmental effects that result from promoting tourism in the countryside. These effects will often overlap with those of transport. In the following sections an inventory is given per sector of existing indirect subsidies in the Netherlands that have the potential to damage the environment. In the Tables there is also an initial indication, per subsidy, of potential significance (in terms of environmental damage).

This is done based on three criteria:

- The size of the subsidy (estimated order of magnitude: • means less than € 10 million per year; •• means between € 10 million and € 100 million per year; ••• means between € 100 million and € 1 billion per year; and •••• means more than € 1 billion per year);
- The expected effect of the subsidy on the extent of the activity (where • means hardly any effect: elasticity close to 0; •• means some effect, but inelastic: elasticity (as an absolute value) less than 1; ••• means significant effect: elasticity (as an absolute value) 1 or more);
- The relative environmental relevance of the activity that is stimulated by the subsidy (• means activity adds probably no more than 1% to any environmental theme; •• means activity adds between 1 and 10% to one or more environmental themes; ••• means activity adds more than 10% to one or more environmental themes).

The information required to allocate the right number of dots was not available in every case. It was therefore necessary in some cases to make an ‘educated guess’. Where there is uncertainty about the order of magnitude one dot is in brackets.

It should be noted that there might be overlaps between different subsidy regulations.

Cases that are analysed in more detail in this study are in italics. In the selection of these cases, not only the 'scores' for the three above-mentioned criteria played a role but also the desire to achieve the best possible spread over the different types of subsidy (cf. Table 2.1). The selected cases are described in chapters 4 to 11.

3.2 Agriculture

Table 3.1 Overview of indirect subsidies in agriculture

Type and description of subsidy	Size of subsidy	Effect on activity	Environmental relevance
Tax subsidies			
LB1: Low rate of VAT on food (incl. *Meat; see ch. 5*) and ornamental plant products	●●●●	●●	●●
LB2: VAT regulation for agriculture (fixed rate)	●●(●)	●	●●
LB3: Low rate of VAT on inputs for agriculture (energy, manure, pesticides)	●	●	●●●
LB4: Exemption from property tax for agricultural land	●●●	●	●●
LB5: Exemption from transfer tax on extension, land consolidation, land development, etc.	●●	●	●●
LB6: *Regulatory Energy Tax reduction for cultivation under glass (see ch. 7)*	●●●	●●	●●●
LB7: Exemption from groundwater tax for spraying (up to 40,000 m^3 per year)	●●	●●	●●●
LB8: Excise duty reduction on red diesel	●●	●	●●
LB9: Tax-free threshold for nutrient taxes	●●●(●)	●●	●●●
LB10: Exemption for agriculture (increase in value of land)	●●	●	●●
Public provision of goods and services below cost price			
LG1: Free allocation of milk, manure and pig farming rights	●●●●	●	●●●
LG2: Not passing on the full cost of veterinary services (e.g. during BSE, swine fever and foot-and-mouth crises)	●●	●	●●●
LG3: Agricultural advice	●(●)	●	●●
LG4: Sale of agricultural land under the market price	●●	●	●●
Capital subsidies			
LK1: Low return on agricultural land utilised by government (Ministry of Agriculture, Nature Management and Fisheries, Service for Land and Water Use; State Property Service)	●●	●	●●
Price regulation			
LP1: Minimum prices for agricultural products (*dairy produce – see ch. 4,* beef, sugar, grain…)	●●●●	●●(●)	●●●
LP2: Artificially low rent	●●	●	●●
Volume regulation			
LQ1: *Designation of land for agricultural use as part of spatial planning (see ch. 6)*	●●●(●)	●●	●●
Trade measures			
LH1: Import quotas (usually coupled with minimum prices)	●	●●	●●●
LH2: Export credit insurance guarantee (from NCM)	●	●	●●

LB1: The low rate of VAT of 6% (instead of 19%) applies among other things to food and ornamental plant products. More than € 4000 per household was spent on food in 2000 (source: Netherlands Statistics), which amounts to some € 25 billion for the entire Dutch population. This means that the subsidy amounts to approximately € 4.5 billion. This subsidy is analysed in more detail for meat in chapter 5 of this report.

LB2: There are two ways in which the agriculture sector benefits from the agriculture regulation for VAT. Firstly, the farmers in question do not have the burden of having to keep VAT records. Secondly, it turns out that the agriculture sector is for the most part overcompensated under this regulation because of the fixed rate for agriculture (the percentage that buyers of agricultural products are allowed to deduct from their taxes). Sijtsma and Strijker (1994) estimate this overcompensation at *ƒ* 225 to *ƒ* 250 million per year (over € 100 million). According to Bos et al (2002) the figure is € 30 million.

LB3: The low rate of VAT for agricultural inputs is largely for fiscal reasons. According to Bos et al (2002) there is no subsidy at all. That is if you assume that the fixed rate for agriculture would also have to be increased (to compensate the farmers to whom the fixed rate applies) if a high rate of VAT were applied to inputs. If the fixed rate for agriculture were not increased it would be more attractive for the farmers to opt for paying VAT, whereby the VAT on the inputs could be set off against the VAT on the output. On balance there would be no net consequences for the treasury in either case.

LB4: Sijtsma and Strijker (1994) estimate that the benefit for agriculture of the property tax exemption for agricultural land is a minimum of *ƒ* 48 million (€ 22 million) and a maximum of *ƒ* 160 million (€ 73 million) per year. According to Bos et al (2002) the figure is € 210 million.

LB5: According to Bos et al (2002), the effect on the budget of the various possible transfer tax exemptions for agriculture is € 65 million.

LB6: According to Bos et al (2002), the treasury misses out on € 113 million a year because of the special rate of Regulatory Energy Tax for natural gas and mineral oils for cultivation under glass. This subsidy forms part of a larger package of Regulatory Energy Tax reductions and exemptions (EB1; see also chapter 7).

LB7: According to Meeusen et al. (2000), the average volume of groundwater abstracted per farm in 1997 was some 5,400 m^3. Only a very small number of farms abstract more than 40,000 m^3. Most farmers therefore pay no groundwater tax. Given that over 100 million m^3 of groundwater is abstracted in the agriculture sector per year and that the tax rate is € 0.1682 per m^3, the size of the subsidy is some € 17 million per year.

LB8: Sijtsma and Strijker (1994) estimated the benefit for agriculture between 1989 and 1991 from the reduced excise duty on ‘red’ diesel at an average of *ƒ* 40 million (€ 18 million) per year. Overlaps with VB1.

LB9: An ‘acceptable loss’ of nutrients remains not subject to nutrient tax. In addition, there is a reduced rate for a volume of phosphate of no more than 10 kg per ha. In 2001 the regular rate for this tax was *ƒ* 1.50 per kg N and *ƒ* 20 per kg P. Nitrogen emissions from agriculture into the ground, water and air amounted to 605 million kg in 1999 and the emissions of phosphate into the ground and water amounted to 64 million kg (CCDM, 2000). The theoretical revenue from nutrient taxes is therefore more than *ƒ* 2 billion; the actual revenue was only *ƒ* 16 million (Ilsink and Schuurman, 2001). The size of the subsidy is therefore in the region of € 1 billion.

LB10: Subject to certain conditions, an increase in the value of agricultural land does not count as taxable income. The size of this subsidy is € 68 million per year (Bos et al., 2002).

LG1: The value of milk quotas is currently some € 0.16 per kg per year. At a production level of 10 billion kg of milk this means that the subsidy amounts to € 1.6 billion per year. There is an overlap with LP1. Similar calculations can be made for manure and pig farming rights.

LG2: The foot-and-mouth epidemic in 2001 cost the government € 257 million (according to the government response to parliamentary questions on 14 June 2002).

LG3: The Ministry of Agriculture, Nature Management and Fisheries spends around € 10 million annually on (socio-)economic advice (since 2001 this has been done via a public call for tenders).

LG4: Between 1998 and 2000 the State sold 1811 ha of freehold agricultural land for an average price of almost € 28,000 per ha (Dutch Lower House document: TK 2001-2002, 28 380, no. 19, p. 108). The average price at which agricultural land was sold between private individuals in this period was almost € 33,000 per ha (Luijt, 2002). Assuming that there is no structural difference in quality, the subsidy is some € 5000 per ha. If the same subsidy applies to leasehold land (of which the State sells more: 8370 ha per year in the period in question), the total subsidy amounts to approximately € 50 million per year. Note that there is currently a temporary freeze on the sale of state agricultural property.

LK1: The State received over € 22 million from the leases on state agricultural property in 2001 (Dutch Lower House document: TK 2001-2002, 28 380, no. 19, p. 106). Since the return from leasehold land tends to be less than 2% (see LP2), there is a subsidy of at least that amount if you assume a notional alternative return of 4% (overlap with LP2).

LP1: The amount of financial support for Dutch agriculture as a result of the EU market and pricing policy in the period 1989 to 1991 has been estimated at *ƒ* 7.4 billion (€ 3.4 billion) per year (Sijtsma and Strijker, 1994). Price support measures for dairy produce are analysed in more detail in chapter 4 of this report.

LP2: Lease agreements are regulated in the Netherlands; they are verified by the Land Control Boards. Lease prices are kept artificially low, which favours the leaseholder. Sijtsma and Strijker (1994) estimated that the benefit to Dutch agriculture from this regulation is *ƒ* 200 million (€ 90 million) per year, but they suggested that this benefit would decrease as a result of the new Agricultural Holdings Act. This Act and the accompanying Agricultural Holdings Decree have been in force since 1995. The leaseholder is still favoured, partly because of the condition that the rent must be based on a net return of 2% for the lessor. The leaseholder also has priority if the land is sold. What the new Agricultural Holdings Act has done is to introduce lease types that are not subject to price controls, such as ‘once-only leases’.

LQ1: Land that has been designated for ‘agricultural use’ as part of spatial planning is worth less than land that has been designated for housing, for example. As a result, the cost of land for the agriculture sector is less than would be the case on a completely free land market. See chapter 6.

LH1: Overlaps with LP1.

LH2: According to OECD figures, EU agricultural export credit guarantees between 1995 and 1998 totalled USD 4.4 billion per year on average (not including intra-trade) (Silvis *et al.*, 2001). At the end of 2001 the Dutch State's total obligation as regards export credit insurance guarantees was almost € 9 billion (Dutch Lower House document: TK 2001-2002, 28 380, no. 19, p. 124). The compensation paid by the Dutch State in 2001 under the export credit insurance guarantee amounted to over € 85 million, whilst more than € 375 million was received in reimbursements for damages (ibid., p. 101 and 112). These figures can fluctuate greatly from year to year. The point of departure for the Dutch government is that the cost of the State reinsuring export credit insurance from NCM should in principle be covered.

3.3 Energy

Table 3.2 Overview of indirect subsidies in the energy sector

Type and description of subsidy	Size of subsidy	Effect on activity	Environmental relevance
Tax subsidies			
EB1: *Exemptions from and reduced rates of Regulatory Energy Tax (e.g. large-scale use*, coal) (see ch. 7)	●●●●	●●	●●●
EB2: Exemptions from and reduced rates of fuel tax (e.g. large-scale use, own use of refineries, use of fossil fuels other than for energy)	●●	●●	●●●
EB3: Unlimited writing-off of investments in oil and gas production on Dutch part of Continental Shelf	●●	●	●(●●)
Public provision of goods and services below cost price			
EG1: Not passing on the full (historical) costs of energy infrastructure	●●(●)	●●	●●
EG2: Limitation of the liability risk of nuclear power stations and oil tankers	●	●	●●●
Capital subsidies			
EK1: Low return on government share in power companies	●(●)	●(●)	●●●
Price regulation			
EP1: Maximum end-user tariffs for protected consumers	●	●●	●●●

EB1: Depending on the reference level that is used, the exemption from Regulatory Energy Tax for large-scale users means a subsidy of between € 1.6 and € 5.2 billion (see § 7.2.2).

For diesel and LPG that is intended for road transport and pleasure cruising there is a zero rate of Regulatory Energy Tax. However, it does not seem logical to view this as a subsidy since these fuels are subject to a (high) rate of excise duty.

EB2: This subsidy is significantly less than an exemption from Regulatory Energy Tax given the much lower rate of fuel tax on natural gas. Large-scale users of natural gas pay € 0.007 per m^3 instead of € 0.0106 on that part of their consumption that is above 10 million m^3. Assuming that the reduced rate applies to several billion m^3 of natural gas consumption, the subsidy amounts to some tens of millions of euros at most.

EB3: The tax expenditure under this regulation was € 16 million in 2001 (source: 2002 Budget, Appendix 5).

EG1: The existing energy infrastructure, such as the natural gas network, was built in a very regulated environment. As a result, the energy providers have lower capital costs than would have been the case if the investment at that time had been made in a free market. However, without a more detailed study it is not possible to determine the extent to which this still benefits the current energy users. What is likely, given the volume of energy consumption, is that considerable sums are involved: even if the benefit is only in the order of € 0.01 per m^3, that still means several hundred million euros per year.

EG2: Under the Nuclear Incidents (Third Party Liability) Act, the State acts as guarantor – where payments from other quarters are not sufficient – for a maximum of € 2.27 billion per licence to cover damages as a result of a nuclear incident. The size of the subsidy element involved strongly depends on assumptions regarding the chance of a serious incident involving a nuclear power station and the damage that such an incident will cause. A high estimate of € 0.022 per kWh of nuclear electricity can be found in Oosterhuis (2001). Given the Dutch nuclear production of approximately 3.5 TWh per year, that would therefore mean a subsidy of € 7.7 million per year.

EK1: The size of this subsidy is probably limited and is also decreasing. Provinces have recently been tightening requirements as regards the profitability of power companies in which they have shares. Furthermore, some public authorities are leaning towards disposing of their shares.

EP1: It is doubtful whether the price regulation that still exists for protected consumers actually can be classed as a subsidy. The current regulation, which is implemented by the Netherlands Office for Energy Regulation, is intended to provide protection against the misuse of a monopoly. Furthermore, it will be abolished when the energy market is completely liberalised. There is also an overlap with EK1.

3.4 Transport and transport charges

Table 3.3 Overview of indirect subsidies on transport and transport charges

Type and description of subsidy	Size of subsidy	Effect on activity	Environmental relevance
Tax subsidies			
VB1: Reductions in and exemptions from excise duty on fuel (including *aviation; see ch. 10*, shipping, (red) diesel, LPG, refund of excise duty on diesel for heavy lorries)	●●●●	●(●●)	●●●
VB2: Fiscal advantages for taxis	●●	●	●●●
VB3: Fiscal advantages for old cars	●●	●●	●●●
VB4: Fiscal advantages for 'company cars', business use of private cars, and *travel costs – see ch. 9*	●(●●)	●(●)	●●●
VB5: Exemption from VAT on tickets for international flights (and low rate of VAT on tickets for domestic flights)	●●●●	●●(●)	●●●
VB6: Exemption from property tax for roads, waterways and railway lines	●●●	●	●●●
VB7: Exemption from corporation tax for municipal transport companies and other public enterprises (incl. Schiphol Airport)	-	-	-
VB8: Low rate of VAT on transport services	●●●	●	●●
VB9: Fiscal advantages for ocean shipping	●●(●)	●(●)	●●
VB10: Fiscal advantages for delivery vans	●●●●	●	●●●
Public provision of goods and services below cost price			
VG1: Incomplete coverage of infrastructure costs by tariffs and transport-related tax revenues (airports, roads, *railway lines – see ch. 8*, harbours, waterways)	●●●●	●(●●)	●●
VG2: Free public transport for students	●●●	●(●)	●●
VG3: War risk insurance for airline companies	●(●)	●●(●)	●●●
Capital subsidies			
VK1: Low return on government share in *Schiphol Airport – see ch. 11*, KLM, NS	●(●)	●	●(●●)
Price regulation			
VP1: Setting of public transport prices by Minister of Transport, Public Works and Water Management	●(●)	●(●)	●●

VB1: The sums involved are very large: the exemption from excise duty on aviation fuel alone involves a subsidy of more than € 1 billion per year (see chapter 10). Note, however, that it is not always possible to set an unequivocal reference level for calculating the size of

the subsidy (for example: should the 'usual' rate for diesel be used as the reference for 'red' diesel?).

VB2: Taxi owners can claim a refund of purchase tax on passenger cars and motorcycles and exemption from road tax. Taxis may also depreciate quickly (in 4 years). According to Werkgroep Vergroening (2001), the State would gain *ƒ* 106 million (almost € 50 million) per year if the exemptions from purchase tax on passenger cars and motorcycles and from road tax were cancelled. If this were passed on in the fares it would mean an increase of approximately 2%. Werkgroep Vergroening expects such a measure would have limited effects on behaviour.

VB3: Abolishing the exemption from road tax for cars that are more than 25 years old would bring in approximately € 25 million per year (Werkgroep Vergroening, 2001). The overall environmental impact is limited, but it is significant per kilometre driven because of the relatively high emissions from cars of that age.

VB4: Private use of 'company cars' is taxed by adding a fixed sum to taxable income at a graduated rate. 25% of the new value is added if more than 7000 km are driven privately. The marginal tax rate per km is zero for those who drive more than 7000 km privately. The size of the implicit subsidy is not known.

Reimbursements for the cost of commuting and for business use of private cars are tax-free within certain limits. It is not known to what extent this is a subsidy.

The 'flat rate allowance for travel costs' was abolished as of 2001 and replaced by a 'commuting allowance', which only applies to commuters who travel by public transport. See chapter 9.

VB5: Over 20 million people fly out of the Netherlands every year. If the average ticket price of all of these people is € 500, then the lost revenue from VAT is € 1.9 billion. In reality it will be less because business travellers can claim back their VAT.

VB6: The size of this subsidy is *ƒ* 600 million (€ 270 million) (Werkgroep Vergroening, 2001). According to Werkgroep Vergroening it is very much open to question whether property tax has an effect on the decision to build or widen roads.

VB7: Schiphol Airport became liable for corporation tax as of 1 January 2002. The exemption from corporation tax for municipal transport companies will also be abolished shortly.

VB8: Public transport, private buses, taxis and the transport of people on ships fall under the low rate of VAT (6% instead of 19%). The production value of passenger transport by train, tram, bus and taxi in the Netherlands was over *ƒ* 5 billion in 1996 (source: Netherlands Statistics). The size of the subsidy is therefore some € 300 million.

VB9: The regulations involved are as follows (the figures in brackets represent the budgetary significance of the regulations in 2001 according to the 2002 Budget, Appendix 5):

- Arbitrary write-off of sea-going vessels (nil);
- Tonnage tax (€ 11 million);
- Reduced payments from shipping (€ 84 million);

- Seafarers' allowance (€ 3 million).

VB10: Werkgroep Vergroening (2001) estimated the tax benefit for delivery vans as a result of exemption from purchase tax on passengers and motorcycles and the lower rates of road tax at approximately € 1.3 billion.

VG1: CE (1999) estimated the costs of investment in *road infrastructure* (interest and depreciation) at approximately € 3 billion for 2002, and the cost of maintenance and management at € 2.8 billion. The fee for the use of *railway infrastructure* is determined according to the Fees for Use of Railway Infrastructure Decree. The fee for use only covers management and maintenance; capital costs are excluded. Furthermore, these costs (approximately € 130 million per year) will not be fully invoiced until 2007. The cost of railway infrastructure investment (interest and depreciation) for which there is therefore no fee for use was estimated at € 1.5 billion for 2002 (CE, 1999). This case is considered in more detail in chapter 8. *Shipping* does not pay for the use of waterways, except for bridge, lock and anchorage charges. CE (1999) estimated the cost of investment in inland shipping infrastructure (interest and depreciation) at € 247 million for 2002 and the cost of maintenance and management attributable to inland shipping at approximately € 165 million. Most investment on *aviation* infrastructure is for the account of the airports themselves and therefore does not involve a subsidy (apart from any low return on government shares in airports; see VK1).

VG2: The contract with the transport companies for free public transport for students currently costs the government € 423 million per year (source: NRC Handelsblad, 5/4/2002). It is debatable whether this amount can be entirely considered a subsidy, since the students 'pay' part of the cost of their annual season ticket in the form of a deduction from their student grants.

VG3: After 11 September 2001 the war risk insurance of a lot of airline companies was cancelled. The Minister of Transport, Public Works and Water Management and the Finance Minister have now taken over these insurances from the open market. Premiums were set on EU level (Dutch Lower House document: TK 2001-2002, 27 925, no. 3). The size of a possible subsidy element in this arrangement cannot be immediately determined.

VK1: The size of the indirect subsidy given by the government because it accepts a low return on its share in Schiphol Airport can be estimated at € 80 million per year (see § 11.2.2). It is not known whether the figures for other government shares in transport companies are of the same order of magnitude.

3.5 Tourism

Table 3.4 Overview of indirect subsidies in the tourism sector

Type and description of subsidy	Size of subsidy	Effect on activity	Environmental relevance
Tax subsidies			
TB1: Exemption from VAT and excise duty on sales at airports, in planes and outside territorial waters	●●	●	●●●
TB2: Low rate of VAT on entry to amusement parks, sports events, etc.	●(●)	●	●
Public provision of goods and services below cost price			
TG1: Incomplete cost coverage from tourist tax, entertainment charges, etc.	●	●	●
TG2: Designation of land for recreational purposes as part of spatial planning	●(●)	●	●
TG3: Granting of land below cost price by municipalities to promote tourist activity	●	●	●

TB1: Since 1999 'duty-free shopping' at airports has been restricted to flights to destinations outside the EU. The subsidy amounts to roughly € 50 million per year (10 million airline passengers with destinations outside the EU; an average of € 5 in lost VAT and excise duty per passenger). The effect on the number of plane (and boat) journeys is presumably small.

TB2: Entry to sports events, amusement parks and the like falls under the low rate of VAT (6% instead of 19%). In 1998, € 74 million was spent on admission to leisure centres (source: Netherlands Statistics). The size of the subsidy is therefore probably around € 10 million. The effect on the extent of the activity and the environmental impact are presumably small.

TG1: The revenue from municipal tourist taxes was € 83 million in 2001 (Ilsink and Schuurman, 2001). It is not known to what extent this was sufficient to cover the costs of public facilities used by tourists. The effect of municipal taxes on the behaviour of tourists is probably very limited.

TG2: As with agriculture, the designation of land for 'recreational' purposes as part of spatial planning can press down the price of the land. The extent to which this is the case is not known. The effect on the extent of the activity is probably far less than with agriculture since the cost of land in relative terms is a much smaller item in the budgets of recreation companies.

TG3: Competition between municipalities, in conjunction with a degree of market power from the companies that are looking for a location for their business, can keep the effective price at which land is granted below the cost price (Netherlands Statistics, 1999). It is not known to what extent this phenomenon occurs in relation to companies in the tourist/recreation sector. It does not seem very likely that the sums involved are large or that there are extensive (potential) environmental effects.

4. Minimum price for milk/dairy products

4.1 Qualitative information

4.1.1 Description and type of subsidy

In this case the implicit subsidy is formed by the minimum prices for milk and dairy products. These minimum prices result in a higher price for the producer than would have been the case without this system. These are price subsidies that fall under item 6 in Table 2.1. The point of application is on the producer (type 4 in Figure 2.2).

4.1.2 Directly stimulated activity

The subsidies relate to the end products of the dairy industry, which pass on the higher prices to the dairy farmers.

4.1.3 Environmental effects

Dairy farms contribute to the following environmental effects (see also section 2.4 in chapter 2):

- Greenhouse gas emissions (particularly methane and nitrous oxide);
- Emissions of acidifying substances (particularly ammonia);
- Eutrophication (discharge of phosphorus and nitrogen compounds);
- Land use (rough measure of biodiversity).

4.1.4 Policy environment

The EU market and price policy for milk and dairy products consists of a support system in the form of minimum prices. There is EU policy that makes milk artificially scarce through import duties, export refunds, intervention purchases (of butter and low-fat milk powder) and specific (domestic) measures to promote sales. Between 1995 and 2000 minimum prices made up 88% of the total subsidy in the EU for milk/dairy products (see OECD 2001a).

Until 1984 the minimum price policy for milk led to surplus production. In order to reduce the resulting budgetary consequences, the EU introduced a system of milk quotas in 1984 to limit the total volume of milk produced. Producers have to pay a (super) levy on the volume of milk that they produce above their allocated quota and this (super) levy is more than the price that the farmer receives. In addition, there is also a quota system in the Netherlands for manure.

In the Netherlands there is not only conventional but also organic dairy farming. The present case study is devoted entirely to conventional dairy farming because that accounts for 99% of Dutch milk production (OECD, 1999).

4.2 Quantitative information

4.2.1 Method

To calculate the environmental effect of minimum price subsidies we use formula (54) from Appendix I with modifications to take account of a quota *Q*:

$$\Delta z = (q^s{}_g - Q + (Q - q_w))\, Z_{q,}\ if\ q^d{}_g < Q \le q_w$$

and

$$\Delta z = (q^s{}_g - q_w)\, Z_{q,}\ if\ q_w < Q < q^s{}_g$$

where:

Δz = the environmental effect of the minimum price;

$q^s{}_g$ = the volume supplied at the minimum price without the a quota;

Q = the volume supplied at the minimum price with the quota;

q_w = the volume supplied at the world market price;

$q^d{}_g$ = the volume of the demand with the minimum price subsidy;

Z_q = the degree of pollution from production.

4.2.2 Size of the subsidy

The OECD estimates the size of agricultural subsidies annually in terms of the so-called 'Producer Subsidy Equivalent'. The OECD does not give estimates for the EU Member States individually but for the EU as a whole. The average PSE for milk in the EU over the period 1996-1999 inclusive was € 17.6 billion per year, of which € 15.5 billion was in the form of market price subsidies (OECD, 2001a). Assuming that the Dutch share in the market price subsidy is equal to the Dutch share in EU milk production (9.1% on average in the years in question), the market price subsidy for milk in the Netherlands (limited by the quota) was on average € 1.4 billion per year over the period 1996 to 1999 inclusive.[16] This amounts to approximately € 0.13 per kg of milk produced.

4.2.3 Quantification of parameters

The volume supplied in a situation with a quota

The volume of milk that is transported to Dutch dairy factories every year is 10.5 million tonnes (Netherlands Statistics, 1999). This is equal to the imposed quota.

The milk quotas are mandatory in the Dutch situation, in contrast to the situation in such countries as Italy and Austria (Frandsen et al, 2002). This means that the quota of

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[16] The calculation of the environmental effects in section 4.2.4 is based on a higher figure, namely what the figure would be without the quota.

10.5 million is somewhere between the volume of the demand at the minimum price, $q^d{}_g$, and $q^s{}_g$, the supply with market price subsidy but without a mandatory quota (see also Figure I.1 in Appendix I).

The volume supplied in a situation without a quota

The milk quota is a constant volume of milk that dairy farmers are allowed to produce every year. The imposition of an effective quota reduces both milk production and its environmental effects compared with a situation without a quota. Since this case is an illustration of how the method is applied for a minimum price subsidy, a correction is needed to take into account the policy environment by calculating the volume of milk that would be supplied in a situation without a quota. This is shown in Figure I.1 in Appendix 1. A dairy farmer follows the supply curve S when the price for his product changes. After all, he maximises his profit if he expands production until the marginal production costs are equal to the given price. In other words, the volume supplied is equal to $q^s{}_g$. The price is then (p_g). This is the minimum price of € 0.32. The volume supplied $q^s{}_g$ is not known and has to be calculated. This is done by using constantly assumed elasticities. In other words, we estimate the world market price (p_w) as the minimum price minus the subsidy of € 0.13 per kilo, which is therefore € 0.19. If we assume in this illustration that the quota (10.5 million tonnes) is an effective quota and at the boundary q_w, then we can use the price elasticities to calculate what the volume supplied would have been without the quota.

We therefore need information about the price elasticity of milk. Lutz (1992) estimates the short-term price elasticity for the entire agricultural sector at between 0.05 and 0.2. Long-term price elasticity would be between 1.0 and 2.0. OECD (2001b) calculates a supply elasticity of 1.0 for the entire agricultural sector. Bouamra-Mechemache et al (2001) put the long-term price elasticity of the supply of milk in the Netherlands at 1.0 (based on Colman et al, 1998). Since the milk quota system was introduced in the 1980s there has been a block on any further increase in the overall level of production. After all, if there are binding milk quotas, a price increase will not lead to any reaction in the supply. In addition, it is very difficult to estimate output price reactions based on actual market results. Boots et al (1997) use an optimising model to simulate what the aggregated supply response would have been in 1992/1993 and arrive at an elasticity of 0.26. Oskam and Osinga (1982) estimate the elasticity at 0.29 in a market that was not yet limited by milk and manure quotas. This is not that different from the value in Boots et al (1997).

Emission factors (Z_q)

The estimated emission factors for dairy farming are given in Table 4.1.

Table 4.1 Emission factors for the relevant emissions in dairy farming

Substance	Agricultural emissions (in kilo tonnes, 2000)	Dairy farming emissions (in kilo tonnes)	Emissions per tonne of milk (in grams)
CO_2	6,876,000	687,600	65,500
N_2O	24,400	12,200	1,160
CH_4	410,000	205,000	19,500
NO_x	8,000	2,000	190
SO_2	280	70	10
NH_3	147,000	73,500	7,000
NMVOC	1,700	425	40
CO	1,200	300	30
Phosphate (in tonnes of P)	64,000	32,000	3,050
Nitrate (in tonnes of N)	471,000	235,500	22,400
Land use		860,000 ha	0.82 m^2

Note: The emission figures for agriculture come from the Environmental Compendium (RIVM, 2001b); the figures for phosphate and nitrate come from CCDM (2000). It is estimated that dairy farming produces 50% of the 'typical cattle farming emissions' (CH_4, N_2O, NH_3, phosphate and nitrate), 10% of the CO_2 emissions (in the agricultural sector cultivation under glass is the greatest source of CO_2 emissions), and 25% of the other emissions (approximately the share of dairy farming in the total value of agricultural production). The factor for land use comes from Netherlands Statistics.

4.2.4 Calculation of environmental effects

Table 4.2 shows the result of the calculations. The results for emissions in column 2 are based on the assumption of a larger milk quota. An elasticity of 0.26 is used (Boots et al, 1997) and a world market price of € 0.19. The figures in column 3 are also based on a larger milk quota, with an elasticity of 0.26 (Boots et al, 1997) and a world market price of € 0.24. This world market price is higher than that used for column 2 because the EU is a major supplier of dairy products on the world market. The extra milk that the EU produces as a result of the minimum price subsidy on milk significantly increases the supply on the world market and decreases the world market price by more than would be the case if the EU did not supply the extra production on the world market. Estimates of the drop in the world market price on a completely liberalised world market are between 20% (Berkhout et al, 2002) and 30% of the current minimum price (Ministry of Agriculture, Culture and Fisheries, 2002). This means that the world market price varies between € 0.22 and € 0.26. In the case in hand calculations will be made with a world market price of € 0.19 and € 0.24 (average). Column 4 is the same as column 3 but for a higher elasticity (1.0). Columns 3 and 4 were calculated to look at the sensitivity of the results.

Table 4.2 Emissions (in kilo tonnes) as a result of milk subsidies in the form of minimum prices

	Elasticities		
Economic parameters	0.26	0.26	1.00
Minimum price (p_g)	€ 0.32	€ 0.32	€ 0.32
World market price (p_w)	€ 0.19	€ 0.24	€ 0.24
Subsidy as % of world market price	68.4	33.3	33.3
Increases in production (($q^s{}_g – Q_w$), in millions of tonnes)	1.87	0.91	3.50
Calculated emissions (Δz)			
CO_2	122.5	59.6	229.2
N_2O	2.2	1.1	4.1
CH_4	36.5	17.8	68.3
NO_x	0.4	0.2	0.7
SO_2	0.01	0.006	0.02
NH_3	13.09	6.37	24.5
VOC	0.08	0.04	0.1
CO	0.05	0.03	0.1
Phosphate	5.7	2.8	10.7
Nitrate	41.9	20.4	78.5
Land use (1000 ha)	114.8	55.9	215.0

In order to clarify the calculations we will calculate column 2 here (the results in the other columns are calculated in the same way). The price subsidy is € 0.32 - € 0.19 = € 0.13, i.e.68.4% of the estimated world market price of € 0.19. That means a percentage increase in production of 68.4 x 0.26 = 17.8. With an elasticity of 0.26 milk production increases by 17.8% of the quota of 10.5 million tonnes, i.e. by 1.869 million tonnes. This absolute increase in production $q^s{}_g - q_w$ is multiplied by the emission factors (Z_q) to obtain the values in Table 4.2. For example, for CO_2 emissions:

$$\Delta z = (q^s{}_g - q_w)\ Z_{q,} = 1.87 \times 65{,}500 = 122.5\ .$$[17]

For land use a correction factor is applied to allow for the assumption that not all of the land is used for production. The correction factor is from RIVM's IMAGE model. This correction factor is 0.75. This means that 75% of the full production capacity of the land is used and as a result the emissions values are also 25% lower.

If the environmental effects are aggregated using weighting factors as indicated in Appendix II the results will be as indicated in Table 4.3.

[17] Slight deviations from the values reported in the Table are the result of rounding off.

Table 4.3 Aggregated environmental effects of milk subsidies

	Elasticities		
Economic parameters	0.26	0.26	1.00
Increases in production (in millions of tonnes)	1.87	0.91	3.50
Greenhouse effect (kilo tonnes CO_2-equivalent)	1,562.7	760.5	2,924.9
Acidification (kilo tonnes SO_2-equivalent)	17.2	8.4	32.1
Photochemical ozone creation (kilo tonnes of ethylene-equivalent)	0.3	0.1	0.5
Eutrophication (kilo tonnes of phosphate-equivalent)	14.5	7.1	27.2
Land use (1000 ha)	114.8	55.9	215.0

4.2.5 Sensitivity analysis

Two important parameters should be considered in more detail: the assumed elasticity and the world market price with liberalised world trade. If the world market price increases, the environmental effects are significantly less. Tables 4.2 and 4.3 are based on the assumption that there is a substantial increase in the world market price from € 0.19 to € 0.24, which would lead to a 48% drop in emissions (from column 2 to column 3 in Table 4.2).

The extra emission of greenhouse gases increases significantly if we take a higher constant long-term elasticity of 1.00 in the supply. The environmental effects are then almost 4 times greater than with elasticity as calculated by Boots et al (1997) (from column 3 to column 4 in Table 4.2). There is a degree of sensitivity to the size of the price reactions and the level of the world market price. This shows that when the method from sub-section 4.2.1 is used the price reaction in the milk supply has to be simulated precisely in the model and also that reliable estimates of the world market price are required.

4.3 Final comments

For a comparison of the calculations with another study we refer to Komen (2000), who calculated that increasing the quotas by 16.2% (= increased production) would reduce the quota prices to 0. Then the quotas are no longer effective. If we assume a quota of 10.5 million tonnes, then an increase of 16.2% (of 10.5 million tonnes) means that an additional 1.7 million tonnes of milk will be supplied. This is not far from the 1.87 million tonnes that was calculated with Boots' elasticity and is indicated in Table 4.2. There is not much material with which to make comparisons as regards the overall environmental effects of dairy farming. Rougoor and van der Schans (2001) calculated the ammonia emissions from Dutch dairy farms. In 2000 the ammonia emission per kg of milk was 8.2 grams. This is slightly higher than the 7.0 grams that is used in this study (see Table 4.1). The extra ammonia emissions as a result of indirect subsidies would then be 17.1% higher than the emissions indicated above.

Table 4.4 indicates factors that can affect how far and in which direction the actual environmental effect deviates from the environmental effect estimated above.

Table 4.4 Factors that are responsible for possible differences between actual and estimated environmental effects

↓ higher world market price
↑ greater elasticity

NB:
↓ means that the environmental effect of the subsidy decreases when this factor is taken into account;
↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

In Tables 4.2 and 4.3 the calculations are only for the environmental effects of the minimum price subsidy for milk in the Netherlands in a notional situation with no milk quota. It does not automatically follow from these results that abolishing milk quotas and minimum prices will automatically reduce the strain on the environment. Before reaching such a conclusion you need to review the entire policy environment, in other words including milk and manure quotas. Such analyses must be examined at EU level and can give entirely different results from one country to another. For example, if the milk quota is between $q^d{}_g$ and q_w (see Figure 2.4 in Appendix I), as is assumed here, then abolition can worsen the environmental situation, whereas abolition of a milk quota in excess of q_w can improve the environmental situation.

5. Low rate of VAT on meat

5.1 Qualitative information

5.1.1 Description and type of subsidy

In the Netherlands the reduced rate of VAT (currently 6%) is applied to foodstuffs. These include meat that is intended for human consumption. Application of this reduced rate is permitted under the 'Sixth VAT Directive' (no. 77/388) of the European Union. Appendix H of this directive indicates the categories of goods and services to which it is permitted (but not obligatory) to apply a reduced rate of VAT.

Using the reduced rate of VAT instead of the general rate involves a subsidy because the costs for consumers are reduced as a result. The subsidy is on consumption and is applied through tax measures at the end of the chain (subsidy type 3b in Table 2.1 and type 5 in Figure 2.2).

5.1.2 Directly stimulated activity

This subsidy directly stimulates the consumption of meat.

5.1.3 Environmental effects

The environmental effects of meat consumption occur primarily in the production phase. The main effects are emissions that accompany the production of manure in cattle farming: methane, ammonia, nitrates and phosphates. Land use also plays a role, particularly in the case of meat from permanent cattle farming.

5.2 Quantitative information

5.2.1 Method

The environmental effects can be calculated using formula (53) from Appendix I:

$$\Delta z = \Delta s \cdot \partial x_i / \partial s_k \cdot Z_q$$

where:

Δz = the environmental effect

Δs = the size of the subsidy

$\partial x_i / \partial s_k$ = the effect of the subsidy on demand

Z_q = the degree of pollution from production (in this case: the production of meat)

5.2.2 Size of the subsidy

The size of the subsidy can be estimated as follows. Dutch households consumed € 4,551 million worth of meat and meat products in 2000 (source: Netherlands Statistics). In that same year € 1,710 million worth of meat and meat products was imported; including 6% VAT the figure is € 1,813 million. Therefore, at least € 2,738 million worth of meat produced in the Netherlands was consumed domestically.[18] This includes (6/106) x 2738 = € 155 million of VAT. Not including VAT, € 2,583 million worth of meat was therefore both produced and consumed in the Netherlands. If the general VAT rate of 19% were applied to this figure, the resulting amount of VAT would be € 491 million. The subsidy is therefore € 491 – 155 = 336 million. This is a conservative estimate because it does not include the subsidy on meat consumption in the catering industry and in company canteens and the like (which also fall under the low rate of VAT in this case) or in institutions that are not liable to VAT (like hospitals). The calculated subsidy also takes no account of the consumption of products, like snacks, that contain meat.

5.2.3 Quantification of parameters

Size of the subsidy (Δs)

The size of the subsidy is (at least) € 336 million (see § 5.2.2).

Effect of the subsidy on demand ($\partial x_i / \partial s_k$)

The demand for meat is not very elastic. Estimates of the price elasticity vary quite widely but usually arrive at (absolute) values that are less than 1. Table 5.1 gives an overview of price elasticities that can be found in the literature.[19]

Table 5.1 Own price elasticities of the demand for meat in certain countries

Author(s)	Country and period	Beef and veal	Pork	Poultry
Verbeke and Ward (2001)	Belgium, 1995-1998	- 0.09	- 0.61	- 0.15
Rickertsen (1997)	Norway, 1962-1991	- 0.72 (type of meat unspecified)		
Fraser and Moosa (2002)	UK, 1960-1994	- 0.99	- 0.57	- 0.63
Chen and Veeman (1991)	Canada, 1967-1987	- 0.77	- 0.81	- 0.95
Moschini and Meilke (1989)	US, 1967-1987	- 0.98 / -1.05	- 0.84 / - 1.02	- 0.09 / - 0.10

N.B.: The price elasticities of Verbeke and Ward and Fraser and Moosa are compensated (i.e. the effect of price changes on income is taken into account); the price elasticities of Rickertsen, Chen and Veeman, and Moschini and Meilke are not compensated.

It seems reasonable to use elasticity of –0.6 for all types of meat to plot points, but given the large spread it is advisable to perform a sensitivity analysis with –0.1 and –1.0 as the upper and lower bounds.

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[18] This is the minimum amount, because some of the imported meat may have been exported again.

[19] Other types of meat than the three that are named are of secondary importance in the Netherlands and are therefore not considered.

A subsidy in the form of a reduced rate of VAT (6% instead of 19%) represents a price reduction of almost 11%.

In 2000 a total of 1,341 million kg of beef, veal, pork and poultry was consumed in the Netherlands (source: Netherlands Statistics). In 5.2.2 we saw that (at least) 60% (of the value) of the meat consumed in the Netherlands was also produced in the Netherlands. Assuming that this ratio also applies to the volume, 807 million kg of meat was therefore produced *and* consumed in the Netherlands. If there was an effective price reduction of 11% and an elasticity of –0.6 we can attribute 6.2% of this consumption (= 0.066/(1 + 0.066)), or 50 million kg, to the subsidy. That is 0.15 kg per euro of subsidy.

Extent of the environmental effects per unit of activity (Z_q)

The estimated emission factors for meat production in the Netherlands are in Table 5.2.

Table 5.2 Emission factors of relevant emissions in meat production

Substance	Emissions in agriculture (tonnes, 2000)	Emissions in meat production (tonnes)	Emissions per kg of meat (gram)
CO_2	6,876,000	687,600	240
N_2O	24,400	9,760	3.4
CH_4	410,000	141,600	49
NO_x	8,000	1,840	0.6
SO_2	280	64	0.02
NH_3	147,000	74,183	26
NMVOC	1,700	391	0.1
CO	1,200	276	0.1
Phosphate (as P)	64,000*	25,600	9
Nitrate (as N)	471,000*	188,400	66
Land use		79,000 ha	0.28 m^2

*: 1999.

Note: The emission figures for agriculture are from the Environmental Compendium (RIVM, 2001); the figures for phosphate and nitrate are from CCDM (2000). The emission figures from meat production were calculated for NH_3 assuming the same share in the overall figure as in 1997 (as reported in RIVM (1998)) and for CH_4 based on RIVM (2002). For the other 'typical cattle farming emissions' (N_2O, phosphate and nitrate) the amount that came from meat production was estimated at 40%; for CO_2 the estimate was 10% (in the agricultural sector, cultivation under glass is the largest source of CO_2 emissions) and for the other emissions the estimate was 23% (the amount of total agricultural production that is cattle farming). The figure for the amount of meat produced (beef and veal, pork and poultry: 2,870 million kg), which was used to calculate the emissions per kg of meat, is based on LEI (2002). Land use for meat production is based on figures from Netherlands Statistics (surface area taken up by cattle farms (not including dairy cattle farms), pig farms and poultry farms).

5.2.4 Calculation of the environmental effects

It is now easy to calculate the environmental effects by multiplying the meat consumption attributable to the subsidy (50 million kg) by the emissions per kg of meat that are indicated in the fourth column of Table 5.2. The results are given in Table 5.3.

Table 5.3 Emissions attributable to the subsidy (low rate of VAT)

Substance	Emission (tonnes)
CO_2	12,000
N_2O	170
CH_4	2,450
NO_x	30
SO_2	1
NH_3	1,300
NMVOC	5
CO	5
Phosphate (in tonnes P)	450
Nitrate (in tonnes N)	3,300
Land use (ha)	1,400

Finally, the weighting factors from Appendix II can be used to determine the effect of the subsidy on the different environmental indicators (see Table 5.4).

Table 5.4 Environmental indicators with low rate of VAT on meat

Greenhouse effect (ktonnes CO_2-equivalent)	116
Acidification (tonnes SO_2-equivalent)	1,703
Photochemical ozone creation (tonnes ethylene-equivalent)	18
Eutrophication (tonnes phosphate-equivalent)	1,239
Land use (ha.)	1,400

5.2.5 Sensitivity analysis

Tables 5.5 and 5.6 show the results with price elasticities of –0.1 and –1.0 respectively. With these elasticities, meat consumption of 9 million and 80 million kg respectively is attributable to the subsidy.

Table 5.5 Emissions attributable to the subsidy with elasticities of –0.1 and –1.0, in tonnes

Substance	Elasticity –0.1	Elasticity –1.0
CO_2	2,160	19,200
N_2O	31	272
CH_4	441	3,920
NO_x	5	48
SO_2	0	2
NH_3	234	2,080
NMVOC	1	8
CO	1	8
Phosphate (in tonnes P)	81	720
Nitrate (in tonnes N)	594	5,280
Land use (ha.)	2,500	22,400

Table 5.6 Environmental indicators at a low rate of VAT on meat with elasticities of –0.1 and –1.0.

	Elasticity of –0.1	Elasticity of –1.0
Greenhouse effect (ktonnes CO_2-equivalent)	21	186
Acidification (tonnes SO_2-equivalent)	307	2,725
Photochemical ozone creation (tonnes ethylene-equivalent)	3	29
Eutrophication (tonnes phosphate-equivalent)	223	1,982
Land use (ha.)	2,500	22,400

5.3 Concluding remarks

The calculations were only done for the environmental effects of meat consumed in the Netherlands that was also produced in the Netherlands. Consumption of imported meat obviously also affects the environment, but those effects are not considered in this study.[20] The same applies to the environmental effects of meat produced in the Netherlands that is exported since Dutch VAT is not charged on that meat.

The estimated environmental effects are ‘gross’ figures. In order to obtain the ‘net’ environmental effect substitute effects also have to be taken into account, e.g. the environmental effects of reduced consumption of vegetable products because meat falls under the low rate of VAT.

No allowance is made above for the difference between ‘regular’ and ‘organic’ meat. After all, the subsidy in the form of the low rate of VAT applies to all types of meat, regardless of the source.

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20 By way of indication: it was estimated in § 5.2.2. that 60% of the meat consumed in the Netherlands was also produced in the Netherlands. Based on the (simplifying) assumption that the environmental effects of meat production abroad per kg of meat are equal to those in the Netherlands, the total (domestic plus foreign) environmental impact of the consumption of meat in the Netherlands would therefore be 67% higher than the figures presented here.

Some elements of the environmental impact of organic meat may well be better than those of standard meat, but organic meat does affect the environment. Furthermore, the current European VAT legislation prohibits applying different rates to the two sorts of meat.[21] Note, however, that the distinction has little effect on the results of the calculations given that organic meat only has a small share of the market.

Table 5.7 gives an overview of factors that can affect whether the actual environmental effect is larger or smaller than the environmental effect estimated above and by how much.

Table 5.7 Factors that can cause actual environmental effects to differ from estimated environmental effects

↓	substitution effects (for example: environmental effects of vegetable production)
↑	environmental effects of imported meat

NB:
↓ means that the environmental effect of the subsidy decreases when this factor is taken into account
↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

21 See the letter of 1 March 2002 from State Secretary Bos to the Parliamentary Finance Committee.

6. Designation of land for agricultural use

6.1 Qualitative information

6.1.1 Description and type of subsidy

Within the framework of spatial planning a large part of the territory of the Netherlands has been designated for 'agriculture'. This designation limits the alternative uses to which the land in question can be put and produces a segmented market where the price of land can vary greatly according to its designated use. In agriculture the added value that can be obtained per hectare of land is usually lower than in the case of other designated uses, such as housing or industrial development. This is reflected in a lower price for agricultural land than would be the case in a (notional) situation with no town and country planning regulations where the use of the land were left entirely to the free market.

The designation of land for 'agricultural' use is a subsidy in the context of this study since the costs of land as a production factor for agriculture are lower than would be the case if there were a free market for land.[22] This is a form of volume regulation of (fixed) inputs (subsidy type 7 in Table 2.1) that is applied at the beginning of the chain (subsidy type 1 in Figure 2.2).

6.1.2 Directly stimulated activity

The subsidy reduces the fixed costs for (permanent) agriculture. This makes agricultural production possible on land that would otherwise be 'too expensive' (at the given prices of agricultural producers). Therefore the agricultural sector and agricultural production are larger than they would be without the protection of town and country planning.

6.1.3 Environmental effects

The relevant environmental effects are those that are caused by (permanent) agriculture. These effects are in particular the emissions that are linked to the production and use of manure (methane, nitrous oxide, ammonia, nitrates and phosphates) and the use to which the land is put. Other environmental effects of agriculture, both negative (e.g. pesticides) and positive (waste disposal, nature and landscape) are not considered in this study.

6.1.4 Policy environment

The policy environment in which land is designated for agricultural use is very complex, as is the land market itself. Spatial planning policy creates a policy environment with numerous forms of government intervention that lead to dominant lock-in effects. For

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[22] At first sight the costs do not seem to be lower for an individual farmer who buys no land. However, one must remember that these are always 'opportunity costs': the value of the land if put to the most profitable use. No actual transactions or flows of funds are necessary.

example, there are all kinds of rules regarding alternative uses of land, e.g. for water management and road building. It is also the case that different public authorities (think of the relationship between municipalities and State) have a say over the use of land.

Furthermore, it is not immediately possible to use agricultural land for other purposes because the designation of land is fixed for a very long period in zoning schemes. Even if the designation of the land were changed, it could take a very long time to put the change into practice. This is because there are rules with regard to property rights whereby compulsory purchase of land cannot be completed in the short term.

The method does not take account of this complexity and is only used here to look at the environmental effects of the designation of land for agricultural use.

6.2 Quantitative information

6.2.1 Size of the subsidy

In a free market for land without town and country planning restrictions there would be no price differences between plots of land with different designations (apart from differences due to varying suitability for the designation in question and due to the location). Theoretically the price of land is determined by the cash value of the expected future proceeds or by the future utility for the user. Based on the data in Luijt (2002) the average price of land that was sold with an agricultural or horticultural designation in the period from 1998 up to and including 2000 was € 33,000 per ha. Assuming that this price is representative of the average value of agricultural land, the total value of all of the agricultural land in the Netherlands[23] (2,350,800 ha) was € 77.6 billion[24]. The average price of agricultural land with a 'red' designation (living space, working space and transport) was € 73,000 per ha in the period in question. It is therefore possible (again assuming that this price also gives a good indication of the average value of 'red' land) to estimate the value of the total surface area of 477,600 ha of 'red' land (built-up areas, transport and building sites) at € 34.9 billion.[25] If we add the two categories ('green' and 'red') together we obtain a value of € 112.5 billion for 2,828,400 ha, which is an average of almost € 40,000 per ha. This is a (rough) indication of the minimum

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[23] This is the surface area in 'agricultural use' according to the Dutch Central Office for Land Statistics. The surface area of 'cultivated land' in Netherlands Statistics's agricultural statistics is 16% smaller.

[24] By way of comparison: Van Tongeren and Van de Ven (1997) estimated that the total value of Dutch agricultural land at the end of 1990 was *f* 108 billion or € 49 billion. Given the increase in the price of land since then, the estimate given here does not seem unreasonable.

[25] This is of course the 'bare' land and consequently does not include the value of the buildings on it and the investments that were made to make the land suitable for its 'red' designation. By way of comparison: Van Tongeren and Van de Ven (1997) estimated the total value of built-on land in the Netherlands at the end of 1990 at *f* 172 billion or € 78 billion. Therefore our estimate seems on the low side.

price of land on a free market.[26] Agricultural land is therefore on average at least some € (40,000 – 33,000 =) 7,000 per ha 'too cheap'. The total difference in price for the entire surface area of agricultural land is € 16 billion. This price difference – converted to annuities (with an indefinite time horizon and a discount rate of 5%) – is approximately € 800 million per year. This estimate can be considered as a lower boundary because it is based on the (hardly realistic) assumption that the total area taken up by Dutch agriculture would not decrease if the land market were free.

A (more speculative) upper boundary for the estimated size of the subsidy can be found by assuming that agriculture is a 'too low-value' form of land use for a large part of the Netherlands and that there is enough latent demand for 'red' land to make half of all agricultural land 'red' (in simple terms: if the land market were free, half of the current agricultural surface area would be used for detached houses with large gardens). In that scenario the agricultural surface area would therefore be reduced to 1,175,400 ha and the surface area of 'red' land would expand to 1,653,000 ha. If the price of land remained the same, the total value of the land would increase to (1,175,400 x 33,000 + 1,653,000 x 73,000 =) 159,457,200,000 or € 67,831 per ha. According to this estimate, agricultural land would not be € 7,000 but € (68,000 – 33,000 =) 35,000 'too cheap' per ha and the subsidy, expressed as an annuity, would exceed € 4 billion per year'.[27]

6.2.2 Method

For the subsidy type applied here (volume regulation) formula (54) from Appendix I can be used:

$$\Delta z = (q^s{}_g - q_e) Z_q$$

Where in this case:

Δz = the environmental effect;

$q^s{}_g$ = the agricultural surface area in the current situation;

q_e = the agricultural surface area in a free market situation;

Z_q = the degree of pollution (emissions per ha).

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26 This is the minimum price because it is based on the current use of the land. However, if there were no protection of agricultural land in town and country planning, part of the current surface area that is agricultural land would be used for purposes with a higher added value per ha. The average price per hectare of all plots of land together would then also be higher.

27 By way of comparison: Aalbers *et al* (1999) estimate the value of all 'open space' in the Netherlands – based on the price difference between housing land and agricultural land in 1996 – at *f* 2,374 billion (€ 1,077 billion) or (with a discount rate of 3%) *f* 71 billion (€ 32 billion) per year. In comparison our 'high' estimate is therefore still low. Our intuition also tells us that our 'high' estimate is not exorbitant. After all, the figure per household is still less than € 700 per year. It does not seem unreasonable to assume that households in the Netherlands on average could find such an amount for a garden of approximately 3,000 m^2.

When the price of agricultural land increases structural effects are dominant. In the case of the Netherlands this means that forms of land use with a relatively low added value – such as arable farming and extensive cattle farming – will come under pressure when the price of land increases. This conclusion can also be derived from Table 6.1: the lowest prices for land are paid in these two sectors. That is why our analysis will focus in particular on the environmental effect of 'artificially' maintaining the amount of arable land and grazing land by applying protective measures in town and country planning.

Table 6.1 Average price of land per type of farming for the period 1998-2000

Type of farming	Price of land per ha in €
Arable farming	28,800
Horticulture	68,200
Permanent crops	39,700
Grazing animals	30,600
Housed animals	34,100
Mixed	31,800

Source**:** Luijt (2002).

6.2.3 Quantification of parameters

Surface area of agricultural land in the current situation ($q^s{}_g$)

As we have already stated, without the subsidy discussed here arable farming and extensive (permanent) cattle farming would be the first to come under pressure. The analysis is therefore tailored to these two sub-sectors of agriculture. The land area in use in these two branches of farming (specialised dairy and arable farms[28]) can be calculated based on Brouwer *et al* (2002, Tables 3.4 and 3.5) at 939,000 and 513,000 ha respectively. That is therefore a total of 1,452,000 ha.

Surface area of agricultural land in a free market situation (q_e)

Since we have no empirical data on the price elasticity of the demand for agricultural land we will calculate the effects of a scenario in which 20% of the current surface area of specialised arable and dairy farms would be given a 'red' designation if there were no subsidy.[29]

Environmental effects per ha (Z_q)

Table 6.2 gives the estimated emission factors for the two branches of farming considered.

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28 Grazing farms in the Netherlands are mainly dairy farms.

29 This implicitly means a 'price elasticity' of the demand for agricultural land of approximately –1 since the estimated size of the subsidy was also some 20% of the price of agricultural land.

Table 6.2 Emission factors for the relevant emissions in arable and dairy farming

Substance	Agricultural emissions (2000)	Dairy emissions		Arable emissions	
	tonnes	*tonnes*	*kg/ha*	*tonnes*	*kg/ha*
CO_2	6,876,000	687,600	732	206,280	402
N_2O	24,400	12,200	13.0	1,220	2.4
CH_4	410,000	205,000	218	20,500	40.0
NO_x	8,000	2,000	2.1	720	1.4
SO_2	280	70	0.07	25	0.05
NH_3	147000	73500	78.3	7350	14.3
NMVOC	1,700	425	0.5	153	0.3
CO	1,200	300	0.3	108	0.2
Phosphate (as P)	64,000	32,000	34.1	3,200	6.2
Nitrate (as N)	471,000	235,500	251	23,550	45.9
Land use		939,000 ha		513,000 ha	

Source: Netherlands Statistics (CBS); Agricultural Economics Research Institute (LEI).

Note: The emission figures for agriculture come from the Environmental Compendium (RIVM, 2001b) and for phosphate and nitrate from CCDM (2000). It is estimated that dairy farming causes 50% and arable farming 5% of the 'typical cattle farming emissions' (CH_4, N_2O, NH_3, phosphate and nitrate). The level of CO_2 emissions is estimated at 10% from dairy farming and at 3% from arable farming (in agriculture, cultivation under glass is the greatest source of CO_2 emissions). The level of other emissions is estimated at 25% from dairy farming and 9% from arable farming (the share of these two branches of farming in the total value of agricultural production). The surface area covered by these two branches of farming (939,000 and 513,000 ha respectively) was calculated based on Brouwer et al (2002, Tables 3.4 and 3.5).

6.2.4 Calculation of the environmental effects

Table 6.3 gives an overview of the calculated emissions that are attributable to the indirect subsidy. Table 6.4 gives the aggregated environmental effects, calculated using the weighting factors from Appendix II.

Table 6.3 Emissions attributable to the indirect subsidy ‘designation as agricultural land’ (in tonnes)

	Arable farming	Dairy farming	Total
CO_2	41,256	137,520	178,776
N_2O	244	2,440	2,684
CH_4	4,100	41,000	45,100
NO_x	144	400	544
SO_2	5	14	19
NH_3	1,470	14,700	16,170
NMVOC	31	85	116
CO	22	60	82
Phosphate (as P)	640	6,400	7,040
Nitrate (as N)	4,710	47,100	51,810
Land use (ha)*	76,950	140,850	217,800

* The land use was calculated using a correction factor to take account of the fact that the land is not entirely used for production. This correction factor is from RIVM’s IMAGE model and is 0.75; in other words 75% of the land is used for production.

Table 6.4. Aggregated environmental effects of the subsidy ‘designation as agricultural land’

Environmental effect	Emissions
Greenhouse effect (ktonnes of CO_2-equivalent)	1,958
Acidification (tonnes of SO_2-equivalent)	21,263
Photochemical ozone creation (tonnes of ethylene-equivalent)	346
Eutrophication (tonnes of phosphate-equivalent)	17,951
Land use (ha)	217,800

6.2.5 Sensitivity analysis

The extent of the environmental effects is in proportion to the percentage of land in the arable and dairy-farming sectors that it is expected would be used for other purposes if there were no town and country planning protection. This percentage was 20% in the above calculations. If another percentage is assumed the results change accordingly.

6.3 Concluding remarks

As in all the case studies, the above gives an indication of the ‘gross’ environmental effect of the subsidy. The ‘net’ effect depends, among other things, on what the land currently used for agriculture would be used for if there were no town and country planning protection. If it were mainly used for purposes with little environmental impact, such as housing, recreation and/or nature, then we can assume that the net environmental effect would not differ much from the gross effect. If the alternative uses were mainly business sites and transport, the net environmental effect of the subsidy might be much less negative and in some respects even positive.

Table 6.5 gives an overview of factors that can affect whether the actual environmental effect is larger or smaller than the effect estimated above and by how much.

Table 6.5 Factors that can cause actual environmental effects to differ from estimated environmental effects

↓	Subsidy discourages the use of space for activities that may have greater environmental effects
↓	Subsidy also stimulates positive environmental effects from permanent agriculture (nature, landscape and waste disposal)
↓	Subsidy causes agricultural production to take place in the Netherlands that would otherwise take place abroad (where it would have environmental effects)

NB:

↓ means that the environmental effect of the subsidy decreases if this factor is taken into account;

↑ means that the environmental effect of the subsidy increases if this factor is taken into account.

Application of the method in this case shows that it is not as suitable for analysing the designation of land for agricultural purposes. The case is made very complicated by in particular the lock-in effects and the complexity of the laws and rules of spatial planning policy that may have opposing effects. It is very difficult to take all of these rules and regulations into account, because the method would then have to include a very large number of ad hoc applications and assumptions. That would be possible, but at the expense of a significant advantage of the method, namely that it quickly gives insight into the first order environmental effects of the measure considered.

7. Regulatory Energy Tax

7.1 Qualitative information

7.1.1 Description and type of subsidy

The Regulatory Energy Tax was introduced in 1996. It is a tax on the (final) consumption of natural gas, electricity and certain oil products. The rules regarding the Regulatory Energy Tax can be found in the Environmental Taxes Act, Articles 36a to 36u. There are different categories of consumption to which decreasing tax rates apply (see Table 7.1). In December 2001 the European Commission approved the application of a special rate for cultivation under glass for the period until the end of 2007. There is an annual tax credit of € 142 per electricity connection.[30]

There is effectively no Regulatory Energy Tax on fuel for road-borne motor vehicles and pleasure boats because they already incur excise duty (see also Article 36i, paragraph 2 of the Environmental Taxes Act). The zero rate also applies to sustainable energy. In addition there are reductions for supplying particular forms of sustainable energy – e.g. electricity from the incineration of waste or total energy – to taxpayers (Articles 36o, 36r and 36t, Environmental Taxes Act). There is also a reduced rate on biomass that is recycled to make natural gas and on heat from biomass. Table 7.1 gives an overview of the Regulatory Energy Tax rates, the tax credit and the reductions.

The lower rates of Regulatory Energy Tax for higher categories of energy consumption and the special rate for cultivation under glass are types of tax subsidies as defined in chapter 2.[31] These are subsidies on inputs (type 3a in Table 2.1 and type 4 in Figure 2.2).

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[30] This tax credit was introduced with a view to not taxing energy use, which is considered unavoidable.

[31] See also Van Beers and De Moor (2001).

Table 7.1 Structure of Regulatory Energy Tax rates for 2002 (in €-cents)

Fuel	General		Cultivation under glass	
	2001	2002	2001	2002
Light heavy oil (€ct/litre)	12.649	13.041	0.05313	0.17329
Gas oil (€ct/litre)	12.756	13.151	0.05357	0.17475
LPG (€ct/kg)	15.088	15.556	0.06337	0.20671
Natural gas (€ct/Nm^3)				
<= 5,000 m^3	12.03[a]	12.4[a]	0.05	0.165
5,000 – 170,000 m^3	5.62	5.79	0.02	0.077
170,000 – 1 million m^3	1.04	1.07	0.004	0.014
> 1 million m^3	0	0	0	0
Electricity (€ct/kWh)				
<= 10,000 kWh	5.83	6.01		
10,000 – 50,000 kWh	1.94	2.00		
50,000 – 10 million kWh	0.59	0.61		
> 10 million kWh	0	0		
Tax credit (€/connection)	142	142		
Sustainable energy	Nil	Nil		
Reduction (supply to taxpayer)[b]				
Sustainable electricity sources (€ct/kWh)	1.94	2.0		
Natural gas from biomass (€ct/Nm^3)	5.62	5.79		
Heat from biomass (€ct/GJ)	1.77	1.82		
Electricity from waste (€ct/kWh)	0.97	1.0		
Electricity from total energy (€ct/kWh)	0.2	0.57		

a The same rate applies for natural gas for collective heating.

b The reduction for purchased forestry certificates is dependent on EU approval.

Source: Ministry of Finance (Environmental Taxes Act)

We focus below on the Regulatory Energy Tax structure for natural gas and electricity.

7.1.2 Directly stimulated activity

These subsidies stimulate above all the energy-intensive sectors and cultivation under glass (see also Table 7.2).

These sectors together account for over 630 PJ, which is almost half the total final energy use in the Netherlands (as energy, not including transport).

Table 7.2 Final energy use in the most energy-intensive sectors in 2000

SBI (1993)	Industry	Energy use (in PJ)
0112	Cultivation under glass	149.6[a]
15 – 16	Regular and luxury foods	94.5
21 – 22	Paper industry, printing businesses	40.5
24	Chemical industry (incl. manures)	222.4
26	Building materials	35.9
27	Base metals	48.3
28-32, 34-36	Metal products	39.4

[a] 1996

Source: Netherlands Statistics

7.1.3 Relevant environmental effects

Of the six environmental effects indicated in chapter 2, the increased greenhouse effect and acidification are relevant as regards Regulatory Energy Tax.[32]

7.1.4 Policy environment

Regulatory Energy Tax, and in particular the lower rates for the various categories of bulk consumers, are part of the agreements in the Benchmark Covenant, an agreement between the government and business regarding energy efficiency. As set out in chapter 1, the present study is a methodological survey aimed at determining the environmental impact of indirect subsidies, with case studies that focus on the application of the chosen method. Therefore in the present case we will also look at only the environmental impact of the Regulatory Energy Tax rate structure; other policies and the effects on the taxpayers' competitive positions are not considered.[33]

7.2 Quantitative information

7.2.1 Method

The formula that is relevant for Regulatory Energy Tax is based on equation (35) in Appendix I:

$$\Delta z = Z_q e_{p^*} \Delta s$$

Formula (35) implies that a given change in a tax subsidy on an input factor into a polluting production process results in greater environmental damage.

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[32] Other environmental effects such as the dangers from leaking oil tankers or the dangers related to nuclear power, waste (e.g. fly ash, slag, nuclear waste), nuisance and disturbance (e.g. gas extraction and high-voltage cables in the countryside) are not considered in this study.

[33] This means that we make no statements about the consequences for the Benchmark Covenant or about whether it would be possible to abolish the subsidy.

The following factors determine the extent to which there will be greater environmental damage:

- The size of the subsidy (Δs)
- The price elasticity of the equilibrium volume (e_{p^*})
- The degree of pollution from production (Z_q).

7.2.2 Size of the subsidy

The size of the subsidy was calculated in the first instance on the assumption that the 2nd tax bracket applies to all final energy use. What this means in this central variant of the subsidy is that the rate from the 2nd tax bracket is continued through to the large-scale consumer categories.[34] We have also calculated a maximum subsidy variant where the Regulatory Energy Tax rate from the 1st tax bracket is applied for all consumer categories. In fact that means that the current rate for the 1st bracket is applied across the board.[35]

The rate differences for 2002 in both variants are then multiplied by the consumption of gas and electricity per bracket.[36] Table 7.3 shows the calculation of the size of the subsidy.

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[34] This central variant is in line with the calculations of Netherlands Statistics.

[35] It is a fairly far-reaching assumption to apply the first bracket across the board. The various issues are discussed in context in section 11.4.

[36] The figures used are from Netherlands Statistics for large-scale consumption in 2001; see Leijsen et al (2001). The consumption figures in the 2nd and 3rd brackets were estimated based on the percentage in the 4th bracket (which is 41% for gas consumption and 34% for electricity consumption).

Table 7.3 Regulatory Energy Tax subsidy with a uniform rate from the 1st and 2nd brackets onwards

	2002 rate	Uniform rate from 2nd bracket onwards			Uniform rate from 1st bracket onwards		
	(in €ct)	Rate (in €ct)	Difference (in €ct)	Subsidy (in € mln.)	Rate (in €ct)	Difference (in €ct)	Subsidy (in € mln.)
Gas							
0-5d m^3	12.4	12.4	0.0		12.4	0.0	
5d-170d m^3	5.8	5.8	0.0		12.4	6.6	
170d-1m m^3	1.1	5.8	4.7		12.4	11.3	
>1m m^3	0	5.8	5.8		12.4	12.4	
Calculation				897			2,406
Electricity							
0-10d kWh	6.0	6.0	0.0		6.0	0.0	
10d-50d kWh	2.0	2.0	0.0		6.0	4.0	
50d-10m kWh	0.6	2.0	1.4		6.0	5.8	
>10m kWh	0	2.0	2.0		6.0	6.0	
Calculation				671			2,810
Total				1,568			5,216

Source: Calculations based on Lijesen et al (2001)

Our calculation indicates a subsidy of between € 1.6 and € 5.2 billion. We will use this range to calculate the environmental impact.[37]

7.2.3 Quantification of parameters

Price elasticity of the equilibrium volume

Studies of price elasticity show a limited elasticity of the demand for energy. A literature study by the OECD (2000) suggests that the long-term price elasticity of the demand for energy is between –0.2 and –0.6.[38] According to the GTAP database, which is much used internationally, the region-specific and country-specific price elasticities for coal, oil and gas vary from –0.13 to –0.92.[39] However, this database also includes developing countries. It is more relevant to use estimates for the EU or other industrialised countries such as the US, Canada or Japan (see Table 7.4).

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37 Another approach is to convert the Regulatory Energy Tax rate into rates per unit of energy. These rates vary from 1.6 to 3.5 eurocents per GJ for natural gas and from 5.5 to 16.7 eurocents per GJ for electricity. The amounts are multiplied by the final use of energy to determine the theoretical revenue from Regulatory Energy Tax. This approach yields a subsidy of between € 0.9 and over € 6 billion.

38 There have been studies where the results fell well outside this range with extremities for short-term price elasticity of –1.1 and for long-term price elasticity of even –4.6. It is unclear how these estimates should be judged; the OECD (2000) advises caution.

39 The database of the Global Trade Analysis Project (GTAP) forms the quantitative basis for many economic models, including the OECD's GREEN model, Netherlands Statistics' WorldScan model and MIT's EPPA model.

Table 7.4 Price elasticities of coal, oil and gas in the GTAP database

	EU	EU3	EFTA	US	Canada	Japan
Coal	–0.79	–0.85	–0.92	–0.82	–0.77	–0.91
Oil	–0.79	–0.85	–0.92	–0.82	–0.77	–0.91
Gas	–0.79	–0.85	–0.92	–0.82	–0.77	–0.91

Source: Hertel (1999).

Table 7.4 shows that the price elasticity for coal, oil and gas is between –0.8 and –0.9 for the most developed industrialised countries.[40]

It is noticeable that Koopmans et al (1999) estimate a much lower price elasticity for the Netherlands, namely –0.29. However, according to the GTAP database, this is the elasticity level of developing countries such as India (-0.29), the Philippines (-0.28) or the countries of Central Africa around the Sahara (-0.26).

Other studies show that the price elasticity is greatest for coal. In general, the price elasticity for gas is lower than for electricity. In our analysis we will assume a price elasticity of –0.3 and –0.8.

Degree of pollution

The degree of pollution is measured as the volume of emissions per unit of GDP. According to international data sources, the greenhouse gas emissions for the Netherlands in 1998 and 1999 were 237 and 230 Mtonnes respectively with a GDP of € 354 and € 367 billion, which implies a level of greenhouse gas of 669 and 626 kilograms per € 1,000 GDP for 1998 and 1999 respectively. Since it is the energy and industry sectors that profit from the Regulatory Energy Tax subsidy, it is more relevant to apply the level of greenhouse gas for these sectors. The level of greenhouse gas for the energy and industry sectors is 1,725 kilograms per € 1,000 GDP, which is a factor of 2.8 higher than the macro-level (see also section 7.3.5).

The level of acidification from the Dutch economy is 60 to 65 acid-equivalents per € 1,000 GDP. For the energy and industry sectors the level of acidification is approximately 14 acid-equivalents. This amounts to approximately 0.4 kg of SO_2-equivalents (in this study we are reporting the impact in SO_2-equivalents).[41]

7.2.4 Calculation of the environmental effects

Table 7.5 shows all the parts of formula (35) as well as the result. A minimum and a maximum result have been calculated for both subsidy variants. The minimum is based on a low price elasticity and a low level of emissions. The maximum is based on the higher values for each of the variables mentioned.

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[40] In general, the demand for energy in the shorter term is less elastic and the price elasticity is therefore slightly lower.

[41] One acid-equivalent corresponds to 0.032 kg of SO_2-equivalents.

Table 7.5 The environmental impact of the Regulatory Energy Tax subsidy as regards greenhouse gas and acid emissions for the central and maximum subsidy variants

		Central subsidy variant Regulatory Energy Tax rate from 2nd bracket onwards		Maximum subsidy variant Regulatory Energy Tax rate from 1st bracket onwards	
		Minimum	Maximum	Minimum	Maximum
Size of subsidy	Δs	1,568	1,568	5,216	5,216
Price elasticity of demand	e_{p*}	–0.3	–0.8	–0.3	–0.8
Emission/production of greenhouse gases	Z_q	1,725	1,906	1,725	1,906
Emission/production of acids	Z_q	418	452	418	452
Effect of greenhouse gas emissions (ktonnes of CO_2-equiv.)		811	2,391	2,700	7,954
Effect of acid emissions (tonnes of SO_2-equiv.)		19,728	56,681	65,494	1,885,271

The effect of the Regulatory Energy Tax on greenhouse gas emissions varies from 0.8 to almost 2.4 Mtonnes of CO_2-equivalents for the central subsidy variant and from 2.7 to almost 8 Mtonnes for the maximum subsidy variant. The environmental effect on acid emissions is between 200 and over 560 tonnes of SO_2-equivalents for the central subsidy variant and between 650 and almost 1,900 tonnes of SO_2-equivalents for the maximum subsidy variant. More precise parameters will obviously narrow these ranges.

7.2.5 Sensitivity analysis

The preceding calculations are based on a number of assumptions regarding the parameters in the method, particularly the choice of values for the elasticity of demand and the degree of pollution. Table 7.6 contains the results for the effect of a number of sensitivity variants on greenhouse gas emissions.

Table 7.6 The effect of other parameter values on greenhouse gas emissions (in ktonnes) for the central and maximum subsidy variants

		Central subsidy variant		Maximum subsidy variant	
		Minimum	Maximum	Minimum	Maximum
Effect on greenhouse gases, central variant		811	2,391	2,700	7,954
Elasticity of demand higher (cent. var: -0.3)	$e_{p*} = -0.5$	1,352		2,879	
Elasticity of demand higher (cent. var: -0.83)	$e_{p*} = -1.0$		2,989		9,943
Greenhouse gases at macro-level (cent. var.: 1725 and 1906)	$Z_q = 626$	295	785	980	2,613

The value used for the degree of greenhouse gases at macro-level and at sector level is particularly important when calculating the environmental impact. At a macro-level for the entire economy of more than one third of the sector level the emissions of greenhouse gases are proportionately lower. This also applies to acid emissions, but the other way around: the macro-level is higher than the sector level by a factor of between 4 and 5. In that case the SO_2-equivalent emissions will also be higher.

7.3 Concluding remarks

Netherlands Statistics recently carried out a study (Lijesen *et al*, 2001) on behalf of the *Werkgroep Vergroening van het Fiscale Stelsel II* [Working Group on Environment-oriented Measures in the Fiscal System II]. One notable point about this study is that a variant 5 is included in the calculations whereby a uniform rate is assumed for all companies (so *not* private consumers) while the level of total revenue remains unchanged. The additional tax revenue is generically recycled through tax measures. Netherlands Statistics puts the amount in question at *ƒ* 3 billion (almost € 1.4 billion). This variant 5 is very similar to the central subsidy variant in this study, for which the subsidy was estimated at over € 1.6 billion. However, the rates in variant 5 are lower than in our exercise because of the recycling of the additional revenue.

Netherlands Statistics calculates that industry will use 0.3% to 1.1% less energy and that CO_2 emissions will reduce by 1.3 Mtonnes by 2010 and by 2.2 Mtonnes by 2020. Unlike in our exercise, the emissions of greenhouse gases other than CO_2 and the acid emissions are *not* included in the study by Netherlands Statistics.

The most important difference compared with this study lies in the instruments used. The Central Statistical Office's results come from a modelling exercise where all kinds of dynamic effects and connections with other sectors are included. Our method is a first-order approximation that does not include dynamic effects and substitution processes; it will therefore yield different results than an exercise with a macro-economic model. Nevertheless, our method gives a rough, initial impression of the environmental impact of the Regulatory Energy Tax subsidy.

The sensitivity analysis shows that using one level of emissions for the entire economy can both decrease and increase the environmental impact, depending on the nature of the environmental problem. In the case of greenhouse gas emissions, using a macro-level will lessen the environmental impact, but the effect is the opposite for acidification. With a greater elasticity as reported in the international GTAP database, the environmental impact is generally greater.

Table 7.7 Factors that can cause actual environmental effects to differ from the expected environmental effects

↑ and ↓	A more specific level of emissions for activities that are stimulated by the subsidy; the impact depends greatly on the type of subsidy
↑	Greater elasticity of the demand (more in line with the international GTAP database)

NB:

↓ means that the environmental effect of the subsidy decreases when this factor is taken into account;

↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

8. Passing on the cost of railway infrastructure

8.1 Qualitative information

8.1.1 Description and type of subsidy

Since 2000 a fee has been charged for the use of railway infrastructure. This fee is payable to the manager of the railway network (Railinfrabeheer). However, the fee only covers (part of) the management and maintenance costs and not the capital costs. Capital costs are (still) paid entirely by the State.

This is a form of public supply below the cost price (subsidy type 4 in Table 2.1). The point of application is the input side of intermediary activities (type 3 in Figure 2.2).

8.1.2 Directly stimulated activity

As a result of this subsidy it is cheaper to use rail infrastructure than if the investment costs were fully passed on. The subsidy stimulates passenger and freight transport by train.

8.1.3 Environmental effects

The environmental effects of rail transport that are relevant for this study are primarily emissions of CO_2, SO_2 and NO_x, CO and VOC. These are emissions from the generation of electricity and from diesel-electric trains.

8.2 Quantitative information

8.2.1 Method

In principle, the environmental effects of the subsidy on railway infrastructure (an input subsidy) can be calculated using formula (41) from Appendix I:

$$\Delta z = Z_q \left(\frac{D_p S_{w^*}}{S_p - D_p} \right) \Delta s$$

where:

Δz = the environmental effect;

Z_q = the degree of pollution from production (in this case: emissions per passenger-kilometre or per tonne-kilometre);

D_p = the price reaction of the demand (for rail transport)

S_p = output price reaction in the supply (of rail transport)

S_{w^*} = input price reaction in the supply (i.e. of the demand for railway infrastructure)

Δs = the (change in the) size of the input subsidy.

However, the information that is required to calculate S_p and S_{w*} is not available. We have therefore made the additional assumption that the subsidy on the input (railway infrastructure) is directly passed on in the price of the output (railway transport). The formula can then be written as follows:

$$\Delta z = Z_q \cdot e_p \cdot q \cdot \frac{\Delta s}{p + \Delta s}$$

where:

e_p = price elasticity of the demand (in this case: for railway transport, as an absolute value);

q = the extent of the activity (in this case: railway transport);

p = the price (in this case: of railway transport, per passenger-kilometre or per tonne-kilometre);

and the other symbols are as above.

8.2.2 Size of the subsidy

The fee for using railway infrastructure is determined based on the Fees for the Use of Railway Infrastructure Decree. The fee only covers the management and maintenance costs and therefore not capital costs. Furthermore, these costs (approximately € 130 million per year) will not be fully invoiced until 2007 (in 2002 the invoice was for 45%, i.e. almost € 60 million).

CE (1999) notes that this fee for use is based on short-term marginal costs only, i.e. the costs that are directly related to the actual use of the infrastructure. A large part of the maintenance and management costs for the infrastructure is 'upkeep', which is not affected by the volume of traffic. The total annual cost of management and maintenance (including the State's contribution for maintenance of the stations) is estimated at € 533 million. The cost of investment in railway infrastructure (interest and depreciation) was estimated for 2002 at € 1.5 billion, of which € 0.8 billion was depreciation and € 0.7 billion was interest (CE, 1999). These estimates are based on the investment expenditure in the period 1970-2005. The total subsidy is therefore almost € 2 billion per year.

The number of train-kilometres driven annually on the Dutch railway network is over 130 million, of which more than 10 million is freight trains and 120 million is passenger trains (Gijsen and Van den Brink, 2002). We will attribute the infrastructure subsidy per train-kilometre to passenger and freight transport in a ratio of 1:3.[42] The subsidy is therefore approximately € 1.6 billion for passenger transport and € 400 million for freight transport.

In 2001 the number of passenger-kilometres in railway transport in the Netherlands was 15.5 billion and the number of tonne-kilometres was 839 million (source: Netherlands

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42 This is in line with the approach used by CE (1999), which is based on the norm in the international literature.

Statistics). The subsidy per passenger-kilometre was therefore some € 0.10 and per tonne-kilometre € 0.48.

8.2.3 Quantification of parameters

Extent of the activity (*q*)

In 2001 the number of passenger-kilometres in railway transport in the Netherlands was 15.5 billion and the number of tonne-kilometres was 839 million (see 8.2.2).

Extent of the environmental effects per unit of activity (Z_q)

The environmental effects of railway transport depend greatly on a number of factors, particularly the assumed capacity utilisation and the traction system (electric or diesel-electric). Table 8.1 gives a number of estimates of emissions per passenger-km and per tonne-km for all train traffic in the Netherlands in 1998. The results were very varied for the three emissions for which two sources were available. We will use the averages of the values determined to make a point estimate for our calculations and we will use sensitivity analyses for the extreme values.

Table 8.1 Emissions from passenger and freight transport by train in 1998 (per passenger-kilometre or per tonne-kilometre)

	CO_2 (grams)	SO_2 (mg)	NO_x (mg)	VOC (mg)	CO (mg)
Passenger traffic					
Dijkstra and Dings (2000)	61	29	92	7	23
Gijsen and V.d. Brink (2002)	42	18	151		
Point estimate	*52*	*24*	*122*	*7*	*23*
Freight traffic					
Dijkstra and Dings (2000)	38	25	302	6	28
Gijsen and V.d. Brink (2002)	14	4	117		
Point estimate	*26*	*15*	*210*	*6*	*28*

Price elasticity of the demand (e_p)

Based on an overview of international studies, Goodwin (1992) calculated an average price elasticity of the demand for railway traffic of –0.65 for the short term and –1.08 for the long term. Oum et al (1990) also used existing studies to arrive at a 'most likely range' for passenger traffic of –1.40 to –1.60 for private travel and –0.60 to –0.70 for business travel. The 'most likely range' for freight traffic was –0.40 to –1.20.

We will use –0.8 as a point estimate for our calculations for both types of transport, with sensitivity analyses for the extreme values of the ranges mentioned: -0.4 and –1.2 (assuming that at least half of passenger transport is business travel).

Price (*p*)

The price of transport by train can vary greatly, depending on the distance, the type of load, availability of season tickets, etc. A reasonable estimate[43] seems to be € 0.03 per tonne-kilometre for freight transport and € 0.09 per passenger-kilometre for passenger transport.

Size of the subsidy (Δs)

The size of the subsidy was calculated in 8.2.2 at some € 0.10 per passenger-kilometre and € 0.48 per tonne-kilometre.

8.2.4 Calculation of the environmental effects

The subsidy considered here implies a 94% reduction in the price of freight transport (€ 0.48 / (€ 0.48 + € 0.03)) and a 53% reduction in the price of passenger transport (€ 0.10 / (€ 0.10 + € 0.09)). With a constant price elasticity of –0.8 the volume of freight transport without a subsidy would therefore be 75% less (at a little more than 200 million tonne-km) and the volume of passenger transport would be approximately 42% lower (at approximately 9 billion passenger-km).

The emissions that are attributable to the subsidy are indicated in Table 8.2.

Table 8.2 Emissions from passenger and freight transport by train that are attributable to the subsidy

	CO_2 (ktonnes)	SO_2 (tonnes)	NO_x (tonnes)	VOC (tonnes)	CO (tonnes)
Passenger transport	342	158	802	46	151
Freight transport	16	9	132	4	18
Total	**358**	**167**	**934**	**50**	**169**

In Table 8.3 the various elements have been converted to environmental indicators using the weighting factors from Appendix II.

43 Based on figures from Netherlands Statistics, assuming that the average distance over which goods are transported within the Netherlands is 150 km.

Table 8.3 Environmental indicators for not passing on the full cost of railway infrastructure

Greenhouse effect (ktonnes CO_2-equivalent)	358
Acidification (tonnes SO_2-equivalent)	550
Photochemical ozone creation (tonnes ethylene-equivalent)	56
Eutrophication (tonnes phosphate-equivalent)	121

8.2.5 Sensitivity analysis

Table 8.4 shows the results with different assumptions for the elasticities and the emission factors, as discussed in 8.2.3. It is noticeable with an assumed elasticity of –1.2 and no subsidy that freight railway transport would be reduced to zero.

Table 8.4 Environmental indicators with other elasticities and emission factors (units as in Table 8.3)

	e_p=-0.4; average emission factors	e_p=-1.2; average emission factors	e_p=-0.4; lowest emission factors	e_p=-1.2; highest emission factors
Greenhouse effect	179	534	142	633
Acidification	275	815	199	1,021
Ozone creation	28	82	24	93
Eutrophication	61	179	44	226

8.3 Concluding remarks

The calculated environmental effects of not passing on railway infrastructure costs are an estimation of the ‘gross’ effect. Substitution effects also have to be taken into account to determine the ‘net’ effect: without the subsidy some of the traffic would go to other means of transport. Whether or not these substitution effects are extensive enough to compensate for the net environmental effect of the subsidy discussed here depends greatly on the assumptions that are made as regards the substitution elasticities, the alternative means of transport (e.g. roads or inland waterways in the case of freight transport), capacity utilisation, emission characteristics and so forth. A detailed analysis of these aspects is outside the scope of this study.

With a view to putting the calculated figures into perspective it is worth noting that the attributed investment costs may well be on the high side, given that there are already investments in such projects as the Betuwe Line and the High-Speed Line although these lines are not yet in use. On the other hand, investment in railway infrastructure in the 1970s and 1980s (which is also included) was very low.

Table 8.5 gives an overview of factors that can affect whether the actual environmental effect is larger or smaller than the environmental effect estimated above and by how much.

Table 8.5 Factors that may cause actual environmental effects to differ from estimated environmental effects

↓	Without the subsidy some of the traffic would go to other means of transport (substitution effect)
↓	Attributed investment costs may well be on the high side

N.B.: ↓ means that the environmental effect of the subsidy decreases when this factor is taken into account; ↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

9. Public transport commuting allowance

9.1 Qualitative information

9.1.1 Description and type of subsidy

Until 2001 the costs of commuting were partially deductible from income tax, even if the journey was made by car. In 1999, 1.25 million people took advantage of this deduction possibility (source: Netherlands Statistics). In the new tax system this flat rate allowance for travel costs no longer exists and there is now only a 'public transport commuting allowance' for the commuting costs that are not reimbursed by the employer.[44] Eligibility for this allowance is subject to certain conditions as regards the distance of the journey (minimum of 10 kilometres) and the frequency of the journey (minimum of 1 day a week or 40 days a year). Table 9.1 shows the amounts that were tax-deductible in 2001.

Table 9.1 Public transport commuting allowances in 2001 (in €)

	Number of days on which journey made per week			
Journey distance (one way)	*4 or more*	*3*	*2*	*1*
10 – 15 km	351	263	176	88
15 – 20 km	470	353	235	118
20 – 30 km	791	593	396	198
30 – 40 km	981	736	491	245
40 – 50 km	1,283	962	642	321
50 – 60 km	1,426	1,070	713	357
60 – 70 km	1,582	1,187	791	396
70 – 80 km	1,637	1,228	819	409
> 80 km	1,659	1,244	830	415

The commuting allowance can be considered a subsidy because the costs for consumers (in this case: commuters) are lower as a result. This is a subsidy on outputs through tax measures, whereby the point of application is on the end of the production-consumption chain (subsidy type 3b in Table 2.1 and type 5 in Figure 2.2).

9.1.2 Directly stimulated activity

The subsidy benefits people who use public transport to commute to and from work. This means that preferential treatment is given to travel by public transport compared to travel by car, but also that the costs of commuting as such are lowered and the transport sector is therefore stimulated.

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44 There is also a commuting allowance of € 339 for cyclists who cycle at least 10 kilometres to work at least three days a week.

9.1.3 Environmental effects

Train, bus, tram and metro are the types of public transport most frequently used by commuters. The environmental effects of buses and diesel-electric trains that are relevant in this study are emissions of CO_2, NO_x, SO_2, VOC and CO. For electric trains, trams and metros the environmental effects relate mainly to generation of electricity. In the Netherlands that means in particular CO_2, NO_x and SO_2 emissions.

9.2 Quantitative information

9.2.1 Method

We can analyse the environmental effects of this subsidy by using formula (53) from Appendix I:

$$\Delta z = \Delta s \cdot \partial x_i / \partial s_k \cdot Z_q$$

where:

Δz = the environmental effect

Δs = the size of the subsidy

$\partial x_i / \partial s_k$ = the effect of the subsidy on the demand

Z_q = the degree of pollution from production (in this case: the emissions per passenger-kilometre in public transport)

9.2.2 Size of the subsidy

Before the size of the subsidy can be determined, it is first necessary to estimate the amount of commuter traffic on public transport.

The average distance commuted by train in 2000 was 43.1 kilometres; the average distance for those who travelled to work by bus, tram or metro was 14.4 kilometres. The number of journeys made to and from work per person per day for both train and bus/tram/metro travellers was 0.02 (calculated over the entire population of the Netherlands of 15.9 million) (source: Netherlands Statistics). The number of commuted passenger-kilometres on public transport can therefore be calculated as follows for 2000 (which was a leap year):

0.02 x 366 x 15.9 million x 43.1 = 5.0 billion for rail, and

0.02 x 366 x 15.9 million x 14.4 = 1.7 billion for bus/tram/metro.

Based on the above-mentioned average commuting distances, it seems reasonable to estimate that 90% of the train-kilometres and 30% of the bus-/tram-/metro-kilometres were travelled by commuters whose commuting distance exceeds 10 kilometres. The number of tax-deductible commuting kilometres can then be estimated at 4.5 billion for rail and 0.5 billion for bus, tram and metro.

Table 9.1 can be used to calculate that the average commuting allowance was some € 0.07 per kilometre.[45] Assuming a marginal tax rate of 42% the size of the subsidy can therefore be estimated at 0.07 x 0.42 x 4.5 billion = € 132 million for rail and 0.07 x 0.42 x 0.5 billion = € 15 million for bus, tram and metro.

9.2.3 Quantification of parameters

Effect of the subsidy on the demand ($\Delta s \cdot \partial x_i / \partial s_k$)

The Social and Cultural Planning Office (1993) gives an own price elasticity of –0.5 for commuter traffic on public transport. This value can also be found elsewhere in the literature; see Acutt and Dodgson (1996), for example. If we compare Table 9.1 with the price information provided by Dutch Rail we learn that around 60% of the travel costs are tax-deductible if the entire distance is travelled by train.[46] We assume that this percentage also applies to the other forms of public transport. At a marginal tax rate of 42%, therefore, the commuting allowance reduces the cost of commuting by approximately 25%. Assuming a price elasticity of –0.5, the volume of commuter traffic on public transport is therefore some 12.5% more than would have been the case without the commuting allowance. In other words: of the total amount of commuter traffic on public transport, 12.5/112.5 = 11% is attributable to the tax deduction for travel costs. That amounts to 550 million passenger train-kilometres and 187 million passenger-kilometres by bus, tram or metro. This is therefore not the marginal effect $\partial x_i / \partial s_k$, but the total effect $(\Delta x_i = \Delta s \cdot \partial x_i / \partial s_k)$.

Extent of the environmental effects per unit of activity (Z_q)

The environmental effects for train, metro and bus were calculated based on Roos *et al* (1997) (see Table 9.2). For buses we took the average for local and regional buses; for trains we used Intercity trains. We also assumed that the electricity used was entirely generated in the Netherlands.

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45 By way of illustration: taking into account 5 weeks holiday per year, the allowance for someone who travels 90 km there and back 5 days a week is as follows: € 1,659 / (47 x 5 x 90 x 2) = € 0.04 per km. For someone who travels 10 km there and back 1 day a week the calculation is as follows: € 88 / (47 x 10 x 2) = € 0.09 per km.

46 By way of illustration: for someone who travels more than 80 km there and back 47 weeks a year and 5 days a week the best option is an NS annual season ticket at € 2,380. The public transport commuting allowance of € 1,659 covers 70% of the cost of this annual ticket. For someone who travels 10 km there and back 47 weeks a year 1 day a week, the cheapest option is to buy individual tickets, which will cost a total of € 155. In this case the public transport commuting allowance of € 88 covers 57% of the overall cost.

Table 9.2 Emissions from trains, buses and metros (per vehicle-kilometre)

	Train	Bus	Metro
CO_2 (kg)	13.7	1.2	12.0
NO_x (g)	24.9	13.6	21.8
SO_2 (g)	18.3	0.3	16.0
CO (g)	2.4	2.6	2.1
VOC (g)	0.8	0.7	0.7

The emissions per passenger-kilometre depend on the capacity of the vehicle and the capacity utilisation. Roos et al (1997) use a capacity utilisation level of 40% in their calculations for intercity trains with a capacity of 829 passengers, i.e. 332 passengers per train. They arrive at 24 passengers for local and regional buses (60 seats, 40% capacity utilisation) and 133 passengers for the metro (332 seats, 40% capacity utilisation). However, as the present case study is about commuter traffic, most of which is in the rush hours, it is more realistic to apply a slightly higher capacity utilisation (50%).[47] Based on these figures, the emissions per passenger-kilometre are as indicated in Table 9.3 (where we have used the non-weighted average of bus and metro for the category bus/tram/metro).

Table 9.3 Emissions from trains, buses, trams and metro (per passenger-kilometre)

	Train	Bus/Tram/Metro
CO_2 (g)	33	56
NO_x (mg)	60	292
SO_2 (mg)	44	53
CO (mg)	6	50
VOC (mg)	2	14

9.2.4 Calculation of the environmental effects

The data from the previous sections can be used to estimate the environmental effects of the public transport commuting allowance as indicated in Table 9.4.

[47] According to Rietveld (2002), the average capacity utilisation of trains during the rush hours in the Netherlands is 48%. This may seem on the low side, but we must remember that capacity utilisation of 100% (or more) is usually only achieved in one direction and even then only on part of the route.

Table 9.4 Passenger-kilometres and emissions attributable to the public transport commuting allowance

	Train	Bus/Tram/Metro	Total
Number of passenger-kilometres attributable to subsidy	550 million	187 million	737 million
CO_2 (tonnes)	18,179	10,499	28,678
NO_x (kg)	33,040	54,666	87,705
SO_2 (kg)	24,282	9,947	34,229
CO (kg)	3,185	9,286	12,471
VOC (kg)	1,062	2,576	3,637

Finally, the effect of the subsidy on the various environmental indicators can be determined using the weighting factors from Appendix II (see Table 9.5).

Table 9.5 Environmental indicators with the public transport commuting allowance

Greenhouse effect (ktonnes of CO_2-equivalent)	29
Acidification (tonnes of SO_2-equivalent)	70
Photochemical ozone creation (tonnes of ethylene-equivalent)	5
Eutrophication (tonnes of phosphate-equivalent)	11

9.3 Concluding remarks

The reduction in the effective costs of commuting on public transport as a result of the commuting allowance can lead not only to greater demand for public transport but also to less use of cars in commuter traffic (substitution effect).[48] When this effect is taken into account the environmental effects of the tax deduction for travel costs are therefore smaller than calculated above.

The extent of the substitution effect depends greatly on the assumed capacity utilisation for cars. According to Roos *et al* (1997) a petrol or diesel car emits between 122 and 305 grams of CO_2 per km. Assuming that the driver is the only occupant of the car, the level of emission per passenger-kilometre is therefore between almost 4 and over 9 times as much as from a train and between over 2 and 5½ times as much as from a bus/tram/metro (in rush hours; cf. Table 9.3). If we assume that the emission level is on average 6 times as much, for CO_2 that means that the environmental effect of the commuting allowance is compensated for by the substitution effect if at least 17% of the demand for public transport that results from the commuting allowance is made up of commuters who previously travelled by car. By way of comparison: Acutt and Dodgson (1996) estimate this ‘diversion factor’ at 12 to 25% for London, depending on the type of public transport. This may mean that the environmental effects of the tax deduction for travel costs are entirely neutralised by substitution effects (i.e. the emissions that are avoided because the commuting allowance leads some of the commuters to transfer from their cars to public transport).

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48 There is also a substitution effect that has the opposite environmental effect: less use of bicycles to commute.

The calculated environmental effects are based on the average emissions per passenger-kilometre. However, Rietveld (2002) points out that it is not so much the average as the marginal emission that is important, i.e. the emission that is caused by the *extra* passenger. He also shows – in any case for trains – that the marginal strain on the environment from an extra passenger is greater in the rush hours than outside the rush hours. This implies that the results of calculations based on average environmental effects are unrealistically low, because commuting is mostly done in the rush hours.

Table 9.6 gives an overview of factors that can affect whether the actual environmental effects differ from the environmental effects estimated above and by how much.

Table 9.6 Factors that can cause actual environmental effects to differ from estimated environmental effects

↓	Less use of cars because of the subsidy (substitution effect)
↑	Marginal strain on the environment in the rush hours is greater than the average strain on the environment

NB: ↓ means that the environmental effect of the subsidy decreases when this factor is taken into account;
↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

10. Exemption from excise duty on aviation fuel

10.1 Qualitative information

10.1.1 Description and type of subsidy

Fuel for international air traffic is exempt from excise duty. This exemption is based on international treaties and EU and national regulations. The most important of these are as follows:

- The Chicago Treaty of 1944: under Art. 24 of this Treaty, it is not permitted to levy tax on fuel that is already on board an aircraft;
- Clauses in bilateral aviation agreements (so-called ‘Air Service Agreements’ or ‘ASAs’): these usually state that country A is not permitted to levy tax on fuel that in country A is taken on board aircraft that are registered in country B;
- EC Directive 92/81: under Art. 8, paragraph 1b, the Member States are obliged to grant exemption from excise duty for mineral oils that are supplied for use as fuel for any aviation other than private pleasure aviation. The Member States can limit this exemption to supplies of reaction engine fuel (CN[49] code 2710 00 51);
- The Excise Duty Act: Art. 66 incorporates the exemption from excise duty on aviation fuel for the Netherlands. The Netherlands has not taken up the possibility offered by the EU to limit this exemption to reaction engine fuel.

The tax exemption for aviation fuel is a subsidy since it leads to lower costs for the aviation sector. It is a subsidy on inputs through tax measures (subsidy type 2 in Table 2.1). As regards point of application (see Figure 2.2) it is a type 3 subsidy: a subsidy on an input into a production activity.

10.1.2 Directly stimulated activity

This exemption primarily benefits domestic and foreign airlines that carry passengers and/or freight. In so far as they have their registered office in the Netherlands these airlines fall statistically under SBI 62 (Air transport) [SBI = Standard Industrial Classification].

10.1.3 Environmental effects

The most important environmental effects of aviation in the framework of this study concern air pollution. Of the total anthropogenic CO_2 and NO_x emissions, 2 to 3% comes from aviation.[50] However, given the altitude at which the emissions take place, the effect

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[49] CN = Combined Nomenclature (the EU goods list for customs).

[50] It should be noted here that the emissions of greenhouse gases in international aviation do not fall under the national obligations to reduce emissions within the framework of the Kyoto Protocol.

of NO_x from aircraft on the atmospheric chemistry may be greater than the effect from other sectors (such as road traffic) on the ground. Furthermore, contrails contribute to the greenhouse effect.[51] The extent to which air traffic contributes to local air pollution (around Schiphol Airport) is limited (RIVM, 1998).

In addition to air pollution, noise pollution and external safety are also important environmental aspects of aviation. However, they will not be considered in this study.

10.2 Quantitative information

10.2.1 Method

Formula (41) from Appendix I can be used to calculate the environmental effects of the subsidy on aviation fuel (which is an input subsidy):

$$\Delta z = Z_q \left(\frac{D_p S_{w*}}{S_p - D_p} \right) \Delta s \qquad (10.1)$$

where:

Δz = the environmental effect;

Z_q = the degree of pollution from production (in this case: emissions per passenger-kilometre);

D_p = price reaction of the demand (for flights);

S_p = output price reaction in the supply (of airline traffic);

S_{w*} = input price reaction in the supply (i.e. the effect of the price of aviation fuel on the supply of airline traffic);

Δs = the (change in the) size of the input subsidy.

However, there is no specific information about price reactions in the supply, which is required to calculate S_p and S_{w*}. We have therefore assumed that the interaction between demand and supply is already included in the empirically determined price elasticities.

Another assumption is that the subsidy on the input (kerosene) has a direct effect on the price of the output (flights) and that this effect is in proportion to the extent to which the total production costs are made up of fuel costs. The formula can then be simplified to:

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51 Source: http://www.knmi.nl/onderzk/atmosam/aviation.html. See also Dings *et al* (2002). However, there is still much scientific uncertainty about the extent of the effects of contrails (Pulles, 2002).

$$\Delta z = Z_q \alpha e_p \frac{q}{w^*} \Delta s \tag{10.2}$$

where:

α = the extent to which the total production costs are made up of fuel costs (or the extent to which the price of a ticket, which is assumed to be equivalent here, is determined by fuel costs);

e_p = the price elasticity of the demand (in this case: for flights, as an absolute value);

q = the extent of the activity (in this case: air traffic);

w^* = the input price (in this case: the price of kerosene) (lowered by the subsidy)

and the other symbols are as above.

10.2.2 Size of the subsidy

Aviation fuels fall under CN codes 2710 00 51 and 2710 00 55 (light heavy oil) and therefore should normally be subject to the same excise duty as diesel (gas oil). Assuming that the level of excise duty on 'red' diesel[52] already implies that there is an indirect subsidy, the standard level of excise duty for diesel would therefore be the correct reference point.[53] In 2002 this standard rate was approximately € 0.33 per litre.[54] In 2000 in the Netherlands 3.2 billion kg of aviation fuel was supplied ('bunkers') exempt from excise duty (source: Netherlands Statistics). Assuming a density of 0.85 kg/l, the total amount of the subsidy is therefore approximately € 1.2 billion per year.

10.2.3 Quantification of parameters

Extent of environmental effects per unit of activity (Z_q)

The environmental effects of aviation depend greatly on the type of aircraft (engine), the distance flown, the altitude at which the aircraft flies and the capacity utilisation.

In a recent CE study (Dings *et al*, 2002) emission data is given for four different combinations of aircraft types and flown distances (see Table 10.1).

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52 Red diesel is gas oil that is not intended for road traffic or pleasure cruising.

53 A counterargument might be that the excise duty on diesel must be considered in part as payment for the use of the public highway. However, this argument is weakened by the fact that the standard rate for diesel also applies to pleasure cruising.

54 € 0.32553 for low-sulphur gas oil and € 0.33956 for other types of gas oil.

Table 10.1 Emissions from different types of aircraft over various flown distances

Type*	Number of seats	Distance flown (km)	Fuel consumption		Emissions (per kg of fuel)				
			kg/LTO **	kg/km in 'cruise' phase	CO_2 (kg)	SO_2 (g)	NO_x (g) LTO	NO_x (g) Cruise	VOC (g) LTO
1	40	200	130	1.0	3.15	0.6	8	7	5
2	100	500	730	2.1	3.15	0.6	10	9	2
3	200	1,500	1,500	5.1	3.15	0.6	14	12	1
4	400	6,000	3,100	11	3.15	0.6	18	15	1

* Dings *et al* do not specify the aircraft type as regards make, number of engines, etc.

** LTO: Landing and Take Off cycle

It is now possible, assuming average capacity utilisation for the four aircraft types, to estimate the emissions per passenger-kilometre (see Table 10.2).[55]

Table 10.2 Emissions per passenger-kilometre from the various types of aircraft

Type	Capacity utilisation (%)*	CO_2 (g)	SO_2 (mg)	NO_x (mg)	VOC (mg)
1	50	260	50	610	163
2	65	173	33	515	45
3	70	137	26	537	7
4	80	113	22	545	2

* Based on Dings et al (2002)

Extent to which the total production costs are made up of fuel costs (α)

At current prices approximately 10% of the total operating costs of aviation are made up of fuel costs (Hof *et al*, 2001). Assuming fuel costs are fully passed on in ticket prices, an increase of 1% in the cost of fuel would therefore be accompanied by an increase of approximately 0.1% in the price of a ticket.[56] A more detailed analysis could take account of distance-dependent α values: the proportion of the ticket price that is due to fuel costs is greater for long distances than for short distances.

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55 For clarification purposes, this is an example of the calculation of NO_x emissions from aircraft type 2:
730 kg of fuel is consumed for the Landing and Take Off (LTO) cycle. This causes an NO_x emission of 10 x 730 = 7,300 grams. In the 'cruise' phase of the flight 2.1 kg of fuel is consumed per km, which gives a total of 2.1 x 500 = 1,050 kg. The resulting NO_x emission is 9 x 1,050 = 9,450 grams. The total emission of NO_x is 7,300 + 9,450 = 16,750 grams. The number of passenger-kilometres (given a capacity utilisation of 65%) is
0.65 x 100 x 500 = 32,500. The NO_x emission per passenger-kilometre is therefore
16,750 / 32,500 = 0.515 grams.

56 In reality the increase will be somewhat less because in addition to operating costs the ticket price can also include overheads, profit margin, travel agency costs, etc.

Price elasticity of the demand (e_p)

Estimates of the price elasticity of the demand for air transport vary greatly. In general, the demand for air transport is more elastic than the demand for other forms of transport. Most existing studies relate to passenger transport. The OECD (2000) reports elasticities that vary from –0.36 to –4.51, whereby the demand for recreational flights is slightly more elastic than the demand for business flights. Brons *et al* (2001) found an average price elasticity of –1.146 in the literature (for a range of +0.21 to –3.20). A clear split is also evident here: studies that focused mainly on business flights arrived at figures of around –0.8 and the other studies obtained figures of around –1.5. Hof *et al* (2001) arrive at a price elasticity of –0.4 to –1.2 for business travellers and –1.1 to –2.7 for recreational travellers. These values are based on a survey by Oum *et al* (1990) and can also be found in the OECD report by Michaelis (1997). Resource Analysis (1999) uses an elasticity for business flights of –0.1 and a region-dependant elasticity for tourist flights between –0.91 (flights within the EU) and –1.76 (international flights from the US). In Wit *et al* (2000) we find elasticities that vary between 0 and –1. These are the authors' own estimates about which they themselves say that they are on the low side compared with the literature (Oum *et al*, 1990).

In the light of the above it is advisable to differentiate between elasticities for business flights and elasticities for tourist flights. We will estimate the e_p for the former category at –0.8 and for the latter category at –1.4. Those are the figures that had the highest frequency scores in the study by Brons *et al* (2001). We consider the study by Brons *et al* to be the most reliable study because they used an extensive empirical database (37 studies with a total of 204 data entries).

Given that non-business travel currently accounts for 60% of air traffic (NLO, 2001) a weighted e_p of –1.2 (rounded off) can be used. This is also completely in line with the average in Brons *et al*.

Extent of the activity (q)

In 2001 over 20 million passengers took flights out of the Netherlands. This equates to a number of passenger-kilometres that can be estimated by multiplying the numbers of passengers per regional destination (the second column in Table 10.3) by an estimated average distance to each of these regions (the third column in Table 10.3). The result is a total of over 50 billion passenger-kilometres (see Table 10.3).[57]

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[57] Freight transport (70 to 75% of which 'hitches a ride' on passenger flights) is not considered further here.

Table 10.3 Estimate of the current number of passenger-kilometres for air travellers leaving the Netherlands

Regional destination	*Number of travellers*	*Average distance*	*Number of passenger-km (millions)*
Europe	14,102,546	800 km	11,282
North Africa	335,597	2,500 km	839
Rest of Africa	495,961	5,000 km	2,480
North America	2,571,575	6,000 km	15,429
Rest of America	772,467	8,000 km	6,180
Western Asia	678,220	3,000 km	2,035
Rest of Asia	1,474,031	8,000 km	11,792
Oceania	9,887	16,000 km	158
Total	**20,440,284**		**50,195**

Source: calculated from Netherlands Statistics data; the average distances are our own estimates.

Input price (w^*)

The real price of aviation fuel can fluctuate greatly. Between 1980 and 1998 the price varied between € 0.10 and € 0.45 per litre (Hof et al, 2001). We will use € 0.20 per litre.

Size of the subsidy (Δs)

The size of the subsidy was determined above to be approximately € 0.33 per litre.

10.2.4 Calculation of the environmental effects

The value of the right-hand term in formula (10.2) can now be calculated as follows:

$$\alpha e_p \frac{q}{w^*} \Delta s = 0.1 \cdot (1.2) \cdot \frac{50 \cdot 10^9}{0.20} \cdot 0.33 = 9.9 \cdot 10^9$$

In other words, the exemption from excise duty results in a number of flown passenger-kilometres that is almost 10 billion (20% of the total number of passenger-kilometres) more than would have been the case without a subsidy.

The figures in Tables 10.2 and 10.3 can now be used to estimate the environmental effects (see Table 10.4) with the most likely aircraft type per region (cf. Table 10.1).[58]

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[58] For the sake of clarification, this is an example of the calculation of the CO_2 emissions attributable to the subsidy from flights to European destinations:
The CO_2 emission per passenger-kilometre flown by assumed aircraft type 2 is 173 grams (see Table 5.3). The number of passenger-kilometres (11,282 million, see Table 5.1) would be almost 20% lower (2,234 million passenger-km lower) without a subsidy. CO_2 emissions would therefore drop by 0.173 x 2,234 = 385 million kg.

Table 10.4 Estimation of the environmental effect of subsidising aviation fuel for flights leaving the Netherlands

Regional destination	*Type of aircraft*	*CO_2 (ktonnes)*	*SO_2 (tonnes)*	*NO_x (tonnes)*	*VOC (tonnes)*
Europe	2	385	73	1,151	100
North Africa	3	23	4	89	1
Rest of Africa	4	56	11	267	1
North America	4	346	66	1,664	5
Rest of America	4	139	26	666	2
Western Asia	3	55	11	216	3
Rest of Asia	4	265	50	1,272	4
Oceania	4	4	1	17	0
Total		**1,272**	**242**	**5,344**	**116**

The weighting factors from Appendix II are applied to obtain the environmental indicators in Table 10.5, which reflect the aggregated environmental effect.

Table 10.5 Environmental indicators for aviation fuel

Greenhouse effect (ktonnes CO_2-equivalent)	1,272
Acidification (tonnes SO_2-equivalent)	2,433
Photochemical ozone creation (tonnes ethylene-equivalent)	208
Eutrophication (tonnes phosphate-equivalent)	695

10.2.5 Sensitivity analysis

Given the assumed linear relationship, a change in the price elasticity will have a proportional effect on the environmental impact. For example, if instead of a price elasticity of –1.2 we take the two most extreme values given by Oum *et al* (1990) in their ranges (-0.4 and –2.7), then the environmental effects are respectively 2/3 lower and more than twice as high as the figures in Tables 10.4 and 10.5.

We can also examine the sensitivity to the assumed size of the subsidy. For example, if the correct reference level for excise duty on kerosene were believed not to be € 0.33 per litre but € 0.05 (the rate for 'red' diesel), then the environmental effect would be only 5/33 of the values given in Tables 10.4 and 10.5 – i.e. 85% lower.

10.3 Concluding remarks

In addition to the calculated effect on demand with a constant utilisation of aircraft capacity, the lack of taxes on aviation fuels could lead to a number of other, possibly additional, effects.

A possible initial (short-term) effect is lower utilisation of aircraft capacity, as a result of which the volume of fuel per passenger-kilometre or per tonne-kilometre is higher. The extent of this effect is probably limited since airline companies try to achieve the highest possible utilisation of capacity anyway because they have high fixed costs.

In so far as the lack of excise duty on kerosene leads to substitution (some of the aircraft-kilometres attributable to the subsidy are flown by passengers who would otherwise have gone by car, ship or train), the environmental effects of the other modes of transport must be deducted from the environmental effects of aviation that are attributable to the subsidy. We did not do that in the previous sections.

In the analysis we have only considered passenger transport. Since some passenger aircraft also carry freight ('bellyhold cargo') the emission per passenger-kilometre can be lower than the figures that we have used.

There may be technology effects in the longer term. Low fuel prices limit the stimulus to develop more fuel-efficient types of aircraft engines. However, there is an 'autonomous' technological development towards more fuel-efficient aircraft with lower emission levels.

Table 10.6 gives an overview of factors that can affect whether the actual environmental impact is larger or smaller than the environmental impact estimated above and by how much.

Table 10.6 Factors that can cause actual environmental effects to differ from estimated environmental effects

↑	Low utilisation of aircraft capacity because of low fuel prices
↓	Environmental effects of other modes of transport (substitution effect)
↓	Freight transport on passenger aircraft ('bellyhold cargo')
↑	Brake on technological development due to low fuel prices

NB: ↓ means that the environmental effect of the subsidy decreases when this factor is taken into account; ↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

Comparison with the results of other studies

Resource Analysis (1999) studied five possible variants of a European tax on aviation fuel. Of these variants, variant 1 (a tax of € 245 per 1,000 litres for all flights of all airline companies that depart from the EU, including intra-EU routes) is closest to abolition of the existing subsidy as we interpret it in the context of this study.

According to the Resource Analysis study (which uses the AERO model), the effect of this measure on routes to and from the EU would be a reduction (in 2005) of 7.5% in the number of Revenue Tonne-Kilometres (RTK)[59] compared with the baseline scenario.

According to that study, the tax of € 245 per 1000 litres will lead to a reduction in CO_2 emissions (in 2005) of some 15 million tonnes and a reduction in NO_x emissions of some 70,000 tonnes. These figures are 12 to 13 times greater than the figures that we calculated for the Netherlands, which is in line with the Dutch share in EU air traffic (approximately 7% according to Eurostat data).

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[59] The RTK is a scale used to measure total aviation activity and comprises the demand for both freight and passenger transport. It is based on an average weight per passenger (including baggage) of 100 kg.

11. Low return on the government share in Schiphol Airport

11.1 Qualitative information

11.1.1 Description and type of subsidy

The shares in NV Luchthaven Schiphol [Schiphol Airport] are (still) in the hands of the Dutch authorities. The distribution is as follows:

- Dutch State: 75.8%
- Municipality of Amsterdam: 21.8%
- Municipality of Rotterdam: 2.4%

In 2001 the total return on Schiphol Airport's own assets was 11% and the return on net assets (RONA) (before tax) was 8.6%. However, this return was primarily achieved on activities that had no direct connection with aviation, e.g. the 'Consumers' business area (shops, office rental, parking, etc.) where the RONA was 28.3% (30.2% in 2000). The RONA for the 'Aviation' business area in 2001 was only 5.0% (4.4% in 2000) (source: 2001 Annual Report of NV Luchthaven Schiphol). This return is the result from revenue and expenditure. Assuming that no great savings can be made on the expenditure side[60], the low return implies that the level of revenue is too low. In the case of the 'Aviation' business area the revenue consists primarily of airport charges.[61]

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[60] How far this (fundamental) assumption is justified is a question that is outside the remit of this study. However, the following comments can be made. A study by Pels *et al* (2001) does show that Schiphol Airport is not one of the most efficient airports in Europe, but the inefficiencies are caused mainly by regulations (in particular rules that limit noise pollution, as a result of which it is not possible to make 'optimum' use of the runways). Even for a privatised airport it would not be possible to save on the extra costs that these regulations entail. On the other hand, a study by the Netherlands Competition Authority showed that Schiphol Airport's aviation activities bear a relatively heavy burden compared with the other (commercial) activities because of the way in which the costs of shared assets are allocated (shared assets, for example the terminal building and the piers, are assets that are used for aviation as well as for other activities). It was not possible to determine whether the airport rates are excessive within the meaning of the Competition Act because Schiphol Airport's accounts are not transparent enough to make that calculation (NMa [Netherlands Competition Authority], 2001). In addition, 1.4% of the tangible fixed assets were already shifted in 2001 from the 'Aviation' business area to other business areas (source: 2001 Annual Report of NV Luchthaven Schiphol).

[61] The airport charges comprise take-off, landing and parking fees for aircraft and usage fees for passengers. The airport charge rates are currently subject to government approval. When the new Aviation Act comes into force the airport charge rates will be subject to the review system of the Netherlands Competition Authority.

The fact that the government accepts a low return on its share in a commercial company can be considered a subsidy in this study because the (capital) costs of the company are reduced as a result.

This is a capital subsidy (type 5 in Table 2.1) that is applied to the input to a production activity (type 3 in Figure 2.2).

11.1.2 Directly stimulated activity

The airport charges are lower than would be necessary to achieve a return that would satisfy commercial shareholders. This results in a lower cost price for air transport provided by airlines that use Schiphol Airport than would be the case if the requirements for a return on shares were met.

11.1.3 Environmental effects

The most important environmental effects of aviation for this study have already been discussed in § 10.1.3. The main effects are emissions of CO_2 and NO_x. SO_2 and VOC emissions are of secondary importance but should also be taken into account.

11.2 Quantitative information

11.2.1 Method

Formula (41) from Appendix I can be used to calculate the environmental effects of the subsidy on airport charges (which is an input subsidy):

$$\Delta z = Z_q \left(\frac{D_p S_{w*}}{S_p - D_p} \right) \Delta s \tag{11.1}$$

where:

Δz = the environmental effect;

Z_q = the degree of pollution from production (in this case: emissions per passenger-kilometre);

D_p = price reaction of the demand (for flights);

S_p = output price reaction in the supply (of air traffic);

S_{w*} = input price reaction in the supply (i.e. the effect of the level of airport charges on the supply of air traffic);

Δs = the (change in the) size of the input subsidy.

However, we do not have specific information about the price reactions in the supply, which is necessary to calculate S_p and S_{w*}. We therefore assume that the interaction between demand and supply is already included in the empirically determined price elasticities. Another assumption is that the subsidy on the input (airport charges) has a direct effect on the price of the output (flights) and that this effect is in proportion to the extent to which the total production costs are made up of airport charges. The formula can then be simplified to:

$$\Delta z = Z_q \alpha e_p \frac{q}{w^*} \Delta s \qquad (11.2)$$

where:

α = the extent to which the total production costs are made up of airport charges (or the extent to which the price of a ticket, which is assumed to be equivalent here, is determined by airport charges)

e_p = the price elasticity of the demand (in this case: for flights, as an absolute value);

q = the extent of the activity (in this case: air traffic);

w^* = the input price (in this case: the airport charges) (reduced by the subsidy)

and the other symbols are as above.

11.2.2 Size of the subsidy

Schiphol Airport's aim for the company as a whole is that the RONA should be higher than the average capital costs. Whilst the airport is still not listed on the stock exchange these average capital costs (after tax) are estimated at 8%. The aim for the 'Aviation' business area is to improve the return in due course 'to approximately the level of the capital costs'. The current RONA of 5% (from an operating result of € 59 million with average fixed assets of € 1,181 million) is therefore at least 3 percentage points too low. Given that Schiphol Airport has to pay corporation tax from 2002, a gross return of over 12% will have to be achieved henceforth to arrive at a net return of 8% (the relevant corporation tax rate is 35%). Taking this into account, the operating result is therefore over 7 percentage points too low: with the current assets the operating result would have to be over € 140 million. The subsidy (which consists of not achieving the envisaged return) is therefore over € 80 million, which (with almost 40 million passengers a year) is over € 2 per passenger.

11.2.3 Quantification of parameters

Extent of the environmental effects per unit of activity (Z_q)

We have taken the emission factors for the four aircraft types in chapter 10 to determine the extent of the environmental effects per unit of activity (see Table 11.1).

Table 11.1 Emissions per passenger-kilometre from the different types of aircraft

Type	*Capacity utilisation (%)**	*CO_2 (g)*	*SO_2 (mg)*	*NO_x (mg)*	*VOC (mg)*
1	50	260	50	610	163
2	65	173	33	515	45
3	70	137	26	537	7
4	80	113	22	545	2

* Based on Dings *et al* (2002)

Proportion of total production costs taken up by airport charges (α)

In 2001 Schiphol Airport received € 334 million in airport charges. That amounts to approximately € 8.50 per passenger. Assuming that the average price of an airline ticket is € 500[62], airport charges therefore account for over 1.5% of the production costs.

Price elasticity of the demand (e_p)

Here, as in chapter 10, we will use an e_p of –1.2.

Extent of the activity (q)

In § 10.2.3 the number of passenger-kilometres flown by passengers departing from the Netherlands was estimated at over 50 billion. However, in the present case study we are considering both departing and arriving passengers. There is no reason to assume that there is a significant difference between the distances flown by arriving passengers and those flown by departing passengers; therefore the estimate of the total number of passenger-kilometres can be twice as high: 100 billion. We also assume an equal distribution over the different regional destinations (or origins) from chapter 10.

Input price (w*)

The input price (reduced by the subsidy) is € 0.00334 per passenger-kilometre if € 334 million is brought in from airport charges and 100 billion passenger-kilometres are flown.

Size of the subsidy (Δs)

The size of the subsidy was calculated above at € 80 million. That is therefore € 0.0008 per passenger-kilometre.

11.2.4 Calculation of the environmental effects

It is now possible to calculate the value of the right-hand side of formula 11.2:

$$\alpha e_p \frac{q}{w^*} \Delta s = 0.015 \cdot (1.2) \cdot \frac{100 \cdot 10^9}{0.00334} \cdot 0.0008 = 431 \cdot 10^6$$

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62 According to Pels (2002) this is a ‘defendable’ assumption.

In other words: as a result of the 'deficit' in the level of airport charges over 400 million more passenger-kilometres were flown (over 0.4% of the total number) than would have been the case without the subsidy. The effect on the emissions is shown in Table 11.2. The method of calculation is the same as that in chapter 10.

Table 11.2 Estimation of the environmental effect of the Schiphol Airport subsidy

CO_2 (ktonnes)	*SO_2 (tonnes)*	*NO_x (tonnes)*	*VOC (tonnes)*
55	11	233	5

The weighting factors from Appendix II can then be used to obtain the environmental indicators, which reflect the aggregated environmental impact.

Table 11.3 Environmental indicators for the Schiphol Airport subsidy

Greenhouse effect (ktonnes CO_2-equivalent)	55
Acidification (tonnes SO_2-equivalent)	106
Photochemical ozone creation (tonnes ethylene-equivalent)	9
Eutrophication (tonnes phosphate-equivalent)	30

11.2.5 Sensitivity analysis

Given the assumed linear relationship, a change in the price elasticity will cause a proportionate change in the environmental effect. For example, if instead of a price elasticity of –1.2 we use the two most extreme values of the ranges given by Oum *et al* (1990) (-0.4 and –2.7), the environmental effects will be respectively 2/3 lower and more than twice as high as the figures in Tables 11.2 and 11.3.

11.3 Concluding remarks

Increasing the airport charges at Schiphol Airport could cause customers to migrate to other airports. On balance, the (global) environmental effect of the subsidy would then be less than calculated above.

The extent of the environmental effects of the subsidy discussed here is approximately 4% of the environmental effects of the exemption from excise duty on aviation fuels (see chapter 10).

This case must be seen above all as an illustration of how the method developed in this study can be applied to a capital subsidy. It is not clear to what extent the low return on the government share in Schiphol Airport actually is a subsidy. That issue is connected to the question of whether the current cost allocation method for 'shared assets' is correct. That discussion is outside the scope of the present study.

Table 11.4 gives an overview of factors that can affect whether the actual environmental impact is larger or smaller than the environmental impact estimated above and by how much.

Table 11.4 Factors that can cause differences between actual and estimated environmental effects

↓	Uncertainty about whether airport charges are in fact 'too low'
↓	Possible 'migration' to other airports in the event of higher airport charges

NB: ↓ means that the environmental effect of the subsidy decreases when this factor is taken into account; ↑ means that the environmental effect of the subsidy increases when this factor is taken into account.

12. Conclusions and suitability of the method

12.1 Results of case studies and conclusions

The method was developed to determine the environmental effects of indirect subsidies. The steps in the determination process are described in chapter 2 and relate to determining the size of the subsidy, the level of elasticity and the extent of the environmental effects. Various cases have been used as illustrations of how the method works and of its suitability. Although a strict comparison of the cases is difficult because the points of application, types of subsidy and sectors are different, a number of general findings regarding the method did result from the specific case studies. These findings are discussed below.

Size of subsidies

Most of the subsidies studied were quite substantial. For example, € 2 billion a year of the cost of railway infrastructure is not passed on, around € 1.5 billion a year is the size of the Regulatory Energy Tax subsidy and the support for the price of milk, and almost € 1.25 billion a year is the subsidy represented by the exemption from excise duty on kerosene. The subsidy given by designating land for agricultural purposes is conservatively estimated at € 0.8 billion a year. All of this is in line with the results of earlier international research, which indicate that indirect forms of government support often involve considerable subsidies.[63]

Elasticities

The level of elasticity has a great influence on the economic and environmental effects. This is even more so if the point of application of the subsidy is early in the chain, as for example with the Regulatory Energy Tax subsidy, the support for the price of milk and the designation of land for agricultural purposes. This is because the disruptive effect of the subsidy can then affect the whole chain of production and consumption (forward linkages) and there is a greater chance that the environmental effects of the subsidy will be extensive.[64] The aforementioned research has shown that these factors may actually harm the effectiveness of the subsidy.

Environmental effects

Application of the method developed in this study has shown for the various cases that the environmental effects of indirect subsidies are often extensive. This is also in line with the conclusions of the international research mentioned above. For example, the milk subsidy, the Regulatory Energy Tax subsidy, the exemption from excise duty on kerosene and the designation of land for agricultural purposes are accompanied by an environmental effect of 1 to 1.5 Mtonnes of CO_2-equivalent each. In the case of the Regulatory Energy Tax and the support for the price of milk the environmental effect can even reach a maximum of 2.5 to

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63 See Van Beers and De Moor (2001), Myers (2001), OECD (1997) and OECD (1998).

64 In theory backward linkages – i.e. effects that work back up the chain – can also occur. However, this did not clearly emerge in the cases studied.

3 Mtonnes.[65] Although the environmental effects in terms of acidification differ from one subsidy measure to another, a number of the subsidies studied are accompanied by relatively extensive acidification. In the energy and transport sectors the environmental effect per subsidy measure can reach 0.5 to 1 Ktonne of SO_2-equivalents and may even exceed 2 Ktonnes. However, this is much less true for the public transport sector. With the larger agriculture-related subsidies the acidifying emissions can rise significantly to more than 20 and 30 Ktonnes. The environmental effect of photochemical ozone creation is generally limited to less than 500 tonnes of ethylene-equivalents. Finally, the agriculture-related subsidies have another effect on land use. According to our analysis, the support for the price of milk results in between more than 100,000 and more than 200,000 hectares of land being used for dairy farming. The equivalent effect as a result of the low rate of VAT on meat and the designation of land for agricultural use results in a maximum of 22,000 and 218,000 hectares of land being used for meat production and agriculture respectively. The environmental effects of the studied capital subsidy (in the form of the low return on the government share in Schiphol Airport) and of public transport-related subsidies are limited. This is particularly because of the low strain on the environment and the relatively low level of subsidies involved.

12.2 Suitability of the method

The results of the case studies show that the method developed is a useful point of departure for application and evaluation in policy studies. For important indirect types of subsidy the method indicates the relevant economic situation and what first order environmental effects can be expected. Since second order effects are generally a lot smaller, a first order effect will give a good picture of both the sign and the size of the total effect. The method developed therefore offers sufficient insight into the environmental impact of indirect subsidies.

The main advantages of the method are the scientific basis and the transparency, speed and flexibility with which calculations are made. The method is based on a theoretical economics model that is generally accepted in science. Consequently the method has a sound scientific basis and clearly describes the economic and environmental effects in different situations and for different types of subsidies. The method is transparent in its calculations and clearly shows the effect of each of the various parameters.[66] At the same time it offers the flexibility required to quickly calculate sensitivity analyses with different values for the parameters, for example. Further refinements and extensions to the calculation of the environmental impact can also be made.

The method therefore provides a suitable framework for further policy analyses. In future this method can be used for analyses or evaluations by researchers or (inter)departmental working groups, for example for an Interdepartmental Policy Analysis. The method can also be used as an ex ante assessment criterion when new forms of subsidy policy are

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65 The reported environmental effects for milk are an illustration of the environmental effects of a minimum price subsidy that occur in a notional situation with no milk quota. The mandatory milk quota in the Netherlands limits these environmental effects.

66 In this respect the method developed is much less of a black box than many macroeconomics models.

introduced. The environmental effect of the new measure can then be taken into account in advance in further deliberations and decision-making.

In a policy analysis or an ex ante or ex post subsidy evaluation a working group should follow the steps as described in Figure 2.1 in Chapter 2:

1. Determine the subsidy type;
2. Calculate the size of the subsidy;
3. After any corrections to allow for the policy environment, determine the economic effect using the formulae in this report;
4. Quantify the parameters (or have them quantified);
5. Determine the environmental impact.

Particular care is required with steps 2 and 4: the working group must be fully aware of the need for precision in making the calculations.

Obviously the method does have limitations. As is shown by the case of land designated for agricultural purposes, the method seems to be less suited for an analysis of subsidies in a very complex situation and policy environment. The method is not yet sufficiently refined to take adequate account of dominant long-term and 'lock-in' effects. In the case of a very complex policy environment with a large number of forms of government intervention (some of which may even run counter to each other), too many corrections and assumptions may be necessary to usefully apply the method. Further study is needed to show what further refinements are necessary to remove these limitations. One possibility might be to add links to general equilibrium and 'bottom-up' models. The calculations also need reliable data on the macro-intensity or the sector intensity of the environmental and land use effects.

Specific environmental effects or levels of intensity must be used with the required degree of care. Subsidies with specific conditions are also difficult to incorporate in the method.

The results of the cases reflect these limitations. The method is essentially a first order approximation that is indicative but incomplete as regards the total effect. First of all the size of the subsidy has a major effect on the calculations. In addition, the results are sensitive to the choice of parameters.[67] It is therefore expressly recommended that a working group carry out or commission a careful and thorough study to determine the values of the parameters accurately and within plausible boundaries. It is also strongly recommended that a database/knowledge base be set up with subsidies and elasticity values that can be used in the policy process.

Another recommendation concerns the performance of a sensitivity analysis. Such an analysis is needed to put the results in the correct perspective. The method offers the possibility of quickly calculating such sensitivity analyses. Depending on the aim, it can be advisable to perform or commission a comparable exercise with a macroeconomic model.

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[67] This is obviously true for any quantification, including the calculations in macroeconomics models.

Indicators can also be derived for prioritising policies. It is worth considering a policy ranking and priority system for subsidies based on points of application and elasticity of demand and supply.

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Appendix I. Modelling the effect of subsidies

Three approaches to studying the environmental impact of indirect subsidies are proposed in this Appendix. The approaches differ as regards the economic information that is required to make the model operational. However, we will first present a simple model of the chain from subsidy to environmental impact to establish the framework of the analysis.

A basic model of the chain from subsidy to environmental impact

The following model of the chain from indirect subsidy to environmental effects shows the elements and relationships in the chain that have to be determined before the environmental effects of subsidies can be calculated.

$$Q = F(P(s), T(s), D(s)) \quad (1)$$

$$S_{ij} = H_{ij}(I(s), T(s), Q, D(s)) \quad \textit{for relevant values of } i,j \quad (2)$$

$$M_i = \Sigma_j w_{ij} S_{ij} \quad \textit{for relevant values of } i \quad (3)$$

The symbols are defined as follows:

s = subsidy

P = vector of production factors or inputs

I = infrastructure

T = technology

D = demand

Q = output

S_{ij} = environmental impact of effect j of general category i,

M_i = general environmental impact

F, G, H_{ij} = functions

w_{ij} = weighting factor for environmental effects ($\Sigma_j w_{ij} = 1$)

The first equation gives a relationship between indirect subsidies and demand, using as an example subsidies that directly affect production factors, technology, output or production level. The second equation is used to calculate specific environmental effects, such as CO_2 emissions, based on inputs, technology or output, or a combination of these three elements. The last equation uses weighting factors to aggregate the individual environmental effects and form general categories of environmental effects, such as the greenhouse effect (global warming potential). This last approach is in line with the EPI method as discussed in section 2.4.1.

A general model of the effect of subsidies on producers' decisions

Here a model is formed of the effect of subsidies on the behaviour of producers, based on neo-classic micro-economic theory. This model is an extension of the basic model – optimisation of profit given a production function that describes a relationship between inputs and output – plus taxes and subsidies. This extended model can be used to study certain changes that are caused by subsidies, but not all. For example, the effects of technological choices within companies, as well as the effects on a higher scale (such as sector structure, volume and composition of demand) are outside the framework of this model.

The company maximizes profit W

$$W = (1-t_w)[(p+s_p)Q - C - v + d_b] + v + d_v \tag{4}$$

given production costs C

$$C = (p_K-s_K)K + p_L L + (p_I-s_I)I + (p_E-s_E)E \tag{5}$$

and given the production relationship

$$Q = F(K,L,I,E) \tag{6}$$

The symbols are defined as follows:

W = profit

C = total costs

Q = output

K = capital

L = labour

I = infrastructure

E = energy

p = output price

p_K = capital price

p_L = price of labour (wages)

p_I = price of infrastructure

p_E = price of energy

t_w = proportional tax on profit

The possible subsidies are:

a) $Q \leq Q_{max}$ volume regulation on output;

b) $p \geq p_{min}$ price guarantee on output;

c) $I = I^*$, and $p_I = 0$ public supply below cost price;

d) s_p = subsidy on the selling price;

e) s_K = subsidy on capital;

f) s_I = subsidy on infrastructure (public provision of goods below cost price);

g) s_E = subsidy on energy (e.g. exemption from Regulatory Energy Tax);

h) v = tax-free allowance;

i) d_v = tax-free direct subsidy;

j) d_b = direct subsidy for taxes (taxable).

Subsidy types (a) and (b) lead to extra conditions in the company's optimisation problem. The ideal way to determine the effect of these indirect subsidies would be to compare the relevant results of the optimisation problem (output or input, depending on the point of application of the environmental effects) with and without the extra condition in question. Since this is not possible in practice, a rough estimate of the effect will have to suffice in order to arrive at quantitative statements.

Rewriting (4) and (5) gives an insight into effective prices:

$$W = p^*Q - p_K^*K - p_L^*L - p_I^*I - p_E^*E + [(t_w - s_w)]v + (1 - t_w + s_w)d_b + d_v \quad (7)$$

where:

$$p^* = (1 - t_w + s_w)(p + s_p) \quad (8)$$

$$p_K^* = (1 - t_w + s_w)(p_K - s_K) \quad (9)$$

$$p_L^* = (1 - t_w + s_w)p_L \quad (10)$$

$$p_I^* = (1 - t_w + s_w)(p_I - s_I) \quad (12)$$

represent the effective prices, i.e. the prices after taxes and subsidies.

Since in (7) the terms that include v, d_b and d_v do not contain Q, K, L, I or E, it follows immediately that the corporate decisions that focus on increasing or decreasing the supplied output volume or the volume of demand for an input are not affected by a tax-free allowance, nor by direct general subsidies whether or not they are taxable. This is because these subsidies do not occur in the marginal rules that follow from the first order conditions for the optimisation problem. Obviously such indirect subsidies do affect the level of profit.[68]

The decisions about the demand for inputs and supply of output can then be derived from the optimisation problem as a function of the various subsidies. This provides the basis for the economic model.

The first order conditions for the optimisation problem are:

$$\delta F/\delta x = (p_x - s_x)/(p + s_p) \qquad \text{for } x = K,L,I,E \tag{13}$$

If we specify the production function as a Cobb-Douglas relationship $AK^{ak}L^{al}I^{ai}E^{ae}$, define B as $B = a_k + a_l + a_i + a_e$ and assume that $B < 1$, i.e. that diminishing marginal revenues apply, then we obtain the following (output) supply and (input) demand functions:

$$Q = [A(p+s_p)^B (p_K - s_K)^{-ak} p_L^{-al} (p_I - s_I)^{-ai} (p_E - s_E)^{-ae} a_k^{ak} a_l^{al} a_i^{ai} a_e^{ae}]^{1/(1-B)} \tag{14}$$

$$K = Q^{1/B} a_k/(p_K - s_K)[p_L^{al}(p_I - s_I)^{ai}(p_E - s_E)^{ae}/(Aa_l^{al} a_i^{ai} a_e^{ae})]^{1/B} \tag{15}$$

with the analogous results for *L*, *I* and *E*.

A number of insights follow. Note first of all that effects on output and input depend on interactions between subsidies, given that there are different subsidies on the right-hand side in (14) and (15). It also follows from (14) and (15) that the supply (or output or volume of production) and the demand for inputs are not affected by a reduction in the proportional tax on profit (s_w). Although this tax does of course affect the level of profit.

Calculating the partial derivatives from the right-hand side in (14) to the various subsidies gives the marginal effects of subsidies on supply.

$$\delta Q/\delta s_p = BQ/[(p+s_p)(1-B)] \tag{16}$$

$$\delta Q/\delta s_K = a_k Q/[(p_K - s_K)(1-B)] \tag{17}$$

$$\delta Q/\delta s_I = a_i Q/[(p_I - s_I)(1-B)] \tag{18}$$

$$\delta Q/\delta s_E = a_E Q/[(p_E - s_E)(1-B)] \tag{19}$$

As expected, all effects in (16) to (19) are positive (assuming as regards the inputs that the subsidy is lower than the market price). The expressions also offer the possibility of calculating the size of the effects, if the necessary data is available.

Calculating the partial derivatives from the right-hand side in (15) to the various subsidies gives the marginal effects of subsidies on the demand for inputs:

$$\delta K/\delta s_p = K/[(p+s_p)(1-B)] \tag{20}$$

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68 Direct subsidies that are subject to meeting certain conditions *can* lead to other corporate decisions. This could be modeled by coupling the direct subsidy to an extra condition in the model. Since direct subsidies fall outside the remit of the current study we will not go into more detail here.

$$\delta K/\delta s_K = a_k K/[(p_K-s_K)B(1-B)] + K/(p_K-s_K) \tag{21}$$

$$\delta K/\delta s_I = -a_i K/[(p_I-s_I)B(1-B)] - (a_i/B)\ (p_I-s_I)^{(ai-B)/B}[p_L{}^{al}(p_E-s_E)^{ae}/(Aa_l{}^{al}a_i{}^{ai}a_e{}^{ae})]^{1/B} \tag{22}$$

$$\delta K/\delta s_E = -a_E K/[(p_E-s_E)B(1-B)] - (a_e/B)\ (p_E-s_E)^{(ae-B)/B}[p_L{}^{al}(p_I-s_I)^{ai}/(Aa_l{}^{al}a_i{}^{ai}a_e{}^{ae})]^{1/B} \tag{23}$$

with the analogous calculations for the derivatives of I and E (and also L if it can be directly linked to environmental effects, which is not obvious). The signs of the effects in (20) and (21) are positive, which is as expected. The signs in (22) and (23) are negative, which is also as expected because price cross-effects are negative in normal practice with inputs that can be substituted (as is assumed with the choice of the Cobb-Douglas production function).

It is now possible to determine the extent of the effect of the subsidy. This depends on five variables:

1. The size of the subsidy (s_j for $j = p, K, I$ or E).
2. The production function parameters (A; a_j for $j = k, l, i$ or e; and B).
3. The size of the relevant input (Q, K, or I).
4. The output price and the input prices (p and p_j for $j = p, K, I$ or E).
5. The effect of the relevant inputs and output on the environmental impact (see equation (2)).

Tax-free allowance for the output price (low rate of VAT for consumers)

If no information is available about the production function, then an analysis can immediately start at the level of demand and supply functions. This is the point of departure of the following two approaches. They are based on interaction between final demand and supply of a particular product, which also makes it possible to involve demand effects in the analysis. Partial equilibrium analyses show the effects of an indirect subsidy, such as a tax-free allowance, on prices and volumes of output and input. The prices are determined by interaction between demand and supply. Two types of tax-free allowances are considered, namely on the output price and on the input price.

Let us start with the following demand and supply functions:[69]

$$q_d = D(p^*,p_i,y) \tag{24}$$

We assume that a tax-free allowance – i.e. an indirect subsidy s – applies for the product in question, so that $p^*=p-s$, where p is the price to which the subsidy is applied. The following also applies:

$D_{p*}<0$; $D_y>0$; $D_{pi}<0$ (complementary goods), or $D_{pi}>0$ (substitutes);

$$q_s = S\ (p, w_i) \tag{25}$$

where:

$S_p > 0; S_{w_i} < 0.$

[69] Demand and supply curves are derived from maximum-utility consumer behaviour and profit-maximising producer behaviour. Functions with a sub-index indicate a first derivative to the variable in the index.

The symbols are defined as follows:

q = equilibrium volume;

q_d = volume of demand;

q_s = volume of supply;

p = price of the product to be subsidised;

s = subsidy in the form of a low rate of VAT;

p^* = effective price of the product (including subsidy);

p_I = prices of other complementary or substitutable products;

y = aggregated income of the consumers;

w = input price.

The equilibrium condition is:

$$q = q_d = q_s \tag{26}$$

which is equivalent to:

$$D\,(p - s,\, p_i,\, y) = S\,(p,\, w_i) \tag{27}$$

In order to find the effect on the equilibrium price, the equilibrium volume and the external effect, the total differential of (27) is determined:

$$D_{p^*}\,(dp - ds) + D_{p_i}dp_i + D_y dy - S_p dp - S_s ds - S_{w_i} dw_i = 0 \tag{28}$$

The subsidy has an effect on the equilibrium price and the equilibrium volume. We can therefore suppose that $dp_i = dy = dw_i = 0$, which leads to:

$$D_{p^*}(dp - ds) - S_p\, dp = 0 \tag{29}$$

It then follows that:

$$\frac{dp}{ds} = \frac{D_{p^*}}{D_{p^*} - S_p}\,. \tag{30}$$

Here we are mainly interested in the effect of the subsidy on the equilibrium volume since that is the point of application for environmental effects in this model. This effect can be determined as follows:

$$\frac{dq}{ds} = \frac{dq}{dp^*}\frac{dp^*}{ds} = D_{p^*}\left(\frac{dp}{ds} - 1)\right) = \frac{D_{p^*}S_p}{D_{p^*} - S_p}\,. \tag{31}$$

Note that the sign here is positive. This means that a higher subsidy (lower VAT) stimulates consumption and thereby production of the product in question.

We assume a positive dependence of an environmental effect *z* on the produced equilibrium volume, so that:

$$z = Z(q) \tag{32}$$

where:

$Z_q > 0$.

From (31) and (32) it can be derived that the environmental effect of the subsidy is equal to:

$$\frac{dz}{ds} = \frac{dz}{dq}\frac{dq}{ds} = Z_q \frac{D_{p*}S_p}{D_{p*} - S_p} . \tag{33}$$

The first variable is important since the effect in (33) is a marginal effect that can be considered the average effect for relatively small changes. In other words, if the size of the subsidy is Δs, then the environmental effect is equal to:

$$\Delta z = Z_q \frac{D_{p*}S_p}{D_{p*} - S_p} \Delta s . \tag{34}$$

The sign here is positive, i.e. the effect of the subsidy (low rate of VAT) on the environmental impact of production is positive. The extent of this strengthening effect of the subsidy depends on four variables:

1. The size of the subsidy;
2. The price reaction of the demand (D_{p*});
3. The price reaction in the supply (S_p);
4. The degree of pollution from production (Z_q).

The second variable in this list depends on the type of product (e.g. necessity or luxury) and on the consumers' preferences. The third element reflects the production costs of the company (or sector), and indirectly also substitution possibilities in the input mix, availability of alternative production techniques, and the competitive situation on the sales market.

Note that (34) can also be expressed in terms of price elasticities of demand and supply. Most price elasticities already include the interaction between demand and supply. In this case a more simple formula can be used:

$$\Delta z = (Z_q e_{p*} q^* / p^*) \Delta s \tag{35}$$

where e_p is the price elasticity of the equilibrium volume. The extent of this strengthening effect of the subsidy depends on four variables:

1. The size of the subsidy;
2. The price elasticity of the equilibrium volume (e_{p*});
3. The equilibrium volume and price (q^* and p^*);

4. The degree of pollution from production (Z_q).

Tax-free allowance for the input price

The point of departure is different if we want to study the environmental effect of a price on production inputs or on production factors. If we start immediately with the equilibrium condition, then a subsidy s on the input price w leads to:

$$D(p, p_i, y) = S(p, w^*). \tag{36}$$

where $w^* = w - s$. From the total differential and logical price changes it then follows that:

$$D_p dp - S_p dp - S_{w^*} ds = 0 \tag{37}$$

such that:

$$\frac{dp}{ds} = -\frac{S_{w^*}}{S_p - D_p} \tag{38}$$

The effect of the subsidy on the equilibrium volume is then:

$$\frac{dq}{ds} = \frac{dq}{dp}\frac{dp}{ds} = \frac{D_p S_{w^*}}{D_p - S_p} \tag{39}$$

The environmental effect changes as follows:

$$\frac{dz}{ds} = \frac{dz}{dq}\frac{dq}{ds} = Z_q\left(\frac{D_p S_{w^*}}{D_p - S_p}\right) \tag{40}$$

If the size of the subsidy is equal to Δs, then the environmental effect is equal to:

$$\Delta z = Z_q\left(\frac{D_p S_{w^*}}{S_p - D_p}\right)\Delta s \tag{41}$$

The sign here is positive. In other words, a given change in a tax-free allowance for an input factor to a polluting production process results in greater environmental damage. The extent of that damage depends on five variables:

1. The size of the subsidy;
2. The price reaction of the demand (D_p);
3. The output price reaction in the supply (S_p);
4. The input price reaction in the supply (S_{w^*});
5. The degree of pollution from production (Z_q).

Finally, note that it is assumed that the market price w of the input is not affected by the subsidy. If it were affected, then a more complicated expression than (41) would result and more information would obviously be needed for the calculations.

Effect of subsidies on consumer decisions

A model is presented here that reflects the effect of subsidies on consumer decisions. Consumer subsidies are to be expected in particular in the transport sector. Think of the flat-rate allowance for travel costs or the exemption from VAT on airline tickets, for example.

As with the model for producers' decisions, we will first consider the general problem and then a specific example using functional specifications of the utility function.

The consumer maximizes utility subject to the parameter condition of his budget. In general terms, the utility function can be expressed as follows:

$$x_i = D_i(p_1 - s_1, \ldots, p_k - s_k, \ldots, p_n - s_n, y, f, t_y) \quad (42)$$

The budget restriction is as follows:

$$(1 - t_y)(y - f) = \sum_{i=1}^{n} (p_i - s_i)\, x_i \quad (43)$$

where:

U = utility;

y = income;

t_y = income tax;

f = subsidy via a flat-rate allowance;

x_i = consumption of product i ($i = 1, \ldots, n$);

p_i = price of product i;

s_i = price subsidy on product i;

$$x_i = D_i(p_1 - s_1, \ldots, p_k - s_k, \ldots, p_n - s_n, y, f, t_y) \quad (44)$$

Working out this maximisation problem yields the following demand functions:

$$\frac{\delta x_i}{\delta y} > 0 \qquad \frac{\delta x_i}{\delta f} > 0 \qquad \frac{\delta x_i}{\delta t_y} < 0 \quad (45)$$

Let us suppose that not all goods are subject to a subsidy: $s_i = 1$ for $i = k$ and $s_i = 0$ for $i \neq k$. In the case of substitution between the goods the following applies:

$$\frac{\delta x_i}{\delta s_k} > 0 \ for\ i = k \tag{46a}$$

$$\frac{\delta x_i}{\delta s_k} < 0 \ for\ i \neq k \tag{46b}$$

In the case of complementary goods the following applies:

$$\frac{\delta x_i}{\delta s_k} > 0 \ for\ all\ i \tag{47}$$

We will work this out by specifying a Cobb-Douglas production function for 2 products, e.g. public transport (x_1) and subsidised private use of cars (x_2). The utility function is:

$$U = x_1^{a_1} x_2^{a_2} \tag{48}$$

This function is maximised under the parameter condition of the budget restriction:

$$(1 - t_y)(y - f) = p_1 x_1 + (p_2 - s_2) x_2 \tag{49}$$

Solving this system gives the demand functions for x_1 and x_2:

$$x_1 = \frac{a_1(1 - t_y)(y - f)}{(a_1 + a_2) p_1} \tag{50a}$$

$$x_2 = \frac{a_2(1 - t_y)(y - f)\ y}{(a_1 + a_2)(p_2 - s_2)} \tag{50b}$$

Differentiating to s_2 only affects the demand for the 'own' product, x_2. A larger subsidy leads to a greater demand for the product on which the subsidy is given, as is shown by the following partial derivative:

$$\frac{\delta x_2}{\delta s_2} = \frac{a_2(a_1 + a_2)(1 - t_y)(y - f)}{\{(a_1 + a_2)(p_2 - s_2)\}^2} > 0 \tag{51}$$

Differentiating to the flat-rate allowance f affects the demand for both products:

$$\frac{\delta x_1}{\delta f} = \frac{a_1(t_y + 1)}{(a_1 + a_2) p_1} > 0 \tag{52a}$$

$$\frac{\delta x_2}{\delta f} = \frac{a_2(t_y + 1)}{\{(a_1 + a_2)(p_2 - s_2)\}^2} \tag{52b}$$

The Cobb-Douglas specification implies that the cross-elasticities are 0. In transport, for example, low values for such elasticities can be substantiated based on the fact that the transfer from private to public transport is difficult due to lock-in effects.

The connection with the environmental impact is made via equation (2) in Appendix I:

$$\Delta z = \Delta s\ \delta x_i / \delta s_k\ Z_q \tag{53}$$

The extent to which tax affects the environmental impact depends on the following variables:

$$(1 - t_y)(y - f) = p_1 x_1 + (p_2 - s_2) x_2 \tag{49}$$

1. The size of the subsidy (Δs);
2. The effect of the subsidy on demand ($\delta x_i/\delta s_k$). This effect depends on the assumed functional specification of the utility function. Here there is a choice between various equations. It is also possible for a subsidy to produce cross-effects. In that case the effects should be added together. However, in practice this is of limited relevance since the cross-effects are relatively small compared to the 'own' effects.
3. The degree of pollution from use or production of the consumed product to which the subsidy applies (Z_q).

Minimum prices

As shown in Figure I.1, a producer reacts to a minimum price $p_g > p_e$ (= market equilibrium price) by producing more and offering more of the product for sale than the equilibrium volume (q_e). Consumers on the other hand reduce the volume of demand for the product because the price is higher. This creates a surplus that is accompanied by an extra subsidy transfer compared with the situation where q_e is offered for sale at price p_g. The total subsidy transfer is cdp_gp_e.

The environmental effect of the price guarantee is expressed as follows:

$$\Delta z = (q^s{}_g - q_e)\ Z_q \tag{54}$$

The volume effect (first part of the term on the right-hand side) can be derived from Figure I.1. The following information is required to apply this formula:

1. Supply with price guarantee, i.e. in the current situation ($q^s{}_g$);
2. Supply at free market price (q_e). This requires hypothetical data, which in some cases can be based on earlier studies (e.g. with CGE models). Note that if the applicable world market price (p_w) is not equal to the domestic free market price (p_e), the supplied volume q_e in the formula should be replaced by q_w;
3. The degree of pollution from production (Z_q).

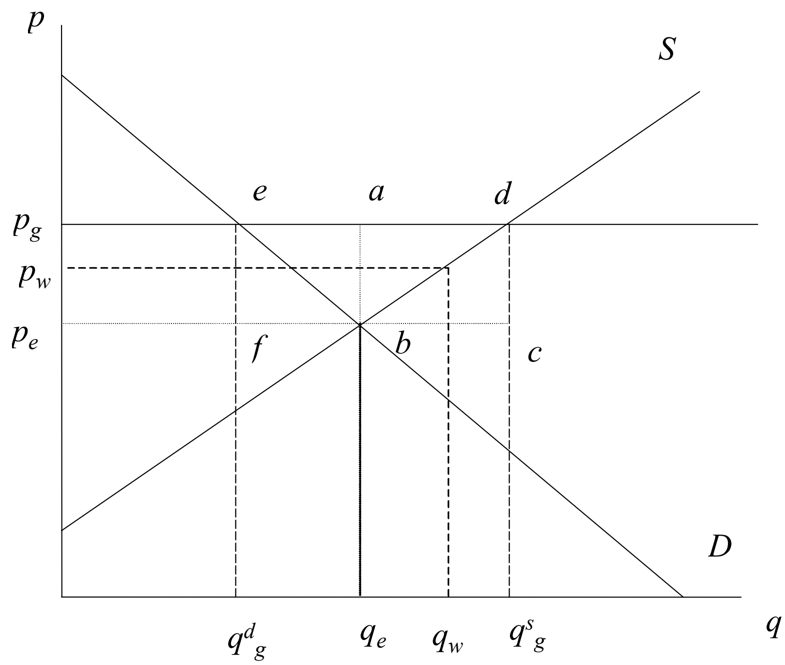

Figure I.1 The economic effect of minimum prices

Notes:

q_i = volume of the product (volume of supply or demand);

p_i = price of the product;

D = demand curve;

S = supply curve (marginal private costs).

Appendix II. Weighting factors used to calculate environmental indicators

Table II.1 contains the weighting factors that are used to calculate environmental indicators. These factors are based on VNCI (2001).

Table II.1 Weighting factors for calculating environmental indicators

	Greenhouse effect	Acidification	Photochemical ozone creation	Eutrophication
CO_2	1			
N_2O	310			
CH_4	21		0.006	
NO_x (as NO_2)		0.41	0.028	0.13
SO_2		1		
NH_3		1.30		0.35
VOC			0.5*	
CO			0.027	
Phosphate				1
Nitrate				0.1

* It is not usually known exactly what substances are involved in (aggregated) VOC emissions. The weighting factor of 0.5 was chosen because most of the VOCs in the EPI method have a weighting factor of between 0.1 and 1 (the reference substance with a weighting factor of 1 is ethylene). Obviously another weighting factor can be chosen if this is warranted by the available information.