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THE CONSIDERATION OF RESOURCES AND EMISSIONS IN INPUT-OUTPUT MODELING

The elaboration of ecological multipliers for Germany

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Abstract

The input-output modeling, which is still a popular technique in the field of economic analysis, can be subdivided into a descriptive and an analytical part. The core of the descriptive part consists of input-output tables. For economic purposes, input-output tables are set up as monetary tables. However, in the case of ecological usages, the input-output tables are comprised in terms of physical quantities, e. g. joule, and tons. The core of the analytical part of the input-output method deals with the determination of multipliers and their applicability in economic/environmental policies.

This paper focuses on the combination of the monetary and physical input/output tables provided by the German office of statistics. The paper makes a suggestion of how the additional information concerning the resources and the pollutants, provided by the physical tables, can be included into the monetary analysis.

With the help of the 'ecolio'-model (ecological input-output analysis) a sensitivity analysis can be done. Depending on the price set for the considered ten resources and eleven emissions, backward (and forward) multiplier of the 58 sectors will change significantly.

1 Introduction

The input-output modeling is one of the most popular techniques in the field of economic analysis and accordingly in the last years its application has become increasingly popular in the field of ecological analysis as well.

The method can be subdivided into a descriptive and an analytical part. The core of the descriptive part consists of input-output tables. For economic purposes, input-output tables are set up as monetary tables. However, in the case of ecological usages, the input-output tables are comprised in terms of physical quantities, e. g. joule, tons. The core of the analytical part of the input-output method deals with the determination of multipliers and their applicability in economic/environmental policies.

When input-output tables formed by one and the same monetary or physical indicator there arise no major methodological problems. Total input and output of each sector, enterprise or location are equal. The complications begin when monetary and physical cycles are combined or interchangeably applied. The following discourse deals mainly with application problems of the input-output modeling in the field of economic and environmental policies, where both monetary and physical indicators play an important role.

2 The Descriptive Part of the Input-Output Method

Already LEONTIEF confronted the issue of the relationship between physical quantities and their monetary value terms. He presents a simplified example of an input-output table depicting a three-sector economy as shown in Table 1 (LEONTIEF, W. (1966), p. 135).

Table 1: LEONTIEF’s Quantitative Input-Output Table

into from	Sector 1 Agriculture	Sector 2 Manufacture	Sector 3 Households	Total Output
Sector 1 Agriculture	25	20	55	100 bushels of wheat
Sector 2 Manufacture	14	6	30	50 yards of cloth
Sector 3 Households	80	180	40	300 man years of labor

The input and output structure of the corresponding sectors outlined above are described in the columns and rows. The flows are measured in different physical units. Therefore a meaningful addition of inputs is not possible. Using the prices for wheat (one bushel of wheat $2), cloth (one yard of cloth $5) and for labor (one man year of labor $1) the different terms of physical quantitatives are formed into homogenous monetary units (see Table 2). In contrast to Table 1, in Table 2 inputs and outputs of each sector can be added. Total input and output of each sector are equal. Since the monetary terms of Table 2 reflect directly the physical quantitatives in Table 1 the comparibility of Table 1 and 2 is ensured.

Table 2: LEONTIEF's Monetary Input-Output Table

into from	Sector 1 Agriculture	Sector 2 Manufacture	Sector 3 Households	Total Output in $
Agriculture	50	40	110	200
Manufacture	70	30	150	250
Households	80	180	40	300
Total Input in $	200	250	300	750

Since the input-output tables are not only the core of the descriptive part, but also the starting point for the analytical section, the homogeneity of the table is of strong importance for the whole input-output method. However, it should be emphasized, that monetary tables are not the only homogenous tables and that the flows could also be measured in joules or in tons instead of dollars. With the growing awareness of environmental issues in western economies **P**hysical **I**nput-**O**utput **T**ables (PIOT) based on material flows (measured in tons) become popular. The structure of the PIOT, that is different from the structure of Table 1, will be discussed later.

Table 3 is still a simplified 'picture' of an economy similar to that described in Table 2, but it characterizes the principle framework of the current German **M**onetary **I**nput-**O**utput **T**able (MIOT). The output is measured in million German Marks (DM). For simplicity's sake the sectors '**Agri**culture' and 'In**dustry**' are aggregated to the sector 'Agridustry'. A sector 'Service' is introduced, and 'Households', listed in table 2 under the vertical column

3, is replaced by 'Final Demand'. Horizontally 'Households' is substituted by 'Primary Input'.

Table 3: Principle Framework of Current German Monetary Input-Output Table

into / from	Sect. 1+2 Agridustry	Sect. 3 Service	Total	Final Demand				Total
				Private Consump-tion	Govern. Expendi-tures	Invest-ments	Export	Output in mill. DM
Agridustry	24	8	32	16	0	12	5	65
Service	15	20	35	5	5	4	1	50
Total	39	28	67	21	5	16	6	115
Primary Input								
Salary, Wages	8	7	15					
Profits	4	3	7					
Taxes minus Subsidies	5	3	8					
Depreciation	7	6	13					
Import	2	3	5					
Total Input in mill. DM	65	50	115					

The segmentation of 'Final Demand' and of 'Primary Input' in Table 3 allows the incorporation of the **S**ocial **N**ational **A**ccount (SNA) concept, which is undoubtedly an advantage of monetary tables. The deficiencies lie in the fact that the importance of 'nature' for production and consumption is not sufficiently integrated either in the concept of SNA or in MIOT approaches. In opposition to MIOT the input-output analysis based on physical terms is offered a more suitable tool applied in ecological accounting. Natural resources such as water, soil and various sources of energy as well as the different kinds of emissions can be taken into consideration on a quantitative base.

Besides LEONTIEF, ISARD wrote various articles about material flow calculations. In 1972 ISARD published the book 'Ecologic-Economic Analysis for Regional Development', which actually identifies environmental effects of certain industries for a specific region. In contrast to renewable resources (solar, wind) and non-renewable resources (fossil fuels) mankind can intervene at naturally renewable resources, e.g. living organisms. However, in ISARD's opinion the measurement of ecological environments must necessarily be done in terms of physical units. Finally ISARD (1972) proves that in the considered region "the pollutants from the leather tanning and finishing industry, which are dumped on the ecologic system are of a critical nature. They affect not only the characteristics of the ecological system, but also the capability of that system to provide adequate inputs for other economic activities." Similar studies for the Rhine and Austria have been described by MULLER and KRATTERL. KRATTERL points out, that besides for environmental analysis the physical flows could be used for the elaboration of transport multiplier, too.

A structured breakdown of a PIOT is given by Table 4, where all entries are now measured in tons. In modern industrialised economies more than 90% of the physical flows are related to natural resources as input, respectively, the emissions as output (STRASSERT, 1997).

Table 4: Structured Breakdown of Physical Input-Output Tables

into from	Agridustry, Services	Sum	Nature	Final Demand	Total Output
Agridustry, Services	goods (<5% of total physical flows)		emissions, non-recyclable waste	goods	
Sum					
Nature	resources				
'Primary Input'	emissions, nonre-cyclable waste				
Total input					

Though Table 5 shows the principle framework of current German physical input-output table, it is - comparible to that in Table 3 - still a simplified economy. 'Nature' appears as 'Resources' on the one hand as an input and as 'Emissions' on the other hand as an output.

The German Office of Statistics publishes physical input-output tables for 59 branches, including a sector 'External Environmental Protection'. This sector covers in particular 'Sewage for Treatment' and 'Waste for Disposal'. While these activities are incorparated into the monetary tables most of the other below listed resources and pollutants such as solid energy resources, minerals, natural water, various kind of gases or sewage are exclusively taken into account by the physical tables.

Table 5: Principle Framework of Current German Physical Input-Output Table

into from	Agridustry	Service	Total	Private Consum.	Invest-ments	Ex-port	Emissions	Total Output (mill. tons)
Agridustry	70	41	111	25	5	6	553	700
Service	32	25	57	23	2	3	495	580
Total	102	66	168	48	7	9	1048	1280
Households	11	34	45					
Import	4	8	12					
Natural Resources	583	472	1055					
Total Input (mill. tons)	700	580	1280					

Although the above discussed economy is a rather simplified one, the critical point of the physical tables becomes clear. If it is true, that "all history - as well as all current experience - points to the fact that it is man, not nature, who provides the primary resource: that the key factor of all economic development comes out of the mind of man" (SCHUMACHER, E. F. (1993)) important information is missing in the physical tables. Neither the muscle work of the farmers, nor the research work of the engineers in the manufacture sector supplied by the private households can be translated adaequately into physical flows. Furthermore the lecture of a university professor and even the major part of the output of modern services such as the internet can hardly be measured in physical quantities. Hence, only the monetary tables provide detailed information about the sectoral structure of modern economies. However, modern approaches of social accounts should offer the possibility to incorporate the use of natural environment.

One of these new input-output techniques is elaborated by KUHN. His idea is to include internal and external environmental protection expenditures into the analysis and thus combining physical and monetary tables. The so-called natural tables still show the flows in monetary units, but the connection between use of resources, industrial production and natural pollution can be analyzed. In contrast to the German monetary tables showing 58 sectors, the natural tables are based on 15 aggregated sectors. However, the tables provide information about the internal efforts to save the nature or to avoid pollution for each sector. Additionally the sector 'external environmental protection expenditures' is introduced into the model (see KUHN, 1996).

Table 6: Method of KUHN applied for the artifical economy (table 3)

into / from	Agridustry		Service		External	Total		Final	Ex-	Total
		Thereof Internal Environ. Protect.		Thereof Internal Environ. Protect.	Expend. for Environm. Protection		Thereof Total Exp. Environm. Protection	Demand	port	Output in mill. $
Agridustry	24	0,3	7,6	0,1	0,4	32	0,8	28	5	65
Service	13,5	0,2	18,2	0,2	0,3	32	0,7	13,4	1	46,4
External Exp. Environ. Prot.	1,5	1,5	0,5	0,5	1	3	3	0,6	0	3,6
Total	39	2	26,3	0,8	1,7	67	4,5	42	6	115
Net Value Added	17	0,9	12	0,7	1	30	2,6			
Depreciation	7	0,4	5,2	0,3	0,8	13	1,5			
Import	2	0	2,9	0	0,1	5	0,1			
Total Input in mill. $	65	3,3	46,4	1,8	3,6	115	8,7			

Compared to Table 3 the total volume of the economy does not change. On the one hand the efforts, that are done to keep nature intact, can be considered easily in the columns of internal and external environmental protection expenditures, but on the other hand even this very simplified economy becomes rather difficult to survey. Another problematic fact is, that only expenditures to environmental protection are considered, which have been included before. The social costs of air pollution, or the values of resources are still missing.

BOETTCHER and SCHAFFER developed an ecological input-output model, that is based on monetary flows making the incorporation of the SNA possible and that on the other hand picks up the idea of the physical approach, which includes material flows from and into environment. Contrary to the input-output-tables, eloborated by KUHN, KRATTERL or ISARD this approach takes into consideration both: the monetary flows for economic activities and the usage of environmental resources. The analysis is based on data for 59 sectors and covers the area of former West-Germany. A regionalization at the geographical scale of the German Laender, is planned as well as the extension towards the area of the unified Germany. However physical data are not yet available at this level.

Compared to the physical tables provided by the national office of statistics, the physical part of the ecological input-output model considers **nature as an intermediate sector**. Thus resources and emissions are incorporated into the first quadrant.

Table 7: Physical part of the ecological input-output model (structure)

PIOT	Agriculture, manu-facturing, services	Nature	Sum	Final Demand	Total Output
Agriculture, manu-facturing, services	Goods (<5% of total physical flows)	Goods, emissions, non-recyclable waste		Goods	
Nature	Resources	No flows		Resources	
Sum					
'Primary Input'	No flows	Emissions, non-recyclable waste			
Total input					

Table 8: Physical part of the ecological input-output model (example)

into from	Agridustry	Service	Nature: Emmissions	Sum	Private Consum	Invest.	Ex-port	Total Output (mill. tons)
Agridustry	70	41	553	664	25	5	6	700
Service	32	25	495	552	23	2	3	580
Nature: Resources	583	472	0	1055	12	0	0	1067
Total	685	538	1048	2271	48	7	9	2347
Priv. HH	11	34	19	64				
Import	4	8	0	12				
Total Input (mill. tons)	700	580	1067	2347				

While the natural resources are obviously inputs for the industrial production, the emissions are physical industrial output. But if it comes to a translation into monetary terms the assimilation of pollution is doubtless an input for the production. Figure 1 shows the direction of the monetary disposition of nature.

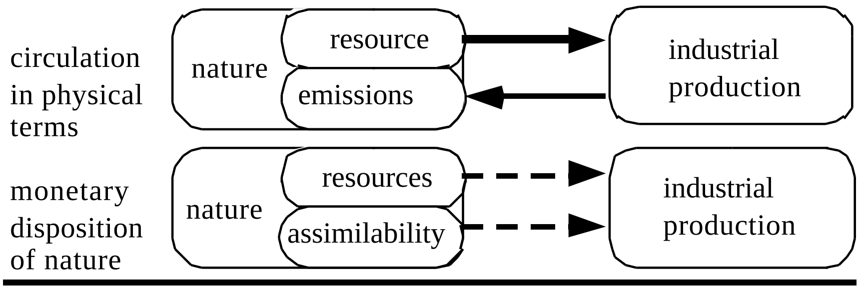


Figure 1: Monetary disposition of ‘nature’

This procedure is oriented on the already practized approach for the above mentioned 'sewage for treatment' and 'waste for disposal'. Aggregated to the sector 'external environmental protection' these activities are considered differently within the physical and the monetary framework.

Table 9: Structure of intermediate quadrant German PIOT and MIOT respectively

PIOT (flows in tons)	Agriculture, manfacturing, services	External environmental services	Sum
Agriculture, manufacturing, services	Goods	Goods / Sewage for treatment, waste for disposal	tons
External environmental services	Goods	Goods / Sewage for treatment, waste for disposal	tons
MIOT (flows in DM)	Agriculture, manfacturing, services	External environmental services	Sum
Agriculture, manufacturing, services	Goods and services	Goods and services	DM
External environmental services	Goods and disposal services	Goods and disposal services	DM

Considering the physical flows, 'sewage for treatment' and 'waste for disposal' are classified as output of the production process. However, the monetary output, delivered from agriculture, manufacturing or services towards the external environmental services, is limited to the valueable output such as capital goods and transport or banking services. The physical units of the polluted output vanish. Only the costs for the disposal are included. These costs are regarded as intermediate inputs.

Equivalent the emissions produced by the industry and absorbed by the nature are considered as assimilability services (output of sector nature), and therefore as intermediate input for the production process. Hence resources as well as emissions are listed in the row ‘nature’ of the monetary part of the ecological input-output table designed by BOETTCHER and SCHAFFER

Table 10: Monetary part of the ecological input-output model (structure)

Flows in DM	Agriculture, manu-facturing, services	Nature	Sum	Final Demand	Total Output
Agriculture, manu-facturing, services	Goods, services	Goods, services		Goods, services	
Nature	Resources, disposal services	No flows		Resources, dis-posal services	
Sum					
'Primary Input'	No flows	No flows			
Total input					

Contrary to the disposal of waste and sewage, the assimilability (services) of the nature are 'free of charge' up to now. Besides, the monetary disposition of the nature is not payed either by the industrial sectors. Therefore natural assimilability and resources are treated like subsidies. The coefficients of the natural outputs appear in the input-output table (Table 11) as negatives.

The idea to include negative x_{ij} and eventually negative a_{ij} into the input-output analysis is not revolutionary. In particular within the primary input quadrant negative values for the

Table 11: Monetary part of the ecological input-output model (example)

into from	Agrar-dustry	Service	Nature	Sum	Privat Consum	Govern. Expend.	Invest.	Ex-port	Total Output in mill. $
Agridustry	24	8	0	32	16	0	12	5	65
Service	15	20	0	35	5	5	4	1	50
Nature: Resources	-7	-2	0	-9	0	0	0	0	-9
Assimilability	-4	-2	0	-6	0	0	0	0	-6
Total	28	24	0	52	21	5	16	6	100
Net Value Add	16	12	0	28					
Depreciation	8	7	0	15					
Import	2	3	0	5					
Indust. Inputs	54	46	0	100					
Natural Depr.	11	4	-15	0					
Total Input in mill. $	65	50	-15	100					

positions 'tax-subsidies' or 'company profits' are known for long time. The new and interesting aspect is to include the negative values into the intermediate quadrant. Economically the idea of natural subsidies may be new but acceptable. However, mathematically the negative x_{ij} and especially the negative a_{ij} have to be scrutinized closely. Technically the Leontieff inverse can not be calculated reasonably with negative a_{ij} without the following assumptions:

A1 $a_{ij} >= 0$, $i,j = 1...n$ (former intermediate sectors)

A2 $a_{ij} <= 0$, $i = n+1$ (nature)

A3 $a_{ij} = 0$, $j = n+1$ (nature)

The first assumption describes the condition for the ordinary intermediate relationships, which do not include the sector 'nature'. The output of the sector nature, that is considered as 'natural subsidies' is negative or zero, i.e. the production value of sector j is decreased by the estimated value of natural resources and assimilability used by sector j (assumption

A2). Assumption A3 shows, that the production process does not provide input for the production of natural resources, that is not already calculated within the usual costs of production and therefore already included within the ordinary monetary tables. E.g. old steel products, that are recycled are part of the market process and can not be considered again. With the exception of 6500 tons (0.001% of total flows), this assumption is consistent with the physical input-output tables provided by the German office of statistics. According to the official statistics roundabout 6500 tons construction waste per year are used for the renaturization of soft coal mines. It is assumed, that the existing costs e.g. for transport are included in the ordinary tables and that the actual value of this waste for generating natural resources is zero.

Another critical point is, that though the value of resources is not yet considered in the monetary tables, the according costs for using these resources are considered already. If finally the value of the natural output is calculated within the i-o framework, these costs should be separated and added to the sector 'nature'. Thus the subsidies would become smaller.

3 The Analytical Part of the Input-Output Analysis

3.1 The Input Coefficients

The descriptive part of the input-output analysis provides an overview about the momentary status of reality. The analytical part of the input-output model delivers information about the consequences, if the status quo is changed.

The intermediate quadrant is the heart of the analytical part. It is often referred to as the interindustry matrix and represents the economic interdependencies of an economy. With the knowledge of these economic linkages it is possible "to measure the effects of a change in output levels of one sector on the output, income or employment levels of other sectors. Any change in output of one sector will set in motion an economic reaction path, via these economic linkages, to other sectors in the economy" (JENSEN,R./WEST, G. 1986, p. 4).

The term x_i represents the total output of sector i and x_{ij} stands for the output of sector i, that is absorbed by sector j as input. The products of sector i that are consumed by the final demand sectors are characterized as y_i. Then the input coefficients a_{ij} are formulated as shown below:

$$(1) \quad a_{ij} = \frac{x_{ij}}{x_i}$$

Since, for analytical purposes, the a_{ij} of the intermediate quadrant are of specific relevance, formula (1) is applied for the first quadrants of table 3 and table 10 (ecological input-output modeling = ecolio). The resulting matrices are generally called A-matrix.

$$\text{A-matrix}_{\text{Table 3}} = \begin{pmatrix} 0.37 & 0.16 \\ 0.23 & 0.40 \end{pmatrix} \qquad \text{A-matrix}_{\text{ecolio}} = \begin{pmatrix} 0.37 & 0.16 & 0 \\ 0.23 & 0.40 & 0 \\ -0.17 & -0.08 & 0 \end{pmatrix}$$

Starting from the A-matrices the Leontief inverse $(I\text{-}A)^{-1}$ can be calculated.

The sets of equations are built upon the assumption of equal input and output. Because of the common assumption of non-negative output, the coefficients of the LEONTIEF inverse are non-negative. The ecological model functions differently. While the output of the industrial sectors is treated as usual, the natural inputs are regarded as environmental subsidies and are subtracted from sectoral inputs (Table 10). Since the nature is incorporated into the intermediate quadrant, negative coefficients appear - for the first time - within the LEONTIEF inverse. The LEONTIEF inverse according to Table 3 and the inverse of the ecological approach are:

$$(I\text{-}A)^{-1}_{\text{Table 3}} : \begin{pmatrix} 1.76 & 0.47 \\ 0.68 & 1.85 \end{pmatrix} \qquad (I\text{-}A)^{-1}_{\text{ecolio}} : \begin{pmatrix} 1.76 & 0.47 & 0 \\ 0.68 & 1.85 & 0 \\ -0.35 & -0.23 & 1 \end{pmatrix}$$

Due to the assumptions A1, A2 and A3 the matrix calculation does not interfere in the interindustrial part.

3.2 Input-Output Multipliers

Input-output multipliers are known as output, income or employment multipliers. Most popular is the output multiplier, which represents the total change of output in all sectors of the economy that is necessary to satisfy one unit change in the final demand of sector j.

First the output multiplier of the sector 'Agridustry' in the economy described by Table 3 is calculated here. Therefore, the final demand of this sector is increased by one dollar ($\Delta y_1 = 1$). Simultaneously the multipliers are calculated without sector 'nature' in Table 3 and with 'nature' in the ecological model.

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 1.76 & 0.47 \\ 0.68 & 1.85 \end{pmatrix} \times \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 1.76 \\ 0.68 \end{pmatrix}$$

$$\text{multiplier}_{\text{Table 3}}: \quad \Sigma\ 2.43$$

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 1.76 & 0.47 & 0 \\ 0.68 & 1.85 & 0 \\ -0.35 & -0.23 & 1 \end{pmatrix} \times \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 1.76 \\ 0.68 \\ -0.35 \end{pmatrix}$$

$$\text{multiplier}_{\text{ecolio}}: \quad \Sigma\ 2.08$$

On the one hand, the additional outputs of x_1 as well as of x_2 are equal for the conventional and the ecological approach but on the other hand, since nature is included into the latter approach, the total multiplier gets smaller. Including the sector 'nature' one dollar additional demand for the Agridustry results in a total effect of \$2.08 (including initial dollar). Without considering the nature the effect is \$2.43. The same procedure applied for the sector 'service' results in the following multipliers:

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 1.76 & 0.47 \\ 0.68 & 1.85 \end{pmatrix} \times \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0.47 \\ 1.85 \end{pmatrix}$$

$$\text{multiplier}_{\text{Table 3}}: \quad \Sigma\ 2.32$$

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 1.76 & 0.47 & 0 \\ 0.68 & 1.85 & 0 \\ -0.35 & -0.23 & 1 \end{pmatrix} \times \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0.47 \\ 1.85 \\ -0.23 \end{pmatrix}$$

$$\text{multiplier}_{ecolio}: \qquad \Sigma\ 2.09$$

The ordinary approach would cause a service multiplier is of \$2.32, that is smaller than the agrardustrial one with \$2.43. But since the natural inputs for the service sectors are below the agrardustrial level, the service multiplier generated by the ecological approach is larger (\$2.09 > \$2.08) (SCHAFFER (1998), p. 20). Instead of evaluating the natural resources or the assimilability services the user could simply apply trash-coefficients at the end of the analysis. In fact the evaluation of the assimilation is quite close to trash-coefficients. However, evaluating the resources leads to thinking about the natural usage before and not after the production process. Additionally the application of trash-multiplier after the calculation of the output multiplier suggests a linear development, that would not match the idea of different first, second and subsequent round effects.

The Leontief inverse matrix is the key for the calculation of the multipliers. Today input-output software can easily be installed into any modern PC. Within seconds the inverse of a 60x60 matrix is generated. Formerly huge work stations needed hours for producing the inverse of much smaller tables. Hence most of the older software packages are calculating the inverse matrix iteratively. Although the iterative process is no longer necessary, it is still comforting to calculate the inverse matrix this way. Ironically the old-fashioned iterative way represents much more accurately the economical process. While the multiplier generated by the inverse matrix suggests a linear development, the iterative process clearly distinguishes into first-, second-, third- and subsequent-round effects. According to WEST (1986, p. 8), it is "used to estimate each round of purchases, which are summed to obtain the total combined direct and indirect effect. The first-round purchases, which represent the inputs purchased directly by the impacted industry from other firms, are simply given by the direct coefficient matrix A. The second-round effects occur as firms supplying inputs to the impacted industry in turn purchase inputs from other firms, and can be calculated by multiplying the A matrix by itself to get A^2. The process continues with third-round effects given by A^3, and so on. Adding the initial unit change in final demand to the sum of the matrices A^2, A^3, ..., A^k, gives the total direct and indirect effects of a unit increase in sales to final demand of each sector, i.e.

$$I + A^2 + A^3 + \dots + A^k \_ (I - A)^{-1} ."$$

Obviously the effects decrease round by round. In practice, k has to be chosen before the calculation, just that the k^{th}-round effect does not change the result more than marginally.

4 Results for the German input-output tables

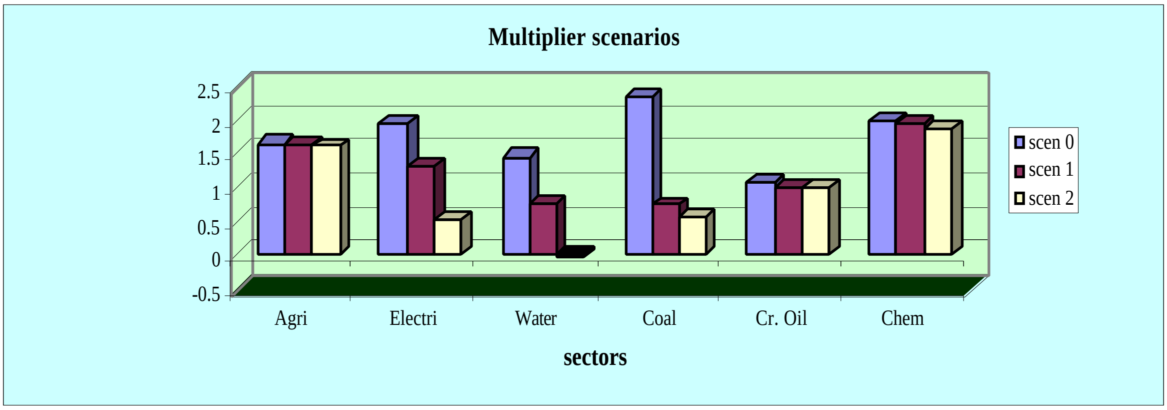
Though many resources and emissions are considered within the official physical tables, there is no common evaluation for only one of these resources or emissions available. Since neither one is part of a market no prices are present and depending on political and ethical positions extremely different values could be imagined. This is exactly what this model is built for. It is the user not the model, who should decide about the value of e.g. solid energy resources, or the disposal and the assimilability respectively of sulphur dioxid. However, two scenarios are presented here. At first the current prices per tons for 59 sectors are calculated by dividing the monetary flows through the physical flows. Since one of the assumptions is the existence of homogeneous production of each sector, the price for the output of sector i should not vary whether it is absorbed from sector j or k. However it does vary significantly (figure2). Several economic sectors produce output, that is similar to the considered resources. The lower prices of these products are the baseline for the appropriate resources. E.g. the prices of output 'water supply' for the resource 'natural water' or prices of coal mining for 'solid energy resources'. The pollution is directly correlated to the usage of resources. To avoid a double pay (usage of resources and generating pollutants), the emissions are evaluated by zero for scenario 1. For scenario 2 moderate values are applied. The used values are given in DM and $ per ton in table 11 (1$ = 1.70 DM).

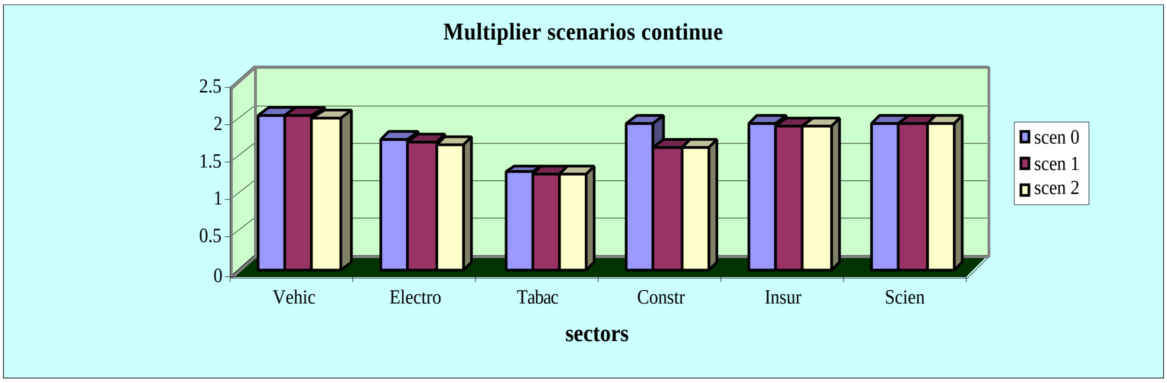
Table 12: Hypothetical prices for the ecological scenarios

	Scenario 0	Scenario 1	Scenario 2
Resources / raw materials	DM / $ per ton	DM / $ per ton	DM / $ per ton
Solid energy resources	0	165 / 97	165 / 97
Minerals	0	60 / 35	60 / 35
Excavation	0	0	1 / 0.59
Other solid materials (stones, clay)	0	120 / 71	120 / 71
Natural water	0	1 / 0.59	2 / 1.18
Oxygen (O_2)	0	0	0.5 / 0.3
Carbon dioxid (CO_2)	0	0	0
Other gases	0	0	0
Pollutants			
Solid waste disposed by nature	0	0	2 / 1.18
Indirect derivated sewage	*	*	*
Direct derivated sewage	0	0	1 / 0.59
Steam	0	0	0
Oxygen (O_2)	0	0	0.5 / 0.3
Carbon dioxid (CO_2)	0	0	1.5 / 0.9
Nitrogen dioxid (N_2O)	0	0	3 / 1.8
Methane (CH_4)	0	0	2 / 1.2
Sulphur dioxid (SO_2)	0	0	1.5 / 0.9
Nitrogen oxids (No_x)	0	0	2 / 1.2
Other gases	0	0	0

The values of nature are hypothetical and only chosen to give a first impression regarding the potential changes of the multiplier. With the help of the zero scenario, the ordinary multiplier can be included into the comparison. Figure 3 shows some examples. The relatively weak punish payments for emissions result in minor changes e.g. for the sectors chemistry and vehicle production, while output multipliers of resource intensive industries such as mining, water supply and electricity decrease significantly. Since service sectors do not need as many resources and do not produce as many emissions (except for the transport field) as manufacturing branches, their output multipliers are much more independent from physical flows and diminish slowly.

Figure 2: Ecological multipliers for selected sectors and the above defined scenarios





Legend:	Agri:	Agriculture	Electri:	Electricity supply
	Water:	Water supply	Coal:	Coal mining
	Cr. Oil:	Crude Oil,	Chem:	Chemistry
	Vehic:	Vehicle production	Electro:	Electronics
	Tabac:	Tabac production	Constr:	Construction
	Insur:	Insurances	Scien:	Science

5 Conclusions

- The ecological input-output approach (ecolio) considers 'nature' explicitly as an intermediate sector. The consideration of nature simply leads to an enlargement of the A-matrix in the form of additional negative coefficients. Therefore the ecological approach is directly comparable with ordinary economic input-output models.
- The examples and the German results show that the consideration of nature can lead to a different result: Table 3 results in a recommendation of an additional demand in the Agridustry sector; the ecolio approach recommends an additive demand in the service sector.
- The key resulting in these differences is the evaluation of nature in monetary terms. Today, monetary terms are seen as subjective terms not expressing intrinsic qualities of anything. Economic evaluation terms are always context-specific. They are depent upon the social-economic conditions of the underlying society. "The environmental literature has identified three basic value relationships which seem to underlie the policy and ethics adopted in society: values expressed via individual preferences; public preferences value which finds expression via social norms; and functional physical ecosystem value" (PEARCE, D. W./TURNER R. K. (1990), p. 22). The evaluation of nature is not fix within the ecolio approach. According to his preferences any user may change the value. Thus user-specific policies can be decucted.
- Without discussing the value of nature in any further depth, the ecological input-output analysis can be recommended for a sensitivity analysis. The ecolio approach can be used to generate the prices of nature when the result of an ordinary economic input-output model alters. The prices for nature depicted, can then be evaluated by the users.

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