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Calculation of direct and indirect material inputs by type of raw material and economic activities

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Summary

This paper presents an ongoing project of the German Federal Statistical Office. In the report a concept is introduced for calculating the Direct Material Input (DMI) in raw material equivalents (RME) in a break down by type of raw material and economic activities. Compared to the original figures the RME additionally include the indirect raw material inputs that are related to the international trade flows. Due to that comprehensive recording of the material inputs the RME is much more suitable for estimating the environmental pressures that are connected with the international trade flows, i.e. that indicator is more appropriate for dealing with the issue of global responsibility, than the original indicator. A breakdown of the indicator by type of raw material is a precondition for linking the use of raw material and the related impacts on the state of the environment more closely. The disaggregation of the material flows by economic activities provides a link to the economic driving forces for the use of raw material.

For calculating co-called indirect effects, which are the basis for estimating RME, the approach of expanded hybrid input-output table (IOT) has been developed, which combines the standard monetary IOT with detailed use tables in physical units.

The project presented in this paper will close a methodical gap in the SEEA, as the calculation of raw material equivalents of the DMI in a break down by type of material and economic activities has not been covered so far in the handbook. Major steps of the project have already been put into practice. First results of an interim step are already available and can be applied for analytical purposes.

1. Introduction

A central point of this paper is the presentation a concept for calculating the Direct Material Input (DMI) in raw material equivalents (RME) in a break down by type of raw material and economic activities. The original DMI-indicator covers the domestic extraction of raw materials from the environment and all imported products in weight units. However, the weight of the imports in original values represents only a part of the weight of the total materials that where used to manufacture these products. Against this, the RME-concept achieves a total coverage of the material input by additionally including the indirect use of material for the production of the imported products. Generally, calculating indirect effects means, to assign the raw material inputs of an economy to the final uses. By that approach the raw materials that were used over the whole production chain are assigned to the final products, including the raw materials that were consumed for manufacturing the imported products in the rest of the world. RME can be calculated for the indicator Direct Material Consumption (DMC) accordingly. The DMC is obtained by subtracting the exports from the DMI. Due to the comprehensive recording of the material inputs the RME is much more suitable for estimating the environmental pressures that are connected with the international trade flows, i.e. that indicator is more appropriate for dealing with the issue of global responsibility, than the original indicator.

The calculation of RME was already recommended in the EUROSTAT-handbook[1] on economy wide material flow accounts. However, the handbook refers only to calculating RME for the total of imports or exports. The new view that is added by the approach of the German Federal Statistical Office (FSO) presented in this paper is the calculation of indirect effects in a breakdown by type of raw material and by economic activities. The assumption behind the EUROSTAT approach is that the total DMI measured in RME represents the pressures on the environment that are related with the use of material by economic activities in a sufficient manner. Against that, the approach of the FSO also takes into account that the pressures caused to the environment differ considerably in characteristics and intensity between the individual raw materials. Therefore it is necessary to underlay the indicator of the total DMI by a disaggregation by type of raw material, in order to relate the material flows more closely to their environmental impacts. That insight has to be applied to the figures for RME accordingly. On the other side the disaggregation of the material flows by economic activities provides a link to the economic driving forces of the use of raw material, i.e. the raw material use by type of material can be explained by the economic demand structure and the production conditions.

Several steps have to be passed for calculating RME, like the breakdown of the direct material inputs by economic activities and the calculation of indirect effects for the domestic products. All the interim steps have analytical properties of their own, which will also be highlighted below.

As a first step the FSO has already developed a concept for disaggregating the DMI by economic activities and raw material categories. The breakdown refers to the **direct use** of primary material (i.e. the original values of the DMI) by categories of raw materials and economic production and final use activities in a rather detailed disaggregation. First results of that project were presented at the last London Group meeting in Copenhagen[2]. Meanwhile the data is calculated at a regular basis. There it was demonstrated that those data can be applied for different analytical purposes, like calculation of hybrid indicators as well as more developed approaches, like decomposition analysis. An important point in that project already was that the breakdown of the direct material inputs by economic activities was not only presented for the total DMI, but also in a breakdown by raw material categories.

2. Political and methodological context

The physical flow data of the Environmental-Economic Accounting find growing attention at the political level. An important example in the international area is the initiative of the OECD environmental ministers and the OECD council for establishing an OECD-wide system of comparable material flow accounts may. The data to be created by those efforts will among others serve as a statistical background for the so-called 3R-initiative (Reduce – Reuse - Recycle) which was announced on the G8 summit in June 2004 as a new high-level political initiative as part of a policy towards sustainable development. Furthermore in 2003 the commission of the European Union launched a “Thematic strategy on sustainable use of natural resources” which is gaining more and more impact on the national activities in this area.

At the national level in Germany the headline indicator “raw material productivity” of the German National Strategy on Sustainable Development is a major point of reference. That indicator relates the gross domestic product (GDP) to a subtotal of the DMI, which includes

[1] See: European Commission: Economy-wide material flow accounts and derived indicators – a methodological guide, Luxemburg 2001.
[2] Karl Schoer and Stephan Schweinert: The use of primary material in Germany by branches and material categories, Wiesbaden 2005.
http://www.destatis.de/allg/e/veroe/proser4senv_e.htm

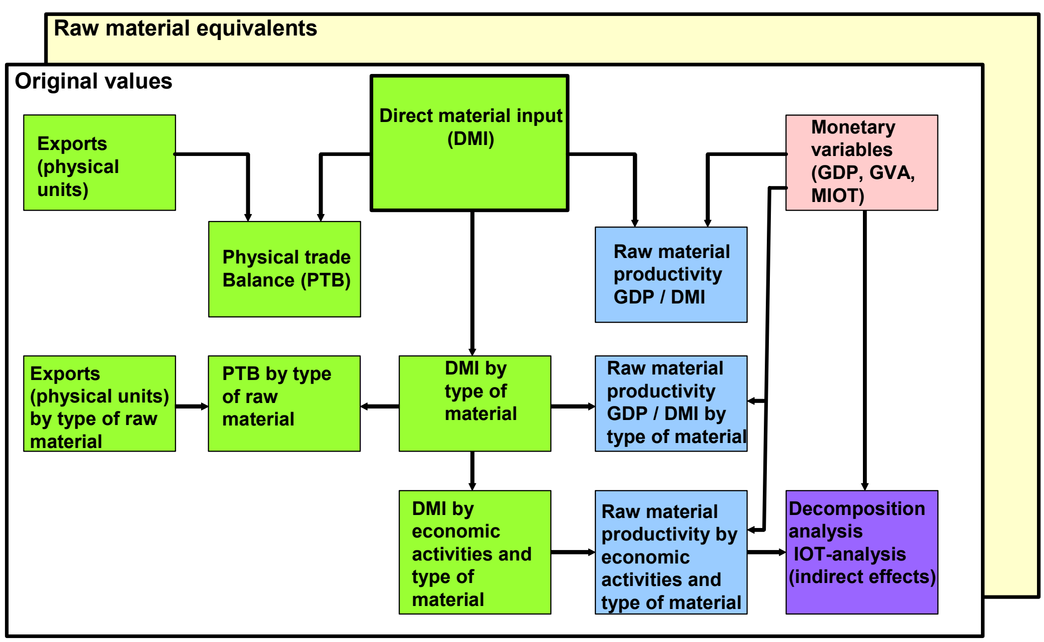
all abiotic primary materials, but excludes the abiotic materials. At present a discussion is going on the raw material indicator in Germany which was initiated by the Ministry of Environment. The aim is to improve the currents indicator by establishing e stronger relationship between the use of raw materials and their impacts on the state of the environment. The efforts may eventually lead to an ecologically adjusted DMI. The disaggregations of the DMI provided in this project could be an important input to that debate.

Methodologically the DMI-indicator is embedded into the accounting system, which covers the pure monetary world of the National Accounts as well as the mainly physical world of the Environmental-Economic Accounting. Figure 1 illustrates the context.

The DMI itself can be used for measuring the direct material input into an economy in physical terms. By adding the exports in physical units a physical trade balance can be established. On the other hand the DMI can be disaggregated by type of material as well as by economic activities. Most important is that that indicator is embedded into a comprehensive and integrated accounting system. By following the concepts and the classifications of the general accounting system, the figures on the raw material flows can be combined with the monetary accounting figures as well as with accounting data on other environmental subjects, like energy, land and water use, or air emissions and waste. By combining the total and the disaggregated figures on material, e.g. hybrid (physical/monetary) indicators, like raw material intensities can be obtained. On the basis of a breakdown by economic activities further, more complex analytical approaches, like decomposition analysis and input-output analysis can be applied.

Figure 1

DMI and related indicators



3. Direct use of primary material

For disaggregating the use of raw material - as well as for disaggregating other material flows - by economic activities or products there are two principal perspectives. The first more straightforward one refers to the direct utilisation of raw materials for production and final use activities (direct use). The second view is to look at the intermediate or final products and it is asked what raw materials in what quantities were consumed over the whole production chain for manufacturing a specific product (indirect use). The availability of data for direct use is a precondition for estimating data on the indirect use.

As far as the direct flows are concerned the SEEA provides two general approaches for disaggregating by economic production and final use activities, the physical input-output table (PIOT) and the NAMEA-concept. In both cases the classification of economic activities, as it is applied for the monetary input-output tables, is used also for the breakdown of the environmental flows. For a schematic description valid for both variants see figure 1.

The PIOT is the more comprehensive approach. As far as the flows within the economy are concerned, the PIOT mirrors the monetary input-output table (MIOT) in physical terms. However the most important point is that it shows in addition to the monetary flows the material flows between the economy and the environment. The environmental inputs of raw material as well as the outputs to the environment (residuals) are shown in a breakdown by type of material. However calculating a PIOT is costly and the data requirements are rather high. The most important information of the PIOT refers to the environmental inputs and outputs. Both points may have contributed that so far PIOT has to be put into practice only in rather few cases, and if, only for pilot years.

Figure 1

Supply and use of products, raw materials and residuals by economic activities and the environment

Supply (domestic production and imports)		Intermediary use				Final use	Output of residuals to the environment			
		PB1	PB2	...	PBn		RS1	RS2	...	RSn
Homogeneous branches	PB1									
	PB2									
	...									
	PBn									
Input of raw materials from the environment	RM1									
	RM2									
	...									
	RMn									

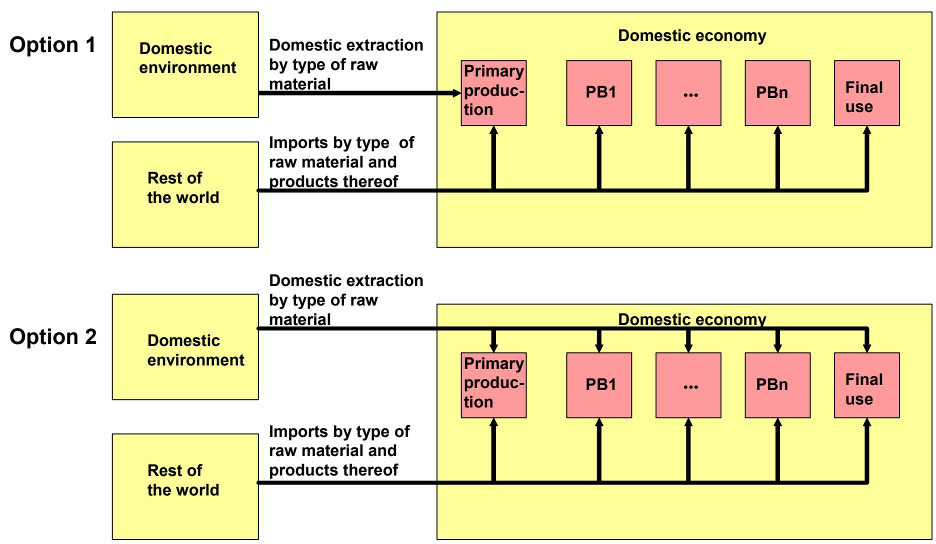
The second and less ambitious approach is the so-called NAMEA-concept. The NAMEA concentrates on the physical flows between the economy and the environment. The accounting matrix, which describes the interrelationship between the economic activities, is shown only in monetary terms. That approach is quite widely used for linking the different type of air emissions (residuals) to the causing economic activities. Those data are usually provided on an annual basis. In that approach also other flows can be related to economic activities, like raw material input which is under consideration in this chapter. Even non-material flows, like the use of built–up and traffic area, goods transport or environment related taxes can be analysed in the same way.

The DMI is measured in weight units. It comprises, as already mentioned, the raw materials extracted from the domestic environment and the imported products (primary material). Import of products includes raw materials as well as semi-finished and finished products. Depending on the purpose either the total DMI or the DMI by type of material could be disaggregated by economic activities. The starting point in this paper for the breakdown by economic activities is the DMI by type of primary material. The primary materials have to be allocated to the consuming economic activities. As far as the domestically extracted raw materials are concerned, there are two options for the treatment of raw materials. The raw materials can be allocated either before or after extraction (see figure 2).

In the first option raw materials are looked at the point where they enter the domestic economy, i.e. they are assigned to the raw material extracting branches. In the second variant the extracting branches are not regarded as users, but are classified rather as extracting agents who provide the service of making available the raw materials. So, in the second option the raw material is assigned to the production branches or final use categories which transform or consume the specific materials. The first perspective may provide useful information as well. But, unlike the figures of the second option, these figures cannot be used for comparing intensities (primary material input / gross value added) of branches. In case of primary branches the output in physical terms is related to the monetary output, but for the rest of the branches this ratio indicates the relationship between a physical input and the monetary output.

Figure 2

Disaggregation of direct use of primary material by economic activities and type of raw material



As already mentioned, those data are already calculated for Germany on an annual basis. In that approach the use of domestic raw material is allocated to the users after extraction. The semi-finished and finished imported products are assigned to the raw material categories according to the main raw material category of which they are made. The database available is shown schematically in figure 3.

It was demonstrtated that those data can provide already a useful basis for analysis, like calculating use intensities in a breakdown by branches or carrying out decomposition analysis. That database can also be used for analysing the environmental effects of international trade. E.g. for Germany it can be shown that during the last decade there was a tendency of shifting extraction of raw material and also primary processing of raw material to the rest of the world.

Figure 3

Direct use of primary materials by economic activities and type of material

Type of material		Economic activities							
		Homogeneous production branches				Final use categories			
		PB1	PB2	...	PBn	Consumption of private households	Public consumtion	Capital formation	Exports
Domestically extracted raw materials	DRM1								
	DRM2								
	...								
	DRMn								
Imported raw materials	IRM1								
	IRM2								
	...								
	IRMn								
Imported semi-finished and finished products assigned to the main type of raw material	IP1								
	IP2								
	...								
	IPn								
Total raw materials and products thereof	DRM1 + IRM1 + IP1								
	DRM2 + IRM2 + IP2								
	...								
	DRMn + IRMn + IPn								

However there are still two types of major shortcomings which are a challenge for a further improvement of the database.

The first one refers to the rather broad disaggregation by category of raw material. For linking the flows closer to the environmental problems, a more detailed breakdown is desirable. This would allow a cross-tabulation of material by detailed type and by economic activities. Such a cross-tabulation is a precondition for linking the environmental problems caused by certain material flows more closely to the economic driving forces (activities).

The second shortcoming refers to the limitations of the figures for imported products:

- The weight of the imported products doesn't show the whole raw material content, as usually only a part of the original mass is incorporated in the finished or semi-finished products. Most of the losses end up as waste or air-emissions in the producing country.
- The assignment of semi-finished and finished products to raw material categories according to the main material gives only a rather rough idea of the actual composition of the raw materials consumed. As this method ignores that often usually more than one raw material category is consumed in the production chain. Such an approach may be acceptable in case of a disaggregation into rather broad raw material categories. However in case of a more detailed breakdown by type of material the results will appear to be increasingly inaccurate.
- By just counting the weight of the imported raw materials it is ignored that also other raw materials are consumed in the producing country for their extraction (especially energy carriers).

The first shortcoming can simply be met by providing a more detailed disaggregation by type of material.

The second shortcoming can be overcome, as already stated in the outset, by converting the original values for the imported products into so-called raw material equivalents (RME). The aim of RME is to cover the total raw material consumption that occurs along the whole production chain for manufacturing an imported product. For the estimation of RME indirect effects have to be calculated. The method for that approach is described in the following chapter.

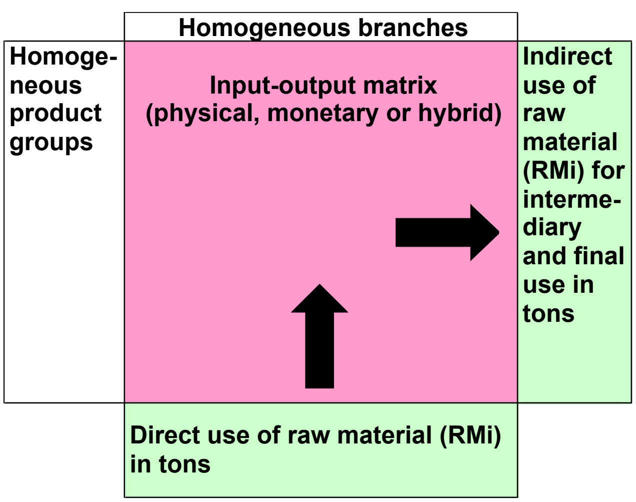
4. Indirect use of raw material

4.1 The concept

As already mentioned, the concept of indirect use of raw material focuses on information on the quantities for certain raw materials and their use as an intermediate input in production or for final use. For single products or individual raw materials it may be possible to obtain an estimate for the whole content of a certain raw material by using information from detailed life cycle analysis. However, our approach is aimed at obtaining a complete picture for the whole economy by including all materials. For such a comprehensive approach estimates can only be obtained in an efficient way by utilising the information on the interrelationship between the economic activities which is contained in the input-output tables. For that calculation a physical input-vector for a specific raw material is combined in a Leontief-type approach with the input-output matrix. This requires a calculation of the use of raw materials by final use categories. In principal a raw material that enters the economy will be combined with other materials and transformed in several steps in the production chain into final products. The mathematical approach simulates this process. As a result of that calculation one gets the assignment of the original raw material quantities to the products (homogeneous product groups) of final use (see figure 4):

Figure 4

Calculation of indirect effects of the use of an individual raw material



Most of the raw material usually enters the production process as an intermediate input. However, another part may also enter directly into final use, like exported raw materials or raw materials that are directly used for the consumption of private households. The first appears to be an indirect input to the final product. Both together the direct and the indirect input comprise the cumulated input.

The IOT-matrix shows the interrelationships between the producing sectors on a certain level of aggregation (within the German IOT about 70 producing sectors, the so-called homogenous product groups, are classified). The following assumptions are made implicitly within the approach:

- The products are produced with a linear technology. That means the relation between inputs used and the output produced is presumed to be constant.
- For any individual product of a homogeneous branch (homogeneous product group), the average input structure of that homogeneous branch is applied.

Therefore the accuracy of the results depends on the degree to which the figures on the use structures by economic activities (the output coefficients) of the IOT-matrix that is applied reflect the actual output structure of the specific raw material that has to be allocated. The suitability of different types of IOT-matrixes for that purpose will be discussed below.

4.2 The principal options for a IO-approach

There are a number of approaches under discussion for the use of IOT for allocating individual raw materials to final use. The three principal options are shown in figure 5. They include the monetary input-output table (MIOT) from the National Accounts, a physical input-output table (PIOT) which depicts the interrelationship between the branches in physical units, or a hybrid input-output table (HIOT), which combines elements of the MIOT and the PIOT:

Figure 5

IOT-matrixes available for calculation of the indirect use of raw material by type of product

Type of IOT matrix		Type of use	Description
Monetary IOT		**Monetary**	**Standard MIOT is applied for each type of raw material**
Physical IOT	**Full**	**Physical**	**Standard PIOT is applied for each type of raw material**
	Simplified	**Physical**	**Simplified PIOT is applied for each type of raw material**
Hybrid IOT	**Simple**	**Mixed monetary and physical**	**1. Special IOT-matrix for each type of raw material 2. The use structure for the first step of the production chain (use of raw material after extraction) is replaced by physical information**
	Expanded	**Mixed monetary and physical**	**1. Special IOT-matrix for each type of raw material 2. The use structures for the first steps (usually more than one) of the production chain are replaced by physical information 3. Symmetrical disaggregation of relevant homogeneous branches of the standard IOT classification**

In the MIOT-approach for each type of raw material information on the direct physical use structure (physical input vector) is combined with the MIOT.

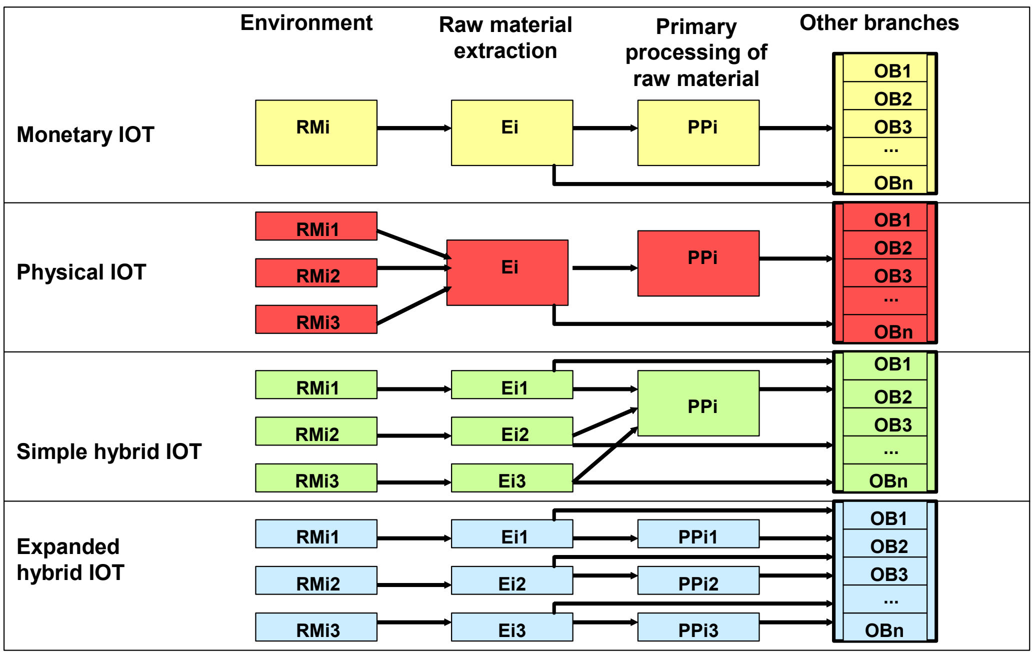
The PIOT-approach applies a physical IOT-matrix with the same standard disaggregation by branches. Compared to that the simplified PIOT approach refrains from disagggregating those branches that are less relevant in terms of material input.

A general feature of the HIOT-approach is that in principal there has to be constructed not only one standard HIOT, but a special HIOT for each type of material. For constructing a HIOT the monetary use structures for the raw material under consideration and related products are replaced by physical information. With regard to the level of branch-disaggregation of the IOT either the standard frame can be used or a symmetrically expanded type of IOT where the relevant production processes for the raw material under consideration, are shown in more detail. Two typical types of HIOT are shown in figure 5, the so-called simple HIOT and the so-called expanded HIOT. The simple HIOT differs from the MIOT only by replacing the first step of the production chain (use of raw material after extraction) by physical information. The expanded HIOT represents an sectoral enhanced IOT matrix. In addition for the expanded HIOT, usually the use structures of more than one step of the production chain are replaced by physical information.

Figure 6 illustrates what type of information is utilised in the different types of IOT-matrices.

Figure 6

Depiction of the flow of a domestic raw material category through the first stages of the production chain by different types of IOT-matrixes



In the example given in the figure the observed raw material category (e.g. metals) consists of three different types of raw material. For each individual raw material a part of the extracted material is used in a special production process for a further processing of that raw material. Another part is directly used by other branches. It is assumed in this example that in the standard IOT there is only one extraction branch for the whole raw material category. The primary processing for that category is also located in one aggregated branch. The example reflects the conditions of the real IOT rather realistically.

Generally it can be stated that miss-assignment in the first steps of the production chain is much more critical for the result than a biased allocation in later stages. The reason is that the materials in the first steps are processed in rather specific processes with special input relations. At later processing stages the original raw material is widely scattered over a large number of branches.

The most widespread approach is using a MIOT for the calculation of indirect effects. The MIOT is easily available as part of the regular programme of the National Accounts with no additional costs. However having in mind the aim of calculating indirect effects for individual raw materials, the MIOT approach will only yield reasonable results for the individual raw materials on condition that the above mentioned “assumption of homogeneity” (i.e. the aggregated monetary output structures represent the physical use structure of the individual material adequately) is valid, especially with regard to the first steps of the production chain. It is more likely that this condition holds for raw materials that are already rather widely scattered over the whole economy in the first steps of the production chain, like energy carriers, than for very specific raw materials which are processed in some few special production processes. To give an example: The MIOT relationship are certainly not appropriate for allocating the raw material copper to the final uses, as the use structures for copper ore and semi-finished copper products certainly differ from the structures for all metals together, which are provided by the standard IOT as a proxi .

There will be some improvement by using a PIOT-matrix because, physical output-structures are applied instead of monetary ones. That means that in the aggregates for the total raw material categories at least the effects of different prices per weight unit are eliminated. But the problem still remains that in purely physical terms the aggregated use-structure can be different from the use-structure for the individual material. Only if it were the aim to allocate the total raw material input and not the individual raw materials to the final uses, the PIOT would be clearly superior to the MIOT.

The simple HIOT-approach will lead to a considerable improvement compared to the results of the PIOT-approach. In this case a special HIOT is established for each type of raw material with physical information for the first step of the production chain. The approach directly includes information on the physical use of the individual raw material. However, in case of copper for example, the simple HIOT approach may still not yield satisfying results, because in the next step of the chain, the primary processing of copper is put together in one production branch with all other non-ferrous metals.

Whereas compiling a complete PIOT is a rather resource consuming task, as the physical relationships have to be estimated over the complete production chain, the data requirement for the calculation of a simple HIOT is comparatively small. As far as no direct physical information is available the required use structures can be derived with sufficient accuracy from the detailed internal supply and use tables for the monetary IOT. A commodity flow table showing the use of goods provides information for about 1500 products.

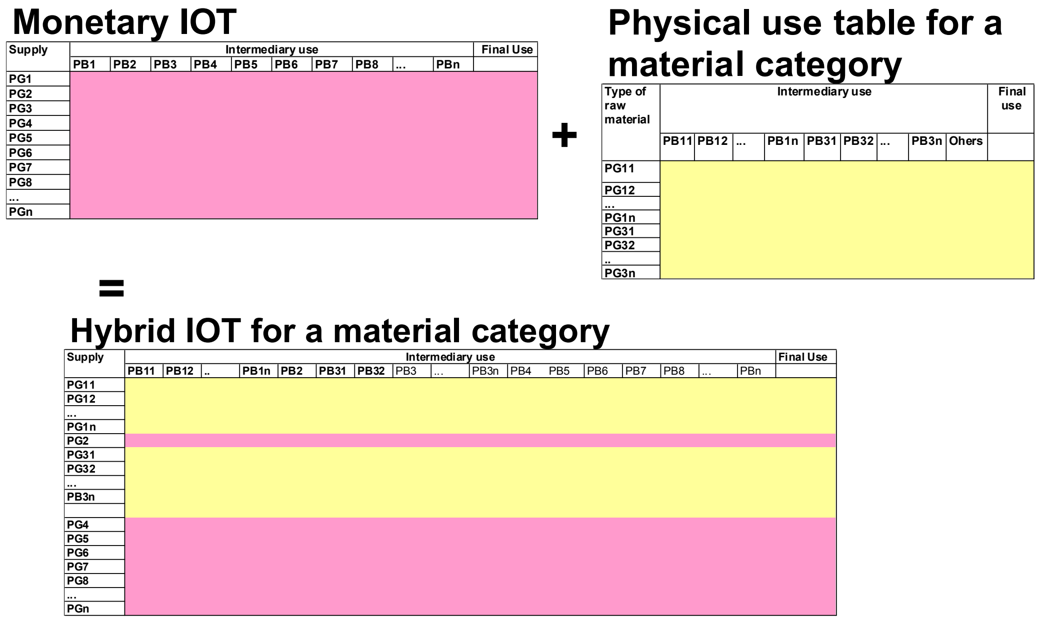
In practice the calculation of indirect effects with the simple HIOT can be done by just combining the MIOT with the respective physical raw material input vector after extraction (see option 2 of figure 2), as that vectors carry already the information of the physical distribution to the first users.

The expanded IOT approach facilitates further improvement of the results compared to the simple HIOT-approach. As can be seen from example shown in figure 6, in that approach the special physical use-structures of the individual raw materials are applied also for the second and if necessary for even more steps of the production chain, due to more detailed disaggregation of the relevant production processes.

4.3 Construction of expanded hybrid input-output matrixes

The approach for constructing expanded hybrid IOT matrixes is illustrated in figure 7.

Figure 7
The elements for the construction of an expanded hybrid IOT



Starting point for an expanded HIOT for a specific type of raw material is the standard MIOT. The specific physical use table for the raw material under consideration has to be integrated into that MIOT for obtaining the specific expanded HIOT.

The procedure of integrating the physical use table into the MIOT is shown below in more detail at the example of copper. The MIOT shows mining of metal ores as well as primary processing of metal ores only as one homogeneous branch respectively (figure 8).

Figure 8

MIOT

Supply	Use			
	…	Mining of metal ores	Primary processing of metal ores	…
…	monetary	monetary	monetary	monetary
Mining of metal ores	monetary	monetary	monetary	monetary
Primary processing of metal ores	monetary	monetary	monetary	monetary
…	monetary	monetary	monetary	monetary

Figure 9 shows a physical use table for copper. The total metal ores and the metal ores after primary processing are split into copper and other metals respectively. The related production processes are disaggregated accordingly. The flows are shown in physical units.

Figure 9

Physical use table for copper

Material		Use					
		...	Mining of metal ores		Primary processing of		...
			Copper	Other metals	Copper	Other metals	
Metal ores	Copper	physical	physical	physical	physical	physical	physical
	Other metals	physical	physical	physical	physical	physical	physical
Metal ores after primary processing	Copper	physical	physical	physical	physical	physical	physical
	Other metals	physical	physical	physical	physical	physical	physical

Figure 10 shows the symmetrically expanded HIOT, which integrates both tables. The row which are taken from the physical use table carry physical units. The inputs of the disaggregated metal branches which are supplied by non metal branches are shown in monetary units. Those cells are obtained by disaggregation of the original values. For estimating that disaggregation a simplified approach can be applied, as miss assignment may have only marginal influence on the final result for the raw material under consideration (copper). The rest of the cells remain unchanged compared to the original MIOT.

The necessary degree of disaggregation of the use table may differ between the individual raw materials.

Figure 10

HIOT (expanded)

Supply		Use					
		...	Mining of metal ores		Primary processing of metal ores		...
			Copper	Other metals	Copper	Other metals	
...		monetary	monetary expanded	monetary expanded	monetary expanded	monetary expanded	monetary
Mining of meta ores	Copper	physical	physical	physical	physical	physical	physical
	Other metals	physical	physical	physical	physical	physical	physical
Primary processing of metal ores	Copper	physical	physical	physical	physical	physical	physical
	Other metals	physical	physical	physical	physical	physical	physical
...		monetary	monetary expanded	monetary expanded	monetary expanded	monetary expanded	monetary

4.4 Indirect use of raw materials for the production of imported products

For the calculation of indirect effects three types of primary material have to be considered as direct physical input, the domestically extracted raw materials, the imported raw materials and the imported semi-finished and finished products. With the approach described above both the domestically extracted as well as the imported raw materials that enter the economy are allocated to the final uses. In addition, there is also an indirect raw material input connected with imported products. This indirect input refers to all materials used for the production of raw materials and of semi-finished and finished products in the rest of the world.

There are two principal approaches for estimating the indirect input of a raw material from the rest of the world:

- The first one assumes that the domestic production conditions sufficiently represent the relationships in the exporting economies. In that case just the domestic IOT-matrix covering inputs from domestic production and from imports can be applied. By doing so the average raw material content of the domestic products is assigned to the respective imports.
- The second approach is based on the production conditions in the exporting countries. Ideally the analysis should be based on IOT covering these very special production processes also. As it is not realistic that this type of comprehensive information could be obtained for all processes, the aim has to be achieved by a simpler co-efficient type approach, which utilises information on direct, and as far as possible, on indirect the raw material inputs into the respective foreign production processes.

Figure 11 gives an overview on the type of approach recommended according to the category of imported product.

Figure 11

Approaches for calculating indirect effects for imported products

Type of approach	Description	Type of product
IOT-approach	Assumption: production process is represented sufficiently by a domestic process	Some raw materials, most finished and semi-finished products
Coefficient-approach	Production process is not represented by a domestic process	Products that are not produced in the domestic economy
Coefficient-approach	Production process is not represented sufficiently by a domestic processes	Products that are produced under climatic, geo-physical or other conditions that are considerably different from the domestic conditions (especially many agricultural and mining products)

What approach is most applicable has to be decided product by product of the detailed product list (about 1500 positions). As it can be assumed that there is a certain convergence of production techniques the IOT-approach will certainly be the standard approach that can be applied to most of the semi-finished and finished products and also some raw materials. The coefficient-approach has to be used for products that are not produced in the domestic economy and for production processes that are considerably influenced by different climatic, geo-physical or other conditions, which may be true in many cases for a lot of biotic raw materials and mining products.

Technically there have to be two different calculations for each type of raw material, one for those imported products that are subject to the IOT-approach and one for those which are treated by the coefficient-approach. Finally the results have to be summed up for each raw material. For the calculation using the IOT-approach, products for which the coefficient-approach is applied have to be deducted from the imports

5. Raw material equivalents

As was shown in figure 1 all indicators that are expressed in the first layer of the graph with their original values can also be expressed in raw material equivalents (RME). As already mentioned, the major aim of the RME-concept is to arrive at a more appropriate description of the international trade flows. For that purpose the original weight of the imported and exported products have to be converted into RME. RME measure the quantity of the different raw materials that have been consumed over the whole production chain for manufacturing a specific product. As discussed above, the weight of the imported products underestimates the "real" raw material content. Therefore the assignment of the imported products can give only a rather rough idea of the actual composition of the raw materials used for their production. This holds also for exported products. If one wants to carry out a meaningful analysis by type of raw material it is indispensable to get better knowledge on the actual amount of the different types of raw material used for the production of the imports and exports.

RME for imports or exports are comprised of the direct and indirect flows of raw materials. Insofar the results of the approach for the calculation of indirect effects for imported products by type of raw material, as described above, can be directly used for the calculation of RME. That approach applies for the exports accordingly. In this connection it should be reminded of the fact, that a detailed breakdown of the DMI by economic activities is an important precondition for calculating RME.

Figure 12 illustrates what elements are needed for arriving at RME by type of raw material:

Figure 12
Raw material equivalents for imported products by type of raw material

Type of product		Type of raw material				Total raw materials
		RM1	RM2	...	RMn	
Direct imports of raw materials	**RM1**					
	RM2					
	...					
	RMn					
Indirect imports of raw materials related to the directly imported raw materials	**RM1**					
	RM2					
	...					
	RMn					
Indirect imports of raw materials related to the direct imports of semi-finished and finished products	**PG1**					
	PG2					
	...					
	PGn					
Total raw material equivalents for imports	**Total**					

These results can be used for recalculating the original values of the different indicators as they are shown in figure 1:

- At the first hand the economy wide figures, like DMI and DMC as well as a physical trade balance can be calculated in RME. On the basis of these results, processes like the tendency of shifting raw material-intensive production processes to the rest of the world may become more transparent. As the original values in that case may indicate a decrease in the use of raw material, the adjusted figure could draw a rather different

figure by indicating no improvement ore even a more intensive, but only indirect use of raw materials.
- The RME by type of raw material are the basis to observe those tendencies at the level of individual raw materials or raw material categories.
- Going back to the details as they are shown in figure 9 may provide a further insight what indirect use of raw material is behind certain imported (or accordingly exported) products.
- The direct raw material inputs by economic activities can also be calculated at the basis of RME. Those figures may also be much more meaningful for analytical purposes than the original figures
- Finally, raw material equivalents by type of raw material could also be applied for calculating ecologically weighted indicators within the system of the material flow accounts. For that purpose so-called specific eco-intensities per ton had to be assigned to the individual types of raw material.

6. The state of the project

The first step of the German project was to calculate figures on the use of primary material in a breakdown by economic activities. These data are available as a complete time series starting with the year 1994 and they are updated annually. The data could already be used for an interim solution by calculating indirect effects with the simple HIOT-approach.

However for a more precise solution expanded HIOT, at least for the most important raw materials are required. The most resource intensive part of the work for achieving this is the calculation of the physical use tables. The state of the work on those tables is documented in figure 13.

Figure 13

The German system of physical use tables for raw material categories

Category of material	Status	Disaggregation
Agricultural products	Under preparation	46 agricultural production processes, disaggregation of food industry and chemical production (only monetary disaggregation)
Wood	Available	Standard IOT classification
Other biotic materials	Planned	
Energy carriers	Available	30 energy carriers and disaggregation of important energy users
Construction and industrial minerals	Planned	
Iron	Under preparation	Disaggregation of iron, steal production and semi-finished iron products
Aluminium	Under preparation	Disaggregation of aluminium production and semi-finished aluminium products
Other metals	Planned	

The agricultural production and the interrelationships within the agricultural sector will be disaggregated into 46 product groups and production processes in a project for establishing the sectoral reporting module agriculture and environment. In a first step the homogeneous branch food products, which includes also the production of animal food will also be disaggregated in that project. First results of this project have already been released[3]. Further results, including the agricultural IOT will be made available in the first part of the next year. Physical use tables for wood and wood products are ready for publication and will be released in the next days. Detailed physical flow tables for energy (in Joules) are internally available and will be published in November this year. It is planned to finish physical flow tables for iron and aluminium by the end of this year. Tables for the remaining raw materials are planed for the near future.

7. Conclusions

The project presented in this paper will close a methodical gap in the SEEA, as the calculation of raw material equivalents of the DMI in a break down by type of material and economic activities has not been covered so far in the handbook. Major steps of the project have already been put into practice. First results of an interim step are already available and can be applied for analytical purposes. Some of the results have already been used for a press conference of the FSO on raw material use in November last year.

[3]Bernd Schmidt und Thomas Osterburg: Aufbau eines Berichtsmoduls Landwirtschaft und Umwelt in den Umweltökonomischen Gesamtrechnungen, Wiesbaden 2005 http://www.destatis.de/allg/d/veroe/berichtsmodullawi.htm