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Robert Straumann

Exporting Pollution?
Calculating the embodied emissions in trade for Norway

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Foreløpig tall	Provisional or preliminary figure	*
Brudd i den loddrette serien	Break in the homogeneity of a vertical series	—
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Abstract

Robert Straumann

Exporting Pollution?
Calculating the embodied emissions in trade for Norway

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Economic activity causes to varying degree pollution to air, soil and water. The pollution that is caused by the production of a single unit of a certain commodity can be said to be embodied in the commodity. This approach allows us to investigate environmental issues from a consumption-centred perspective, and this is especially important in the case where the embodied pollution in a certain commodity is not restricted to the country where the commodity is consumed.

In this thesis, I present some possible approaches to measure the emissions embodied in the exports and imports of different commodities. The indicator which I focus on, the so-called Pollution Terms of Trade is presented in the second chapter, and its main features is discussed and I also propose several possible applications. The indicator is based on trade data and emission intensities in the production of different commodities, and I pay particular attention to the importance of using country-specific intensities in order to capture the total embodied emissions in trade.

In the third chapter I calculate the indicator for the case of Norway, and find significant differences in the balance of emissions in trade for different pollutants. The importance of the oil industry, as well as ocean transport, for Norwegian exports greatly affects the results, especially in the case of pollutants like NO_x and NMVOC. The technology effect is also significant in some cases, as expected.

In the fourth chapter I discuss the impacts of trade on the environment, and present a theoretical model to illustrate some of these issues. I also use data from an earlier general equilibrium study to assess the effects of a certain shift in trade policy on the Pollution Terms of Trade. I find that as the net import of agricultural goods increases, the balance of embodied emissions in trade improves to a great deal when it comes to pollutants like CH_4 and NH_3. The effects are both positive and negative in terms of the PTTI, depending on type

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1. Introduction

1.1. Motivating the paper

In many cases, economic activity has important environmental side effects that are external to the economic agents causing them. Many production processes create different kinds of waste or harmful emissions, or involves depletion of natural resources not priced in the markets. Such bi-products of industrial and other economic activity can in turn give rise to so-called external effects such as health problems caused by harmful emissions, changes in the global climate due to GHG-emissions and ecological collapse following resource exhaustion. A major contribution from the economics profession to the environmental debate has been the attempts to quantify these effects in monetary terms, that is the amount of economic damage they cause. One important example was the work of several economists in the aftermath of the Exxon Valdez incident, where the economic damage of oil spills in a fragile environment were assessed.[1] Another major field of study has been the calculation of abatement costs for different levels of pollution. This thesis will focus on the link between economic activity and pollution, and particularly emissions to air.

From emissions data it is also possible to calculate the amount of emissions embodied in the end product, which is the pollution load (Muradian et al. 2002) caused by the production of a single unit of the commodity. In most cases, only environmental effects of the domestic production processes are being considered, ignoring that consumption of imported goods may have similar effects in the exporting country. In addition, the production of these commodities may induce emissions of greenhouse gases or transboundary pollutants in which case several countries share the environmental load. Muradian et al. (2002) argue for a consumption-centred rather than a production-centred perspective:*…if consumption is assumed as the key economic force "steering" the environmental transformation, the assessment of the environmental performance of a national economy requires us to make the distinction between environmental costs borne and caused by a nation, and therefore, to expand the scale of analysis beyond the national political frontiers.* In other words, such a consumption-centred view of the link between production activity and the environment, which regard the demand for the products as the indirect cause of the environmental costs borne by the producing countries, is appropriate in several cases.

Acknowledging that domestic economic activity is linked to the global market, and contributes to global pollution both directly and indirectly, the scale of the problem can be difficult to assess. The complexity of the global economy create a problem when it comes to quantification of the environmental effects of trade, and the most common approach in recent literature seems to be the embodied emissions approach. The basic principle is that one unit of a certain commodity consumed has a certain amount of emissions that originates from the production of the commodity. Following the embodied emissions in trade, it is possible to find the environmental load caused by a nation, relative to the environmental load it actually carries. Instead of concentrating on the actual sources of pollution, the actual pollution demand is being addressed through the end-users, the consumers. Some previous papers have tried to assess these effects, proposing several kinds of indicators that show the relative environmental load in trade for a certain country, one of the most influential is the Pollution Terms of Trade (PTTI). (Antweiler (1996)) This index consists of a technological and a composition component, where both components can be isolated.

In addition to emissions from production activities, which according to this view is indirectly caused by consumption, emissions can also directly from consumption activities, the obvious example being combustion of fuel. From a production-centred perspective, one could argue that direct emissions from consumption should be viewed as a result of the provision of petrol and fuel oil, and thus be assigned to

[1] See: Carson, Richard et al. A Contingent Valuation Study of Lost Passive Use Values Resulting From the Exxon Valdez Oil Spill. Report to the Attorney General of the State of Alaska, prepared by Natural Resources Damage Assessment, Inc. La Jolla, California: 1992.

the producing countries. This study, however, focuses on the possible environmental displacement load from trade, which in the case of emissions from direct consumption activity is non-existent.

My main contribution relative to previous studies of PTTI, or related measures, is to quantify the technological component, i.e. the differences in emission intensities between countries. While this effect is recognised as important in theoretical discussions, the empirical importance has not yet been calculated. I will present these calculations for the Norwegian case. As emissions related to both export and import have to be computed, I have used emissions and economic data to calculate different sets of intensities for all significant trade partners for Norway. In this manner, both the technological component and the composition component of the PTTI are captured. Previous studies have only been able to calculate the composition component, thereby ignoring any differences in production technology between countries. In the second part of the thesis, the PTTI is applied to changes in Norwegian trade policy during the 1990's based on an earlier CGE study (Fæhn and Holmøy 2000). This is to show an example of a field of study where this indicator can be valuable. I will also discuss possible applications and extensions of this framework.

2. The index and how to calculate it

2.1. The Pollution Terms of Trade - definition

The term "pollution terms of trade" was introduced by Antweiler (1996), as he proposed an index for measuring the embodied pollution in trade, and others have further investigated the concept. For a certain country (the home country) it is defined as:

$$PTTI = \frac{\text{pollution content of exports}}{\text{pollution content of imports}}$$

The pollution content is defined as the emissions associated with production of import or export commodities. The pollution content of imports for the home country is defined by:

$$\sum_{c=1}^{C}\sum_{i=1}^{n}\frac{IMP_{ic}}{IMPTOT}\frac{E_{ic}}{Y_{ic}},$$

where i = sector and c = country (excluding the home country). IMPTOT refers to total imports to the country, E is emissions and Y is output. Similarly, but slightly more easy to calculate, one defines pollution content of exports:

$$\sum_{i=1}^{n}\frac{EXP_i}{EXPTOT}\frac{EDOM_i}{YDOM_i},$$

where EDOM and YDOM are the domestic emissions and output. It is easy to see from this decomposition of the index that both the trade pattern (first factor in both the pollution content concepts) and the emission intensities (second factor), determine the value of the PTTI. The index can be calculated for any emissions of which data are available.

One important quality of the index is that it combines several features that can explain emissions linked to international trade flows, and put it into one index. Firstly, the degree of environmentally friendly technology is represented in the emissions intensities, that is the amount of emissions pr. unit produced. Differences in this technology component (TC) are likely to cause differences in emissions across countries.

Secondly, the index takes into account that industries vary according to pollution intensity, which in many cases correspond to their energy intensity. The PTTI is a measure of embodied pollution in trade, thus the export and import patterns represent this composition component (CC).

2.2. Possible applications of the index

According to Antweiler(1996), the index "measures the environmental gains or losses that a country sustains from engaging in international trade." Environmental gains in this sense is when the pollution intensity of the country's imports are higher than that of its export, both because of technological and compositional features of domestic and foreign production. If a country imports a certain commodity rather than make it domestically, and production of this commodity is highly pollutive, one can say that the country receive an environmental gain from this action. The country has shifted the pollution source abroad, but still imports the commodity that causes the pollution. Policies that encourage such a shift, which some would call "eco-dumping", are favourable for the first country in an environmental sense, but they are a way of passing on the problem of pollution without reducing consumption possibilities. Still, such a situation could be caused by well-meant policies, such as "green" taxes. It is clear that this concept of "environmental gains" from trade is only valid when we look at pollutants with purely local impact. Emissions of any greenhouse gas or acidifying gases has global or at least regional impacts, so "environmental gains" may be a misleading term when studying these pollutants.

It is important to note that the PTTI is a relative measure, in the way that a large quantity of embodied pollution in exports can still lead to a low value of the indicator, provided that the embodied pollution in imports are even larger. A country with pollution-intensive export industries can still display a low PTTI, if its imports are similarly "dirty". For this reason, the indicator is not a good absolute measure of the pollution impact of a country, not domestically nor foreign. A country with low PTTI may have high emissions intensities in production, but its trade partners are even worse.

One important feature of the index is that it illustrates that domestic consumption behaviour has environmental consequences beyond the national level (Muradian et al 2002). An increase in imports leads to greater environmental load on the exporting country in the case of pollution with merely local impact, while in the case of greenhouse gases; an increase in imports has global consequences, even though national emissions are unchanged. In this way, the PTTI shows the strong relationship between consumption and emissions, and gives indications on whether a country's domestic emissions are smaller or larger than the emissions actually caused by domestic consumption. In international political debate, the focus is on the amount of emissions within the national borders, mainly because this is the simplest way to address the problem and the way it is usually accounted in statistical sources. The PTTI can be a step on the way to a more consumption-centred perspective, which in my opinion is more sensible, especially when dealing with transboundary pollutants.

Another interpretation of the index may be as a relative measure of environmental performance in comparison with the country's trade partners, that is, as a trade-weighted pollution intensity rate. In this context, the country with the lowest PTTI has succeeded the most in reducing emissions from its exports relative to the same attainment of its trade-partners, either through its composition or through technological progress. The index does compare a country's emissions intensity in domestic export production to that of foreigners' export to the same country. It is still not a good measure for environmental performance. One main reason is that the emission intensities are weighted with trade, not with production or consumption patterns, as would be more relevant to environmental performance. As stated above; with a consumption-based perspective a reduction in PTTI can just as well be seen as evidence that the country to a greater extent imports "dirty" goods that used to be produced domestically.

There is one major problem with ranking countries by their PTTI. It is true that a low value on the indicator is evidence of a relatively lower pollution content in domestic export production than that of imports, but on the other hand, a high PTTI may be caused by an overrepresentation of high-pollution industries in domestic export production, simply as a result of comparative advantages or abundance of natural resources. The last case could represent a highly developed country, employing all available technology in order to reduce emissions, but the nature of the production will inevitably lead to a high pollution content in exports, simply because of energy requirements or use of raw materials. The opposite case would be a country largely dependent on exports of less pollution-intensive goods or services, while importing "dirty" goods. Their use of emissions-reducing technology may be small; even so they would have a low PTTI. Herendeen (1994) call attention to Japan as a country that is largely dependent on import of non-renewable resources and would therefore fall into this category.

Changes in the index over time could be investigated simply by employing time series of emissions and economic data. While this is more of a data analysis approach, it is likely that important conclusions could be drawn from such a data material, especially if variables like general technology level or energy prices are accounted for. A key issue in this kind of analysis would be to determine which industries got "cleaner" over time, and to what degree changes in the trade pattern has an effect on the indicator.

Several possible approaches could be considered, firstly one could look at actual changes in the PTTI over a given time period, and discuss this in accordance with existing theory on environment and economic developement. The Environmental Kuznets Curve (EKC) hypothesis[2] predicts that the relationship between economic development and the environmental degradation follows an inverted U-shaped curve, with a increase in for example emissions in an early development phase, while the level of emissions decrease as the economic development goes beyond a certain point. A great number of econometric and other studies trying to find evidence of the EKC hypothesis have found turning points that support the theory, but the results are not unanimous. A review of several studies is found in Stagl (1999) and Strand (2002). The theoretical foundation of the hypothesis is often centred on the following three elements:

- Composition of consumption: One of the main characteristics of development in the last 100 years, and particularly post-WWII, has been the shifting from consumption of goods to the consumption of services. While most income just 50 years ago was spent on food, clothing and housing, the modern consumer spends a larger portion on transport services, entertainment and other services. A recent Norwegian report[3] finds that we spend more on cultural services than on food. One positive side effect of this development is that services, due to low resource intensity, contribute less to pollution

[2] The Kuznets curve was originally proposed as the relationship between economic development and income equality. It was named after 1971 Nobel laureate Simon Kuznets

[3] Norwegian Consumption Accounts, Statistics Norway (2003)

than production of traditional goods. In this way, the shifting of consumption from goods to services leads to a lower average emission intensity, and may partly explain the EKC.

- *Employment of new technology:* Technological development may include more efficient use of natural resources, particularly when it comes to energy. Economic development is driven partly by the wish to get more welfare for a given amount of resources, therefore energy-efficient technologies will be employed when energy become scarce enough for the technology to be profitable. Again, a positive side effect of this is a reduction in emission intensity in the industries that install new technology. Such technology may also include recycling, new uses for materials that otherwise would be pollutants and so on.
- *Political preference:* As countries become more developed, and material welfare increases, some argue that the next step would be a greater "demand" for a clean environment. It is believed that the demand for "nature and environment" has an income elasticity greater than one, that is, they are "luxury" goods. As incomes grow, more people express this demand in the form of political pressure and simply by voting for politicians with an environmentally friendly program. The result may be stricter environmental regulations and imposition of "green" taxes.

A time series application of the PTTI for a single country, either a simple data analysis or a more formal statistical analysis can be used to test the validity of the EKC-hypothesis. By combining time series and cross section data, a more dynamic picture can be drawn of the development of pollution flows between countries. In some cases, an environmental gain in one country may as well be offset by the corresponding loss of another, leaving the world as a whole with zero gain. The "gains and losses" are determined by both the technological and the trade composition effect, thus the PTTI captures these developments.

Combining PTTI calculations with model simulations is another possible application, which is rarely used in the literature. In this way, it may be possible to assess the effects on PTTI of the hypotheses underlying the EKC. Bruvoll and Fæhn (2003) investigate the effects of endogenous changes in political preferences on emissions related to the Norwegian trade flows. Other subjects could be the changes in PTTI following technology shifts or shifts in demand for services, as economies grow. The EKC hypothesis predicts that this will lower overall emission intensities. The changes in PTTI will indicate whether emissions from domestic production develop in the same way as emissions caused by domestic consumption. Numerous other themes that may well be investigated with these tools, including international agreements or other policy instruments and their effect on the PTTI. The case of trade agreements is discussed in the second part of this paper.

It is important to note that a time series or model simulation approach to the PTTI may have a certain drawback, connected to the fact that trade balances are seldom constant over time. If we look at the net pollution flow, defined by:

$$POLFLOW = \sum_{i=1}^{n} EXP_i \frac{EDOM_i}{YDOM_i} - \sum_{c=1}^{C}\sum_{i=1}^{n} IMP_{ic} \frac{E_{ic}}{Y_{ic}}$$

It is clear that this measure is affected by the balance in trade in the way that a large trade deficit typically leads to a large inflow of pollution embodied in trade, while a large trade surplus comes with a large outflow of pollution embodied in trade. In order to secure a balanced economic development, trade deficits will sooner or later have to be followed by trade surpluses, and for this reason the net pollution is not a good measure for embodied emissions in trade, since the choice of year(s) of examination is crucial for the result. It is "not very meaningful because it is merely a reflection of trade balances" (Antweiler 1996)[4]. Even though the PTTI, as a relative measure, eliminates the problems occurring when using the actual pollution flow, fluctuations in the balance between exports and imports over time is likely to have an effect on the composition of trade as well. A good example is Norway, at present enjoying large trade surpluses from oil exports, while the prediction is that oil production and thereby exports will fall considerably in the next 50 years, turning the trade balance into a deficit. A side effect of the decline in oil exports will be a decline in oil-related emissions such as NMVOC.

A main advantage with the PTTI is that it is relatively easy to interpret. A low value (or more specifically; smaller than one) of the index suggests imports have relatively larger pollution content than domestic production, and vice versa. This indicates that the domestic consumption is supported by foreign production with higher pollution intensity than the corresponding pollution intensity of domestic production for consumption abroad. We therefore gain environmentally by engaging in this trade. The fact that the results are so easily interpreted gives the PTTI the advantage of being presentable for a larger audience, even though the results does not give specific normative suggestions on further action.

[4] Correcting for the imbalances in trade is a possible way to avoid this problem, but a "corrected" trade composition is likely to be affected by the choice of reference year(s)

2.3. Previous studies

2.3.1. Antweilers introduction of the concept

Antweiler (1996) uses a model with C countries, I industries and F input factors, indexed by their lower cases. Input factors represent the different pollutants. Country c's net exports is defined by the vector:

$$T_c = X_c - M_c$$

, where X is exports and M is imports. Using a technology vector A_c, we get the pollution content of exports per unit of exports:

$$F_c^X \equiv \frac{A_c X_c}{j_I X_c},$$

where $j_I = (1,1,.....,1)$

Similarly calculating the pollution content of imports per unit of imports:

$$F_c^M \equiv \frac{\sum_{j \neq c} A_j M_{cj}}{j_I M_c}$$

Antweiler also defines a vector of pollution weights W, in order to compare the different pollutants and be able to combine them into one indicator.

Using the definitions above, it is then possible to construct the Pollution Terms of Trade:

$$PTTI_c = 100 \frac{WF_c^X}{WF_c^M}$$

Antweiler has made several assumptions when computing the PTTI. First, he uses a set of weights W based on US emissions data, which is biased towards gas emissions and reflects the pollution pattern of industrial countries. His main argument for this assumption is that gas emissions tend to have more transboundary effects than other types of emissions and therefore should receive a larger weight in the index. The concept of this weight matrix is backed by an assumption that the environmental and thus economical impact of a one unit emission of a certain material can be compared with one unit emission of a different material. In the case of greenhouse gases, some have argued upon a set of so-called GWP-indicators (Global Warming Potential), which is used to measure several types of emissions in CO_2-equivalents, a common indicator of the total greenhouse effect. While the use of GWP-weights or similar weights for the different impacts of emissions gives us the presentational advantage of an index embracing several types of emissions, these sets of weights will be somewhat controversial in the sense that they often lack clear empirical backing[5]. The W matrix used by Antweiler is primarily a technical construction based on some simple assumptions, and can be seen as a illustration of a possible calculation method, but it will clearly not be sufficient even as an approximation.

Secondly, Antweiler assumes identical technologies for all countries, using US emissions data to calculate a technology vector A, that is used with trade data for the different countries in order to calculate the PTTI. The reason for this is mainly lack of data material for several countries. Assuming identical emissions intensities, he is only able to measure the compositional effects of trade, excluding any differences in environmental performance due to level of technology. This is a major limitation with his study, as he also notes. However, a point is being made that identical technologies is a common assumption in trade theory and that composition of trade may be the most important in determining the value of the PTTI.

The results themselves show that industrialized countries are more likely to have a large PTTI, thus having larger pollution content in exports than imports. Developing countries tend to have a low PTTI, indicating low pollution intensity in exports. One has to bear in mind, as mentioned above, that these calculations are based on the assumption of identical technology, and it is realistic that correcting for different technology will lower the PTTI for industrialized countries and vice versa for developing countries. This prediction is based upon the fact that developed countries are more likely to use energy-efficient technology[6] and possibly also impose stronger environmental regulations on industries. Using the technology vector for the US is very likely to create a bias; in comparison to Norway one would for example expect differences in the technology employed in the energy and transport sectors. But, keeping possible distortions in mind, the calculation gives an insight into the impact of international trade on emissions. The most developed countries are major exporters and therefore producers of pollution intensive goods, while developing countries produce such goods to a lesser degree. One possible explanation is the differences in energy supply and use between the two groups of countries; energy intensive industries and services are often similar to pollution intensive sectors.

[5] The calculation of the weights are hefted by great uncertainty (UNEP-GridArendal, www.grida.no)

[6] UNESCO- Energy Efficiency in Africa for Sustainable Development (2001)

2.3.2. The approach and results of Muradian, O'Connor and Martinez-Alier

This paper has a somewhat broader perspective than Antweilers short and technical approach. The main focus is on the role of consumers and consumption as the ultimate cause of pollution. Consumer decisions are seen as the driving force in determining which type of production process will be employed and how the demand for pollution (e.g. demand for environment) develops. This is particularly important when it comes to trade, as the consumers will not be completely liable for decisions that increase imports and thereby pollution in other countries. As the authors note in the beginning of the paper, they try to aid in the development of indicators of inter-country environmental load displacement. They start out with a discussion on various types of indicators, including the concept of "ecological footprints", which is a way of measuring the sustainable level of economic activity and resource depletion. Most of the indicators discussed are fairly general and in some cases not easily interpreted, as the authors note. Still, all previous studies that is examined pursue a consumption-oriented analysis, which is seen as the right way to go.

For this reason, the Pollution Terms of Trade is adopted as a possible way of measuring the environmental load displacement. The authors argue that this indicator has a clearer interpretation along with other preferable features. Like Antweiler, this paper presents results based on identical emission intensities for all countries, and only the most polluting economic sectors is included in the calculation. Some concern is raised over the fact that the original indicator is based on monetary terms, since price variations could cause problems. Therefore physical terms are used in the calculations; although identical prices for export goods is a common and mainly non-controversial assumption. The authors find some evidence which support the EKC-hypothesis, especially for Western Europe and Japan. However, this conclusion is not given for all countries and all types of pollutants. Some countries, like the USA, have not experienced the inverted U-curve as expected by the EKC-hypothesis. This is explained by a change in export composition towards less clean products. My main objection is that these conclusions are not based on the calculation of PTTI, but by the net pollution flow. As I discussed earlier, the latter indicator is strongly correlated with the trade balance, and any analysis over a time perspective will be severely affected by this.

The calculation of the PTTI gives a more ambiguous result, but there seem to be some indication that Western Europe and Japan to a larger degree than the USA places the environmental load on other countries. But as the authors states, lack of detailed data on emissions intensities for different countries and the problem of linking pollution to actual consumption, limits the analysis a great deal. Even so, the topics studied are very important, and the PTTI, especially when computed with more precision, is a excellent tool for this kind of analysis.

3. My approach and technicalities regarding the PTTI

3.1. Theoretical approach

The problem of including technological effects in the calculation of the PTTI has been central in my project. As I mentioned above, Antweiler assumes identical technologies across countries, excluding differences in production processes that can lead to differences in emissions per unit produced. My approach has been to obtain empirical data that can be used to calculate pollution intensities for each country and sector. Using these data, I am able to compute the Pollution Terms of Trade in a way that is less biased towards a certain set of technology parameters. Differences in technology vary with environmental standards, level of R&D, level of general development and several other factors. With these differences all catered for, I am able to investigate the embodied emissions in trade for a certain country as well as showing some possible applications for the one-country-case.

The basis of the data set employed in the analysis is emissions and output data from different countries, broken down by economic sectors. In several cases, this has been obtained from national statistical offices or similar sources, while the main source has been Eurostat[7]. The emission intensities:

$$\frac{E_{ij}}{Y_{ij}}, i = \text{economic sector}, j = \text{country},$$

have been the basis for calculating the technology index. Since my aim is to compare the trade-weighted Norwegian and foreign emission factors by calculating the Environmental Terms of Trade, it seemed reasonable to concentrate on finding data for Norway's main trade partners, which includes the rest of Scandinavia, the EU and the US.

The PTTI is calculated partly by weighting emission factors by commodity-specific fractions similar to the aggregate ones in the table on the previous page, so that countries with minor or no trade relations to Norway will receive relatively small or no weight in the indicator. Thus data from a collection of less than 10% of the world's countries still gives a good approximation for the PTTI.

Table 3.1. Norwegian national trade accounts, 1995

	FRACTION OF IMPORTED GOODS TO NORWAY BY COUNTRY OF ORIGIN
SWEDEN	14,69
GERMANY	14,57
GREAT BRITAIN	10,31
DENMARK	7,34
U S A	6,49
FRANCE	5,21
NETHERLANDS	4,94
ITALY	4,03
FINLAND	3,79
JAPAN	3,53
BELGIUM	2,82
REST OF THE WORLD	22,28

Collecting and processing the data has been a rather large, but important, part of the work. Because of different statistical sources, it has been difficult to make comparable data sets for the different countries, thus some assumptions had to be made. The assumptions are in some cases trivial, but in other cases they pose more important limitations to the study, which I will discuss further on. The approximations and assumptions have all been made in order to retain the main contribution of the study, namely differences in emission intensities across countries. I have extended the analysis by calculating the technology for as many countries as possible. With this additional information, I take into account that countries differ in terms of production technology and also in terms of environmental standards. These technology differences are also reflected in the trade composition, as long as they affect comparative advantages, thus affecting the CC indirectly. For example, a country may have low total emission intensity for SO_2 due to environmental legislation, but it may also be that all sectors with a high SO2-intensity have shifted production abroad, thereby moving the problem to someone else. This is known as the "Pollution Havens hypothesis", which I will discuss later.

[7] The statistical office of the Commision, the European Union

While the theoretical PTTI is defined as the pollution content of exports relative to the pollution content of imports, it is difficult, for each defined sector or product group to distinguish empirically between pollution content in exports and pollution content in production for the domestic market. Data on emissions and output that are specific for the exported part of production is not readily available. Mainly due to lack of sufficiently detailed data it has been necessary to use emissions and output data for entire economic sectors as representative measures of exports in the same sectors. Some problems may follow these assumptions, since export demand facing Norwegian producers as well as the foreign suppliers does not necessarily correspond to the respective domestic demand. For example, total exports of food from Norway have a high share of exports of fish and related products, while exports of other food products are marginal. The pollution content of fishing and fish farming are quite different from land-based food production, thus the pollution content of food exports are different from food production for the home market. A corresponding problem applies to the pollution content of imports, which should be identical to the pollution content of the export products from each exporting country to Norway. We cannot distinguish between this from the pollution content of the whole production of the commodity in the exporting country. However, these problems only apply to cases where imports or exports in a sector are dominated by a certain commodity much different from the rest in terms of pollution content. With a sufficiently detailed sector system, such differences are catered for, and should not affect the results in an excessive manner.

Another restriction is due to the import/export matrixes used in calculating the indicator. The first-order effects are captured through the emission intensities in each sector, but any second-order effects are ignored. For example, if the home country increases the imports of a certain good, this has effects in other parts of the economy of the foreign exporter, with consequences for the level of pollution. The indicator will in this case only capture the direct effect of increasing imports in the first sector, not the input-output corrected pollution impact. For example, increasing import demand for electricity-intensive commodities will increase the demand in the exporting country for electricity, which may be produced in a highly pollutive way. Another example is food products that indirectly cause pollution through the demand for agricultural commodities to be processed. The total effect is the sum of the direct effect and the cross-effects, and could be calculated if I/O-tables for all the exporting countries were available and comparable. Extending the study in this way would sharpen the analysis, but also impose numerous problems concerning compatibility with different I/O systems, both with respect to aggregation levels and dating. A Japanese study (Moriguchi et al. (2002)) has estimated input-output corrected emission intensities for Japan through such tables, which is probably the way to go. Further extending this study and allowing for changes in the I/O structure over time would be the next step. Modelling this perfectly would essentially require an input-output model or likewise for all countries exporting significant amounts to Norway, which is not a trivial task. These extensions would in theory give more precise indications of changes in the pollution pattern, but problems with compatibility lack of reliable data and presumably numerous approximations could easily cancel out such increases in precision. Therefore, to keep the simplicity of the original indicator and avoid possible pitfalls with extending the analysis, this study does not investigate such approaches.

While the limitation of only calculating the indicator for a single country poses some restrictions on further applications, it still leaves interesting topics to study within the framework of the pollution terms of trade. In Antweilers study, the PTTI is calculated for most countries, and then the countries are ranked according to the calculated value. The list from highest to lowest PTTI is interpreted in the framework of the "development ladder", where the level of economic and technological development determines the pattern of production. As I have mentioned, my analysis concentrates on calculating the indicator for Norway, and investigating changes in it due to a policy shift. Based upon a CGE model or similar, several scenarios for policy, growth etc. could be implemented with the PTTI, using the indicator as an environmental "benchmark" for any scenario that leads to changes in the import/export structure. Using the results from a previous study (Fæhn and Holmøy, 2000), of a trade liberalisation scheme, I will illustrate such an application.

3.2. Technical issues

When calculating the PTTI, I have defined it in the following manner:

$$ETT = \frac{\sum_{i=1}^{n} \phi_i \sum_{c=1}^{C} \delta_{ic} \frac{E_{ic}}{Y_{ic}}}{\sum_{i=1}^{n} \gamma_i \frac{E_{i,NORWAY}}{Y_{i,NORWAY}}}$$

where i =commodity and c=country. Commodity refers to the commodities in MSG-6, the applied general equilibrium (AGE) model developed at Statistics Norway. I will explain features and application of this model later. The parameter δ is calculated from Trade Account data for Norway 1995, provided by Statistics Norway, and represents the share of Norwegian imports of a certain commodity from a certain country. The parameters ϕ and γ are the share of a certain commodity in total exports and imports, respectively. The latter two parameters are calculated directly from the base year of the 1995 calibration of the MSG-6 model, which is also the year most other data are collected from.

Commonly, one uses economic sectors instead of commodities in trade studies, mainly due to data availability. Since commodities are the objects in trade and there is no one-to-one relation between commodities and industries in real world or the statistical accounts, the better approach is to handle the problem in terms of flows of goods and services. The Norwegian Trade Accounts is mainly based on the commodity approach, and have provided me with commodity data.

The PTTI is defined as pollution content of exports relative to pollution content of imports. It has been convenient in this study to inverse the definition to a measure of the pollution content of import relative to pollution content of exports, that are mainly larger than one (hundred). Besides providing me with results that I find easier to interpret and work with, inverting the fraction implies that the higher the index the higher the environmental gain, which seem more logical. I will refer to this "upside-down" PTTI as the Emission Terms of Trade (ETT), in order to avoid confusion.

Further assumptions on rates of currency, conversion factors of pollutants and so on have been made, and are all non-controversial.

3.3. Results

In popular belief, Norway is said to be a proponent of environmentally friendly policies. Both from participation in international bodies dealing with environmental issues and from official policy, Norway has been in front of the movement for global action in the field of pollution and protection of nature. A recent case is the argument between the Norwegian Secretary of the Environment and similar authorities in the UK over emissions from the nuclear power plant Sellafield. Although strong commercial interests are involved in this case, especially concerns about the impact on the fish population in the North Sea, Norway has pursued active policies towards regional environmental problems. Another example is the Norwegian involvement in the Kola Peninsula[8]. Domestically, CO_2 taxes have been imposed on several areas of private consumption such as gasoline and other petroleum based fuels, and several measures has been taken to lower emissions of SO_2, lead etc. The home industries enjoy the benefit of cheap electricity from clean hydropower plants, which is also seen as an environmental advantage for Norway.

[8] For a closer look on Norway's involvement in regional environmental issues, see http:\www.environment.no

Figure 3.1. Composition of Norwegian imports (1995)

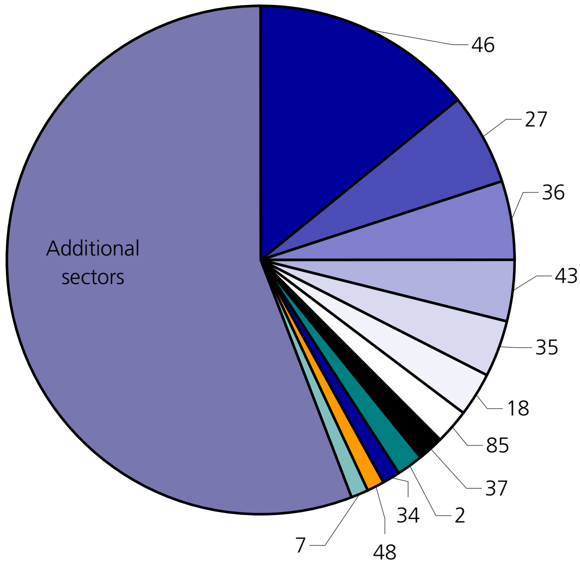
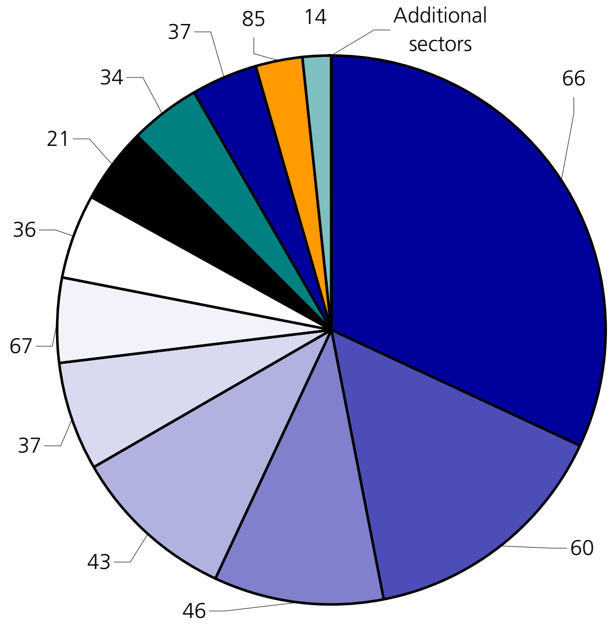


Figure 3.2. Composition of Norwegian exports (1995)



Norwegian domestic consumption has implications for production and therefore pollution in other countries through trade linkages. While domestic production in many cases is said to be relatively "clean", this does not necessarily imply that domestic consumption is clean in terms of embodied pollution from imported goods relative to that of exports. The net amount of embodied pollution will depend largely on the composition of imports and exports, as well as the technology component. The trade composition is shown in figures 3.1 and 3.2.

The numbers correspond to the commodities in MSG-6, the multi-sectoral growth model developed at Statistics Norway. A complete list of all types of commodities is given in the appendix, but the main contributions to total imports come from C46 (Metal products and Machinery), C27 (Chemical and Mineral products), C35/36 (Operating expenditure abroad, fishing/ shipping and direct purchases abroad by Norwegians/ direct purchases in Norway by non-residents) and C43 (Metals)

Norwegian exports are dominated by C66 (Crude oil) as well as C60 (Ocean transport) in addition to the metal and machinery commodities mentioned above.

Before I discuss the results, it is important to keep in mind that these calculations have included not only the composition component of the PTTI as other studies. I have also accounted for different technology matrixes, which is a major improvement compared to previous studies. In some cases, differences in the computed emissions intensities have proved to be large[9], and it is therefore evident that these differences need to be catered for in such an analysis. The gain from including different sets of intensities can be seen in table 2, right column, where the indicator is calculated using an identical set (Norwegian emission intensities) for all countries. It is evident that for some types of emissions the difference between emission intensities can play an important role, this is the case for NH_3, SO_2, CO and N_2O. The technology component is less significant in the case of CO_2, CH_4, NO_X and NMVOC. I will comment more on these differences under each emission type

The results from my calculations give an ambiguous answer to this question. As we have seen in the previous chapter, a value greater than 1 implies that imports have greater pollution content than exports and a value between 0 and 1 implies that exports are more pollutive. A production-weighted index based on total emissions and total output for each country was calculated in (Bruvoll, Fæhn and Strøm 2003), these values are in the middle column. I will discuss the types of emissions one by one[10].

It is appropriate with a general comment on the difference between the trade-weighted and the production-weighted values. The latter values are calculated from total emissions in the different countries, including emissions accounts for the household sector, which in this setting is regarded as a production sector. My calculation gives no weight to domestic and foreign emissions not related to production of tradable commodities, since the aim is to find the balance of environmental pressure from trade. This difference in weighting schemes will particularly be reflected in the indexes when emissions come from households or production solely for the home market.

Table 3.2.

Emission type	Emission Terms of Trade	Production-Weighted Index	Emissions Terms of Trade, identical emission intensities
CO_2	0,763	2,2	0,762
CH_4	1,594	2,2	1,391
NH_3	7,466	not available	4,984
NMVOC	0,320	0,7	0,288
SO_2	1,208	9,8	0,868
CO	2,055	1,6	1,069
NO_X	0,509	1,0	0,511
N_2O	1,140	1,7	1,945

CO_2

A value of 0,763 indicates that Norwegian exports contain a slightly larger amount of CO_2 than its imports. If we look at the trade composition, the most important export commodity by far is crude oil, in which the production creates CO_2 emissions through flaring of gas. Other large export sectors include metals and machinery products, where emissions of CO_2 are due to the use of reducing agents in production. The fact that the technology component does not change the value indicates that the emission intensities for CO_2 is relatively similar for Norway and its trade-partners, probably a reflection of small differences in this output from combustion of fuel. One has to note that the emissions intensity of metal production in other countries is likely to be underestimated compared to the similar emissions intensity for Norway, the reason being that the input-output effect is not accounted for on emissions from the production of the input electricity. While this does not affect Norwegian figures much, as electricity is mainly clean, this will underestimate figures for countries based on thermal power. It is likely that the secondary input-output effect would imply a larger value of the indicator. This is also shown in the difference from the ETT to the Production-Weighted Index (PWI).

While differences in emissions intensities[11] are considerable in some cases, it seems that the composition effect due to the extreme specialisation of Norwegian exports are very important in explaining the fact that the CO_2 content of exports are larger than of the imports.

[9] For an illustration of differences in emissions intensities between Norway and other countries see appendix A

[10] More facts on the different types of emissions can be found in Natural Resources and The Environment (Statistics Norway 2002) in addition to numerous other sources, including the United Nations Environment Programme (www.unep.org)

[11] See Appendix A) Emission Factors

CH_4
The most methane-intensive sectors are the agriculture sector and services dealing with waste and landfills. In addition, combustion of fossil fuels contributes some to the emissions. CH4 contributes to the greenhouse effect, in addition to local air quality through the formation of ground-level ozone. The ETT for CH_4 is found to be 1,594, indicating a "net import" of methane. Main contributing commodity is agricultural products, not because it dominate imports relative to exports (both imports and exports of such commodities are marginal), but because of the relatively large emission intensities in agriculture. The import share of agricultural commodities is large than the export share, followed by a relatively large emission intensity in imports. It is important to note that the content of CH_4 in Norwegian exports would have been significantly smaller without the emissions from the oil industry. In addition to the large share of exports, production of crude oil in Norway has a large emission intensity, thus both the TC and the CC of exports is dragging in the same direction. It is also a question whether emission accounts abroad include emissions from waste and landfills related to handling of waste from production processes, which is accounted for in the Norwegian figures. If not, the value of the index should be somewhat higher. This may be the explanation for the difference between the ETT and the PWI.

NH_3
This is a pollutant with merely local effect, due to its acidification properties. Sources are agriculture, through use of fertilizers, and some emissions from road traffic. Calculated ETT is 7,466, a rather high value, which can be explained by the same argument as for CH_4, the emission intensity for foreign agriculture is several times larger than for other sectors. Even though the CC gives a small weight to agriculture, the TC still dominates in the ETT. This is also evident in from the difference between the ETT with and without different sets of EI's.

NMVOC
The case of Non-Methane Volatile Compounds or NMVOC's is particular for Norway. Emissions of these compounds mainly come from oil and other petroleum related activities including use of solvents, and due to the economic importance of the oil industry in Norwegian exports, domestic emissions are rather high. This is clearly seen from the ETT, with a value of 0,320 indicating large pollution content in exports relative to imports. It is obvious that both the TC and CC contributes to the low value, the large emission intensity in production of crude oil is also given a large weight because of its large share of exports. The result also corresponds to the PWI value. NMVOC affects local air quality through the conversion into ground-level ozone.

SO_2
As a product of combustion processes, sulphur dioxide is emitted from many sources; some of the most important is metal production, thermal power plants and transportation. It is one of the main acidifying agents in addition to NH_3 and NO_X. The production-weighted index presented earlier indicates a very low level of Norwegian emissions compared to other countries, a conclusion that is backed by strict regulation compared to other countries over the last years. Still, the calculated value shows a different story, a value of 1,208 gives a more moderate conclusion. The reason is emissions from ocean transport, which is an important sector in Norwegian exports, and again, both the TC and the CC is pulling in the same direction. Norwegian sulphur regulation may be stricter than in other countries, but it seems to be most effective in sectors with little relevance to international trade, such as domestic transport and heating from combustion. It is interesting to see that the indicator drops below one if identical emission intensities are employed, this shows that composition of trade is of less importance in this case.

CO
This pollutant is also mainly related to combustion of fuel etc., and particularly so in production of metals and chemical production. These commodities are important parts of the composition of imports and exports for Norway. On the other side, the TC contributes to the value of 2,055 especially in the case of metal production, where Norwegian emission intensity is smaller than the similar EI for our trade partners. We see that the indicator is close to balance (one) when using identical emission intensities, this emphasizes the importance of different emission intensities. The ETT value is larger than the PWI, which indicates that emissions in exports pr. domestically produced unit in total are relatively larger than emissions in imports pr. produced unit abroad. CO emissions mainly affect local air quality.

NO_X
Ocean transport is an important industry in Norway, and since it is defined as exports, it contributes substantially to the CC. Emissions of NO_X are mainly due to combustion, and have a particularly high intensity in ocean transport and other transport sectors. Emissions are also considerable in the oil industry, possibly due to flaring of natural gas, in addition to some emissions from the metal and chemical industries. Along with the compositional contribution, Norwegian emissions intensities in the latter sectors of production are slightly higher than for other countries, all in all resulting in a relatively low ETT of 0,509. This is lover than the PWI, mainly because of the importance of ocean transport in exports relative to its importance in total production.

NO_X is an acidifying agent, in addition to a general contributor to poor local air quality.

N_2O

The value of 1,140 indicates "balance" in the relative emission content of trade. Emissions from agriculture seem to dominate the CC, which indicates a higher value, but this is opposed by a large emission intensity in Norway relative to other countries. The difference when employing identical emission intensities in the calculation is worth noticing, in this case the technology component increases the ETT, meaning that the Norwegian production is less clean than its foreign counterparts.

4. Trade liberalisation and the ETT

4.1. Introduction

4.1.1. Why should greens love trade?[12]

Basic trade theory predicts through the hypothesis of comparative advantages that the world as a whole will benefit economically from trade liberalization, simply because of more efficient use of available resources, given that any external effects are accounted for. The external effects, which in many cases are environmental effects, are often assumed to be dealt with at a local level. This is, at best, a simplification in light of the more global environmental problems we face today. The environmental outcome of the increasingly globalised market has been the issue of some debate, and while environmentalists see free trade as a threat to the sustainability of the earth, those in favour of trade liberalisation argue that environmental issues should not be addressed through trade measures (Nordstrøm & Vaughan 1999). The first group tend to argue that a scaling up of world production will lead to a similar scaling up in pollution, hence increasing the pressure on the environment. The "liberals" predict that economic development will lead to more efficient use of resources and distribution of technology (Tisdell 2001), in addition to other factors that can ease the pressure on the environment. The latter argument is a reference to the so-called Environmental Kuznets Curve Hypothesis (EKC).

It is evident that increasing trade and therefore interaction between trade partners can create an environment for international agreements, because fear of weakened profitability is less likely to dominate over environmental concerns if governments of several countries agree upon common minimum standards. Even though the issues of economic growth has been in the forefront of the discussion in the World Trade Organization, environmental issues has also been raised, and the organization has clearly created a forum in which such concerns can be debated and possibly agreed on in the future. The EU is of course another forum where the promotion of the free and common market has been followed by discussions on environmental issues. A recent case is the massive oil spill on the coast of Spain, which was brought up in official EU fora, and safety regulations to prevent such disasters were proposed. However, free-riding could easily undermine any such agreements.

The interaction through trade may also push the development and use of environmentally friendly technology forward. Extended access to markets for real capital and raw materials may induce companies to change the means of production to a more energy-efficient and therefore cleaner one. It is also possible that increased interaction can expand the knowledge about available technology, and in some cases access to a larger market can make investments in technology more profitable than it would be if only the domestic market was to be served.

A larger market will definitely lead to increased demand for transport services, as goods need to be transported to the consumer. This is the most direct and unquestionable environmental effect of trade, as transport services are closely linked to several types of emissions. This is especially true for road transport, the most important type of goods transport in Europe, but also ocean and air transport is greatly embodied with pollution.

4.1.2. Displacement effect

While several effects push towards cleaner and less resource intensive production in rich countries, we see that global consumption and use of natural resources are increasing. There has been some concern that the "green effects" in developed countries have become possible due to increasing pollution-intensive production in developing countries, referring to this as a displacement effect.

Displacement in this sense may be what some call "environmental dumping" and by others "environmental gains of trade", depending on point of view. It is the situation when a country ceases to produce certain pollution-intensive goods domestically and shifts to import of similar goods from other countries. There may be several reasons why such a situation

[12] From The Economist, oct. 7th 1999

occurs; environmental regulations may be one, in addition to other changes in terms of production. Some studies[13] explain the EKC partly by this leakage effect; it is believed that pollution-intensive industries shift production from developed countries to less developed ones, for the reasons stated. If this holds as the main explanation, global emissions will not follow the EKC, since some countries will always be on the increasing part of the curve, and the average emission intensity will therefore be constant or increasing. The case of relocation of firms to countries with laxer environmental standards is often referred to as pollution havens or the race-to-the-bottom hypothesis. It has been argued that relatively stronger environmental regulations in a single country cannot be sustained because the affected industries will relocate their production to other countries to avoid the regulation costs[14]. If industries can move freely around the world, there will be a pressure towards lower taxes and other costs in order to attract investment. In other words, stringent environmental policies tend to move pollution to other countries, and in the case of pollution with global impact; no benefits can be drawn from such policies at all. In fact it is the other way around, since environmental regulations create additional costs for the firms affected. The outcome will depend greatly on the type of business; some industries are more prone to relocate because of stringent environmental regulations. These industries have relatively larger abatement costs for a given regulatory regime, and include petroleum, coal, chemical and metal industries.[15]

With stronger environmental regulation in a sector, one can expect that some firms will close down production or move it abroad, while other firms adapt to the new regulations and continue production with "cleaner" technology. Thus, the remaining firms in the sector are likely to have lower emission intensity than before the new regulation, and presumably lower than other countries with laxer environmental standards. As long as there are some production left after the introduction of new regulations, and the emission intensity has declined, there has been a technological effect in addition to any changes in the trade composition. The use of technology has shifted towards cleaner and more environmentally friendly means of production; therefore the relationship between emission intensities of different countries will be an indicator of the degree of emission regulations. Such a relationship will, in the case of the pollution terms of trade, indicate a low value of the PTTI for tough-on-pollution countries and a similarly high number for countries with laxer standard. It must be emphasized that environmental regulation is only part of the picture, factors like resource availability and country-specific differences in technology and domestic demand explains a great deal of the differences in PTTI's.

Surveys[15] have also found that the additional costs from environmental regulations borne by industries are in most cases a small fraction of total production cost, and that these costs do not affect the location decision to a large degree. The US Census Bureau has found that the average industry in the United States spent some 0,6 per cent of its revenue on pollution abatement, rising to between 1,5 and 2 per cent for the most pollutive industries. An OECD study found that the costs are believed to account for 1-5 per cent of production costs. Compared to factors like wage level, average productivity, general tax level, availability of resources etc. it seems unreasonable in most cases that a firm would move its production solely on the basis of stringent environmental regulation. However, the secondary effect of regulations on the competitiveness of industries is not clear; for example do Bruvoll & Fæhn (2003) find significant downward pressure on wages of introducing abatement policies, and effect that, if isolated, increase competitiveness. Herendeen (1994) also points at the problems for countries to sustain environmental policies in a liberalised trade regime.

4.1.3. The role of comparative advantages

The compositional effect of trade liberalization needs to be addressed specifically in order to investigate theoretical properties of trade and the environment. Linked to the basic concept in trade theory of comparative advantages, the composition of output, import and export is vital for the pollution pattern of a country and can therefore give important indications of the relationship between trade and the environment. The main result from the theory is that a country increase production in the sector where it has its comparative advantages when it moves from autarky to a situation with free(r) trade. Global production increases because of more efficient use of the available production factors, and all countries will be better off economically given the assumptions of standard Heckscher-Ohlin-Samuelson models. The change in production patterns produce similar changes in the pollution pattern, countries with comparative advantages in emission-intensive industries will obviously increase their domestic emissions and vice versa.

Looking at a small open economy with two industries producing (y, x)[16]. Assuming perfect competition and constant returns to scale and setting the price of commodity y as numeraire, we get:

[13] Stern et al. (1996) for a theoretical discussion etc., Bruvoll and Fæhn (2003) for simulations for Norway

[14] Smarzynska and Wei (2001) discuss this hypothesis, and find some support for it; although the evidence is not very robust.

[15] Nordstrøm & Vaughan: Trade and Environment, WTO (1999)

[16] This model was adopted from Antweiler, Copeland & Taylor (2001), and adapted to my purpose

$$C_x(w,r) = p$$
$$C_y(w,r) = 1$$

We consider two countries, "domestic" and "foreign", which is in fact the rest of the world, and assume that the foreign country is net importer of good x, thereby assuming that "domestic" has a comparative advantage in production of this good. More specifically, we shall assume that this good is produced mainly with capital, while the other good, y, is produced mainly with labour. Trade restrictions are given by the parameter β (<1), and the price is given by this parameter and the price on the world market.

$$p^f = p^w$$
$$p^d = \beta p^w$$

Freer trade would imply that goes towards one. This would improve the terms of trade for the exporter.

Note that in a two-country model like this, changes in trade composition cannot be addressed in a sufficient manner, that is, as an illustration of the mechanism behind the PTTI. The ratio between pollution intensities as shown above is not equivalent to the PTTI, since the former measures pollutive industries as a portion of total production, and not as a portion of total exports. Therefore, the concept of balance of embodied emissions in trade is not meaningful in this model, although the result gives an indication of the underlying changes in production pattern. The relevant measure in this model corresponds to the production-weighted index, PWI, introduced in Chapter 3.

In order to investigate the effects on the production-weighted index of a change in the trade regime, I consider the change in total pollution (z) as a function of changes in three components. Firstly the emissions intensity pr unit output (e), secondly the relative share of x in total pollution (ϕ) and thirdly the scale of the economy (S). Using this, we can define an aggregate measure of the PWI:

$$\left.\begin{aligned} z^i &= e^i x^i = e^i \phi^i S^i \\ S^i &= p^i x^i + y^i \end{aligned}\right\} i = d, f :$$

Defining γ as total emissions per total production, we obtain the PWI as:

$$\Rightarrow \frac{\frac{z^f}{S^f}}{\frac{z^d}{S^d}} = \frac{\gamma^f}{\gamma^d}$$

The capital-intensive industry is assumed to be the only polluting sector. Emissions intensities can differ from country to country. In order to find the effect of a change in the emission intensity (e) and the composition indicator (ϕ), we differentiate and find that:

$$d\gamma^i = \phi^i de^i + e^i d\phi^i$$

Assuming constant emission intensities we are left with the effect of a change in production composition:

$$d\gamma^i = e^i d\phi^i$$
$$\kappa^i = \frac{K^i}{L^i}$$
$$\phi^i = \phi(\kappa^i, p^i)$$

Using the composition function defined above, we obtain:

$$\frac{d\phi^i}{\phi^i} = (El_{\kappa^i}\phi)\frac{d\kappa^i}{\kappa^i} + (El_{p^i}\phi)\frac{dp^i}{p^i}$$

, where both elasticities are positive. With these results, and the fact that:

$$\frac{dp^d}{p^d} = \frac{d\beta}{\beta}$$

$$\frac{dp^f}{p^f} = 0$$

we see that:

$$\frac{d\gamma^d}{d\beta} > 0$$

and

$$\frac{d\gamma^f}{d\beta} = 0$$

Since trade liberalization imply that goes towards 1 and the initial situation is that <1, this implies that:

$$\frac{d(\frac{\gamma^f}{\gamma^d})}{d\beta} < 0$$

when the domestic country has comparative advantage in capital goods also after the liberalisation. The effect will be depend on the initial situation, and will specifically be larger if the emission intensity of the capital abundant country is large. If the difference in the capital/labour rate is large, this will also increase the effect on the ratio between the pollution intensities. In any case, the effect on the pollution pattern is clear, the country that is relatively more abundant in capital than in labour and therefore has comparative advantages in capital-intensive industries increases its emissions, while the other country gets a reduction in emissions due to increasing import substitution in pollution-intensive commodities.

Most importantly, it shows that freer trade will lead to relocation of industries, which in turn will lead to changes in the way that the total environmental load is divided between countries. Moreover, assuming that capital-intensive industries are relatively more pollutive, the capital-abundant countries will increase their environmental load, while countries with comparative advantages in labour-intensive production will pollute less.

4.2. A model study - reinterpreted

Fæhn and Holmøy (2000) conducted a study on welfare effects from a set of trade liberalisation agreements for Norway. The analysis was based on the MSG-6 General Equilibrium model, developed at Statistics Norway. In the following, I will give a brief summary of the study, and later use some of their results to assess the effects on the ETT of the changes in the trade regime.

4.2.1. The Multi-Sectoral Growth Model (MSG6)

The Multi-Sectoral Growth Model (MSG6), developed at the Research Department, Statistics Norway, has been central in this study. It is an AGE-model (Applied General Equilibrium), which has been developed for studying policy changes and other structural changes in a long-term perspective. Features like welfare effects; allocation of resources and trade composition can all be studied within the model. Main features of the model are exposed below. For a more detailed description, confer Strøm (2001)

The model specifies 32 private business industries, 7 government sectors and 60 commodities, of which 34 are tradables. 9 tradables are provided by imports only. The remaining 25 are produced in domestic industries exposed to foreign competition, mainly in manufacturing, primary industries and offshore industries. The model is characterized by intertemporal optimisation, where consumers maximize the allocation of savings and consumption over time, given a budget constraint. Producers maximize the present value of the cash flow to its owners. Both consumers and producers have perfect foresight of future prices and wages, so real- and financial capital are endogenously determined. The main empirical data source for calibration and estimation of behavioural and technology parameters is the Norwegian National account, with 1995 as base year.

Household consumption is determined from the choice of one representative price-taking household with model consistent expectations, maximizing a CES utility function over an infinite horizon subject to an intertemporal budget constraint. This gives the optimal level of consumption in each time period, of goods, services and leisure. The preference structure also take into account the fact that the different goods and services is at least consumed in a certain quantity, that is, a minimum quantity of each commodity.

The model distinguishes between the behaviour of individual firms and the aggregate industry. Output and input in an industry can change both because of changes at the firm level and as a result of entry and exit of firms. Entry in an industry occurs when the after-tax profit increases relatively to the net fixed cost associated with entry, and vice versa for exit from an industry. Producers within an industry may have different productivity and size, and their production process is assumed to exhibit decreasing returns to scale with an initial fixed cost of production. The prices of exported and imported goods are exogenously determined on the world market, and may deviate from domestic prices. Norwegian consumers are assumed to view imported and domestic produced commodities as imperfect substitutes, allowing for different price developments (the Armington hypothesis). There is monopolistic competition among domestic producers in most of the industries, giving rise to some mark-up. This is not true for the primary industries; the government sets prices on agricultural output. Each firm allocate their output between the domestic and foreign markets, and it is assumed costly to change the composition of these deliveries. This feature allows for the price development deviations between domestic and world market export prices.

The Armington hypothesis assumed in the model implies that changes in the calibrated import shares are determined by the ratio between the import price and the domestic price index. Some commodities, including electricity and petroleum products as well as agricultural goods, are assumed to be homogenous, with their prices determined on the world market. For all imported goods, tariffs and non-tariff barriers, identified in the model as protection rate, limit foreign access to domestic markets. This rate is composed by three components: The tariff rate (t), the quota rent (QR) and the penetration cost rate (PCR). The two latter are examples of non-tariff barriers. This gives us the import price for commodity i:

$$P_i^I = P_i^W(1 + PR_i) = P_i^W(1 + t_i)(1 + PCR_i)(1 + QR_i),$$

where P_i^W is the price of the commodity set on the world market.

4.2.2. The Dynamic General Equilibrium Assessment

The base of the analysis has been to study a set of policy reforms that were implemented in Norway during the 1990's, and study the impact of these reforms. It included the signing of two major trade treaties, the EEA agreement put in place from January 1994 and the WTO agreement -the Uruguay Round, implemented the year after. In addition, one agreement on lowering fishery subsidies and a similar agreement on shipbuilding were considered, the last to apply from 2001. In order to treat these reforms in the model frame, it has been assumed that all reforms are introduced as planned, and that the announcement of the reforms is treated as an exogenous shock in the first year of the simulation period (1992). The simulation path is compared to a path characterized by a status quo policy from before the reforms.

Norwegian tariffs are generally low, even before the set of reforms were implemented. Free trade agreements cover a great deal of exports and imports, with exception for food, beverages, tobacco, textiles and clothes. Domestic agriculture production has in particular benefited from strong protection, both from tariffs and other trade barriers. A great deal of total trade barriers consist of various subsidies to national industries, including fisheries and shipbuilding, and one can expect that the removal of these subsidies will have some effect on the trade composition.

The simulation also assumes that during the period of reform world market prices increase slightly as a consequence of increased demand following the reduction in trade barriers. In general, the export prices increase by 0,5 percent from the reference path to the reform path. Concerning the import prices, these increases are more than offset by reduced costs of penetrating the Norwegian markets, and they fall by 1.14 percent on average.

The main focus of the analysis is on the possible welfare gain from the reforms, defined as the present value of utility flows. The model's dynamic properties are utilised to examine this. My paper has a different focus, namely the underlying changes in the trade pattern, and thus in the ETT. The welfare gains connected with the introduction of the trade reforms are due to the reductions in dead weight losses caused by protective policies and subsidies. A significant negative welfare contribution comes from reduced employment, but the net effect is positive, though small, amounting to about a 1 per cent increase. Still, the welfare gain can come at a price, if the environmental effects, which are not included in the welfare concept, are large. I will not try to quantify these effects, but give an indication of how the environmental load is shifted between Norway and abroad.

4.3. Changes in the emission terms of trade

From the simulations for the reference and reform paths, different trade compositions are realised for Norway. For imports, the main differences are in the commodities agricultural products and tobacco/ beverages with an increase from the reference path of around 18 per cent. There are also considerable increases in the import of oil production platforms and chemical and mineral products, while no other commodities seem to be imported to a significantly larger degree. As for exports, industrial chemicals and meat and dairy products see some increase in their sales abroad, in addition to small increases for commodities from fishing and fish farming. Exports of metals are also increased, while the ship building industry experience a large cut in foreign sales of nearly 25 per cent. The decline in exports also holds true for agricultural products, net imports in this sector increase considerably.

Using the set of trade weights obtained from the two different paths, and calculating the difference in the ETT from the reference to the reform path, we get:

Table 4.1.

Emission type	CO_2	CH_4	NH_3	NMVOC	SO_2	CO	NO_X	N_2O
Change from the reference path (%)	-1,0	5,3	16,0	1,3	-0,8	-2,3	-0,5	3,9

A positive change indicates that more of the pollution load is placed on other countries, while a negative change means that Norwegian exports has become relatively more pollution-intensive.

The effects of lowered exports and increased imports of agricultural commodities are particular when we look at CH_4 and NH_3. In both of these emissions, the ETT has improved from the Norwegian point of view, leaving other countries with a larger portion of pollution from production of these commodities. The effect of the change in the trade pattern is accelerated by the slightly larger emissions intensities in these sectors abroad. The reason why ammonia emissions are shifted abroad to such a large extent is that the emission intensity in agricultural commodities is very much higher than in other sectors. The change in net imports of agricultural commodities is also the reason for a positive change in the ETT for N_2O, even though other industries, such as chemical and mineral products, are responsible for a large part of the embodied emissions in trade. The relatively large difference in net imports of agricultural commodities between the reference and the reform path offsets any changes in the imports of other commodities, mainly due to the large emission intensity of CH_4, NH_3 and NMVOC in agricultural production.

As for other types of emissions, we see that the pollutants mainly associated with combustion of fossil fuels experience the opposite development in terms of the ETT; the embodied emissions in trade seem to increase for the part of Norway. These pollutants are CO_2, CO, SO_2 and to some degree NO_X. Typical commodities with high emission intensities in production caused by combustion are metal products, chemical products and transport services, but the latter is to a lesser degree an object of trade. Net exports of metal products is increased by nearly 5% in the reform path, while net exports of chemical products increase with a slightly smaller share, and this seems to be the explanation for the "worsening" of the ETT for these emissions. Changes of between 0,5 and 2,3 in the index does not seem to draw us towards any significant conclusion, but considering the fact that Norway is a small open economy largely dependent on trade (and increasingly so), the trade volume constitutes a large part of the economy and emissions embodied herein is therefore also large relative to the total domestic emissions.

A special comment is needed for the emissions of NMVOC, a pollutant that mainly comes from the production and handling of petroleum products. In the study, Norwegian exports of the offshore products oil and gas are not affected by the trade reform. This means that as total exports increase, this takes place in other exporting industries, thus decreasing the export share of the offshore products. This contributes to increase the ETT for NMVOC as the environmental load of our export products falls. Thus, the embodied emissions in exports of offshore products are in fact unchanged, but as the total export volume goes up, while the export volume of offshore products remains unchanged the ETT is altered.

The last observation illustrates the point that the composition of trade and thus the ETT may be sensitive to changes in the import and export balance, and that this can affect any analysis similar to the present one. It is particularly clear in cases where a few industries account for most emissions of a certain pollutant, such as in the case of NMVOC. Therefore, it is necessary to keep in mind when employing the ETT as an analytical tool, that in many cases it will be preferable to correct for temporary shocks to the trade balance. Such changes can only explain small changes in the index, the larger changes as we see here on NH_3 and CH_4 is not purely due to trade balance issues. In some cases, the best approach is to interpret the index as the aggregated relative emission intensity in trade and not as a direct measure of pollution flow, thereby disregarding the problems caused by changes in the trade balance, in particular if there are large fluctuations in imports and exports. In other cases, the index and changes in it can be interpreted as I have done here, as an indication of the pollution load associated with trade. The latter interpretation is applicable to most cases where the fluctuations in total imports and exports are not too large compared to changes in the trade composition, and where single industries are not responsible for a large part of the emissions.

The ETT is in this case largely affected by changes in the trade composition, and even though different sets of emissions intensities have been used for different countries, the EI's are not assumed to change from the introduction of trade reforms. The reforms could have an indirect effect on technology and resource intensity, but it is apparent that some changes in the emission intensities will occur during the period of implementing the reforms, both due to general technological development and government regulation. Predicting these changes for all involved countries is difficult and could easily create a greater insecurity concerning the results.

It is apparent that the model reproduces the predictions from the theory of comparative advantages, the industries in which Norway is assumed to have comparative advantages expand from trade liberalisation, and thereby also the emissions from these industries increase. In this case, some capital-intensive and emission-intensive production such as metal and chemicals industries increase their share of total exports, causing the ETT to decrease for certain emissions. Likewise, the reforms have lead to a larger net import of agricultural products, due to other countries' increased comparative advantages in these industries, and therefore embodied emissions of NH_3 and CH_4 in imports has had a relative increase. The effects are largest in the industries directly affected by the new trade regime, in this case agriculture, shipbuilding and fisheries. This illustrates the fact that most other industries are already exposed to foreign competition, in that their tariffs are low.

The analysis shows that changes in the trade pattern can have significant implications for the pollution load displacement, depending on which industries that experience the changes in the trade conditions. Interestingly in this case, Norway is found to receive a significant environmental gain from reduced emissions of ammonia if the trade reform was introduced. This result is modified if increased emissions in neighbouring countries pollute Norwegian territories. The same result is found for methane when it comes to its air quality properties. As for greenhouse gases, we see that the pollution content of Norwegian exports increase in the reform path. This lowers the environmental terms of trade for Norway. However, as the climate changes of greenhouse gas emissions are independent of the localisation of the emission source, there is no real advantage of such a pollution terms of trade improvement. In fact, it may create additional problems if the country is to fulfil its obligations in the Kyoto agreement, as the terms of this agreement is based on a production-centred view.

5. Conclusions

As I have shown, the PTTI can give important indications on the environmental load displacement that occurs from trade. It is an indicator that in a simple and comprehensible way shows the degree of pollution leakage effects from the exchange of goods and services across borders, and therefore gives a reminder of the fact that domestic consumption affects emissions in other countries. The effect depends on both the emission intensities in production and on the trade composition, so an assessment of the total displacement load must include these two features. The indicator fulfils this condition, and is therefore a preferable approach to an empirical study.

Results for Norway show that both the composition effect and technological effect is important in this sense, and that their magnitude differs greatly between emission types. The composition effect is interesting both from the fact that the oil industry dominates Norwegian exports, and that exports of agricultural products are relatively small compared to imports. Both of these industries have a unique pollution pattern, in the way that they account for a large portion of total emissions of NMVOC and NH_3. As for these pollutants, the composition effect dominates the indicator.

Inclusion of the technology effect is a major contribution of this study, and it has proven to be important for determining the PTTI. In particular, we see that Norwegian emission intensities are in some cases higher than for our trade partners, and therefore indicates a larger pollution load in exports than initially thought. This goes for CO_2, where the Norwegian metal and chemical industries, in addition to the oil industry, have higher pollution intensities than their foreign counterparts. Also in the case of NO_X, the technology effect seems to indicate that imports are generally cleaner than exports.

It is obvious that differences in emission intensity need to be accounted for in a study like this one. Due to dissimilarities in the use of raw materials, environmental regulations etc., countries will generally not display identical pollution patterns, and as we have seen, these differences can be rather large. Norwegian electricity consumption is because of the large supply of hydropower, much cleaner than in most other European countries. Other examples may include differences in the use of artificial fertilizers in agriculture, waste management and general emissions requirements in the industrial production.

The emission intensities are not corrected for any input/output effects, which is a major limitation to this analysis. The concept of embodied pollution is therefore misleading, since I do not account for second-order effects of imports or exports in a certain commodity. Differences between total embodied pollution and direct embodied pollution can be significant, depending on type of commodity. In the case of Japan (Moriguchi et al. (2002), total embodied EI is similar to the direct EI in electricity and gas supply, but the first is about 25 times larger than the latter when we look at production of machinery. It is likely that any study not taking this into account will be affected by the limitation of direct EI's, and would therefore be a natural extension of my analysis.

Some would argue that a consumption-based perspective need to take into account the emissions directly associated with consumption, such as the combustion of petrol. This would be necessary if one were to calculate total embodied emissions in consumption, but in this case I have concentrated on the balance of embodied emissions in trade. In the framework I have presented, the main focus has been on the difference in embodied emissions between production and consumption, and the emissions directly associated with consumption would not affect the PTTI.

Further applications of the PTTI have been discussed earlier in the paper; the main reason for preferring this indicator is the consumption-centred perspective. I have focused on the cause of pollution, that is the demand side, rather than looking at the production or the supply side. This perspective is in many cases preferable, and represents a way of including the impacts of economic behaviour on both domestic and foreign emissions.

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Appendix A

Emission factors

	CO_2	CH_4	NH_3	NMVOC	SO_2	CO	NO_x	N_2O
2	2,056	145,914	N/A	8,831	0,843	4,258	1,745	15,279
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	0,000	0,000	N/A	0,000	0,000	0,000	0,000	0,000
7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	2,777	41,092	N/A	4,176	1,991	3,629	2,313	29,535
9	0,935	11,738	3,137	1,051	1,373	0,370	0,987	0,387
11	1,807	1,273	1,335	9,177	4,117	2,861	1,127	0,764
12	1,584	1,277	1,513	11,877	3,273	3,754	1,869	0,521
13	1,809	4,078	5310,649	4,512	25,627	3,026	0,801	8,066
14	1,920	4,071	8242,261	7,144	22,787	2,847	0,930	7,324
16	2,180	29,156	9,079	4,639	5,146	1,472	1,604	1,314
17	1,929	11,879	5,579	4,218	4,666	1,386	1,524	0,799
18	1,901	9,503	6,279	3,306	5,675	2,116	1,423	1,399
19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21	1,966	34,287	23,617	5,498	10,002	2,832	0,884	10,215
22	2,350	63,758	17,199	4,547	6,771	1,841	1,607	6,740
26	2,353	0,007	51,418	2,639	1,720	0,431	1,337	1,137
27	0,731	1,926	2,296	0,635	1,188	0,319	0,771	0,439
28	2,483	0,161	7,360	1,035	1,376	2,180	1,603	1,697
34	2,343	0,163	7,624	1,115	1,528	2,154	1,652	1,683
35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
37	0,694	1,957	2,554	1,090	0,840	0,275	0,713	0,473
41	1,095	4,116	N/A	0,417	5,855	44,055	1,439	3,402
42	0,519	2,026	269,851	0,180	2,841	22,824	0,703	1,576
43	0,905	6,404	12,459	1,324	1,092	8,471	0,841	2,066
46	1,153	1,209	7,140	4,706	1,233	5,015	1,171	1,005
47	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
48	7,447	29,066	N/A	5,551	7,237	11,015	6,286	53,870
49	2,725	29,318	N/A	5,872	1,473	4,651	2,463	8,194
55	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
60	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
63	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
66	0,990	3,524	N/A	0,275	81,447	5,450	0,738	3,360
67	0,899	3,527	N/A	0,108	180,711	6,026	0,265	2,523
68	1,000	1,000	N/A	1,000	1,000	1,000	1,000	1,000
69	1,000	1,000	N/A	1,000	1,000	1,000	1,000	1,000
71	262,194	37,231	49,807	3,604	1665,087	21,695	78,649	231,508
75	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
76	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
77	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
78	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
79	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
81	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
83	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
85	2,439	1,720	6,261	1,172	3,852	2,407	1,229	1,296
89	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
92S	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
93S	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
94S	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
95S	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
93K	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
94K	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
95K	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
96K	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
92GS	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
93GS	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
94GS	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
95GS	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
93GK	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
94GK	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
95GK	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Appendix B

Commodities in the MSG-model

VA
List of Commodities

MSG Code	Full Name (Norwegian name in parenthesis)
	Commodities from Industries
11	Agricultural Commodities (Jordbruksprodukter)
12	Commodities from Forestry (Skogbruksprodukter)
13	Commodities from Fishing (Fiske og fangst)
14	Commodities from Fish Farms (Oppdrettsfisk)
16	Processed Commodities of Grains, Fruits and Vegetables (Korn-, frukt- og grønnsaksprodukter)
17	Beverages and Tobacco (Drikkevarer og tobakk)
18	Textiles and Apparel (Tekstil- og bekledningsvarer)
21	Processed Commodities from Fishing (Foredlede fiskeprodukter)
22	Manufactured Meat and Dairy Products (Foredlede kjøtt og meieriprodukter)
26	Wood and Wood Products (Trevarer)
34	Pulp and Paper Articles (Treforedlingspodukter)
28	Commoditities from Printing and Publishing (Grafiske produkter)
37	Industrial Chemicals (Kjemiske råvarer)
41	Gasoline (Bensin)
42A	Diesel Oil (Dieselolje)
42B	Fuel Oils etc. (Fyringsolje mv.)
27	Chemical and Mineral Products (Kjemiske og mineralske produkter)
43	Metals (Metaller)
46	Metal Products, Machinery and Equipment (Verkstedprodukter)
47	Repair (Leiearbeid og reparasjoner)
48	Ships (Skip)
49	Oil Production Platforms (Oljeutvinningsplattformer)
71	Electricity (Elektrisitet)
55	Construction (Bygg og anlegg)
68	Oil and Gas Exploration and Drilling, Leasing of Oil Drilling Rigs (Boring etter olje og gass, utleie av borerigger)
81	Wholesale, Retail Trade and Transport Margins (Varehandel og transportmarginer)
66	Crude Oil (Råolje)
67	Natural Gas (Naturgass)
69	Oil and Gas Pipeline Transport (Olje- og gasstransport med rør)
60	Ocean Transport (Fraktinntekter fra skip)
75	Road Transport etc. (Veitransport mv.)
76	Air Transport etc. (Lufttransport mv.)
77	Transport by Railways and Tramways (Jernbanetransport og sporveier)
78	Coastal and Inland Water Transport (Innenriks sjøfart)
79	Postal and Telecommunication Services (Post og telekommunikasjon)
63	Finance and Insurance Services (Bank og forsikringstjenester mv.)
83	Dwelling Services (Boligtjenester)
85	Other Private Services (Annen privat tjenesteyting)
89	Imputed Service Charges from Financial Institutions (Frie banktjenester)

	Non-Competing Imports
09	Food and Raw Materials (Matvarer og råvarer)
02	Cars, Tractors etc. (Biler traktorer mv.)
08	Aircraft (Fly)
03	Military Submarines and Aircraft (U-båter og F16-fly)
35	Operating Expenditure Abroad, Fishing and Shipping (Skipsfartens drifts-utgifter i utlandet)
06	Imports of Services in Connection with Oil Activities (Oljeutvinning, diverse tjenesteimport)
07	Import of Goods in Connection with Oil Activities (Oljevirksomhet, diverse vareimport)
19	Other Non-Competing Imports (Annen ikke-konkurrerende import)
36	Direct Purchases Abroad by Resident Households/Direct Purchases in Norway by Non-Resident Households (Nordmenns konsum i utlandet/Utlendingers konsum i Norge)
	Fees Charged on Central Government Services
92S	Fees Charged on Defence Services (Gebyrer betalt for tjenester fra forsvaret)
93S	Fees Charged on Education Services (Gebyrer betalt for undervisning)
94S	Fees Charged on Health and Veterinary Services etc. (Gebyrer betalt for helse- og veterinærtjenester)
95S	Fees Charged on Other Public Services (Gebyrer betalt for annen offentlig tjenesteyting)
	Fees Charged on Local Government Services
93K	Fees Charged on Education Services (Gebyrer betalt for undervisning)
94K	Fees Charged on Health and Veterinary Services etc. (Gebyrer betalt for helse- og veterinærtjenester)
95K	Fees Charged on Other Public Services (Gebyrer betalt for annen offentlig tjenesteyting)
96K	Fees Charged on Water Supply and Sanitary Services (Gebyrer betalt for vannforsyning og sanitære tjenester)
	Production for Government Consumption
92GS	Government Consumtion, Defence Services (Offentlig konsum produsert i forsvaret)
93GS	Government Consumption, Central Government Education (Offentlig konsum, statlig undervisning)
94GS	Government Consumption, Central Government Health-Care and Veterinary Services etc. (Offentlig konsum, helstetjenester mv., stat)
	Production for Government Consumption
95GS	Government Consumption, Production of Other Public Services in Central Government (Offentlig konsum, annen statlig tjenesteproduksjon)
93GK	Government Consumption, Local Government Education (Offentlig konsum, kommunal undervisning)
94GK	Government Consumption, Local Government Health-Care and Veterinary Services etc. (Offentlig konsum, helstetjenester mv., kommuner)
95GK	Government Consumption, Production of Other Public Services in Local Government (Offentlig konsum, annen kommunal tjenesteproduksjon)

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