# 1 Abstract

This paper yields an introduction into a new domain of National and Regional Input-Output Accounting, called Physical Input-Output Accounting, and undertakes first steps into Physical Input-Output Analysis. In the first part, a summary of the production-theoretical foundations is given and the distinctive features of Monetary and Physical Input-Output Tables are pointed out. Open conceptual problems will be mentioned. In the second part, it is shown that input-output analysis offers both some new methodological problems and new perspectives as well. The problems refer, for example, to the comparison of Leontief inverses on the basis of Monetary or Physical Input-Output Tables in the context of interlinkages analyses in a broad sense. To illustrate new perspectives of analysis a price model of a modified Sraffian type is presented and an attempt is made to determine a value for the total primary input that consists mainly of natural resources.

# 2 Physical Input-Output Accounting

## *2.1 Introduction*

A physical input-output table (PIOT) is a macroeconomic activity-based physical accounting system. A PIOT comprises not only the product flow of the traditional input-output table in physical units, but also material flows between the natural environment and the economy. Complete material balances can therefore be generated for the various economic activities (Stahmer, Kuhn and Braun, 1997, p. 1).

The physical input-output accounting has many roots. Two main analytical strata can be distinguished, that is production theory and national accounting. The former stratum is represented by Georgescu-Roegen (1971, chapter IX; 1981, p. 56; 1984, p. 28) and Perrings (1987, part I), both developing the physical economy-environment system, and the latter is represented by Stahmer (1988; 1993), United Nations (1993 a/b), Radermacher and Stahmer (1996), Stahmer, Kuhn and Braun (1996; 1997; 1998).
Both strata were interlinked and complemented by Daly (1968), Katterl and Kratena (1990[1]), and Strassert (1993; 1997; 2000a/b).

Moreover, for Physical Input-Output Accounting the way was paved by the introduction of the Materials/Energy Balance Principle (Kneese, Ayres and d´Arge, 1970; Ayres, 1978; 1993) and the Material Flow Accounting (MFA).
A first complete PIOT, that is a macroeconomic material flow account in the form of an input-output table, was presented for Germany 1990 (´Old Länder´) by the Federal Statistical Office (see Stahmer, Kuhn and Braun, 1996; 1997; 1998). As statistical units of materials tons are used. The original matrix comprises 58 production activities of the conventional monetary input-output accounting, plus an additional sector for external environmental protection services. In the meantime, the German input-output accounting has been revised repeatedly and the analytical concept has developed (see below).
Another official national PIOT was established for Denmark 1990 (Gravgård, 1998).[2]

[1] A first attempt to establish a physical input-output table was made by these authors for Austria using input-output data for 1983. This pioneering study presented yet incomplete results, especially with respect to primary inputs and final products.

[2] Also other initiatives should be mentioned, for example, a derivative PIOT for a German Bundesland (Baden-Württemberg, 1990; see Acosta, 1998), a small national PIOT for Italy (Nebbia, 1999), or an experimental 3-sector PIOT for USA, 1993 (see Acosta, 2000, who used revised flow charts for the major mass flows in the US economy, 1993, from Ayres, Ayres and Hammond 2000 in press).

## *2.2 Concept of a Physical Input-Output Table (PIOT)*

A PIOT is a tabular scheme in which n activities (´production processes´ or ´sectors´) are represented by both, their material inputs and outputs, for example measured by units of 1 000 tons. The inputs are detailed by origin categories in the columns and the outputs are detailed by destination categories in the rows.

Figure 1 shows the typical rectangular scheme of an input-output table with three quadrants (I, II, III) where the fourth quadrant is omitted because it does not correspond to the intended exclusive representation of activities with respect to either the composition of inputs or of outputs.
As compared with a traditional monetary input-output table (MIOT) in a PIOT the quadrants II and III are subdivided into two components, A and B, respectively (figure 1):

In a first step, let us assume that the components I, II A and III A correspond completely to a MIOT (for modifications see below). Then, for a PIOT is essential that the components II B and III B, which are omitted in a MIOT, are added now.

To be complete in terms of a material balance and to show the total production on the input side and the output side as well, in a PIOT principally it is necessary to include these two components of primary input and final use respectively. First, we add on the input side, the direct inputs from nature in gaseous, solid or fluid condition. These inputs are typical primary inputs because they are non-produced natural resources (quadrant III B). Second, we add on the output side the outputs of residuals, in terms of solid, fluid and gaseous residuals (quadrant II B).

The extension of the primary input component by the primary natural resources component (quadrant III B) is due to the fact that the products of the economic production system are only transformation products which require a corresponding provision of primary natural resources of low entropy. Without such a provisioning of energetic and material inputs the economic production system would not be viable, because it is not able to create these products itself.
As these primary inputs cross the boundary of the economic production system, one can speak of quasi imports.

In physical terms, economic production is defined as the transformation of a set of energetic and material inputs by a specific production activity into another set of energetic and material outputs. These outputs are either main products, included in the final use component (II B), or joint by-products, so called waste (gaseous, solid, fluid residuals), included in the final production component II B. As these final outputs cross the boundary of the economic production system, one can speak of quasi exports.

| I | II A | II B |
|---|---|---|
| Inter-activity TRANSFORMATION<br><br>Intermediate Production | Final Production A<br><br>Gross National Product Account<br><br>(Y = C+I+EX-IM) | Final Production B<br><br>Residuals<br><br>Solid<br>Fluid<br>Gaseous |
| III A<br><br>Primary Input A<br><br>Use and Conservation of Funds | | |
| III B<br><br>Primary Input B<br><br>Resources from Nature<br>Solid<br>Fluid<br>Gaseous | | |

Figure 1: Scheme of a PIOT with five components

In a MIOT these inputs and outputs, although representing the greatest portion of total production, are excluded, from what follows that a MIOT generally can only represent a relatively small part of total material production and cannot meet the condition of a material balance.

The described construction of a PIOT represents the vision that in the economic production system, as an open subsystem of a finite and non-growing ecosystem (environment), the economy lives by importing low-entropy matter-energy (raw materials) and exporting high-entropy matter-energy (waste) (Daly, 1991, p.xiii). Capital proper and labour are conceived of as funds or agents that transform the flow of natural resources into a flow of products. The added components on the input and on the output side represent the one-way flow beginning with resources and ending with waste, and can be conceived as the digestive tract of an open bio-system that connects them to their environment at both ends (Daly, 1995, p. 151).
Insofar, a PIOT is a descriptive scaffold for the one-way flow or ´entropic flow´ through the economic production system (Daly, 1995, p.151).

Coming back now to the other three familiar quadrants of a MIOT: the transaction or transformation matrix (quadrant I), the final production A, normally called final demand accounting (quadrant II A) and the primary input A, normally called value added accounting (quadrant III A).

In terms of the System of National Accounts (SNA) the final demand corresponds to the gross national product account (consumption plus gross investment plus exports minus imports) and the primary input A to the gross national income account including wages, interests, rents and profits and depreciation and public transfers.

Here, in the physical context, instead of the monetary value added accounting we have, as the physical counterpart, a physical fund-oriented accounting which includes the material input flows needed for maintaining the funds intact[3].
Although not material, in a broader sense of a PIOT also the services of the funds used as inputs for economic production can be recorded[4].

Because a PIOT incorporates materials balances it overcomes the conventional focus of National Accounting which is based on the vision of the economic process as an isolated circular flow from firms to households and back again, with no inlets or outlets, (Daly, 1995, p. 151), and incorporates consequently the Material Balance Approach.
Hence, the accounting is concentrated on the completeness of the material balance and not on the correspondence of the final demand component (II A) to the value added component (III A) as in conventional (monetary) National Accounting.
Consequently, in a PIOT households can get a different role, so that, with respect to their transformation function which does not differ from firms, households can be included in the transaction matrix as a quasi production activity.

## *2.3 Illustration: A PIOT for Germany, 1990: a functional 5-sector version*

In the following, an aggregated version of the original PIOT is used (figure 2, appendix). It is, however, modified under functional respects based on a bio-economic approach proposed by Georgescu-Roegen (1971; 1984) and modified by Strassert (1993; 1997). For the details of the aggregation procedure and conceptual assumptions see Acosta (1997).

The transformation matrix comprehends the following five production activities:

M: Procurement of raw materials for processing through extraction of matter in situ
E: Procurement of effective (available) energy (fuel) through extraction of energy in situ
I: Production of new capital goods (investment): capital fund (assets) and maintenance goods (servicing)
C: Production of consumer goods for manufacturing and private households
P: Environmental protection services: collection and recycling of residuals in the same establishment and further treatment in external protection facilities or storage in controlled landfills.

Only for practical reasons households are not included here. The price model to be presented below (section II) required a corresponding activity set for both the monetary and the physical input-output table used.

For a first characterization of the physical production system of West Germany (´Old Länder´, 1990) we do not refer to the transaction matrix of this 5-sector PIOT but first have a look on characteristic relations/shares which are represented in the total input column and total output row or, what is the same, in the corresponding (aggregated) production account (figure 3).

[3] A fund is defined as an agent in the sense of a natural or artificial system (worker, produced capital good, land) which is used and not consumed, as compared with a stock of goods which is accumulated and de-accumulated by flows. A flow is defined as a stock spread over time. A fund element enters and leaves the production process with its functional unit intact. A fund is a ´stock of services´. (For the production theoretical foundation of a ´flow-fund model´ see Georgescu-Roegen, 1971: chapter IX).
[4] From this point of view, Stahmer introduced time units into physical input-output accounting (see Stahmer, 1999).

| Input | | | | | Output |
|---|---|---|---|---|---|
| Type | million t | % | Type | million t | % |
| Intermediate production | 7 577 | 12,7 | Intermediate production | 7 577 | 12,7 |
| Primary Input A: Household wastes plus De-accumulation (stocks, fixed assets) | 2 668 | 4,5 | Final Output A: Household consumption, Accumulation (stocks, fixed assets), Exports minus Imports | 3 603 | 6,1 |
| Primary Input B: Materials from nature: | 49 230 | 82,8 | Final Output B: Residuals to nature: | 48 997 | 81,2 |
| Solid | 1 901 | 3,2 | Solid | 1 871 | 3,1 |
| Fluid: | | | Fluid: | | |
| - process water | 6 041 | 10,2 | - process water | 6 125 | 10,2 |
| - throughput w. | 40 166 | 67,5 | - throughput w. | 40 166 | 67,5 |
| Gaseous | 122 | 1,9 | Gaseous | 835 | 1,4 |
| Total Input | 59 475 | 100,0 | Total Output | 59 475 | 100,0 |

Figure 3: Production account of the German PIOT 1990, million t
(Source: Figure 2, original PIOT and own estimation)

On the input side, starting bottom up, we see that 82,8 per cent of the total input are primary (raw) material inputs from nature, that is natural resources in solid, fluid and gaseous condition, which are transformed by all production activities (excluding private households) into a set of outputs. As households wastes and de-accumulations of stocks and fixed assets take a share of 4,5 per cent, the total primary material input amounts to 87,3 per cent of total input. The remainder of 12,7 per cent of total input belongs to the total secondary or transformation production, that is the intermediate production of all production activities excluding private households.

What is the output? On the output side, starting now top down, we have, first, the corresponding transformation production (12,7 per cent), second, the final main products in terms of consumption, accumulation of stocks and fixed assets (material gross investment) plus exports minus imports, with a share of 6,1 per cent, and, third, the total final by-production of material residuals or waste, in solid, fluid and gaseous condition, with a share of 81,2 per cent.

To get an overall vision an efficiency indicator (e) can be used. From the production account (figure 3) follows the gross production equation:

$$TPI + SI = SO + FPA + FPB \quad (1)$$

with
TPI: Total Primary Input
SI: Secondary Input
SO: Secondary Output
FPA: Final Production A
FPB: Final Production B.

$$1 = FPA / TPI + FPB / TPI \quad (2)$$

or

$$1 = y + r \quad . \quad (3)$$

Efficiency (e) is defined as[5] :
$e = 1 - r = y.$ (4)

Using the numerical data from the production account (figure 3) efficiency (e) comes to:
$e = 1 - 48\,997/51898 = 1 - 0{,}94 = 0{,}056.$ (5)

The presented results support the hypothesis that the German economy represents the type of a so-called throughput economy (Strassert, 2000 a). The transformation capacity of the economy is still so low that the Total Primary Input is almost totally transformed into residuals[6].

For a more detailed analysis of the properties of the German throughput economy see Strassert 2000 a; also Strassert 2001 in press).

## *2.4 Open conceptual problems*

In an early phase of physical input-output accounting it is quite natural that a lot of conceptual questions is still under discussion. An important example out of a set of ambiguities is the water problem. On the one hand, a comprehensive approach is preferred (the German case), where all water quantities are counted, that is the water quantities directly related to a production process (process water) or indirectly related to a production process, as it is especially the case for cooling or irrigation water.
On the other hand, a more restrictive approach, in principle oriented to process water, is suggested (Ayres and Ayres 1998; Gråvgard, 1998; Nebbia, 1999).

The general problem to solve is to avoid that the overall total of all materials is dominated by the quantities of water. This refers not only to raw materials and residuals, but also to products, which also include the quantities of drinking water sold by water supply enterprises. So, when, as in the German case, roughly two thirds of the total quantity of products in tons is drinking water and the overall content of water is about 92 percent, then a PIOT is endangered to represent only a more or less impure water account.

From this point of view, several authors (Ayres and Ayres 1998; Gråvgard, 1998; Nebbia, 1999) propose a restrictive convention; namely that water that participates in an economic process only as a passive carrier of heat or a diluent of waste should definitely not be counted. On the other hand, water that participates actively in a chemical or biological process must be counted on both sides i.e. both as an input and as an output[7].

In contrast to these positions, the German approach is a comprehensive one, that is, it is oriented to a complete picture of all material (mass) flows through the economic system, but in such a way that active and passive water is separated. In an actual and revised version of the German PIOT the primary input component comprises two corresponding water categories. Besides, a complementary own water account was presented from the beginning of physical input-output accounting.

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[5] For an ecological context see Ulanowicz, 1986; for an economic context see Strassert, 2000c.

[6] From the point of view of National Accounting a complementary calculation is of interest: As Final Production A corresponds to the Gross National Product (GNP) with a share of only about six per cent of Total Material Output, we can say, the other way round, that Total Material Output is about sixteen times higher than material GNP.

[7] Consequently this means ´that water and carbon dioxide consumed in photosynthesis, together with water vapour and carbon dioxide produced by respiration (as well combustion) must both be included. The same is true of oxygen consumed by respiration and combustion and generated by photosynthesis´ (Ayres, Ayres and Hammond 2000 in press).

Considering the different positions, the general problem arises, how to draw appropriate analytical borderlines of production processes and corresponding statistical units[8].
From the point of view that ´every production system of any type whatsoever is a system of elementary processes´ and ´that the concept of elementary process is well defined in every system of production´ (Georgescu-Roegen, 1971, p. 235), two different positions are possible: on the one hand, the position oriented to elementary (say physical and chemical) processes, and the position oriented to a certain overall set of elementary processes, on the other hand.

Although both positions are related to a functional perspective, the latter position includes some organizational and institutional elements as it is the case when an establishment is chosen as a basic statistical unit. This position, letting aside practical statistical aspects and recording principles, has a proper justification insofar as all water is a complementary and therefore essential input with the consequence that the transformation process cannot take place without it (independently of the fact that passive water, say cooling water, undergoes any transformation or not). In this context, one should remember that cooling water belongs to the material input flows needed for maintaining the funds intact.

Similar convention problems, albeit possibly different solutions, apply to air[9], overburden, crude metal ores or biomass in agriculture (See, for example, Ayres and Ayres 1998).

# 3 Input-Output Analysis: New Perspectives

## *3.1 Impact analysis*

The focus is now on the common input-output model, that is the open, static, demand driven Leontief model, in matrix notation:

$$\mathbf{x}^m = \mathbf{L}^m \mathbf{f}^m \qquad (6)$$

where the upper m indicates that the model refers normally to a monetary context
with:
$\mathbf{x}^m$: a vector of gross output
$\mathbf{f}^m$: a vector of final output (in a monetary context called final demand)
$\mathbf{L}^m$ : a matrix called Leontief inverse.

In a physical context, the formula continues but all components change essentially. Now, the upper p indicates that the model refers to a physical context:

$$\mathbf{x}^p = \mathbf{L}^p \mathbf{f}^p \qquad (7)$$

As concerns the left hand side, remember that in a PIOT gross output ($\mathbf{x}^p$)is by far more comprehensive than in a MIOT because the physical flows represented by monetary terms are only a small portion of total flows.
The differences on the right hand side refer to both $\mathbf{f}^p$ and $\mathbf{L}^p$. the final output $\mathbf{f}^p$ is composed of the components **f**-A and **f**-B and we know from the production account (fig. 3) that the latter component, normally omitted in a MIOT, accounts for about 80 per cent of total flows (physical gross production).

The Leontief inverse $\mathbf{L}^p$ is different because the physical matrix of input coefficients ($\mathbf{A}^p$) is different. This follows from the fact that a MIOT can only depict a relatively small portion of total material flows included in a PIOT. Generally, the results of a physical Leontief inverse $\mathbf{L}^p$ can be considered to be more reliable when the

8 In a sense, one can speak of a revival of an old debate in input-output theory concerning functional or institutional concepts of data representation.
9 Excluding the air mass that ´accompanies´ the flow of used oxygen, nitrogen and carbon dioxide (Nebbia, 1999, p. 6).

data base is a PIOT than a MIOT. The interindustry linkages within the flow network of an economy depend predominantly on the physical working conditions of the production system which are represented by the network of material flows and corresponding technical input coefficients.

From this point of view, a monetary Leontief inverse $\mathbf{L}^m$ can be considered equivalent if it refers to monetary flows which are comprehensive in the like manner as a PIOT, and the intrinsic weights correspond to the so-called eigenprices (dual price system). But both conditions are not fulfilled in actual MIOTs. Therefore, monetary and physical relations deviate from each other.
The German example confirms that monetary and physical matrices (matrix of input coefficients, **A,** and Leontief inverse, **L**, and comparisons element by element only has the the result of a non-uniform pattern of coefficients. It seems dispensable to investigate more in this context since nothing more can be revealed than the problem of an adequate representation and recording of the flow network of an economy[10].

## *3.2 A Price model based on a PIOT*

A PIOT opens a new opportunity to apply a price model. When we dispose of physical system as represented by a PIOT it makes sense to take it as a so-called primal system and to ask for the so-called dual system, that is, for the price relations which are inherent in the physical system.
In principle, such a price model approach corresponds to the solution of a so-called eigenvalue problem, for example written as follows:

$$p = \gamma A^T p \qquad (8)$$

with
**p**: a column vector of prices (called eigenprices)
$\gamma$: a scalar, that is $\gamma = (1 + r)$ (see below)
$\mathbf{A}^T$: the transpose of the matrix of input coefficients.

The set of solutions presupposes that the co-called characteristic determinant equals zero:

$$D(\lambda) = \det(\mathbf{A}^T - \lambda\,\mathbf{I}) = \mathbf{0} \qquad . \qquad (9)$$

If $\lambda$ is known, then, since $\lambda = 1/\gamma$ and $\gamma = 1 + r$ also r is known:
$r = \gamma - 1$.

This approach refers to Sraffa (1960).
The scalar $\gamma$ represents an overall relation between total secondary (intermediate) and total primary input. It is postulated that for all activities of the transformation matrix total secondary (intermediate) input has to yield a value added by the same rate r. From this follows that after solution of the price model total primary input (see figure 1, quadrants III A + B) all activities have an equal proportion of total input.

The initial idea of Sraffa, who could not know a PIOT as defined above, was that total secondary (intermediate) input represents the productive capital which is expected bearing interest at the same rate. His point of view was the correspondence of that part of final output, called surplus, which in fig. 1 is represented by quadrant II A, and that part of primary input, called value added, which in figure 1 (appendix) is represented by quadrant III A. He

[10] The comparison of Leontief inverses is not an easy task as it may seem at a first glance. In a monetary matrix it is easier to come, for example, to an overall measure for interindustry linkages because addition of elements , especially by columms, is possible. This is not the case with a physical Leontief inverse where an addition of quantities (t) of different kind would not make sense.

wanted to solve the so-called imputation problem, that is, the distribution of total surplus to the famous trinity of production factors, labour, capital and land according to their productivity.

In a physical context, the perspective widens. As shown above (figure 3) the material importance of quadrants II A and III A is relatively tiny whereas the material importance of quadrants II B (residuals) and III B (resources from nature) is relatively marked. Therefore, the imputation problem is much more comprehensive, that is, it refers to the correspondence of total final output (quadrants II A+B) to total primary input (quadrants III A+B). In this context, a price model based on a PIOT opens an opportunity to put a step forward towards pricing the use of natural resources.

We use the Sraffian type of a price model because it is apt to the theoretical problem that the vector of prices cannot be determined independently of the rate r and, vice versa, the rate r cannot be determined without knowledge of the vector of prices.

In the following, we present the results of a price model of the Sraffian type, although with an important modification, applied to the above presented PIOT for Germany 1990 (figure 2, appendix).

To begin with our example, we have five price equations for prices we denominate Sraffian prices ($P^s_i$):

$$P^s_1 = (1 + r) (P^s_1a_{11} + P^s_2a_{21} + P^s_3a_{31} + P^s_4a_{41} + P^s_5a_{51}) \quad (10a)$$
$$P^s_2 = (1 + r) (P^s_1a_{12} + P^s_2a_{22} + P^s_3a_{32} + P^s_4a_{42} + P^s_1a_{52}) \quad (10b)$$
$$P^s_3 = (1 + r) (P^s_1a_{13} + P^s_2a_{23} + P^s_3a_{33} + P^s_4a_{43} + P^s_5a_{53}) \quad (10c)$$
$$P^s_4 = (1 + r) (P^s_1a_{14} + P^s_2a_{24} + P^s_3a_{34} + P^s_4a_{44} + P^s_5a_{54}) \quad (10d)$$
$$P^s_5 = (1 + r) (P^s_1a_{15} + P^s_2a_{25} + P^s_3a_{35} + P^s_4a_{45} + P^s_5a_{55}) \quad (10e)$$

with the following input coefficients:

| | | | | | |
|---|---|---|---|---|---|
| 1 | 0,128669 | 0,000027 | 0,466901 | 0,003941 | 0,006115 |
| 2 | 0,001651 | 0,018109 | 0,000499 | 0,006458 | 0,004735 |
| 3 | 0,000099 | 0,000079 | 0,006994 | 0,000030 | 0,025714 |
| 4 | 0,116965 | 0,038656 | 0,178375 | 0,072620 | 0,186622 |
| 5 | 0,008886 | 0,000000 | 0,017863 | 0,000786 | 0,042370. |

The solution follows three conditions:

- (one) r and all $P^s_i$ have to be determined simultaneously
- r has to be positive
- one price must be given.

In a next step standardization is necessary because the Sraffian prices are not independent of alternative takings of the same price as given, what means that results will change nominally if, for example, $P^s_2$ is set to one instead of $P^s_i$.
Therefore, the Sraffian prices should be transformed into standardized eigenprices ($P^e_i$) as follows[11]:

$$P^e_i = k_i \, s \quad (11)$$

with

$$k_i = P^s_i \; / \textstyle\sum_i P^s_i \quad (12)$$

(Sraffian price coefficient being constant for the i possibilities to take the same price as given)

[11] For methodological explanations see Strassert 2000b.

*s*: a scalar, defined as the sum of i estimated (actual) prices on the basis of both a MIOT and a PIOT.

With the five eigenprices finally found a hypothetical MIOT was established (figure 4, appendix).

Our focus is now on the Total Primary Input which amounts to 10 553,5 billion DM. Dividing this amount by the corresponding 51 897,4 million t (see PIOT, figure 2) we receive an overall hypothetical price for one t of Total Primary Input of about 203 DM. That means that each ton of the mixtum compositum (solid, fluid, gaseous) has a positive price, in terms of the eigenprice theory, and corresponds to a monetary equivalent of about 203 DM.

We stop here. It is not this result per se we wanted to present but to pursue two purposes. First, the presented price model should serve as an example and practical illustration for new applications of input-output analysis on the basis of the new domain of physical input-output accounting. Second, the presented price model, taken for itself, should initiate further discussion of methodological and practical aspects and complement the agenda of the so-called ecological pricing.

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***Figure 2:.A Physical Input-Output Table for Germany 1990 (´Old Länder´) for Five Functional Activities, Million t***

| | | Output | M Extraction of Matter in situ | E Extraction of Energy in situ | I Production of Capital Goods | C Production of Consumer Goods | P Environ-mental Protection | IO Interme-diate Output | FO-A Final Output A: Household Consump-tion plus Investment plus Exports minus Imports | FO-B Final Output B: Residuals (gaseous, solid, fluid) | TO Total Output | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Input | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| 1 | M | Extraction of Matter in situ | 295,1 | 0,1 | 551,8 | 178,6 | 52,5 | 1 078,1 | 32,8 | 1 182,2 | 2 293,1 | 1 |
| 2 | E | Extraction of Energy in situ | 3,8 | 38,1 | 0,6 | 292,7 | 40,6 | 375,8 | - 113,2 | 1 842,4 | 2 105,0 | 2 |
| 3 | I | Production of Capital Goods | 0,2 | 0,2 | 8,3 | 1,4 | 220,6 | 230,7 | 608,4 | 342,8 | 1 181,9 | 3 |
| 4 | C | Production of Consumer Goods | 268,2 | 81,4 | 210,8 | 3 290,9 | 1 600,8 | 5 452,1 | 3 043,6 | 36 821,2 | 45 316,9 | 4 |
| 5 | P | Environmental Protection | 20,4 | 0,0 | 21,1 | 35,6 | 363,4 | 440,5 | 31,0 | 8 106,2 | 8 577,7 | 5 |
| 6 | II | Intermediate Input | 587,7 | 119,8 | 792,6 | 3 799,2 | 2 277,9 | 7 577,2 | 3 602,6 | 48 294,8 | 59 474,6 | 6 |
| 7 | PI-A | Primary Input A: Household Services plus De-accumulation | 0,0 | 0,0 | 0,0 | 0,0 | 2 667,5 | 2 667,5 | | | | |
| 8 | PI-B | Primary Input B: Materials from Nature (gaseous, solid, fluid) | 1 705,4 | 1 985,2 | 389,3 | 41 517,7 | 3 632,3 | 49 229,9 | | | | |
| 9 | TI | Total Input | 2 293,1 | 2 105,0 | 1 181,9 | 45 316,9 | 8 577,7 | 59 474,6 | | | | |

***Figure 4: A Hypothetical Monetary Input-Output Table with Eigenprices according to a Modified Sraffian Price Model***

| | | Output / Input | M Extraction of Matter in situ | E Extraction of Energy in situ | I Production of Capital Goods | C Production of Consumer Goods | U Environ-mental Protection | IO Interme-diate Output | FO-A Final Output A: Consump-tion plus Investment plus Exports minus Imports | FO-B Final Output B: Residuals (gaseous, solid, fluid) | TO Total Output | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| 1 | M | Extraction of Matter in situ | 194 350 | 66 | 363 410 | 117 624 | 34 576 | 710 026 | 21 602 | 778 585 | 1 510 213 | 1 |
| 2 | E | Extraction of Energy in situ | 57 | 575 | 9 | 4 420 | 613 | 5 674 | -1 709 | 27 820 | 31 785 | 2 |
| 3 | I | Production of Capital Goods | 470 | 470 | 19 518 | 3 292 | 518 756 | 542 506 | 1 430 695 | 806 118 | 2 779 319 | 3 |
| 4 | C | Production of Consumer Goods | 12 037 | 3 653 | 9 461 | 147 696 | 71 844 | 244 691 | 136 597 | 1 652 536 | 2 033 824 | 4 |
| 5 | P | Environmental Protection | 14 292 | 0 | 14 783 | 24 942 | 254 602 | 308 619 | 21 719 | 5 679 285 | 6 009 623 | 5 |
| 6 | II | Intermediate Input | 221 206 | 4 764 | 407 181 | 297 974 | 880 391 | 1 811 516 | 1 608 904 | 8 944 344 | 12 364 764 | 6 |
| 7 | PI | Primary Input A + B Household wastes plus De-accumulation | 1 289 007 | 27 021 | 2 372 138 | 1 735 850 | 5 129 232 | 10 553 248 | | | | |
| 8 | TI | Total Input | 1 510 213 | 31 78 5 | 2 779319 | 2 033 824 | 6 009 623 | 12 364 764 | | | | |