NATIONAL ACCOUNTS

occasional paper

Nr.NA-077

Material flows, energy use and the structure of the economy

Paul J.A. Konijn, Sake de Boer and Jan van Dalen

Statistics netherlands

Statistics Netherlands
P.O.Box 4000,
2270 JM Voorburg
The Netherlands

STATISTICS NETHERLANDS
National Accounts
P.O.Box 4000, 2270 JM Voorburg
The Netherlands

MATERIAL FLOWS, ENERGY USE AND THE STRUCTURE OF THE ECONOMY

Paul J.A.Konijn, Sake de Boer and Jan van Dalen*)

*) Besides the authors, the following persons of Statistics Netherlands have participated in this research project (in alphabetical order): P.G.Al, F.Blaauwendraat, F.Drost, F.W.Harteveld, R.E.H.van der Holst, S.van der Laan, M.P.G.Monsieurs, C.S.M.Olsthoorn, W.Tebbens, P.Verbiest and R.Ph.van der Wal

Nr. NA-077
1995

MATERIAL FLOWS, ENERGY USE AND THE STRUCTURE OF THE ECONOMY

Abstract

Many environmental problems are connected to production and use of materials and energy. It would therefore be desirable to have an information system that gives consistent, complete and detailed information on the material and energy flows. Such a system would even be more useful if it could be connected directly to economic data. This paper presents such a system. On the foundation laid by the national accounts we construct a consistent, integral and detailed data system for the analysis of flows of materials and energy through the economy.

In this paper the proposed system is illustrated with an application to the flows of iron/steel and energy. An input-output table is presented that describes the production processes in the ferrous metal branch entirely in physical units. Subsequently, steel contents of final products are calculated, and an analysis is made of the consequences of a new technology in the basic steel industry on total energy use in the economy.

1. Introduction

1.1 The project "Substance flows at meso-level"

In 1993 the ministry of Housing, Spatial Planning and the Environment, and the National Institute of Public Health and Environmental Protection initiated the project "Substance flows at meso level". In this project a number of research institutes participated. This paper presents the contribution of the department for National Accounts of Statistics Netherlands in this project. In DHV (1994) a complete description of the whole project can be found.

The main idea behind the project is that to be able to analyse environmental-economic problems, it is very important to have a framework that brings together environmental and economic data in a consistent, integral and detailed way. The framework should be consistent in order to have only one figure for a phenomenon instead of several varying figures, integral in order not to overlook important issues, and detailed in order to have a system that can be used for analysing policy problems related to technology.

Many environmental issues are related to production and use of substances, materials and products. It seems therefore logical to start with the development of a framework which describes the flows of substances and materials through the economy in physical terms. Such a framework is in itself very useful for many kinds of analyses, and can for example be used to construct environmental accounts (e.g. in the form of a NAMEA (see de Haan et al (1993)). But it would also be very useful to be able to connect the material flows to products. If that would be possible we could, for example, see how much of some raw material has to be used in order to be able to consume some product.

So-called input-output analysis provides a tool to relate material flows (or in fact any other item) to final products. Input-output analysis has always been closely related to the national accounts. In the national accounts production and use of goods and services are described in a consistent, integral and detailed way. One of the main goals of the project is therefore to investigate whether the national accounts and input-output analysis can yield the framework we are looking for. On the foundation laid by the national accounts we construct a consistent, integral and detailed data system for the analysis of flows of materials through the economy.

At the same time, the project aims to generate information on a number of materials, i.e. paper, cement, iron/steel and energy. These materials are selected for reasons of data availability, complexity and importance for environmental issues. For these materials data on production and use in physical terms are compiled. Subsequently these flows are analysed by means of input-output techniques. In the construction of data, technological information is used, collected by other participants in the project. Another aim of the project is to analyse the effects of alternative technologies on the material flows and on the economy.

The constructed data system consists of three "parts". In the first place, we compile *material balances* in physical terms, which are directly derived from the economic data of the national accounts. These balances form the descriptive part of the system: they form the basis for the analysis. Second, we derive from these material balances *input-output tables* in physical terms, describing the production processes of the respective materials. These physical input-output tables form the bridge between description and analysis: it is a data system specially designed for input-output analysis. The derivation of physical input-output tables can be regarded as the first step of the analysis. The third part of the system is a monetary input-output table, to which the physical input-output tables can be connected.

The contribution of Statistics Netherlands to the project can be subdivided into three stages, which is reflected in the structure of this paper. The first stage, described in section 2, comprises the compilation of material balances. This is illustrated with the material balances for iron, steel and zinc. The second stage, described in section 3, is the compilation of physical and monetary input-output tables. Here, the physical input-output table for the iron/steel case is presented.

Sections 4 and 5 relate to the third stage of the project: the analysis. Section 4 describes the several possible forms of input-output analysis that can now be performed on the basis of the data system developed. It also describes the integration of physical input-output tables of several materials. Section 5 gives the empirical results of the analysis based on the integrated iron/steel and energy input-output tables. For results of the analysis of other materials, see Konijn *et al* (1995). In section 6 the pros and cons of the system are evaluated.

In this paper, we consequently use the term "material", where also substances or products may be meant. The main text of this paper is drawn from Konijn *et al* (1995). Use is also made of de Boer and van Dalen (1995).

1.2 Material flows and input-output analysis

Input-output analysis of material and energy flows is not new. Especially the calculation of energy requirements of final products is nowadays a fairly regular application of input-output analysis (see e.g. CBS (1979) and Hannon *et al* (1984)). The application of input-output techniques to physical material flows is less well-known. A comprehensive study of physical input-output analysis is Ayres (1978).

The present study combines such approaches and unifies them in one consistent framework which is rooted in the national accounts. The method presented here is applicable to both energy and material flows. The physical flows are described in separate physical input-output tables, which are linked to a detailed monetary input-output table covering the whole economy. These features are the strong points of this study compared to previous studies.

Compared to flow analysis of particular substances (e.g. Kleijn *et al* (1993)), or life cycle analysis of particular products, this study stays at a rather aggregate level. It is, for example, not possible to calculate the energy requirements of plastic cups versus stone mugs.

2. Compilation of material balances

2.1 Introduction

With the term *material balance* we denote a detailed description of the supply and use of a certain material. The purpose of the compilation of material balances is, besides the fact that it is useful information in itself, to have a starting point for different kinds of analysis of production chains, e.g. concerning their impact on the consumption of exhaustible materials and on the environment. Such analyses not only require a description of raw materials and basic products, but also of the final products made from these materials. The description must be detailed in the number of producing and consuming production activities and in the number of different products that is described. The term "material", therefore, should be interpreted in a broad sense. For example, if we speak of the material flow of "paper", we mean the flows of a range of materials and products related to paper, such as pulp, basic paper, cardboard, journals, wall paper, wrapping materials, etc. The analyses mentioned above also require that the material flows are described in physical terms like kilograms or Joules.

In this section we discuss the methods and data sources used in the compilation of material balances. In section 2.2 the two basic identities underlying the description of material flows are discussed. Section 2.3 deals with the data sources and the integration of the data in physical terms. Section 2.4 presents the resulting material balances for iron, steel and zinc and products of these materials.

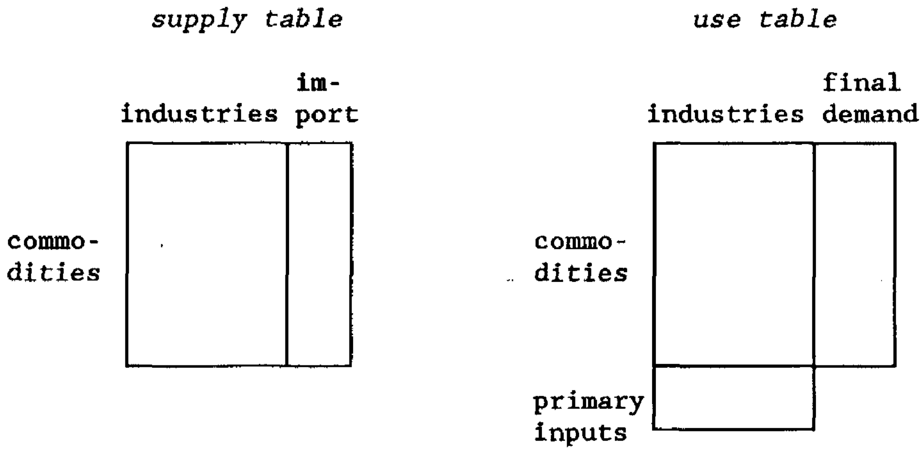
2.2 The basic identities

Starting point for the compilation of the material balances are the so-called *supply and use tables* which are compiled annually as a subsystem of the national accounts for the Netherlands. These tables describe the supply and use of goods and services in monetary terms (millions of guilders). The supply and use tables have the structure as depicted in figure 2.2.1.

The supply table describes the domestic production of goods and services by about 250 industries, and the imports of those goods and services from abroad. The use table describes the use of the same goods and services by the same 250 industries. It also describes the final demand for those goods and services (consisting of exports, consumption of households and government, gross fixed capital formation and changes in stocks), and the primary inputs (wages, social charges, indirect taxes and operating surplus) used by each industry. Goods and services are classified into about 800 commodity groups. See, for example, CBS (1994) or Konijn (1994) for a more detailed explanation of the system of supply and use tables.

The supply and use tables give an *integral* picture of the flows of commodities through the economy, i.e. in principle every product is described. That makes this system a convenient starting point for the compilation of material balances.

Figure 2.2.1: Structure of supply and use tables



However, we should add that the term "product" is defined according to the rules of the national accounts. That means, e.g., that only products sold by producers on the market are recorded in the supply and use tables. Products manufactured and consumed in the same year within a company itself are not recorded.

The supply and use tables fulfil two so-called basic identities. While compiling the material balances these identities are used. The first identity holds for each commodity group (i.e. for each row of the supply and use tables), in guilders as well as in physical units:

total supply
=
total use.

More in detail, for each commodity group:

output of industries + imports
=
input of industries + exports + consumption of households + fixed capital formation + change in stocks.

This identity gives a complete description of the flows of a certain commodity in the economy. The compilation of a material balance implies the transformation of each item of this identity for each relevant commodity group from supply and use in guilders into supply and use in physical units.

The second identity holds for each industry, but only in guilders:

total output
=
total (intermediate) input of goods and services + value added (wages, social charges, indirect taxes and operating surplus).

This identity is a confrontation of the inputs and outputs of an industry: in monetary terms equality must exist for each industry. In physical terms, however, this confrontation is much more difficult to make. We can only make a confrontation for those industries that transform the products under consideration into other products, and we can only compare the output in physical terms with the inputs that are physically *embodied* in the output. For instance, for an industry making machines from steel we should have:

output of machines (in kg)
=
input of steel + input of other materials embodied in the machines -/- scrap of steel -/- other scrap and waste (all in kg).

In practice we will frequently not be able to make reliable estimates of every item of this identity. In most cases we define a category "balance of additions and subtractions", containing the balance of inputs of other materials and the loss of material via scrap and waste. For an electricity plant we should have:

output of electricity (in PJ)
=
input of coal or natural gas - energy losses (all in PJ).

For each industry such an identity gives a description of the production processes of that industry in physical terms. Below we shall see that both identities play an important role in the compilation of material balances in physical terms.

Generally speaking, the extent of detail of the commodity classification in the supply and use tables appears to be sufficient for a meaningful description of the respective material flows. This does not always hold for the classification of industries. In some cases the analysis of a material requires a further specification of the production processes within an industry. Nevertheless, the supply and use tables (in guilders) appear to be a good starting point for the compilation of material balances in physical terms.

2.3 Data sources and balancing

The (monetary) supply and use tables are compiled annually. They are based on a wide range of data sources: production statistics, statistics of foreign trade, wage statistics, budget surveys, investment surveys, etc. The data from these sources are integrated in the supply and use tables. This is not an easy task: the basic statistics will not always give mutually consistent information. The integration of data in the supply and use tables hence implies the elimination of inconsistencies between the sources of the data.

The compilation of the material balances is in fact a similar process. The compilation is based on the two identities given above. For each commodity group, we have to estimate the physical counterpart for every item of the first identity. Sometimes the physical quantities can be directly derived from the basic statistics underlying the supply and use tables. E.g. for imports and exports this information can be derived from foreign trade statistics. We can also find direct information in basic statistics like production statistics and energy statistics. However, in most cases the quantities have to be computed by dividing the value by a price. Sometimes a representative price can be found in or derived from the production statistics. In other cases quantities nor prices are available. Then some approximate price has to be chosen. E.g. in the absence of a direct price for the output of a commodity, we can take the export price as an approximation.

If for each item a quantity has been estimated, total supply and total use of each commodity are compared. In first instance there may be no equality between supply and use. The causes of the inconsistencies have to be analysed, followed by an adjustment of prices and/or quantities in such a way that the required balance will hold. Items for which no direct information on prices or quantities are available will, of course, be adjusted first.

Secondly, we can compare the total inputs and outputs of each industry that is involved in the production of the commodities under consideration. Here we may need additional information, e.g. an estimate of the quantities of other materials used in the production process and which are embodied in the product, and an estimate of the amounts of scrap and waste. If the second identity for some industry is not fulfilled, there will be another search for mistakes and uncertainties in the prices and quantities, again followed by corrections. These corrections, however, may disturb the balances per commodity, so that the first identity has to be evaluated again, and so on, until full balance per commodity and industry is achieved. By means of this "trial and error" process a description of the material flows and corresponding production processes in physical terms is created, that make maximum use of the underlying data.

2.4 Balances for iron, steel and zinc

In this section the material balances for iron, steel and zinc are presented, and a few characteristics of the results are discussed. The balances for other materials can be found in Blaauwendraat and van Dalen (1993), van der Laan and Monsieurs (1993) and van der Wal and Drost (1993). The iron and steel balances are described in more detail in de Boer *et al* (1994).

In table 2.4.1 and table 2.4.2 the supply and use of iron, steel and zinc in the Netherlands are given for the year 1990. They summarize in a highly aggregated way the more comprehensive tables showing about 150 commodities and 250 industries (of which 35 in the metal branch, including the electrotechnical and the transport equipment industry).

Table 2.4.1: Supply of iron, steel, zinc and products, 1990, mln.kg.

	Basic metal ind.	Manufact. of metal products	Manufact. of machinery	Electr. techn. ind.	Manuf. of transport equipment	Other industries	Total domestic production	Imports	Total supply
1 Ores	-	-	-	-	-	-	-	7861	7861
2 Basic steel products 1)	6190	2	-	44	-	40	6275	5209	11484
3 Manufactured metal products 2)	65	2749	98	43	28	85	3067	1110	4177
4 Machinery	1	41	1018	31	30	15	1136	1215	2351
5 Electrotechnical products	-	4	2	372	-	11	389	651	1040
6 Transport equipment	2	19	8	2	1204	25	1259	1365	2624
7 Steel scrap	142	144	16	20	30	1590	1941	1172	3113
Total	6399	2959	1141	511	1292	1766	14068	18583	32651

Table 2.4.2: Use of iron, steel, zinc and products, 1990, mln.kg.

	Basic metal ind.	Manufact. of metal products	Manufact. of machinery	Electr. techn. ind.	Manuf. of transport equipment	Construction	Other industries	Consumpt. of households	Capital formation	Changes in stocks	Total domestic use	Exports	Total demand
1 Ores	7889	-	-	-	-	-	19	-	-	-251	7656	205	7861
2 Basic steel products 1)	1195	2133	546	143	475	640	460	4	-	239	5835	5649	11484
3 Manufactured metal products 2)	34	389	295	90	204	717	955	136	539	31	3391	785	4177
4 Machinery	4	9	152	6	105	70	135	7	781	68	1338	1013	2351
5 Electrotechnical products	1	8	30	75	67	101	106	154	84	3	628	411	1040
6 Transport equipment	-	-	10	-	150	9	286	326	884	97	1761	863	2624
7 Steel scrap	401	116	6	-	-	-	3	-	-	-46	480	2633	3113
Total	9524	2655	1040	314	1000	1537	1963	628	2288	142	21091	11560	32651

1) Including zinc
2) Semi-manufactured articles, metal construction, metal furniture, metal packing materials, etc.

Table 2.4.1 shows the supply of raw materials, basic products, semi-manufactured products, final products and steel scrap. The figures in rows 1 to 6 of the column "Other industries" refer to the production of metal products as a secondary activity by industries outside the metal branch. The figure in row 7 refers to the collection of steel scrap all over the economy, e.g. by the trade industry. Since reliable data are not yet available here, this figure has been calculated residually. Table 2.4.2 shows the use of the same commodities.

A few remarks are in order concerning the reliability and the relevance of the results. First, in the opinion of the participating statistical experts the reliability of these results turned out to be in general higher than was expected beforehand. Second, since the results fulfilled the requirements of the supply/use system, the size of the inaccuracies was reduced. An important advantage to the applicability of the results for further analysis of the material flows is, that they are embedded in the integral National Accounts system.

However, a number of critical remarks should be made too. The results are less accurate when directly measured quantities and prices are not available and they occur in combination with relatively high inputs of other materials. Table 2.4.3 gives the balances of additions (input of other materials) and subtractions (other scrap and waste) for the iron and steel case. From this point of view the balances for the groups "metal products" and "machinery" appear to be rather accurate. However the additions for transport equipment and especially for electrotechnical products are relatively high. These are groups where direct price and quantity data are often lacking. Probably these results are least accurate.

Up to now the material balances for different materials have been compiled independently. In the future it would be helpful to combine various materials in a single compilation process. An example may illustrate this statement. The inputs of other materials in the electrotechnical and transport equipment industries mainly consist of non-ferrous metals and of plastics. So if in the future the compilation of balances for iron and steel were to be combined with balances for plastics and non-ferrous metals, the percentages of the balance of additions and subtractions would be considerably lower and the results would be more accurate.

Table 2.4.3: Balance of additions and subtractions per group of industries (mln.kg.)

	input	output	balance	% of input
Manufacture of metal products	2655	2959	304	11
Machinery	1041	1140	99	10
Electrotechnical industry	314	511	197	63
Manufacture of transport equipment	1000	1292	292	29

Finally, the compilation of the material balances revealed a number of shortcomings and mistakes in the monetary supply and use tables. This led to the conclusion that physical information could be used to improve the reliability of the data in monetary terms. For instance it appeared that the collecting and processing of scrap and waste was rather inadequately recorded.

3. The analytical data system

3.1 Introduction

This section focuses on the construction of the data required to perform input-output analysis of material flows. The main idea of input-output analysis is that production processes in an economy are all interconnected: products of one process are used in another, while, conversely, the products of that process may be used in the former. By describing the production processes in a so-called *input-output table*, we obtain a quantitative picture of the relations between production processes. The input-output table forms the bridge between descriptive and analytical purposes: it gives a description of the economy, but is designed in such a way that it suits input-output analysis.

On the basis of the input-output table we can perform input-output analysis. One of the most classical types of input-output analysis is the calculation of the total input requirement for a unit of final demand, i.e. how much of some input is required to be able to deliver one unit of some product to final demand (e.g. consumption or export). This input requirement not only includes the direct requirement in the production process of the respective product, but also all *indirect* requirements, i.e. the amounts of the input required to produce all other (intermediate) inputs of the product. The total, i.e. direct and indirect requirements, are also called the *cumulated* requirements. This kind of analysis is called the *imputation* of inputs to final demand.

Another type of analysis is called *impact analysis*. It answers questions like "what happens to production and employment if the demand for some product changes?". In such an analysis not only the direct consequences can be analysed, but also the indirect consequences.

It is important to note that input-output analysis is static: no dynamic changes are incorporated. We can only perform analyses in a comparative static way. Also, there is no role for prices: all input-output relations between processes are fixed, and hence independent of the prices of inputs and/or outputs. These are two important limitations of input-output analysis. For more information on input-output analysis, we refer to e.g. Miller and Blair (1985) and Konijn (1994).

As said, input-output analysis is based on an input-output table. So we have to compile an input-output table first. The basis for the compilation process is formed by the supply and use tables. Section 3.2 describes the construction of the (monetary) input-output table. For the physical part of the data system we will also need input-output tables, for reasons to be explained later. The process of the compilation of physical input-output tables is more or less analogous to the compilation of the monetary input-output table. Here we also have a combination of descriptive and analytical purposes: a physical input-output table gives detailed insight into the structure of the production chain of some material, and can at the same time be used for input-output analysis.

This is explained in section 3.3. In section 3.4 the main advantages of the system of physical input-output tables are set out.

3.2 Compilation of a homogeneous input-output table

In section 1.1 we noted that we would like to be able to connect material use to products. For this purpose, we use what is called a *homogeneous input-output table* of the economy. Such an input-output table describes which commodities are required to produce commodities. In this way it gives a description of the technology of an economy (in monetary terms). There also exist input-output tables which describe the flows of products between industries. Statistics Netherlands annually compiles such a table. The homogeneous input-output table differs from such a table, by the fact that the entries are much more homogeneous (and thereby more suitable for input-output analysis). Commodities are classified according to their technologies: products are only taken together if they are produced in roughly the same way. A set of goods and services which have the same technology is denoted with the term *activity*. Hence, the homogeneous input-output table is also called the activity-by-activity input-output table. We now have a three-fold classification system:

- industries: groups of observable establishments having the same main products
- commodities: groups of observable goods and services having some relationship
- activities: an analytical concept (i.e. not always observable), defined as a set of goods and services which are produced in the same way.

The activity-by-activity input-output table is given schematically in figure 3.2.1.

Figure 3.2.1: The homogeneous input-output table

	activities	final demand	imports	total
activities	Z	F	$-m$	x
primary inputs	Y	-	-	Yi
total	x'	$i'F$		

with:

Z : intermediate demand by activities for products of the activities
F : final demand for the products of the activities
m : import of products of the activities
x : domestic production of activities
Y : primary inputs of activities

The vector i is the vector of ones, which functions as a summation operator: Yi is the total of primary inputs. The prime denotes transposition. The following identities hold:

(1) $Zi + Fi - m = x$

(2) $i'Z + i'Y = x'$.

The activity-by-activity input-output table has to be derived from the supply and use tables. However, these tables describe, as we have seen, the production and use of commodities by industries. We have to make additional calculations, based on assumptions and extra data, to compile the input-output table. A description of this procedure can be found in Konijn (1994) and CBS (1994). A row of the input-output table can be seen as a balance of the products of an activity: it describes the distribution of the amounts of products domestically produced and imported over the various using activities and final demand categories (expressed by identity (1)). Since assumptions are required to compile the homogeneous input-output table, this table should be seen more as a model than as a statistic.

We mentioned above that the supply and use tables contain information about 800 commodities. The homogeneous input-output table contains 316 activities. The activity classification of the input-output table is not simply an aggregate of the commodity classification of the supply and use tables. Sometimes a commodity group is divided into a number of subgroups because the products in that group are too heterogeneous with respect to the way they are produced.

The homogeneous input-output table for the year 1990 is the basic instrument for analysis in this project. Using this table we can relate the use of materials to final products of activities in a classification of more than 300 activities. The table can be found, in aggregate form, in Konijn and de Boer (1993) and CBS (1994).

3.3 Compilation of physical input-output tables

A similar procedure as the one used in the compilation of the homogeneous input-output table is applied to the physical material balances, in order to derive input-output tables which describe the production chain of the respective material in physical terms. The derivation of these input-output tables, which we call shortly *physical input-output tables*, is described in this section.

The first step required to construct physical input-output tables is to derive from the physical material balances, which give supply and use of materials by industries, a table giving the use of materials by activities. This step is required because, for the analysis to follow, it is necessary to have inputs by activity. For example, if we want to calculate the cumulated energy use of the activities, we need to have the direct energy use of activities instead of the energy use by industries.

The procedure is not without complications: it may yield implausible results. Therefore, the results have to be closely evaluated and adjusted if necessary. To this end, additional technological information about inputs and outputs of production processes may be used.

The result is a description of the use of materials per activity. If we would calculate the total material requirements of activities based on these figures, we would however count some inputs twice. Consider for example some activity using petrol. This petrol is made from crude oil by a refinery activity. If both the use of petrol and the use of crude oil would be counted in the total energy use, we would make a double count, since the crude oil is already embodied in the petrol. This means that we have to exclude from the analysis those amounts of material inputs that are physically transformed into other materials.

We therefore make a distinction between the *use for transformation* into other materials and the so-called *final use*. Final use of materials is the use which is not physically transformed into other materials. For example: the use of natural gas to produce electricity is classified as use for transformation. The use of electricity for lighting is final use, as is the use of natural gas for heating.

Final use should not be confused with final demand. The term final use will be reserved for the use of materials (not for transformation) measured in physical units. The term final demand refers to the final demand for goods and services divided into the categories export, consumption, fixed capital formation and changes in stocks. Both activities and final demand categories can be final users of materials.

Nevertheless, the distinction between use for transformation and final use corresponds to the distinction between intermediate inputs and final demand in an input-output table. Intermediate inputs are used by the activities to produce other products, final demand is not used anymore in a production process. A difference is that in the monetary input-output table it is not necessary that inputs are physically embodied in the outputs. Since an input-output table is in monetary units, the inputs are only economically "embodied" in the outputs. Furthermore, a monetary input-output table gives a complete description of the inputs of a production process: not only material inputs are considered, but also non-material inputs as services and labour. The physical input-output table of a particular material gives a partial description of the inputs: only the materials under consideration are taken into account.

We must also make a distinction between those materials whose production we will describe, and those whose production we will not describe. The materials whose production processes are not described are called the *primary* materials. The primary materials are usually those materials that are directly available from nature. The materials whose production processes are described are called *secondary* materials: they are produced from the primary and (other) secondary materials. In a sense the distinction between primary and secondary materials is arbitrary: it depends on what we see as a (physical) transformation process. Consider for example the mining of coal. We can see this as the transformation of yet unmined coal into mined coal. In this case the yet to be mined coal becomes a primary material, and the mined coal a secondary material. It is also possible to see the mined coal as a primary material, in that case we regard it as a non-produced material which is already available.

The distinction between primary and secondary materials is analogous to the distinction between primary and intermediate inputs in a regular input-output table. Primary inputs (wages, operating surplus, etc.) are not produced, as opposed to intermediate inputs.

Having the use of materials by activities classified into use for transformation and final use, and the materials themselves into primary and secondary materials, we can now set up a physical input-output table. Such a table has the structure given in figure 3.3.1 (every entry is in physical units):

Figure 3.3.1: Structure of the physical input-output table

	use for transformation to secondary materials	final use by		imports	total domestic output
		activities	final dem. categories		
secondary materials	O_s	E_{sI}	E_{sF}	$-m_s$	x_s
primary materials	O_p	E_{pI}	E_{pF}	$-m_p$	x_p
total input	x_s'				

in which:

- O_s : use for transformation of secondary materials for the production of secondary materials
- E_{sI} : final use of secondary materials by activities
- E_{sF} : final use of secondary materials by final demand categories
- m_s : import of secondary materials
- x_s : domestic production of secondary materials
- O_p : use for transformation of primary materials for the production of secondary materials
- E_{pI} : final use of primary materials by activities
- E_{pF} : final use of primary materials by final demand categories
- m_p : import of primary materials
- x_p : domestic production of primary materials.

The following identities hold:

(3) $O_s i + E_{sI} i + E_{sF} i - m_s = x_s$

(4) $O_p i + E_{pI} i + E_{pF} i - m_p = x_p$

and, only if each row of the table has the same unit,

(5) $i'O_s + i'O_p = x_s'$.

In this table any losses or additions of other materials in the production processes are recorded in special categories which are classified as primary materials. In this way total input of the production processes becomes equal to the total output x_s (provided all entries have the same unit).

The classification of secondary materials may differ from the classifications of activities, industries and commodities. It is constructed in such a way that the available information on inputs and outputs of production processes is used as much as possible. A material is only separately distinguished if the structure of the inputs (be it material or energy) of the respective material is clearly different than the structure of the inputs of other materials.

3.4 Purposes of this system

The principal purpose of the system developed thus far is a more accurate imputation of primary materials to final demand. This is explained in section 4.2. However, the system has a number of other advantages too. First, we can achieve greater detail in the description of the production chains of specific materials than we have in the homogeneous input-output table. This is so, because the classification of materials is independent of the classification of activities. We may create as many rows and columns for materials as we want, provided we can supply the information to do so.

For example, in the homogeneous input-output table we have only one column for the basic steel industry, describing the production process of that activity. In the physical input-output table concerning the iron and steel flows it is desirable to split this activity into a number of subprocesses, because the use of energy and basic materials varies considerably between the subprocesses. Such a split-up also means that we have to describe the flows of internal products between the subprocesses. These internal products are not registered in the national accounts, since no economic transaction is involved. This implies that additional technological information is required to be able to distinguish the subprocesses.

We could also try to make this split-up in the homogeneous input-output table. However, that would require much more information, since in that case all non-material inputs (e.g. costs of administration, labour) would have to be divided over the subprocesses as well. This is a much more difficult problem than the assignment of material inputs for which we can possibly get technological information. The physical input-output table enables us to divide the material inputs over the respective produced materials, without having to divide the non-material inputs too.

Technological information can also be used for dividing materials in more detailed materials. For example, the commodity "paper and cardboard" is divided into four different types of paper and cardboard. This means that we had to add data on how these four types were produced, but also on the products for which they are used as input.

Another advantage of the system is that any non-economic flow can be included. We have seen already that internal deliveries can be included, but we can also include, for example, recycling. Some recycled materials, such as waste paper and iron scrap, are already described in the national accounts. For others however we will have to obtain additional information on recycled quantities. It is possible to describe production and re-use of recycled products in the physical input-output table, by including separate rows and columns.

The physical input-output table thus is a framework in which we can integrate information from economic sources (the supply and use tables) and technological information. By integrating these sources the quality of the information can be improved, but, more importantly, they are brought together in a unifying framework, with which we can perform analyses in an integral and consistent way.

3.5 The physical input-output table for iron, steel and zinc

The compilation of material balances for iron, steel and zinc is described in section 2.4. For the compilation of the physical input-output tables, INTERDUCT (a technological research office) provided the required technological knowledge, and contributed to the discussion on the classification of the table. Technological descriptions of production processes contained in the physical input-output table are given in Smits and Dijkema (1994).

In the physical input-output table 54 secondary materials and 6 primary materials are distinguished. A good description of the production processes of the basic steel industry (which consists in the Netherlands of only one firm) was, in cooperation with Interduct, given most priority. For the physical input-output table, the activity "iron and steel" of the homogeneous input-output table is subdivided into 8 secondary materials: cokes from coal, sintered iron ore, crude iron, crude steel, rolled steel, zinked steel, steel scrap and combined heat and power. For each of these materials the use of (raw) materials and energy use is estimated.

The car producing activity is subdivided into three secondary materials: passenger cars, trucks and busses. Three materials are added for the "production" of scrap: scrap produced by the basic steel industry, by other activities in the metal industry, and by car breakers, respectively. Another 6 materials in the physical input-output table are subdivisions of activities producing metal products.

Table 3.5.1: Input-output table iron, steel and zinc, 1990, mln.kg.

	Use for transformation									Total	Final use					Total		Total
											Activities		Final demand					
	Iron, steel, zinc	Metal products	Steel structures	Machines (& parts)	Electro-techn. prod.	Cars, busses, trucks	Ships	Other transp. equipm.	Scrap met.branc & cars	use for transfor-mation	Construc-tion	Other activities	Export	Capital formation	Other fin. demand	final use	Import	domestic production
Iron, steel and zinc	17982	1319	755	526	113	215	138	50	854	21952	608	459	5645	-	245	6957	-5209	23700
Metal products	0	76	89	194	65	169	10	9	18	629	254	956	535	222	162	2128	-898	1859
Steel structures	-	31	176	105	-	-	2	-	5	319	441	103	242	318	7	1110	-219	1210
Machines (incl. parts)	-	2	-	156	6	51	22	6	5	247	69	171	1037	781	74	2132	-1246	1133
Electrotechnical products	-	15	7	40	56	35	9	26	6	194	116	125	415	84	162	902	-620	477
Cars, busses, trucks	-	-	-	10	-	110	0	6	1	126	7	227	641	583	317	1774	-1132	768
Ships	-	-	-	-	-	-	-	-	-	-	-	13	74	218	11	316	-38	278
Other transport equipment	-	-	-	-	13	-	-	32	-	46	2	26	130	77	94	328	-181	192
Scrap from metal branch & cars	643	16	-	0	-	-	-	-	-	659	-	2	536	-	-8	530	-	1189
Total secondary materials	18625	1459	1027	1030	253	581	180	128	889	24172	1497	2080	9254	2282	1063	16176	-9543	30805
Iron ore	7441	-	-	-	-	-	-	-	-	7441	-	-	205	-	-251	-46	-7395	-
Zinc ore	446	-	-	-	-	-	-	-	-	446	-	20	-	-	-	20	-466	-
Other scrap	321	106	-	1	-	-	-	-	1	428	-	19	2097	-	-38	2078	-1172	1335
Car wrecks	-	-	-	-	-	-	-	-	400	400	-	-	-	-	-	-	-	400
Blast furnace slag (by-product)	-1172	-	-	-	-	-	-	-	-	-1172	-	3098	157	-	115	3370	-2198	-
Balance of add. & subtr.	-1961	294	182	102	224	188	97	64	-100	-911								-911
Total primary materials	5075	399	182	103	224	188	97	64	301	6633	-	3136	2459	-	-173	5422	-11231	824
Total use	23700	1859	1210	1133	477	768	278	192	1189	30805	1497	5217	11713	2282	890	21598	-20774	
Energy use in peta-joules										Total								
Coal	102.9	-	-	-	0.3	-	-	-	-	103.2	-	280.0	66.6	-	62.9	409.5	-512.7	-
Gasses (by-product)	-19.7	-	-	-	6.7	-	-	-	-	-13.0	-	22.0	4.3	-	2.2	28.5	-3.7	11.8
Natural gas	10.2	-	-	-	-	-	-	-	-	10.2								
Oil and coal products	1.4	3.0	1.5	2.6	13.7	1.1	0.6	0.4	-	24.3								
Electricity	8.4	4.7	0.5	2.5	4.8	0.9	0.2	0.5	-	22.5								
Natural gas via distribution	0.8	6.6	0.6	2.9	6.1	1.3	0.5	0.6	-	19.4								
Total energy use	104.0	14.3	2.6	8.0	31.6	3.3	1.3	1.5	-	166.6								

The primary products are iron ore, zinc ore, other scrap, car wrecks, coal and a balance of additions and subtractions. Other scrap includes scrap from construction rubble and demolished buildings. At the time of carrying out this analysis we did not succeed in finding sufficient facts about the quantities of this kind of scrap. So we were not able to distinguish a special category.

The physical input-output table is presented in table 3.5.1. The data are strongly aggregated (to 9 secondary materials) for ease of survey and because some figures, e.g. related to the basic steel industry, are confidential. Table 3.5.1 also contains the energy use required to produce the materials. The primary material coal is recorded under energy use, since it is measured in peta-joules. Some by-products of the steel industry (blast furnace slag, blast furnace gas and cokes furnace gas) are recorded as negative inputs. In this way the imputation of e.g. iron ore to final products is more exact since no iron ore is imputed to these by-products. Blast furnace slag is measured in mln.kg., and is recorded as a primary material. Blast furnace gas and cokes furnace gas are measured in peta-joules, and are both recorded in the category "gasses" under energy use.

The category "balance of additions and subtractions" contains all other materials and substances that are added to or subtracted from the inputs. Additions may be non-ferrous metals, plastics etc. Subtractions of substances take place in the production of iron and steel. The figure in the first column of table 3.5.1 is the result of an addition of lime and limestone and subtractions of zinc slag, by-product gasses and emissions of a.o. carbon dioxide. The subtraction figure in the column "scrap" (-100) contains plastics, tyres etc. included in car wrecks.

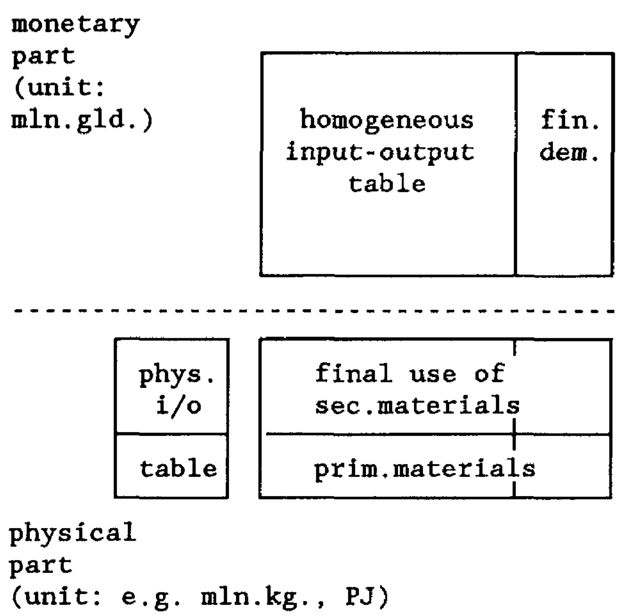
At the right hand side of table 3.5.1 we find the final use of secondary and primary materials. This is an aggregate of a much more detailed table which is used in the subsequent calculations. Final use is divided in use by activities and by final demand categories. The activity construction is presented as a special category within final use, since this activity uses considerable amounts of metal products. The category other final demand contains the demand by households and changes in stocks.

4. Input-output analysis of material flows

4.1 Introduction

Figure 4.1.1 gives a stylized picture of the data system as developed thus far. Above the dashed line we find the monetary part of the model: the homogeneous input-output table and the final demand for the products produced by the activities (value added is left out here). The entries are in (millions of) guilders.

Figure 4.1.1: Structure of the data system as a whole



Below the dashed line the physical part of the model is shown, in which the units are, for example, (millions of) kilograms or peta-joules. On the right hand side we find the final use of secondary materials in the upper part (matrices E_{sI} and E_{sF}, see figure 3.3.1), and the primary materials in the lower part (matrices E_{pI} and E_{pF}), by the 316 activities of the homogeneous input-output table and the final demand categories. On the left hand side the physical input-output table is given, which describes the use of primary and secondary materials for transformation into secondary materials (matrices O_s and O_p). The matrix of final use forms the link between the physical and monetary input-output tables.

In this section we turn to the application of this system. We describe, in a formal way, several types of input-output analysis that can be performed. In section 4.2 we discuss the imputation of primary materials to final products. In section 4.3 we describe an important aspect, namely the treatment of imports. Since the economy of the Netherlands depends to a great extent on imported products, it is of great importance to clarify the assumptions made about how the imported products are produced. We also describe the way in which the cumulated use of materials can be subdivided into domestic use and use abroad.

In section 4.4 the analysis of alternative scenarios is explained. Section 4.5, finally, discusses how different material flows described thus far can be connected, in order to be able to analyse the effects of changes in one production chain on other chains.

4.2 Imputation of primary materials to final products

As said above, an important aim of input-output analysis of material flows, is the imputation of the use of materials to final products of activities. In other words: we would like to know how much of each material is required, in the production chain as a whole, to produce each final product. The standard input-output method calculates this as follows. First, the (direct) use of primary materials of each activity is estimated, from which the (direct) use of primary materials *per guilder* output of that activity can be calculated. Subsequently, the cumulated use of primary materials per guilder of final output can be found by using the homogeneous input-output table.

This can be clarified by an example about paper. Consider the following production chain:
a) production of basic paper from pulp and waste paper,
b) production of wrapping material from basic paper,
c) wrapping of food products in paper bags and cardboard boxes,
d) use of food products by restaurants,
e) use of meals in restaurants by consumers.

Standard input-output analysis works with fixed ratios between inputs and *guilders* of output of activities. For the example this means that we would assume
a) a fixed input of *kilograms* of pulp and waste paper per *guilder* of basic paper,
b) a fixed input of *guilders* of basic paper per *guilder* of wrapping material,
c) a fixed input of *guilders* of wrapping material per *guilder* of food products,
d) a fixed input of *guilders* of food products per *guilder* of meals.

In the analysis with an additional physical input-output table describing the production chain of paper, we use the following assumptions:
a') a fixed input of *kilograms* of pulp and waste paper per *kilogram* of basic paper,
b') a fixed input of *kilograms* of basic paper per *kilogram* of wrapping material,
c') a fixed input of *kilograms* of wrapping material per *guilder* of food products,
d) a fixed input of *guilders* of food products per *guilder* of meals.

For the purpose of the calculation of material requirements of final products the second group of assumptions will lead to more accurate results, since these assumptions exclude the influence of price differences between the users of a certain product.

These assumptions are formalized by using the following coefficient matrices:

(6) $C_{os} = O_s(\hat{x}_s)^{-1}$

(7) $C_{op} = O_p(\hat{x}_s)^{-1}$

(8) $C_{esi} = E_{sI}(\hat{x})^{-1}$

(9) $C_{epi} = E_{pI}(\hat{x})^{-1}$.

with

- C_{os} : use of secondary materials per physical unit of output of secondary materials
- C_{op} : use of primary materials per physical unit of output of secondary materials
- C_{esi}: final use of secondary materials per guilder of output of activities
- C_{epi} : final use of primary materials per guilder of output of activities.

Matrix C_{op} formalizes assumption a'), matrix C_{os} formalizes assumption b') and matrix C_{esi} formalizes assumption c').

Furthermore we define

(10) $A = Z(\hat{x})^{-1}$

(11) $W = Y(\hat{x})^{-1}$

with

- A : activity-by-activity matrix of monetary input-output coefficients
- W : primary input coefficients of activities.

Matrix A formalizes assumption d).

We can rewrite identity (1) of the monetary input-output table using A:

(12) $Ax + Fi - m = x$

For the primary inputs we get, using W:

(13) $Wx = Yi$

Together, this gives

(14) $x = (I - A)^{-1}(Fi - m)$

(15) $Yi = W(I - A)^{-1}(Fi - m)$.

This is the standard input-output model with which we can calculate the production and primary inputs required to satisfy a given final demand F. Analogously, we can rewrite identities (3) and (4) of the physical part of the model:

(16) $C_{os}x_s + E_{sI}i + E_{sF}i - m_s = x_s$

(17) $C_{op}x_s + E_{pI}i + E_{pF}i - m_p = x_p$

=>

(18) $x_s = (I - C_{os})^{-1}(E_{sI}i + E_{sF}i - m_s)$

(19) $x_p = C_{op}(I - C_{os})^{-1}(E_{sI}i + E_{sF}i - m_s) + E_{pI}i + E_{pF}i - m_p$

This is the physical input-output model. The link between both input-output models is made through C_{esi} and C_{epi}:

(20) $x_p = C_{op}(I - C_{os})^{-1}(C_{esi}x + E_{sF}i - m_s) + C_{epi}x + E_{pF}i - m_p$

=>

(21) $$\begin{aligned} x_p &= C_{op}(I - C_{os})^{-1}(C_{esi}(I - A)^{-1}(Fi - m) + E_{sF}i - m_s) + \\ &\quad + C_{epi}(I - A)^{-1}(Fi - m) + E_{pF}i - m_p \\ &= (C_{op}(I - C_{os})^{-1}C_{esi} + C_{epi})(I - A)^{-1}(Fi - m) + \\ &\quad + C_{op}(I - C_{os})^{-1}(E_{sF}i - m_s) + E_{pF}i - m_p \end{aligned}$$

With this equation we can calculate the required quantities of primary materials to satisfy the final demand for products of activities.

The cumulated use of primary materials per final demand category is given by:

(22) $(C_{op}(I - C_{os})^{-1}C_{esi} + C_{epi})(I - A)^{-1}F + C_{op}(I - C_{os})^{-1}E_{sF} + E_{pF}$

The three terms of this equation can be interpreted as follows. The last term, E_{pF}, gives the direct use of primary materials by final demand categories. The middle term, $C_{op}(I - C_{os})^{-1}E_{sF}$, gives the use of primary materials required to produce the secondary materials used directly by final demand categories. The first term contains two subterms. The last of them, $C_{epi}(I - A)^{-1}F$ gives the cumulated use of primary materials required in total to produce the total final demand for goods and services. The first subterm, $C_{op}(I - C_{os})^{-1}C_{esi}(I - A)^{-1}F$ gives the use of primary materials required to produce the secondary materials required in total (i.e. directly and indirectly) to produce the total final demand for goods and services.

We would also like to calculate the cumulated use of primary materials required to produce the final demand of each activity. However, since E_{sF} and E_{pF} are not formulated in terms of activities, these uses have to be assigned to activities first. The materials have to be aggregated to the activity level. This means that, for example, the direct export of natural gas is counted as energy use of the activity "natural gas". These aggregations cannot easily be formalized, therefore we will not do so. Only the first term of the above equation can be rewritten for the use per activity as:

(23) $(C_{op}(I - C_{os})^{-1}C_{esi} + C_{epi})(I - A)^{-1}(\hat{Fi})$.

4.3 Treatment of imports

The treatment of imports in input-output analysis deserves special attention. The homogeneous input-output table as formulated above does not distinguish between the use of domestically produced products and imported products. The imports are recorded, with a negative sign, in a separate column. This type of input-output table therefore is called the table *including imports*. This type of table is required for the calculation of, for example, the total energy requirement of a product, since for such a calculation we need to take the energy used abroad into account. The materials used abroad is estimated using, for most products, the assumption that *imported products are produced in the same way as domestically produced products*. Some products, the so-called non-competitive imports, are however not produced domestically. For these products an estimation is made of the inputs which are used in the producing country or countries, and this information is added to the analysis by augmenting the matrix of input-output coefficients A.

For some purposes, such as the calculation of domestic energy use, it would however be useful to be able to distinguish between the use of materials in the Netherlands and the use of materials abroad, required to produce a particular product. This distinction can be made if we have a homogeneous input-output table *excluding imports*. Such a table describes only the use of domestically produced inputs per activity. The imports are then included in a special row of the table, giving the total use value of imported products by each activity. See section 3.4 of Konijn (1994) for a detailed explanation of the different ways of registering imports.

We denote the input-output table excluding imports with Z^D. We can derive the import matrix as

(24) $Z^M = Z - Z^D$

with Z^M giving the use of imported products by each activity. Similarly, we denote final demand for domestic products with F^D, and the final demand for imported products with F^M. We have

(25) $F^M = F - F^D$.

From Z^D we can derive the matrix of domestic input-output coefficients A^D:

(26) $A^D = Z^D(\hat{x})^{-1}$.

We now get the following identity (analogous to (21)):

$$(27)\quad x_p = (C_{op}(I - C_{os})^{-1}C_{esi} + C_{epi})(I - A^D)^{-1}F^D i + $$
$$+ C_{op}(I - C_{os})^{-1}(E_{sF}i - m_s) + E_{pF}i - m_p$$

from which we can derive the cumulated domestic use of primary materials per final demand category (analogous to (22)):

$$(28)\quad (C_{op}(I - C_{os})^{-1}C_{esi} + C_{epi})(I - A^D)^{-1}F^D + C_{op}(I - C_{os})^{-1}E_{sF} + E_{pF}.$$

By substracting the result of formula (28) from the total cumulated use of primary materials (formula (22)) we obtain an estimate of the foreign use, i.e. the use of primary materials outside the Netherlands required to satisfy the final demand in the Netherlands.

4.4 Analysis of alternative scenarios

One of the aims of the project is the construction of a data model with which effects of changes in technology could be analysed. We can analyse such (and any other) changes in a comparative static way. For each material flow we have compiled a physical input-output table describing the production processes related to that material. Changes in the technology of a production chain, for example a substitution of inputs, are therefore expressed as changes in the respective physical input-output table.

Suppose we have constructed a new matrix of physical input-output coefficients, representing the production chain after a technological change. We denote the new matrices with a ~ symbol, i.e.

$\tilde{C}_{os}$, $\tilde{C}_{op}$.

The new production levels of secondary materials can be found by

$$(29)\quad \tilde{x}_s = (I - \tilde{C}_{os})^{-1}(E_{sI}i + E_{sF}i - m_s),$$

(cf. equation (18)) assuming that the final use and import of secondary materials do not change. With this new vector of production levels we can derive the new physical input-output table:

$$(30)\quad \tilde{O}_s = \tilde{C}_{os}(\hat{\tilde{x}}_s)$$

$$(31)\quad \tilde{O}_p = \tilde{C}_{op}(\hat{\tilde{x}}_s).$$

We can also derive the new vector of production levels of primary materials with

$$(32)\quad \tilde{x}_p = (\tilde{C}_{op}(I - \tilde{C}_{os})^{-1}C_{esi} + C_{epi})(I - A)^{-1}(Fi - m) + $$
$$+ \tilde{C}_{op}(I - \tilde{C}_{os})^{-1}(E_{sF}i - m_s) + E_{pF}i - m_p.$$

(cf. equation (21)) on the assumption that the final use of materials, the final demand for goods and services, the overall production structure of the economy, and the amount of imported products remain unchanged. It is of course also possible to introduce changes for each of these items, and to analyse the effects of these changes.

By changing, for example, C_{esi}, C_{epi}, E_{sF} and/or E_{pF} we can analyse the effects of changes in the final use of materials by activities and final demand categories. Such an analysis is performed in section 5.5 for the use of energy. It depends on the assumptions used whether such changes also effect the monetary part of the model, i.e. A and F.

Of course, also other aspects than the production of primary materials can be calculated. For example, we can analyse the changes in value added due to changes in the production structure. If we assume that the technological changes induce changes in the cost structures of activities, the homogeneous input-output table will change, and thus matrices A and W. We can then derive

$$(33) \quad \tilde{Y}i = \tilde{W}(I - \tilde{A})^{-1}(Fi - m)$$

assuming F and m remain constant (the total change in imports can be calculated if we use the homogeneous input-output table excluding imports, but we will not discuss this further). For such analyses of the economy as a whole, using the homogeneous input-output table, we should note that many relevant matters, such as price changes, are not taken into account.

4.5 Chaining material flows

The physical input-output table developed above describes the production chain of one material. It would be interesting to connect the production chains of several materials. In that case we could analyse, for example, combined effects, or substitution effects that go beyond the borders of one chain, such as substitution between plastics and paper, or between metal and wood. Furthermore, if the production chain of energy could be connected to any other production chain, we could simultaneously analyse the effects of alternative technologies on the use of materials and energy.

Connecting several material flows implies integrating the input-output tables of the respective materials. Suppose we would like to connect the plastics and iron flows (note that the flow of plastics has not yet been investigated). In a number of products, for example electrotechnical products, cars and airplanes, plastics and iron (or steel) are both important inputs. Therefore, we have to find out how much of each material becomes embodied in the products. We can then make an input-output table that describes the production chains of plastics and iron simultaneously. This may look as in figure 4.5.1.

Figure 4.5.1: Example of an integrated input-output table

		use for transformation: plastics	use for transformation: iron	final use
secondary materials	plastics	I	II	III
	iron	IV	V	VI
primary materials		VII	VIII	IX

There are nine blocks, denoted with roman capitals. Their contents are as follows:

- I: use of secondary plastic materials to produce secondary plastic materials (matrix O_s of the physical input-output table of plastics)
- II: use of secondary plastics materials to produce secondary iron materials
- III: final use of secondary plastic materials
- IV: use of secondary iron materials to produce secondary plastic materials
- V: use of secondary iron materials to produce secondary iron materials (matrix O_s of the physical input-output table of iron)
- VI: final use of secondary iron materials
- VII: use of primary materials to produce secondary plastic materials (matrix O_p of the physical input-output table of plastics)
- VIII: use of primary materials to produce secondary iron materials (matrix O_p of the physical input-output table of iron)
- IX: final use of primary materials.

The primary materials are not divided into primary materials concerning plastics and concerning iron respectively, since the primary materials may be the same in both cases. For example, coal is a primary input into the production chains of both plastics and iron. The distinction between the secondary materials of plastics and iron may not always be clear since there is overlap for those products that are produced in more or less equal quantities from plastics and iron, such as some electrotechnical products.

The distinction between use for transformation and final use may also be difficult to make in some cases. We defined the use for transformation as the use of materials which are physically transformed into other materials (see section 3.3). The used materials have to be *embodied* in the produced materials. Suppose we would like to connect the paper and cement flows. There is no paper physically embodied in cement or concrete products, nor is there cement physically present in paper or cardboard products. However, what to do with, for example, paper bags to carry cement? Is this final use of paper by the cement industry, or use for transformation? It depends in principle on whether the output of cement is measured including or excluding the paper bags, but it may not be possible to answer this question. If we consider it to be final use, then there is no physical interconnection between these flows. That means that blocks II and IV of the above figure (where iron and plastics are replaces with cement and paper) will remain empty. If we consider it to be use for transformation, then some elements of those blocks will be filled.

In the case of a connection with the energy flow the distinction between final use and use for transformation becomes even less clear. We can say, in a sense, that crude oil is embodied in petrol, since petrol takes over (part of) the energy content of the oil. However, it is difficult to say that, for example, electricity is embodied in steel. We can use the following criterion as a guideline to distinguish between use for transformation and final use of energy: only the energy that is directly required to make the transformation of materials possible should be seen as use for transformation. For example, electricity that is used in the production process of steel should be seen as use for transformation. The electricity required to illuminate the offices of the steel factory should however be seen as final use. Nevertheless, even with this criterion it will sometimes be difficult to make the distinction.

Furthermore, we cannot say that any steel (or any other product) is physically embodied in energy products, so that the connection between the energy flows and other material flows is always one-directional. We can extend figure 4.5.1 with the energy data as indicated in figure 4.5.2.

Figure 4.5.2: Integrated input-output table with energy

		use for transformation			final use
		plastics	iron	energy	
secondary materials	plastics	I	II		III
	iron	IV	V		VI
	energy	X	XI	XII	XIII
primary materials		VII	VIII	XIV	IX

with as new blocks:

X: use of secondary energy to produce secondary plastics materials
XI: use of secondary energy to produce secondary iron materials
XII: use of secondary energy to produce secondary energy (matrix O_s of the physical input-output table of energy)
XIII: final use of secondary energy
XIV: use of primary materials to produce secondary energy (matrix O_p of the physical input-output table of energy)

The shaded blocks are empty.

In section 5 we discuss the empirical results of the input-output analysis of the iron/steel and energy flows. For this purpose we have made a full integration of the physical input-output tables of iron/steel and energy.

5. Results for iron, steel, zinc and energy

5.1 Introduction

Thus far, four material flows are investigated: paper, cement, iron/steel and energy. Full results for each flow are reported in Konijn *et al* (1995). In this paper we present only the results of the integrated analysis of the iron/steel and energy flows (which is new compared to the previous report). In section 5.2 we present the results of the imputation of materials to final products. In section 5.3 the results of an analysis of an alternative technology in the steel industry are presented.

In many cases the results will be given at a much more aggregate level than they are available. There are two reasons for this aggregation. The first reason is that there simply are too many data to present. (Remember that all calculations are performed at the level of more than 300 activities.) Thus, for a comprehensible presentation of the results, we have to aggregate to a considerable extent. The second reason for aggregation is that many of the data are confidential, because they apply to only one firm, or a very small number of firms.

5.2 Imputation of materials to final products

This section presents the results of the integrated analysis of the energy and iron/steel flows. As noted in section 4.5 an integrated physical input-output table containing the energy and iron/steel processes, is constructed. The reason for integrating these two flows is that some of the materials concerned are important in both flows. Coal, for example, is an important input in both flows. Furthermore, the production of cokes takes place in the cokes industry as well as in the steel industry. The by-product blast furnace gas of the steel industry is used by electricity plants. And, of course, the production of steel requires large amounts of energy.

The integration of the two flows has revealed a number of small inconsistencies between the figures in both original physical input-output tables. Therefore, the integration has led to adjustment of earlier obtained results. This shows the relevance of integration: it leads to more consistent, and hence more accurate data.

With the physical input-output table we can calculate the cumulative requirements of materials in order to produce one unit of each (secondary) material. Regarding the cumulative requirements we should note that the steel embodied in capital goods (e.g. machines) used in the production processes is *not* included, since in the cumulation process only intermediate inputs are taken into account. Capital goods are included in final demand. Furthermore, the resulting cumulated requirements given in this section *include* requirements abroad. It is also possible to calculate the domestic cumulated requirements (see section 4.3), but these results are not presented here.

We will first look at the cumulated requirements of rolled steel for the production of metal products. Table 5.2.1 gives the direct, indirect and cumulated requirements of rolled steel for a representative selection of materials (i.e. not the ones with the highest requirements!) in the metal industry. It is self-evident that iron and steel products, tubes and rolled steel rank high in this list due to high direct requirements. For metal packing materials and screws etc. direct requirements and thus cumulative requirements are high. For machinery and cars, direct and indirect (parts!) requirements have the same order of magnitude. For the construction of greenhouses direct requirements are low, but indirect requirements are high. Table 5.2.1 illustrates the fact that for the calculation of the total steel requirement of a product, it is very important to estimate indirect requirements.

Table 5.2.1: Direct, indirect and cumulated requirements of rolled steel of some selected metal materials

Materials	Direct requirement (kg./kg.)	Indirect requirement (kg./kg.)	Cumulated requirement (kg./kg.)
Iron and steel products	1.020	0.009	1.029
Steel tubes	0.898	0.118	1.016
Rolled steel	1.000	0.004	1.004
Metal packing	0.805	0.081	0.886
Metal-working machinery	0.493	0.311	0.804
Screws and other mass products	0.758	0.033	0.791
Construction of greenhouses	0.114	0.649	0.763
Metal furniture (+ parts)	0.368	0.387	0.755
Home appliances	0.526	0.187	0.713
Passenger cars	0.402	0.265	0.667
Ships	0.426	0.147	0.573
Other electrotechnical products	0.273	0.138	0.411
Aircrafts (+ parts)	0.010	0.240	0.250

Comparable calculations are made for the cumulated use of zinc per activity. We give only the most interesting results. Apart from zinc and galvanized products the highest zinc requirements are found for passenger cars (0.042 kg. zinc per kg.), trucks (0.026 kg./kg.) and other transport equipment (0.041 kg./kg.).

Table 5.2.2 gives similar figures for energy. The cumulated requirements given in the third column are also known as ERE-values: the Energy Requirement for Energy. They show, for example, that to produce one PJ of electricity, in total 2.651 PJ energy is required, of which 2.368 PJ is used in the electricity plants themselves, and 0.283 PJ in energy producing processes delivering to electricity plants.

Table 5.2.2: Direct, indirect and cumulated requirements of energy to produce energy materials

Materials	Direct requirement (PJ/PJ)	Indirect requirement (PJ/PJ)	Cumulated requirement (PJ/PJ)
Electricity	2.368	0.283	2.651
Basic chemical products	1.045	0.394	1.439
Combined heat and power	1.308	0.026	1.335
Cokes, tar, bitumen	1.193	0.106	1.300
Oil products produced by chemical industry	1.122	0.085	1.207
Oil products produced by refineries	1.064	0.009	1.073
Natural gas distribution	1.007	0.000	1.007

Table 5.2.3 gives the shares of final demand categories in the cumulated use of some selected materials. For all materials presented, the export requires the largest part of the total cumulated use. For energy materials, consumption is the second largest user: 22% of all primary energy is required to satisfy the demand by households. For steel etc. fixed capital formation ranks second.

Table 5.2.3: Shares of final demand categories in the cumulated use of some selected materials, and energy and rolled steel requirements, 1990

	Export	Consumption	Fixed capit. formation	Changes in stocks	Total
coal and lignite	53	23	17	6	100
steam from nuclear energy	46	40	12	1	100
natural gas and condensate	69	26	5	1	100
crude oil	81	17	4	-1	100
total primary energy	71	22	6	1	100
rolled steel	61	14	23	3	100
zinc	78	8	14	1	100
iron ore	64	13	21	2	100
zinc ore	76	10	13	1	100
other scrap	85	5	10	0	100
final demand in mln.gld.(basic pr.)	38	48	13	1	100
primary energy requirement (TJ/mln.gld.)	21.6	5.2	5.3	-	11.5
rolled steel requirement (ton/mln.gld.)	28.4	5.0	31.8	-	17.7

The share of export in the cumulated use of materials is much larger than the share of export in the total final demand (38%). For consumption the opposite holds, which can be explained by a relatively large share of services in the composition of consumption. This implies that, per guilder, export requires more materials than consumption. This is reflected in the energy and steel requirements given on the last two rows of table 5.2.3. These requirements give the amounts (TJ of primary energy and tons of steel) required directly or indirectly to produce one million guilder for final demand. We see that, for example, to produce one million guilders for export requires (on average) about four times as much energy as to produce one million guilders for consumption. Fixed capital formation has the largest requirement of rolled steel. For changes in stocks no meaningful requirements can be calculated since this category is a balance of additions to and subtractions from stocks.

Table 5.2.4 gives the shares of the activities in the cumulated use of primary energy and rolled steel. The first column shows that a quarter of all required primary energy is used to satisfy the final demand for oil products, 14% to satisfy the demand for mining and quarrying products (mostly export of natural gas), and 10% to satisfy the demand for chemical products. The demand for the products of the metal branch (from metal to transport equipment) is responsible for 69% of the total cumulative use of steel, as can be seen from the second column. Other large users of steel are construction (10%) and food products (4%).

Compared to the shares of the activities in total final demand (column 3), we see most importantly that the services have a much larger share in final demand than in steel and energy use.

The fourth column shows that the highest energy requirements per million guilders of final demand are found for the energy products, not surprisingly. It is interesting to see that the energy requirements decrease when the products are further processed (and thus have higher prices). The highest requirements are found for the mining and quarrying products. Then follow (in descending order) oil products and cokes, electricity and natural gas, chemical products, rubber and plastics, and metal.

The fifth column shows that the highest steel requirements are found for the metal products and construction. A similar order of products can be found here: basic metal products have a higher requirement than further processed products.

Table 5.2.4: Shares of activities in the cumulated use of primary energy and rolled steel, and energy and rolled steel requirements, 1990

Activity	Shares in primary energy (%)	Shares in rolled steel (%)	Shares in final demand (%)	Energy require-ment (TJ/mln.gld.)	Rolled steel requirement (ton/mln.gld.)
Agricultural and fishing products	3	1	3	11.1	2.9
Mining and quarrying products	14	0	1	155.2	2.6
Food products	5	4	9	6.5	8.4
Textile, leather, shoes	2	2	3	6.9	9.4
Wood, wooden furniture, construction materials	1	1	1	7.5	11.0
Paper, cardboard and graphical products	1	0	2	7.6	4.0
Oil products produced by refineries	25	0	2	125.6	2.0
Oil products produced by chemical industry	1	0	0	122.1	2.4
Cokes, tar, bitumen	2	0	0	141.7	24.1
Chemical products	10	1	4	28.5	6.0
Rubber and plastics	6	2	3	23.6	9.3
Metal	2	35	1	20.8	504.0
Metal products	1	10	2	6.7	109.9
Machinery and parts	2	11	4	4.5	48.6
Electrotechnical products	2	3	4	5.2	13.1
Transport equipment	2	10	4	5.6	43.9
Other industrial products	1	1	1	6.0	17.0
Electricity	2	0	0	55.2	4.6
Gas and water	4	0	1	59.1	2.8
Construction	4	10	6	6.2	27.8
Wholesale and retail trade	2	2	10	1.9	4.3
Catering, lodging, repair services	1	1	3	3.9	7.0
Transport, storage and communication	4	1	5	7.9	2.8
Bank services and insurances	0	0	2	1.3	1.6
Operation of real estate	0	0	6	0.4	1.3
Other commercial services	0	0	3	1.7	1.4
Public administration, social insurance	1	2	5	2.5	5.3
Defense	1	1	2	3.9	7.6
Subsidized education	0	0	3	1.5	1.8
Other non-commercial services	2	1	8	2.1	1.2
Other activities	0	0	1	2.3	6.8
Non-competitive imports	2	0	0	64.1	12.2
Total	100	100	100	11.5	17.7

Table 5.2.5 gives more detailed insight in the largest users of steel. This table gives the rolled steel requirements of the 10 most steel requiring activities outside of the metal industry. Remarkably, these activities represent quite different parts of the economy. This illustrates that the use of iron, steel and products of iron and steel is highly distributed all over the economy.

Table 5.2.5: Cumulated requirements of rolled steel of the ten most requiring activities (excl. metal and metal products)

Activities	Cumulated requirement of rolled steel (ton/mln.gld.)
Concrete products	57.4
Rubber products	56.0
Toys and sports equipment	48.4
Central heating installation	44.8
Plumbing work	36.6
Other quarrying products	35.2
Cleaning products	30.7
General construction	29.8
Retreaded tyres	28.2
Beverages	26.9

Table 5.2.6, finally, shows the ten most energy-requiring activities, disregarding energy products and basic chemical products. Fertilizers are the most energy-intensive products. They are produced directly from natural gas. Plastics, ranking second, are produced indirectly from crude oil and natural gas. Steel and its by-products require large amounts of coal and electricity. Fish is at a surprising fourth place, due to a large input of fuel oil. The other appearing products are less surprising. (The figures in this table may differ from earlier published figures, due to the recalculation with the integrated energy/steel data.)

Table 5.2.6: Cumulated requirements of primary energy of the ten most requiring activities (excl. energy products and basic chemical products)

Activities	Cumulated requirement of primary energy (TJ/mln.gld.)
Fertilizers	64.6
Plastics	34.8
Steel and by-products	23.2
Fish	23.2
Bricks and tiles	22.7
Zinc	22.2
Aluminum	20.6
Greenhouse vegetables	20.5
Ores	19.8
Pulp	19.6

5.3 An alternative scenario: the COIN process.

This section discusses the effects of the introduction of the so-called COIN-process (Krupp COal INjection process) in the steel industry. In the COIN-process (which is described in Smits and Dijkema (1994)) a number of current production processes of the steel industry are integrated: the production of cokes from coal, the sintering of iron ore, the production of crude iron and the production of crude steel. In the COIN-process crude steel is produced from iron ore and coal in a single production plant. This alternative offers a number of environmental advantages:

- the use of coal, natural gas and electricity decreases (see below)
- the input of steel scrap increases: purchases of scrap by the steel industry rises from 368 to 513 mln.kg. (+39%),
- the output of by-products and pollutants decreases: the output of blast furnace slag falls from 1172 to 956 mln.kg. (-18%), there is no output of cokes furnace gas anymore, and the output of blast furnace gas decreases.

The use of iron ore is almost the same as in the present production process.

The buyers of the by-products of the steel industry are confronted with a lower supply of these by-products. We have to make assumptions how they face this problem. We have assumed that the producers of cement and road construction compensate the reduced supply of slag by importing more slag from abroad. The same is assumed for the buyers of cokes furnace gas. Furthermore, the electricity producers buy more natural gas to compensate for the reduction of blast furnace gas.

The result of our suppositions is that the produced amounts of the activities that depend on the by-products do not change initially. However, due to the decrease in the use of electricity, the demand for coal and natural gas by the electricity plants decreases. Also, the demand for electricity decreases further. Thus, the total decrease in energy use is larger than the initial decrease in the steel industry. For the rest we assume that the level of iron and steel production does not change.

Table 5.3.1: Changes in energy use (of the whole economy) due to introduction of the COIN-process

	before	after	change
coal and lignite	514.2	498.3	-15.9
nuclear energy	37.1	36.7	-0.4
natural gas and condensate	2615.9	2614.6	-1.3
crude oil	2118.6	2118.6	-
gasses (by-product)	3.7	8.7	+5.0
+			
total	5289.5	5276.9	-12.6

Table 5.3.1 shows the changes in total energy use, decomposed by primary energy product. The initial decrease in the use of coal by the steel industry is 14.0 PJ. The total decrease is 15.9 PJ, which means that 1.9 PJ is saved by the reduction in the demand for electricity. The change in the use of nuclear energy is also caused by the decreased electricity production. The reduction in the use of natural gas is the result of a decrease in the steel industry (-4.6 PJ), an increase in the electricity plants as substitute for blast furnace gas (+5.7 PJ), and a decrease due to reduced electricity production (-2.4 PJ). The use of gasses increases with 5 PJ because the steel industry does not produce cokes furnace gas anymore. By-products such as gasses are recorded as negative inputs of the producing processes. Therefore, if the production of gas decreases, the total input of energy increases. The total net energy saving becomes 12.6 PJ.

6. Conclusions

The aim of this research project is to investigate whether input-output analysis can be the unifying framework required to describe and analyse material flows through the economy. This research question can be answered positively. Although input-output analysis is not an instrument which can answer *all* policy questions, it can certainly yield a standardisation of the description of material flows in a way that allows for various kinds of analysis.

Other goals of the project are generating data on, and analysing, the flows of four materials: paper, cement, iron/steel and energy. These four flows of materials can be described and analysed using the same principles of the input-output framework. The same data structure and the same analytical techniques can be applied to each of the four cases, with only minor adaptations to account for specific characteristics of particular materials. This proves the applicability of input-output analysis to a wide range of topics, and the possibilities for standardisation.

The data structure consists of three parts: the first part are the material balances in physical terms, describing production and use of materials. The second part are the physical input-output tables, representing the transformation processes in a material flow. The third part is the homogeneous input-output table, giving the relations between economic activities in monetary terms, as well as the final demand for products and the value added generated by the activities.

The material balances are constructed on the basis of economic information from the national accounts. The feasibility of the construction of material balances from the national accounts, using additional information on prices and quantities, is clearly shown. It is also shown that the concept of physical input-output tables for materials gives a convenient framework for integrating the information from the material balances and technological information. These physical input-output tables also enable the analysis of alternative technologies. Finally, the homogeneous input-output table is the basis for all analysis. Its activity classification is the coordinating instrument to link data in physical terms about materials or energy with the economic data on final demand. Hence, the use of the homogeneous input-output table is in fact a step towards further standardisation.

The methodology of combining physical and monetary input-output tables, developed in this project, thus appears to be appropriate for both descriptive and analytical purposes. It also gives the opportunity to integrate data on several material flows, and subsequently analysing these flows simultaneously, using again the same data structure and analytical techniques, as is shown by the example of iron/steel and energy. This is important to get insight into the relations across material flows: changes in production processes in one flow may induce changes in production processes in other flows. An example of this can be found in the case of the introduction of a new technology in the production of steel. This new technology yields less by-products, which has consequences for a.o. the production of cement and the production of electricity.

Input-output analysis cannot describe the transition of one state of the economy to another, due to its static character. Nor is it possible to analyse the effects of taxation (or any other effects of prices) on the behaviour of producers and consumers, as the input-output relations are fixed and substitution of inputs is not possible.

However, input-output analysis provides the possibility to get a first indication of the direction and order of magnitude of the consequences of changes in the economy or technology on material flows and energy use. Input-output analysis enables to get insight into the places in the economy where the changes will have the largest influence. Also, it can provide the basis for comparing the effects of different scenarios, for example of different policy measures. For a full analysis of the economic consequences of the effects of e.g. technological changes, energy saving or taxation, a more general economic model is required.

References

Ayres, R.U. (1978), *Resources, Environment and Economics; applications of the materials/energy balance principle*, John Wiley & Sons, New York.

Blaauwendraat, F. and J. van Dalen (1993), *Papier en papierprodukten in de Nederlandse economie, 1990*, Centraal Bureau voor de Statistiek, BPA nr. 05939-93-PS.E8/Extern (in Dutch).

Boer, S. de, and J. van Dalen (1995), *Compilation of material balances in a national accounts system*, paper presented at the Conference on Natural Resource and Environmental Accounting, Washington DC, March 1995.

Boer, S. de, R.E.H van der Holst, C.S.M. Olsthoorn, W. Tebbens and R.Ph. van der Wal (1994), *IJzer, staal en zink in de Nederlandse economie, 1990*, Centraal Bureau voor de Statistiek, BPA nr. 05742-94-AGT.NR/Extern (in Dutch).

Centraal Bureau voor de Statistiek (1979). *Energieverbruik, luchtverontreiniging en produktiestructuur, 1970*, Statistische onderzoekingen, deel M6, Staatsuitgeverij, The Hague (in Dutch).

Centraal Bureau voor de Statistiek (1994), *De produktiestructuur van de Nederlandse volkshuishouding, deel XXI* (in Dutch).

DHV (1995), *Eindrapport onderzoeksprogramma "Stofstromen op mesoniveau"* (in Dutch).

Drost, F. and R.Ph. van der Wal (1993), *Cement, beton en betonprodukten in de Nederlandse economie, 1990*, BPA nr. 11322-93-PS.E8/Intern (in Dutch).

Haan, M. de, S.J. Keuning and P.R. Bosch (1993), *Integrating indicators in a National Accounting Matrix including Environmental Accounts (NAMEA)*, Statistics Netherlands, Occasional Paper nr. NA-60.

Hannon, B., T. Blazeck, D. Kennedy and R. Illyes (1984), *A comparison of energy intensities, 1963, 1967 and 1972*, Resources and Energy, Vol. 5, pp. 83-102.

Kleijn, R., E. van der Voet and H.A. Udo de Haes (1993), *Controlling substance flows: the case of chlorine*, Environmental Management, Vol. 18, no. 4, pp. 523-542.

Konijn, P.J.A. and S. de Boer (1993), *Een homogene input-outputtabel voor Nederland, 1990*, Centraal Bureau voor de Statistiek, BPA nr. 11191-93-PS.E8/Intern (in Dutch).

Konijn, P.J.A. (1994), *The make and use of commodities by industries*, Faculty of Public Administration and Public Policy, University of Twente, Enschede, The Netherlands.

Konijn, P.J.A., S. de Boer and J. van Dalen (1995), *Material flows and input-output analysis; methodological description and empirical results*, Centraal Bureau voor de Statistiek, BPA nr. 698-95-EIN.PRN/int.

Laan, S. van der and M.P.G. Monsieurs (1993), *Energie in de Nederlandse economie, 1990*, Centraal Bureau voor de Statistiek, BPA nr. 12607-93-PS.E8/Extern (in Dutch).

Miller, R.E. and P.D. Blair (1985), *Input-output analysis: foundations and extensions*, Prentice-Hall, Englewood Cliffs.

Smits, D.F. and G.P.J. Dijkema (1994), *Produktie van ijzer, staal en zink tot en met de schrootverwerking, Techniekbeschrijvingen*, Interduct, Delft (in Dutch).

Statistics Netherlands
National Accounts Occasional Papers

NA/01 **Flexibility in the system of National Accounts**, Van Eck, R., C.N. Gorter and H.K. van Tuinen (1983).
This paper sets out some of the main ideas of what gradually developed into the Dutch view on the fourth revision of the SNA. In particular it focuses on the validity and even desirability of the inclusion of a number of carefully chosen alternative definitions in the "Blue Book", and the organization of a flexible system starting from a core that is easier to understand than the 1968 SNA.

NA/02 **The unobserved economy and the National Accounts in the Netherlands, a sensitivity analysis**, Broesterhuizen, G.A.A.M. (1983).
This paper studies the influence of fraud on macro-economic statistics, especially GDP. The term "fraud" is used as meaning unreporting or underreporting income (e.g. to the tax authorities). The conclusion of the analysis of growth figures is that a bias in the growth of GDP of more than 0.5% is very unlikely.

NA/03 **Secondary activities and the National Accounts: Aspects of the Dutch measurement practice and its effects on the unofficial economy**, Van Eck, R. (1985).
In the process of estimating national product and other variables in the National Accounts a number of methods is used to obtain initial estimates for each economic activity. These methods are described and for each method various possibilities for distortion are considered.

NA/04 **Comparability of input-output tables in time**, Al, P.G. and G.A.A.M. Broesterhuizen (1985).
It is argued that the comparability in time of statistics, and input-output tables in particular, can be filled in in various ways. The way in which it is filled depends on the structure and object of the statistics concerned. In this respect it is important to differentiate between coordinated input-output tables, in which groups of units (industries) are divided into rows and columns, and analytical input-output tables, in which the rows and columns refer to homogeneous activities.

NA/05 **The use of chain indices for deflating the National Accounts**, Al, P.G., B.M. Balk, S. de Boer and G.P. den Bakker (1985).
This paper is devoted to the problem of deflating National Accounts and input-output tables. This problem is approached from the theoretical as well as from the practical side. Although the theoretical argument favors the use of chained Vartia-I indices, the current practice of compilating National Accounts restricts to using chained Paasche and Laspeyres indices. Various possible objections to the use of chained indices are discussed and rejected.

NA/06 **Revision of the system of National Accounts: the case for flexibility**, Van Bochove, C.A. and H.K. van Tuinen (1985).
It is argued that the structure of the SNA should be made more flexible. This can be achieved by means of a system of a general purpose core supplemented with special modules. This core is a fully fledged, detailed system of National Accounts with a greater institutional content than the present SNA and a more elaborate description of the economy at the meso-level. The modules are more analytic and reflect special purposes and specific theoretical views.

NA/07 **Integration of input-output tables and sector accounts; a possible solution**, Van den Bos, C. (1985).
The establishment-enterprise problem is tackled by taking the institutional sectors to which the establishments belong into account during the construction of input-output tables. The extra burden on the construction of input-output tables resulting from this approach is examined for the Dutch situation. An adapted sectoring of institutional units is proposed for the construction of input-output tables.

NA/08 **A note on Dutch National Accounting data 1900-1984**, Van Bochove, C.A. (1985).
This note provides a brief survey of Dutch national accounting data for 1900-1984, concentrating on national income. It indicates where these data can be found and what the major discontinuities are. The note concludes that estimates of the level of national income may contain inaccuracies; that its growth rate is measured accurately for the period since 1948; and that the real income growth rate series for 1900-1984 may contain a systematic bias.

NA/09 The structure of the next SNA: review of the basic options, Van Bochove, C.A. and A.M. Bloem (1985).
There are two basic issues with respect to the structure of the next version of the UN System of National Accounts. The first is its 'size': reviewing this issue, it can be concluded that the next SNA should contain an integrated meso-economic statistical system. It is essential that the next SNA contains an institutional system without the imputations and attributions that pollute the present SNA. This can be achieved by distinguishing, in the central system of the next SNA, a core (the institutional system), a standard module for non-market production and a standard module describing attributed income and consumption of the household sector.

NA/10 Dual sectoring in National Accounts, Al, P.G. (1985).
Following a conceptual explanation of dual sectoring, an outline is given of a statistical system with complete dual sectoring in which the linkages are also defined and worked out. It is shown that the SNA 1968 is incomplete and obscure with respect to the links between the two sub-processes.

NA/11 Backward and forward linkages with an application to the Dutch agro-industrial complex, Harthoorn, R. (1985).
Some industries induce production in other industries. An elegant method is developed for calculating forward and backward linkages avoiding double counting. For 1981 these methods have been applied to determine the influence of Dutch agriculture in the Dutch economy in terms of value added and labour force.

NA/12 Production chains, Harthoorn, R. (1986).
This paper introduces the notion of production chains as a measure of the hierarchy of industries in the production process. Production chains are sequences of transformation of products by successive industries. It is possible to calculate forward transformations as well as backward ones.

NA/13 The simultaneous compilation of current price and deflated input-output tables, De Boer, S. and G.A.A.M. Broesterhuizen (1986).
A few years ago the method of compiling input-output tables underwent in the Netherlands an essential revision. The most significant improvement is that during the entire statistical process, from the processing and analysis of the basic data up to and including the phase of balancing the tables, data in current prices and deflated data are obtained simultaneously and in consistency with each other.

NA/14 A proposal for the synoptic structure of the next SNA, Al, P.G. and C.A. van Bochove (1986).

NA/15 Features of the hidden economy in the Netherlands, Van Eck, R. and B. Kazemier (1986).
This paper presents survey results on the size and structure of the hidden labour market in the Netherlands.

NA/16 Uncovering hidden income distributions: the Dutch approach, Van Bochove, C.A. (1987).

NA/17 Main national accounting series 1900-1986, Van Bochove, C.A. and T.A. Huitker (1987).
The main national accounting series for the Netherlands, 1900-1986, are provided, along with a brief explanation.

NA/18 The Dutch economy, 1921-1939 and 1969-1985. A comparison based on revised macro-economic data for the interwar period, Den Bakker, G.P., T.A. Huitker and C.A. van Bochove (1987).
A set of macro-economic time series for the Netherlands 1921-1939 is presented. The new series differ considerably from the data that had been published before. They are also more comprehensive, more detailed, and conceptually consistent with the modern National Accounts. The macro-economic developments that are shown by the new series are discussed. It turns out that the traditional economic-historical view of the Dutch economy has to be reversed.

NA/19 Constant wealth national income: accounting for war damage with an application to the Netherlands, 1940-1945, Van Bochove, C.A. and W. van Sorge (1987).

NA/20 **The micro-meso-macro linkage for business in an SNA-compatible system of economic statistics**, Van Bochove, C.A. (1987).

NA/21 **Micro-macro link for government**, Bloem, A.M. (1987).
This paper describes the way the link between the statistics on government finance and national accounts is provided for in the Dutch government finance statistics.

NA/22 **Some extensions of the static open Leontief model**, Harthoorn, R.(1987).
The results of input-output analysis are invariant for a transformation of the system of units. Such transformation can be used to derive the Leontief price model, for forecasting input-output tables and for the calculation of cumulative factor costs. Finally the series expansion of the Leontief inverse is used to describe how certain economic processes are spread out over time.

NA/23 **Compilation of household sector accounts in the Netherlands National Accounts**, Van der Laan, P. (1987).
This paper provides a concise description of the way in which household sector accounts are compiled within the Netherlands National Accounts. Special attention is paid to differences with the recommendations in the United Nations System of National Accounts (SNA).

NA/24 **On the adjustment of tables with Lagrange multipliers**, Harthoorn, R. and J. van Dalen (1987).
An efficient variant of the Lagrange method is given, which uses no more computer time and central memory then the widely used RAS method. Also some special cases are discussed: the adjustment of row sums and column sums, additional restraints, mutual connections between tables and three dimensional tables.

NA/25 **The methodology of the Dutch system of quarterly accounts**, Janssen, R.J.A. and S.B. Algera (1988).
In this paper a description is given of the Dutch system of quarterly national accounts. The backbone of the method is the compilation of a quarterly input-output table by integrating short-term economic statistics.

NA/26 **Imputations and re-routeings in the National Accounts**, Gorter, Cor N. (1988).
Starting out from a definition of 'actual' transactions an inventory of all imputations and re-routeings in the SNA is made. It is discussed which of those should be retained in the core of a flexible system of National Accounts. Conceptual and practical questions of presentation are brought up. Numerical examples are given.

NA/27 **Registration of trade in services and market valuation of imports and exports in the National Accounts**, Bos, Frits (1988).
The registration of external trade transactions in the main tables of the National Accounts should be based on invoice value; this is not only conceptually very attractive, but also suitable for data collection purposes.

NA/28 **The institutional sector classification**, Van den Bos, C. (1988).
A background paper on the conceptual side of the grouping of financing units. A limited number of criteria are formulated.

NA/29 **The concept of (transactor-)units in the National Accounts and in the basic system of economic statistics**, Bloem, Adriaan M. (1989).
Units in legal-administrative reality are often not suitable as statistical units in describing economic processes. Some transformation of legal-administrative units into economic statistical units is needed. This paper examines this transformation and furnishes definitions of economic statistical units. Proper definitions are especially important because of the forthcoming revision of the SNA.

NA/30 **Regional income concepts**, Bloem, Adriaan M. and Bas De Vet (1989).
In this paper, the conceptual and statistical problems involved in the regionalization of national accounting variables are discussed. Examples are the regionalization of Gross Domestic Product, Gross National Income, Disposable National Income and Total Income of the Population.

NA/31 **The use of tendency surveys in extrapolating National Accounts**, Ouddeken, Frank and Gerrit Zijlmans (1989).
This paper discusses the feasibility of the use of tendency survey data in the compilation of very timely Quarterly Accounts. Some preliminary estimates of relations between tendency survey data and regular Quarterly Accounts-indicators are also presented.

NA/32 **An economic core system and the socio-economic accounts module for the Netherlands**, Gorter, Cor N. and Paul van der Laan (1989).
A discussion of the core and various types of modules in an overall system of economy related statistics. Special attention is paid to the Dutch Socio-economic Accounts. Tables and figures for the Netherlands are added.

NA/33 **A systems view on concepts of income in the National Accounts**, Bos, Frits (1989).
In this paper, concepts of income are explicitly linked to the purposes of use and to actual circumstances. Main choices in defining income are presented in a general system. The National Accounts is a multi-purpose framework. It should therefore contain several concepts of income, e.g. differing with respect to the production boundary. Furthermore, concepts of national income do not necessarily constitute an aggregation of income at a micro-level.

NA/34 **How to treat borrowing and leasing in the next SNA**, Keuning, Steven J. (1990).
The use of services related to borrowing money, leasing capital goods, and renting land should not be considered as intermediate inputs into specific production processes. It is argued that the way of recording the use of financial services in the present SNA should remain largely intact.

NA/35 **A summary description of sources and methods used in compiling the final estimates of Dutch National Income 1986**, Gorter, Cor N. and others (1990).
Translation of the inventory report submitted to the GNP Management Committee of the European Communities.

NA/36 **The registration of processing in supply and use tables and input-output tables**, Bloem, Adriaan M., Sake De Boer and Pieter Wind (1993).
The registration of processing is discussed primarily with regard to its effects on input-output-type tables and input-output quotes. Links between National Accounts and basic statistics, user demands and international guidelines are examined. Net recording is in general to be preferred. An exception has to be made when processing amounts to a complete production process, e.g. oil refineries in the Netherlands.

NA/37 **A proposal for a SAM which fits into the next System of National Accounts**, Keuning, Steven J. (1990).
This paper shows that all flow accounts which may become part of the next System of National Accounts can be embedded easily in a Social Accounting Matrix (SAM). In fact, for many purposes a SAM format may be preferred to the traditional T-accounts for the institutional sectors, since it allows for more flexibility in selecting relevant classifications and valuation principles.

NA/38 **Net versus gross National Income**, Bos, Frits (1990).
In practice, gross figures of Domestic Product, National Product and National Income are most often preferred to net figures. In this paper, this practice is challenged. Conceptual issues and the reliability of capital consumption estimates are discussed.

NA/39 **Concealed interest income of households in the Netherlands; 1977, 1979 and 1981**, Kazemier, Brugt (1990).
The major problem in estimating the size of hidden income is that total income, reported plus unreported, is unknown. However, this is not the case with total interest income of households in the Netherlands. This makes it possible to estimate at least the order of magnitude of this part of hidden income. In this paper it will be shown that in 1977, 1979 and 1981 almost 50% of total interest received by households was concealed.

NA/40 Who came off worst: Structural change of Dutch value added and employment during the interwar period, Den Bakker, Gert P. and Jan de Gijt (1990).
In this paper new data for the interwar period are presented. The distribution of value added over industries and a break-down of value added into components is given. Employment by industry is estimated as well. Moreover, structural changes during the interwar years and in the more recent past are juxtaposed.

NA/41 The supply of hidden labour in the Netherlands: a model, Kazemier, Brugt and Rob van Eck (1990).
This paper presents a model of the supply of hidden labour in the Netherlands. Model simulations show that the supply of hidden labour is not very sensitive to cyclical fluctuations. A tax exempt of 1500 guilders for second jobs and a higher probability of detection, however, may substantially decrease the magnitude of the hidden labour market.

NA/42 Benefits from productivity growth and the distribution of income, Keuning, Steven J. (1990).
This paper contains a discussion on the measurement of multifactor productivity and sketches a framework for analyzing the relation between productivity changes and changes in the average factor remuneration rate by industry. Subsequently, the effects on the average wage rate by labour category and the household primary income distribution are studied.

NA/43 Valuation principles in supply and use tables and in the sectoral accounts, Keuning, Steven J. (1991).
In many instances, the valuation of transactions in goods and services in the national accounts poses a problem. The main reason is that the price paid by the purchaser deviates from the price received by the producers. The paper discusses these problems and demonstrates that different valuations should be used in the supply and use tables and in the sectoral accounts.

NA/44 The choice of index number formulae and weights in the National Accounts. A sensitivity analysis based on macro-economic data for the interwar period, Bakker, Gert P. den (1991).
The sensitivity of growth estimates to variations in index number formulae and weighting procedures is discussed. The calculations concern the macro-economic variables for the interwar period in the Netherlands. It appears, that the use of different formulae and weights yields large differences in growth rates. Comparisons of Gross Domestic Product growth rates among countries are presently obscured by the use of different deflation methods. There exists an urgent need for standardization of deflation methods at the international level.

NA/45 Volume measurement of government output in the Netherlands; some alternatives, Kazemier, Brugt (1991).
This paper discusses three alternative methods for the measurement of the production volume of government. All methods yield almost similar results: the average annual increase in the last two decades of government labour productivity is about 0.7 percent per full-time worker equivalent. The implementation of either one of these methods would have led to circa 0.1 percentage points higher estimates of economic growth in the Netherlands.

NA/46 An environmental module and the complete system of national accounts, Boo, Abram J. De, Peter R. Bosch, Cor N. Gorter and Steven J. Keuning (1991).
A linkage between environmental data and the National Accounts is often limited to the production accounts. This paper argues that the consequences of economic actions on ecosystems and vice versa should be considered in terms of the complete System of National Accounts (SNA). One should begin with relating volume flows of environmental matter to the standard economic accounts. For this purpose, a so-called National Accounting Matrix including Environmental Accounts (NAMEA) is proposed. This is illustrated with an example.

NA/47 **Deregulation and economic statistics: Europe 1992**, Bos, Frits (1992).
The consequences of deregulation for economic statistics are discussed with a view to Europe 1992. In particular, the effects of the introduction of the Intrastat-system for statistics on international trade are investigated. It is argued that if the Statistical Offices of the EC-countries do not respond adequately, Europe 1992 will lead to a deterioration of economic statistics: they will become less reliable, less cost effective and less balanced.

NA/48 **The history of national accounting**, Bos, Frits (1992).
At present, the national accounts in most countries are compiled on the basis of concepts and classifications recommended in the 1968-United Nations guidelines. In this paper, we trace the historical roots of these guidelines (e.g. the work by King, Petty, Kuznets, Keynes, Leontief, Frisch, Tinbergen and Stone), compare the subsequent guidelines and discuss also alternative accounting systems like extended accounts and SAMs.

NA/49 **Quality assessment of macroeconomic figures: The Dutch Quarterly Flash**, Reininga, Ted, Gerrit Zijlmans and Ron Janssen (1992).
Since 1989-IV, the Dutch Central Bureau of Statistics has made preliminary estimates of quarterly macroeconomic figures at about 8 weeks after the end of the reference quarter. Since 1991-II, a preliminary or "Flash" estimate of GDP has been published. The decision to do so was based on a study comparing the Flash estimates and the regular Quarterly Accounts figures, which have a 17-week delay. This paper reports on a similar study with figures through 1991-III.

NA/50 **Quality improvement of the Dutch Quarterly Flash: A Time Series Analysis of some Service Industries**, Reininga, Ted and Gerrit Zijlmans (1992).
The Dutch Quarterly Flash (QF) is, just like the regular Quarterly Accounts (QA), a fully integrated statistic based on a quarterly updated input-output table. Not all short term statistics used to update the QA's IO-table are timely enough to be of use for the QF, so other sources have to be found or forecasts have to be made. In large parts of the service industry the latter is the only possibility. This paper reports on the use of econometric techniques (viz. series decomposition and ARIMA modelling) to improve the quality of the forecasts in five parts of the service industry.

NA/51 **A Research and Development Module supplementing the National Accounts**, Bos, Frits, Hugo Hollanders and Steven Keuning (1992).
This paper presents a national accounts framework fully tailored to a description of the role of Research and Development (R&D) in the national economy. The framework facilitates to draw macro-economic conclusions from all kinds of data on R&D (also micro-data and qualitative information). Figures presented in this way can serve as a data base for modelling the role of R&D in the national economy.

NA/52 **The allocation of time in the Netherlands in the context of the SNA; a module**, Kazemier, Brugt and Jeanet Exel (1992).
This paper presents a module on informal production, supplementing the National Accounts. Its purpose is to incorporate informal production into the concepts of the SNA. The relation between formal and informal production is shown in the framework of a Social Accounting Matrix (SAM). To avoid a controversial valuation of informal production, the module constists of two SAMs. One expressed in actual prices with informal labour valued zero, and one which expresses the embedded informal labour input measured in terms of hours worked.

NA/53 **National Accounts and the environment: the case for a system's approach**, Keuning, Steven J. (1992).
The present set of main economic indicators should be extended with one or a few indicators on the state of the environment. This paper lists various reasons why a so-called Green Domestic Product is not suitable for this purpose. Instead, a system's approach should be followed. A National Accounting Matrix including Environmental Accounts (NAMEA) is presented and the way to derive one or more separate indicators on the environment from this information system is outlined.

NA/54 How to treat multi-regional units and the extra-territorial region in the Regional Accounts?, De Vet, Bas (1992).
This paper discusses the regionalization of production and capital formation by multi-regional kind-of-activity units. It also examines the circumstances in which a unit may be said to have a local kind-of-activity unit in the extra-territorial region and what should be attributed to this "region".

NA/55 A historical Social Accounting Matrix for the Netherlands (1938), Den Bakker, Gert P., Jan de Gijt and Steven J. Keuning (1992).
This paper presents a Social Accounting Matrix (SAM) for the Netherlands in 1938, including related, non-monetary tables on demographic characteristics, employment, etc. The distribution of income and expenditure among household subgroups in the 1938 SAM is compared with concomittant data for 1987.

NA/56 Origin and development of the Dutch National Accounts, Den Bakker, Gert P. (1992).
This paper describes the history of national accounting in the Netherlands. After two early estimates in the beginning of the nineteenth century, modern national accounting started in the 1930s on behalf of the Tinbergen model for the Dutch economy. The development spurred up after World War II to provide data to the government for economic planning purposes. In the 1980s, the development was towards a flexible and institutional approach.

NA/57 Compiling Dutch Gross National Product (GNP); summary report on the final estimates after the revision in 1992, Bos, Frits (1992).
This summary report describes the sources and methods used for compiling the final estimate of Dutch Gross National Product after the revision of the Dutch National Accounts in 1992. Attention is focused on the estimation procedures for 1988. A more extensive report is also available (**NA/57_Ext.**).

NA/57_Ext. Compiling Dutch Gross National Product (GNP); full report on the final estimates after the revision in 1992, Bos, Frits and Cor N. Gorter (1993).
This report describes the compilation of the final estimate of Dutch Gross National Product after the revision of the Dutch National Accounts in 1992. Attention is focused on the estimation procedures for 1988. The description covers i.a. data sources, sampling features of the surveys, grossing up procedures, adjustments for underreporting and the integration process.

NA/58 The 1987 revision of the Netherlands' National Accounts, Van den Bos, C and P.G. Al (1994).
The 1987 revision that was completed in 1992 has improved the Dutch National Accounts in three ways. First, new and other data sources have been used, like Production statistics of service industries, the Budget Survey and Statistics on fixed capital formation. Secondly, the integration process has been improved by the use of detailed make- and use-tables instead of more aggregate input-output tables. Thirdly, several changes in bookkeeping conventions have been introduced, like a net instead of a gross registration of processing to order.

NA/59 A National Accounting Matrix for the Netherlands, Keuning, Steven and Jan de Gijt (1992).
Currently, the national accounts typically use two formats for presentation: matrices for the Input-Output tables and T-accounts for the transactions of institutional sectors. This paper demonstrates that presently available national accounts can easily be transformed into a National Accounting Matrix (NAM). This may improve both the transparency and analytic usefulness of the complete set of accounts.

NA/60 Integrated indicators in a National Accounting Matrix including environmental accounts (NAMEA); an application to the Netherlands, De Haan, Mark, Steven Keuning and Peter Bosch (1993).
In this paper, environmental indicators are integrated into a National Accounting Matrix including Environmental Accounts (NAMEA) and are put on a par with the major aggregates in the national accounts, like National Income. The environmental indicators reflect the goals of the environmental policy of the Dutch government. Concrete figures are presented for 1989. The NAMEA is optimally suited as a data base for modelling the interaction between the national economy and the environment.

NA/61 Standard national accounting concepts, economic theory and data compilation issues; on constancy and change in the United Nations-Manuals on national accounting (1947, 1953, 1968 and 1993), Bos, Frits (1993).
In this paper, the four successive guidelines of the United Nations on national accounting are discussed in view of economic theory (Keynesian analysis, welfare, Hicksian income, input-output analysis, etc.) and data compilation issues (e.g. the link with concepts in administrative data sources). The new guidelines of the EC should complement those of the UN and be simpler and more cost-efficient. It should define a balanced set of operational concepts and tables that is attainable for most EC countries within 5 years.

NA/62 Revision of the 1987 Dutch agricultural accounts, Pauli, Peter and Nico van Stokrom (1994).
During the recent revision of the Dutch national accounts, new agricultural accounts have been compiled for the Netherlands. This paper presents the major methodological and practical improvements and results for 1987, the base year for this revision. In addition, this paper demonstrates that a linkage can be established between the E.C. agricultural accounting system and the agricultural part of the standard national accounts.

NA/63 Implementing the revised SNA in the Dutch National Accounts, Bos, Frits (1993).
This paper discusses the implementation of the new United Nations guidelines on national accounting (SNA) in the Netherlands. The changes in basic concepts and classifications in the SNA will be implemented during the forthcoming revision. The changes in scope will be introduced gradually. Important changes scheduled for the near future are the incorporation of balance sheets, an environmental module and a Social Accounting Matrix.

NA/64 Damage and insurance compensations in the SNA, the business accounts and the Dutch national accounts, Baris, Willem (1993).
This paper describes the recording of damages to inventories and produced fixed assets in general, including damages as a result of legal product liability and of the liability for damage to the environment. In this regard, the 1993 System of National Accounts and the practice of business accounting are compared with the Dutch national accounts.

NA/65 Analyzing economic growth: a description of the basic data available for the Netherlands and an application, Van Leeuwen, George, Hendrie van der Hoeven and Gerrit Zijlmans (1994).
This paper describes the STAN project of the OECD and the Dutch national accounts data supplied to the STAN database, which is designed for a structural analysis of the role of technology in economic performance. Following an OECD analysis for other industrial countries, the importance of international trade for a small open economy such as the Netherlands is investigated. The STAN database is also available on floppy disk at the costs of DFL. 25, an can be ordered by returning the order form below (Please mention: STAN floppy disk).

NA/66 Comparability of the sector General Government in the National Accounts, a case study for the Netherlands and Germany, Streppel, Irene and Dick Van Tongeren (1994).
This paper questions the international comparability of data concerning the sector General Government in the National Accounts. Two differences are distinguished: differences due to lack of compliance with international guidelines and institutional differences. Adjustments to National Accounts data are reflected in a separate module which comparises Germany versus The Netherlands. The module shows that total General Government resources as well as uses are substantially higher in the Netherlands.

NA/67 What would Net Domestic Product have been in an environmentally sustainable economy?, Preliminary views and results, De Boer, Bart, Mark de Haan and Monique Voogt (1994).
Sustainable use of the environment is a pattern of use that can last forever, at least in theory. This pattern is likely to render a lower net domestic product than the present economy. The coherence between reductions in pressure on the environment and changes in net domestic product is investigated with the help of a simple multiplier model. This model is based on a National Accounting Matrix including Environmental Accounts (NAMEA).

NA/68 **A Social Accounting Matrix for the Netherlands, concepts and results,** Timmerman, Jolanda G. and Peter J.M. van de Ven (1994).
In this paper a Social Accounting Matrix (SAM) for the Netherlands is presented. Two years are covered: 1988 and 1990. The SAM is an integrated data framework based on national accounts extended with information on distribution of income, consumption and wealth among household. Furthermore, labour income and employment are subdivided into several labour categories. The tables of the SAMs of both 1988 and 1990 are available on separate floppy disks at the costs of DFL. 65 each.

NA/69 **Analyzing relative factor inputs of Dutch exports: An application of the 1990 Social Accounting Matrix for the Netherlands** (forthcoming), Reininga, Ted (1995).
In this paper the validity of neoclassical trade theory for explaining Dutch international trade patterns is studied. The analysis is carried out with the use of a Social Accounting Matrix for The Netherlands. This study corroborates the outcome of other recent analysis in this field: classical trade theory offers a better starting-point to understand Dutch trade patterns than neoclassical trade theory. Moreover, these recent studies point to the increasing relevance of insights derived from modern trade theory. The results presented here seem to support this point of view.

NA/70 **SESAME for the evaluation of economic development and social change**, Keuning, Steven J. (1994).
This paper elaborates on the concept of a System of Economic and Social Accounting Matrices and Extensions, or SESAME for short. The SESAME-concept serves to meet the criticism that conventional national accounts take a too limited view at social, environmental and economic development. SESAME details the monetary accounts and couples non-monetary information in an integral system approach. SESAME is meant as a synthesis of national accounts and the social indicators approach.

NA/71 **New revision policies for the Dutch National Accounts**, Den Bakker, Gert P., Jan de Gijt and Robert A.M. van Rooijen (1994).
This paper presents the (new) revision policy for the Dutch National Accounts. In the past, several major revisions of national accounting data have been carried out in the Netherlands. In the course of time, the policy has changed several times. Recently, the aim has become to publish relatively long time-series shortly after the publication of the revised benchmark year data.

NA/72 **Labour force data in a National Accounting framework**, Den Bakker, Gert P. and Jan de Gijt (1994).
This paper deals with the Dutch interwar labour force data. Starting with census data the estimation of the working and non-working labour force by industry and by occupational type is described and the results are discussed. The data have been estimated within the national accounts framework. It is the first time that labour market figures at a meso-level have been estimated which are linked to other national accounting figures.

NA/73 **Integrated estimates of productivity and terms-of-trade changes from a Social Accounting Matrix at constant prices**, Keuning, Steven J. 1994).
This paper demonstrates that measures of real income change for the total economy can best be derived from real income changes per subsector. For this purpose a Social Accounting Matrix (SAM) at constant prices has been compiled. By breaking down value added at constant prices into constant price estimates for each primary input category, productivity changes by industry can be estimated as an integral part of the regular national accounts compilation. The national total trading gain or loss from a change in the terms of trade is as well allocated to subsectors, thus embedding the estimation of this macro-measure into a meso-consistency framework. These ideas have been applied in a case-study for Indonesia.

NA/74 **Taking the environment into account: The Netherlands NAMEA's for 1989, 1990 and 1991**, De Haan, Mark and Steven Keuning (1995).
The National Accounting Matrix including Environmental Accounts (NAMEA) contains figures on environmental burdens in relation to economic developments as reflected in the National accounts. NAMEA's for the Netherlands in 1989, 1990 and 1991 have now been completed. They include a more detailed industrial classification and a series of environment taxes and levies, plus environmental protection expenditures by industry and households. Further, the depletion of two important mineral resources in the Netherlands is now incorporated in the NAMEA's.

NA/75 Economic theory and national accounting, Bos, Frits (1995).
This paper describes the relationship between economic theory and national accounting. This relationship is often misunderstood, by economic theorists and national accountants alike. Attention is drawn to the consistency required in a national accounting system, to national accounts figures as a transformation of primary data and to the fundamentally different valuation principles employed in economic theory and national accounting (forward looking and analytic versus backward looking and descriptive). The gap between economic theory and national accounting can only be bridged by satellite accounts, as in these accounts consistency with the overall system and valuation at current exchange value are not strictly required.

NA/76 An information-system for economic, environmental and social statistics, Keuning, Steven J. and Jolanda G. Timmerman (1995).
The 1993 SNA mentions that a SAM can also be extended to deal with environmental issues. This entails the integration of a SAM and a NAMEA into a SAMEA (Social Accounting Matrix including Environmental Accounts), a further extension into the direction of a so-called SESAME (System of Economic and Social Accounting Matrices and Extensions). This paper shows how environmental data and environmental indicators can be integrated into such a system. A Dutch case-study shows the interrelations between e.g. the employment of various types of workers (by sex/educational level) and the environmental problems caused by the activities in which they are employed. Moreover, this pollution is also allocated to the subsectors that receive value added. This enables a comparison with the consumption-based pollution by subsector. The SAMEA yields a framework for an integrated analysis and modelling of social, economic and environmental issues.

NA/77 Material flows, energy use and the structure of the economy, Konijn, Paul J.A., Sake de Boer and Jan van Dalen (1995).
Many environmental problems are connected to production and use of materials and energy. It would therefore be desirable to have an information system that gives consistent, complete and detailed information on material and energy flows. Such a system would even be more useful if it could be connected directly to economic data. This paper presents such a system. Based on the foundation laid by the national accounts the authors construct a system for the analysis of flows of materials and energy through the economy. In this paper the proposed system is illustrated with an application to the flows of iron/steel and energy. An input-output table is presented that describes the production processes in the ferrous metal branch entirely in physical units. Subsequently, steel contents of final products are calculated, and an analysis is made of the consequences of a new technology in the basic steel industry on total energy use in the economy.

Statistics Netherlands
National Accounts
Occasional Papers

Please send me the following paper(s): ....

.... (For each copy DFL. 20 will be incurred as a contribution to the costs).

Name: ....

Address: ....

Country: .... Organization: ....

Return to: Statistics Netherlands, National Accounts
P.O. Box 4000, 2270 JM Voorburg
The Netherlands