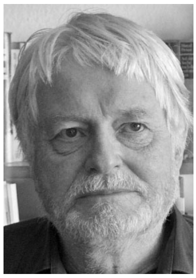
THE MAGIC TRIANGLE OF INPUT-OUTPUT TABLES

Carsten Stahmer[1]

Carsten Stahmer, former professor of statistics at the University of Heidelberg, former member of the German Federal Statistical Office, research fields: economic, social and environmental accounting, Draft of the *System for Environmental and Economic Accounting* (1992) of the United Nations, co-author of the Club of Rome Report *Accounting for the Nature* (1995), co-author of the *Eurostat Manual of Supply, Use and Input-Output Tables* (2008). Website: www.carsten-stahmer.de. Email: carsten.stahmer@uni-bielefeld.de



Abstract: Input-output tables (I-O tables) can play an important role in delivering a suitable data base for studies on sustainable development. Experience has shown that the quality of specialized studies on various aspects of sustainability is enhanced by drawing on I-O tables presented in different units, such as: I-O tables in monetary units for economic issues; I-O tables in physical units (tonnes etc.) for ecological issues; I-O tables in time units for social issues. This article gives a detailed description of the advantages and disadvantages of the three types of units for presenting I-O data. For illustrative purposes, comparable I-O tables using the above-mentioned different types of units are shown describing the German economy in the year 1990. The production boundary is extended to all paid and unpaid human activities, consumer durables and educational services are treated as investment goods.

Key words: sustainable development; German economy; input-output tables; monetary, physical and time units; extended production boundary; educational services as investment

1 Introduction

The discussion on sustainable development tends to focus on the three dimensions of the problem in a one-dimension-at-a-time, disconnected and discontinuous manner. Yet, a strategy apt for reality and policy requires that the social, environmental and economic aspects of sustainability are considered in conjunction. The symbol of such conjunction is the triangle, its corners being the three dimensions. The meeting point of stakeholder interests, but also of economists, environmentalists and social scientists, has to be found in a process of negotiation, possibly by stepwise bargaining and compromising, inside this triangle. All interests/specialists have to come out of their corners to consider other vantage points if a common, mutually beneficial strategy for achieving sustainability is to emerge.

In the following, I want to revisit some tools available for facilitating the understanding both of the dimension-specific aspects of sustainability and for finding the "inner common ground." Input-output tables (I-O tables) can play an important role in delivering a suitable data base for studies on sustainable development. Experience over the past two decades has shown that the quality of specialized studies on various aspects of sustainability is enhanced by drawing on I-O tables presented in different units, such as:

- I-O tables in monetary units for economic issues
- I-O tables in physical units (tonnes etc.) for ecological issues
- I-O tables in time units for social issues

Yet, a comprehensive and policy-oriented analysis of sustainability requires that these three types of I-O tables are used not only separately but also in combination. In the following, a detailed description of the advantages and disadvantages of the three types of units for presenting I-O data will be given. For illustrative purposes, comparable I-O tables using the above mentioned different types of units are shown describing the German economy in the year 1990.

Sections 2 to 4 of this article draw on a paper published ten years ago (cf. Stahmer 2000; see also Eurostat's I-O handbook, Eurostat 2008: 406–424). Nevertheless, the simultaneous presentation of the three different types of units within the same I-O framework has remained unique. Furthermore, the data shown could still be used as a first impression of proportions. The new sections 5 and 6 of this article present some information on the actual discussion applying different types of units within an I-O framework and on the model of a half-day society based on socio-economic I-O tables.

2 General Conceptual Considerations

2.1 Beyond the narrow concept of production

Two concepts of the production boundary of an economy are distinguished in the System of National Accounts (SNA): the traditional approach which mainly includes production for other economic units and a broader concept, also taking into account that part of household production which could be done by third parties (SNA 1993: par. 6.14–6.36).

These concepts seem to be too narrow for analyzing social, economic and environmental problems in a comprehensive way. For describing the social dimension of sustainability, all activities of the population have to be considered. On the average of the whole population including all ages from babies up to retired persons, employment activities comprise only two of the 24 hours per day, whereas all other activities are normally neglected in traditional economic analysis.

It was shown in the 1960s that a useful general activity analysis can be introduced which interprets all household activities as the production of services (Becker 1964; Lancaster 1966). Such a concept is useful for social as well as for environmental studies. Households are producing not only goods (services) but also “bads,” such as wastes and air pollutants.

According to such a comprehensive activity concept, the production boundary as well as the corresponding concept of capital have to be extended. All purchases of consumer durables become part of capital formation, and the depreciation of these goods is part of household costs.

2.2 Beyond the economic concept of transactions

In national accounting, the description of transactions focusses on transactions which are actually carried out in monetary units. In special cases such as barter transactions, non-monetary transactions are valued using comparable market values (SNA 1993: par. 3.34–3.49).

Such an approach cannot be sufficient if the aim is a comprehensive activity analysis. The physical flows of materials from nature to the economy have to be described, as well as all transformation processes within the economy and the material flows back to nature. In the traditional framework, only about a twelfth of the material flows are valued in monetary units, while all other transactions are neglected.

Furthermore, not even all service flows within the household sector are taken into account. The following paragraphs will discuss the possibility of extending this narrow economic concept of transactions, to achieve a comprehensive database for sustainability studies.

2.3 Limits of monetarization

In the 1960s and 70s, many economists hoped to describe economic activities in a comprehensive way using the concept of economic welfare (Nordhaus and Tobin 1972; NNW Measurement Committee 1973; Uno 1995; Diefenbacher 1995; Reich and Stahmer 1983). The measure of economic welfare not only included the traditional economic transactions, but also a comprehensive valuation of all household activities, as well as of the environmental costs of economic activities.

Further momentum for comprehensive monetarization was provided in the 1980s and 90s by the discussions on environmentally adjusted gross domestic product. The aim of these approaches was to calculate a sustainable level of economic activity. Different versions of this measure were presented in the System for Integrating Environmental and Economic Accounting (SEEA) of the United Nations (United Nations 1993; van Dieren 1995). These concepts revealed fundamental differences in comparison to the welfare measures presented in the 1970s. The aim of economic activities cannot only be defined as the maximization of present welfare of people within one country but rather as a path of development which also takes into account the welfare in other countries and the needs of future generations too. It was *A Long Goodbye* (Raymond Chandler) to the dream of overall welfare measurement (Radermacher and Stahmer 1996).

The debate on possibilities of calculating a sustainable level of economic activities has also shown that an approach dealing with sustainability in a national accounting framework has severe drawbacks. Sustainability paths could often only be reached after a longer period of adjusting economic processes. Thus, modeling of future scenarios seems to be unavoidable, which cannot be adequately reflected in the backward-oriented national accounting system. Furthermore, the international interrelationships, especially the global impacts of economic activities and the indirect environmental impacts of imported goods and services abroad, have to be taken into account (Ewerhart and Stahmer 1998; Radermacher 1999). Proops (1991) made a good point in his comments to the World Bank on the SEEA when he proposed the use of the term "global modeling" instead of "national accounting."

Considering this discussion, national accountants may arrive at a more modest approach of additional monetarization. In any case, it seems to be useful to value those non-monetary flows which might have similarities to market transactions and, thus, could be monetarized by using comparable market values. Examples of such imputations are estimates at market values for the flows of natural resources from nature to the economy (e.g. biodiversity), and for the services provided by households as far as they could also be delivered by third persons. This concept is described as version V.1 in the SEEA (United Nations 1993: 124–128; Stahmer 1995).

Of course, such a limited concept of imputed monetary values cannot be sufficient for an extensive description of the social, environmental and economic dimensions of human activities. Household activities not following the third-person criterion, as well as the impacts of economic activities on the natural environment (like climatic changes), cannot be adequately analyzed. In the following paragraphs, several other types of input-output tables are discussed which might play a complementary role.

2.4 Uses of physical accounting

A complete description of the interactions between nature and human beings can only be given by using physical units, such as tonnes, joules, etc. Such physical accounting can show the material flows from nature to the economy, the different steps of transformation within the economy and, finally, the material flows back to nature. Physical accounting also allows consistent balancing of all metabolic processes of living beings, such as plants, animals and human beings. A concept for treating human beings as an integral part of nature seems to be urgently needed (Ayres and Simonis 1994; Strassert 1993, 1998; de Boer et al. 1996).

These considerations have already led to physical accounting as an integral part of the SEEA (United Nations 1993: part III). Similar concepts have been used to compile physical input-output tables in Germany, Denmark and Italy (Stahmer et al. 1997; Gravgard 1998; Nebbia 1999; de Boer et al. 1996). In the case of the German physical input-output tables, units of weight (tonnes) have been used supplemented by a description of energy flows in thermal values (joules) (see also Schaffer 2002).

The physical I-O tables also show physical changes connected with household activities. Of course, these physical processes are mainly transformations of goods into residuals which are stored, treated or disposed of into nature.

The difficulty of taking into account qualitative aspects of material flows is a severe disadvantage of physical accounting. Poisonous and innocuous materials are "valued" only by their weights, but not according to their impacts, e.g. on living beings. Such analysis has to be made in a second step, using suitable weighting schemes. Nevertheless, consistent material balances of all metabolic processes in units of weight are indispensable as a database for all further studies of the physical world.

Another shortcoming of physical accounting is the insufficient description of the production of services. These activities have an increasing importance in all countries. Hence, additional information on services has to be given by I-O tables in other units, e.g. in monetary units or units of time.

2.5 Uses of time accounting

It is an old dream of economic science to describe economic activities by using non-monetary units. It has been discussed over and over again whether it is possible to break through the appearance of revealed monetary values and to discover the hidden mystery of the substance of economic production (Reich 1981, 1989).

In classical economic science, such analysis was carried out by using the necessary labor time for producing goods and services as an indicator of their true values (cf. Wolfstetter 1973; Fleissner 1991; Fleissner et al. 1993). Unfortunately, this approach again raises problems. In which way should skilled labor be weighted in comparison to simple work? Could the contribution of machines, buildings, etc., for producing goods and services be neglected?

These problems could only be solved by introducing the concept of the "frozen" labor time used for producing education services as well as investment goods in the past. Such labor time "melts" in the described present when skilled labor or fixed capital goods are used. Following this concept, depreciation of both education (human) capital and fixed assets can be calculated in time units (cf. Austrian capital theory: Böhm-Bawerk 1889/91; Faber and Proops 1990: especially Chapter 3). In this case, the time of skilled labor is composed of both the actual working hours and the depreciation of the accumulated hours of educational services necessary to achieve the respective level of labor (cf. Schultz 1961, 1962; Becker 1964; Bos 1996; Keuning 1998; OECD 1998).

The transformation of monetary values into time values has to take into account not only direct inputs of working time, but also the labor inputs on preceding stages of production. Such analysis can only be done by using input-output models (cf. Stäglin and Pischner 1976; Flaschel 1980; Engelbrecht 1996). The time directly and indirectly necessary to produce goods and services can be calculated in the following way (Stahmer and Ewerhart 2000):

$$\mathbf{p} = \mathbf{s}(\mathbf{I} - \mathbf{A} - \mathbf{D})^{-1} \qquad (1)$$

Here:

- **p** total labor "cost" of production (vector)
- **s** coefficients of direct labor inputs (related to gross output) (vector)
- **I** the unity matrix
- **A** coefficients of intermediate inputs including imported intermediate products (related to gross output) (matrix)
- **D** coefficients of depreciation by investment good and branch (related to gross output) (matrix)

The Leontief-inverse coefficients in formula (1) also include the coefficients of depreciation **D**. This extension of the normally used inverse coefficients allows an endogenization of the use of capital goods (including the depreciation of human capital). Thus, the time values of products comprise both current and capital costs. (For an extensive introduction to input-output analysis, see Miller and Blair 1985).

As already discussed in section 2.1, a suitable concept of economic activities would comprise all human activities (cf. Pyatt 1990; Aulin-Ahmavaara 1991; Kazemier/Exel 1992; Fontela 1994; Stahmer 1995; Franz 1998. Cf. also Becker 1965; Lancaster 1966; Brody 1970). According to this approach, the inputs of time contain not only the labor hours of occupied persons but also the 24-hour day of the whole population. Such comprehensive description of all activities in an input-output framework has been completed for Germany in spring 1999 (Stahmer and Ewerhart 2000; Aslaksen et al. 1995). For facilitating comparisons with the physical I-O Table 1990, the same reporting year has been chosen. The time I-O table is especially based on the results of a time budget study which has been conducted for the years 1991/92 (Blanke et al. 1996; Franz 1998; Schäfer and Schwarz 1994). Special emphasis has been laid on a detailed description of teaching and studying activities, which improve the educational level of the population.

The values of products according to an I-O table in units of time cannot reflect an ideal concept of true values even if the depreciation of human capital and produced fixed assets are taken into account. It seems to be impossible to include all important factors of production. As an example, the infrastructure of organization and knowledge documented in books and other media cannot be adequately represented in units of time. The present situation is determined by activities which reach back to the preceding decades and even centuries. It seems impossible to transform this influence into data on time use. Furthermore, all environmental problems connected with human activities are neglected in a time I-O table.

Nevertheless, the comprehensive valuation of human activities in units of time has huge advantages. While physical I-O tables can give a complete description of all interrelationships between human activities and their natural environment, the time I-O tables can present a complete picture of all human activities. Furthermore, it allows linkages to quantitative as well as qualitative data on the whole population. Such linked analysis of economic, environmental and demographic aspects of the society has been widely neglected in the past.

This brief presentation of the advantages and disadvantages of the three types of units within an I-O framework has shown the necessity of combining their advantages for achieving a comprehensive description of human activities. The old debate on suitable units of presenting economic activities might be closed by admitting that no approach can be regarded as loser or winner. Instead of fighting against each other, cooperation seems to have a higher priority.

The next section of this article will discuss similarities as well as differences between the three types of I-O tables for describing primary and intermediate inputs, gross output and final uses of the economy in the different quadrants of the tables. The 1990 data of Germany are taken as a numerical example. For comparing the extended versions of I-O tables with the traditional concept, the original monetary I-O Table 1990 is additionally presented (Statistisches Bundesamt 1994). In an introductory section the classification of activities is described.

3 Comparison of the Concepts of the Three Types of I-O Tables

3.1 Classification of activities

A common activity classification has been used for facilitating a comparison between the three types of I-O tables. This classification comprises the breakdown of activities by 58 branches and 30 additional branches normally applied in I-O tables. The activities shown in addition are two branches of environmental protection services (waste water treatment, waste disposal), ten branches of education services (from the level of kindergarten up to university level) and 18 branches of household services containing ten activities related to studying (corresponding with the ten branches of education services).

In the traditional 1990 classification, the environmental protection services and the education services were not separate, but included in the respective branches of enterprises, non-profit institutions serving households and government. The classification used in this chapter is already similar to NACE rev. 1 (see code no. 80: Education services, code no. 90: Sewage and refuse disposal services, sanitation and similar services). The activities of environmental protection and education have been separated from their institutional background and shown in branches comprising all activities of the same kind.

The branches of household services are additional branches. In the traditional context, purchases of households are only shown as part of private consumption. It should be stressed that all activities are included comprising the household production activities (following the third-person criterion) as well as other activities, such as services related to employment (e.g. driving to the work place), study activities, activities of media consumption, social contacts and physiological regeneration.

The I-O tables presented in section 4 of this article are aggregated to twelve branches: agriculture, forestry, fishing; mining, water and energy supply; manufacturing; construction; market services (except environmental and education services); environmental protection services; education services; non-market services; household production services; household services related to employment; household services related to studying; other household services.

3.2 Primary inputs

Table 1 gives an overview of the different types of primary inputs presented in the monetary, physical and time I-O tables. In the case of monetary I-O tables, the traditional one is shown in addition to the extended version.

Primary inputs represent a fresh impetus given to economic circulation. In this sense, primary inputs are treated as external factors whereas intermediate inputs already contain primary inputs of preceding production stages. Thus, they are shown as an endogenous part of the economic circulation. In the I-O tables, primary inputs are presented in the third quadrant of the table, whereas intermediate inputs are items of the first quadrant.

In the traditional monetary I-O tables (Table 1, column 1), three types of primary inputs play prominent roles:

- the production factor of labor measured with its income flows
- the production factor of fixed capital measured with its depreciation
- the flow of imports of goods and services used for domestic production

In addition, the government revenues on products (like non-deductible value-added tax and production taxes) are treated as primary inputs.

Table 1 Primary inputs in the German monetary, physical and time input-output tables (IOT) 1990

Row No.	Description	Monetary IOT traditional million DM (1)	Monetary IOT extended million DM (2)	Physical IOT 1,000 tonnes (3)	Time IOT million hours (4)
1	**1. Labor inputs**	**1,868,800**	**2,584,225**		**554,096**
2	employment	1,868,800	1,866,887		46,268
3	margin of labor and education		–135,814		
4	household activities		853,152		507,828
5	*household production*		*853,152*		*82,312*
6	*activities related to employment*				*12,255*
7	*activities related to education*				*15,430*
8	*other household activities*				*397,831*
9	**2. Revenues on products**	**101,680**	**179,391**		
10	non-deductible value-added tax	28,240	105,951		
11	taxes less subsidies on products	73,440	73,440		
12	**3. Consumption of fixed produced capital**	**303,010**	**572,542**	**42,216**	**36,012**
13	fixed assets (except consumer durables)	303,010	307,874	38,106	9,451
14	consumer durables		126,030	4,110	3,907
15	education (human) capital		138,638		22,654
16	**4. Withdrawal from the non-produced natural capital**			**49,510,759**	
17	water			46,427,665	
18	other raw material			3,083,094	
19	*oxygen*			*810,171*	
20	*carbon dioxide, other air emissions*			*311,838*	
21	*soil excavation*			*1,151,818*	
22	*energy carriers*			*193,347*	
23	*other solid materials*			*615,920*	
24	**5. Imports from the rest of the world**	**342,179**	**502,842**	**387,100**	**16,741**
25	goods (without private consumption goods)	301,892	301,892	342,904	9,441
26	services (without private consumption services)	40,287	40,287	46	1,268
27	private consumption goods and services		160,662	44,150	6,032
28	**Total primary inputs**	**2,615,669**	**3,839,000**	**49,940,075**	**606,849**

In the extended monetary I-O tables (Table 1, column 2) the same types of primary inputs are used, but the contents of the different items are substantially extended.

In the case of labor inputs, imputed values of time spent on household production, according to the third-person criterion, are included. Furthermore, a margin of labor and education is included which balances the depreciation of education (human) capital, as well as additional intermediate inputs regarding household services related to employment. It is assumed that labor income includes components corresponding to the depreciation of education capital, recorded as part of the consumption of fixed produced assets and with the additional costs of households related to employment. To avoid double counting, the income flow has to be corrected by using the mentioned margin.

The extension of the production boundary also influences the other primary inputs of the extended monetary I-O table. Purchases of private consumption products are now treated as intermediate inputs. This concept implies that the non-deductible value-added tax on private consumption products, as well as the imported part of private consumption, are now treated as primary inputs and therefore they are increasing the respective items.

The purchase of consumer durables is part of capital formation in the extended monetary I-O tables. According to this concept, depreciation of consumer durables is treated as a primary input.

Monetary data on economic uses of the natural environment are missing in the extended monetary I-O table of 1990. This compilation work will hopefully be done by the Wuppertal Institute for Climate, Environment and Energy.

Market valuation of the raw materials extracted from nature could be used as a starting point for such an estimation. Estimates of the use of nature as a sink for economic residuals are much more difficult to obtain, because the impacts of present activities are normally only observable in the future. Furthermore, such impacts could be international, even global.

Primary inputs of physical I-O tables (see Table 1, column 3) can only comprise data which could be measured in physical terms. Such information is especially available in the case of raw materials which are withdrawn from nature. These materials comprise water flows, air components, such as oxygen (inputs of animals) or carbon dioxide (inputs of plants), as well as solid materials, such as sub-soil assets. Other physical flows recorded as primary inputs are imported goods from the rest of the world which are used as intermediate inputs.

In physical I-O tables, a presentation of the uses of fixed assets creates difficulties. The concept of depreciation cannot be applied, because decreasing monetary values do not necessarily correspond with decreasing physical stocks. Hence, the so-called gross concept of fixed assets has to be preferred. According to this concept, fixed assets are recorded in two different periods: in the reporting period of investment and in the period when the respective asset is leaving the production process. In this period, a physical flow is shown from final uses back to the branch which had used the asset. Such a flow is treated as a primary input, substituting for the depreciation value of the monetary tables. It increases gross output and is distributed according to the destination of the asset (e.g. being re-used, being treated as waste, or being discharged on controlled landfills).

Such a concept cannot be considered an ideal approach. From my point of view, it would be preferable to treat fixed assets at the beginning of the respective period as intermediate inputs of production processes, and assets at the end of the period as additional inputs of production (cf. the growth model of von Neumann 1945; Lancaster 1971: 164 ff). Such a procedure would allow an endogenous treatment of assets in activity analysis and would also facilitate a description of physical flows connected with fixed assets. Further discussion is necessary to clarify the concepts which should be aimed at.

A comprehensive description of human activities as a primary factor of production can only be given by using an I-O table based on time as the unit of presentation. According to the concepts of time I-O tables (see Table 1, column 4), primary inputs of labor are not limited to the working hours of employed persons, or to the time spent for household production (following the third-person criterion), but comprises the complete time budget of the whole population.

The labor inputs of time (1990: 554.1 billion hours) representing the whole time spent by the population can only reflect quantitative, but not qualitative, aspects of labor. This disadvantage of time accounting can be reduced by introducing a concept of education (human) capital and calculating the depreciation of such capital stock in time units. Such an estimate could be based on information about the accumulated use of time spent for teaching and studying. In a second step, the education capital can be depreciated according to the length of life time persons are using the knowledge accumulated.

A similar procedure has been used to calculate the direct and indirect time inputs which had been necessary to produce fixed produced assets (e.g. machinery, equipment, buildings and consumer durables) used for production purposes. The monetary depreciation of fixed assets could be completely transformed into time units. Furthermore, the imported intermediate inputs are calculated in direct and indirect labor inputs, by assuming that the structures of production (input coefficients related to outputs) are the same for both domestic production and production in foreign countries.

The concept of time used in these I-O tables cannot be sufficient in the field of environmental studies; raw materials withdrawn from nature are normally not produced by human beings. Therefore, they cannot be transformed into production time of human activities. Supplementary data in physical units are necessary to give a more comprehensive picture of the economic-environmental interrelationships.

3.3 Intermediate inputs

The intermediate inputs of economic activities in the different types of I-O tables are presented in Table 2, rows 1 to 11. The intermediate inputs shown in the first quadrant comprise only domestic goods and services used in production processes. Imported intermediate products are treated as primary inputs and recorded in the third quadrant of the I-O tables (see section 3.2).

Table 2 Intermediate inputs and gross outputs in the German monetary, physical and time input-output tables (IOT) 1990

Row No.	Description	Monetary IOT traditional million DM (1)	Monetary IOT extended million DM (2)	Physical IOT 1,000 tonnes (3)	Time IOT million hours (4)
			Intermediate inputs		
1	**1. Product inputs**	**2,041,341**	**4,040,240**	**8,437,839**	**203,487**
2	goods (except water and private consumption goods)	1,031,867	1,031,867	1,565,100	33,915
3	water	8,953	8,953	6,654,051	220
4	services (incl. re-used products, without private consumption services)	1,000,521	992,090	73,872	40,166
5	private consumption goods and services (except water)		879,173	109,279	27,262
6	services related to employment		58,372		14,685
7	intermediate uses of household production services		1,069,784	35,537	87,239
8	**2. Residual inputs**			**4,536,634**	
9	wastes for economic re-use and treatment			140,468	
10	waste water for treatment			4,396,166	
11	**Total intermediate inputs**	**2,041,341**	**4,040,240**	**12,974,473**	**203,487**
			+ Primary inputs		
12	**Total primary inputs**	**2,615,669**	**3,839,000**	**49,940,075**	**606,849**
			= Gross outputs		
13	**1. Product outputs**	**4,657,010**	**7,879,240**	**9,266,130**	**810,336**
14	goods (except water)	2,380,859	2,380,859	2,452,146	77,769
15	water	8,972	8,972	6,661,841	220
16	services (incl. re-used products, except household services)	2,267,179	2,261,702	116,606	83,011
17	household services		3,227,707	35,537	649,336
18	*household production services*		*1,351,755*	*35,537*	*111,302*
19	*services related to employment*		*58,372*		*14,685*
20	*services related to education*		*42,215*		*18,255*
21	*other household services*		*1,775,365*		*505,094*
22	**2. Residual outputs**			**53,648,418**	
23	waste water			49,246,503	
24	water vaporized			1,566,597	
25	other residuals			2,835,318	
26	*oxygen*			*226,052*	
27	*carbon dioxide, other air emissions*			*811,944*	
28	*soil disposal, other solid materials*			*1,507,635*	
29	*wastes*			*289,687*	
30	**Total outputs**	**4,657,010**	**7,879,240**	**62,914,548**	**810,336**

The extended monetary I-O table (Table 2, column 2) differs from the traditional version (Table 2, column 1) with regard to the treatment of environmental protection services and household activities. Environmental protection services for housing (e.g. payments of households for waste water and waste treatment) are not recorded as intermediate inputs of the housing sector (as a part of the rent), but as direct inputs of household activities. The purchases of household consumption goods and services are (except for consumer durables) intermediate inputs of household activities. An additional increase of intermediate inputs of household activities is caused by internal flows of household services which are used as intermediate inputs of other household activities.

In physical I-O tables (Table 2, column 3), intermediate inputs consist of domestic products and of residuals of domestic production which are recycled or treated in environmental protection facilities. Intermediate flows of services are not recorded in the physical table (exceptions are e.g. some equipment for defense purposes or meals prepared in restaurants).

In time I-O tables, the product flows of the extended monetary I-O tables are transformed into the hours directly and indirectly necessary to produce the respective products. In contrast to the physical version, both goods and service flows can be valued in time units (see Table 2, column 4).

3.4 Outputs

The outputs of the different activities (see Table 2, rows 13 to 30) are identical to the totals of intermediate and primary inputs.

In traditional monetary I-O tables (Table 2, column 1), outputs comprise products sold, increases of stocks of own products and products used in the same unit for own purposes (e.g. own-account production of assets). In the case of non-market production, market values of the products are not available. Consequently, gross outputs are calculated as totals of intermediate and primary inputs.

In the extended monetary I-O tables (Table 2, column 2), additional outputs of household activities are shown. These outputs are compiled in the same way as non-market services in the traditional framework, by adding all intermediate and primary inputs of the respective activity. These inputs comprise private consumption goods, depreciation of both consumer durables and education (human) capital and, in the case of household production services (following the third-person criterion), monetary values of the time spent on these activities.

In physical I-O tables (Table 2, column 3), outputs consist of products and residuals of production processes. The outputs of service activities (also including all household activities) normally comprise only residuals. Thus, the importance of the service sector for the whole economy cannot be adequately reflected in a physical framework.

In time I-O tables (Table 2, column 4), outputs are valued by the hours directly or indirectly being necessary to produce the respective goods and services. Such a concept also allows an adequate treatment of all household activities; labor inputs of these activities are valued by the hours spent. As far as imported products are used for domestic production, the time values of these products are calculated by using the assumption that the production processes of both domestic production and production abroad have the same input structures. Furthermore, it has already been mentioned that the depreciation of fixed assets, including consumer durables and education capital, is calculated by the time necessary to produce the respective investment goods and services in the period of investment.

3.5 Final uses

Final uses are outputs of economic activities which leave the economic circulation. They are described in the second quadrant of I-O tables. An overview of the final uses presented in the different types of tables is given in Table 3.

In the traditional monetary I-O tables (Table 3, column 1), four types of final uses are distinguished:

- private consumption
- government consumption
- fixed capital formation (including change in stocks)
- exports of goods and services

Private consumption comprises purchases of private consumption products and the consumption of non-profit institutions serving households. The products purchased disappear into a "black hole," because their further uses in household activities are not described. Furthermore, it is assumed that consumer durables are consumed in one period. This concept reveals the low priority household activities are given in traditional national accounting.

Government consumption comprises all government services which are provided for the whole community, without payment of specific users.

Fixed capital formation contains only investment goods which are used for production purposes. Thus, consumer durables are not taken into account because household activities are not treated as production in the conventional framework. Furthermore, changes of non-produced natural capital are not recorded.

The flows between the home country and the rest of the world only comprise goods and services. Flows of residuals (e.g. air emissions) which might affect the natural environment of other countries are not taken into account.

Substantial changes can be observed in the extended version of monetary I-O tables (Table 3, column 2). Private consumption is now defined as the final uses of household services produced in the different branches of household activities. The aggregates could be interpreted as consumption for own use, similar to government consumption. Similar to government consumption and consumption of non-profit institutions serving private households, private consumption is valued by the costs of household activities (intermediate consumption, depreciation, value of time spent for household activities).

Table 3 Final uses in the German monetary, physical and time input-output tables (IOT) 1990

Row No.	Description	Monetary IOT traditional million DM (1)	Monetary IOT extended million DM (2)	Physical IOT 1,000 tonnes (3)	Time IOT million hours (4)
1	**1. Private consumption**	**1,085,325**	**2,076,030**		**529,997**
2	consumption products	940,548	2,057,337		529,157
3	*goods*	*306,052*			
4	*services*	*634,496*			
5	*household services*		*2,057,337*		*529,157*
6	consumer durables	114,047			
7	consumption of non-profit institutions serving households	30,730	18,693		840
8	**2. Government consumption**	**444,070**	**361,944**		**13,761**
9	except education services	358,994	361,944		13,761
10	education services	85,076			
11	**3. Fixed capital formation**	**425,577**	**685,408**	**733,007**	**40,041**
12	produced natural assets			28,699	
13	machinery and equipment	176,928	176,928	8,554	5,605
14	buildings	248,248	248,248	553,052	8,339
15	consumer durables		114,047	4,403	4,040
16	education (human) capital		145,784	20,949	22,006
17	change in stocks	401	401	117,350	51
18	controlled landfills				
19	**4. Disposal into the non-produced natural capital**			**48,994,384**	
20	waste water			44,846,589	
21	water vaporized			1,565,925	
22	other residuals			2,581,870	
23	*oxygen*			*226,052*	
24	*carbon dioxide, other air emissions*			*811,655*	
25	*soil disposal, other solid materials*			*1,507,577*	
26	*wastes*			*36,586*	
27	**5. Exports to the rest of the world**	**660,697**	**715,618**	**212,684**	**23,051**
28	goods	577,696	602,226	192,591	19,119
29	services	83,001	113,392	17,950	3,932
30	wastes for treatment			2,143	
31	**Total final uses**	**2,615,669**	**3,839,000**	**49,940,075**	**606,850**

The concept of government consumption has not been substantially modified. The treatment of education services as investment is the only conceptual change.

The concept of fixed capital formation shows more important changes in the extended monetary I-O tables. Apart from the treatment of consumer durables as investment goods, the education services and the household services related to studying are treated as fixed capital formation which increases the education (human) capital. The household services related to studying comprise all costs of pupils and students directly associated with their studies (e.g. traveling costs, costs of teaching aids, part of dwelling costs). Further changes of fixed capital formation would be necessary if changes of natural capital were taken into account.

The final uses of physical I-O tables (Table 3, column 3) do not comprise private and government consumption, because all physical inputs of government and private activities are treated as intermediate inputs. The outputs of these activities are services without material counterpart, as well as residuals which partly increase the flows back into nature. Fixed capital formation and disposal into non-produced natural capital are the most important aggregates of final uses in the physical I-O tables. As far as exports comprise physical goods, physical flows to the rest of the world are shown.

The concept of final uses in the time I-O tables (Table 3, column 4) is very similar to that of the extended monetary I-O tables. The value of private consumption, also comprising most of the time spent for household activities, dominates all other aggregates. In the context of fixed capital formation, the increase of education (human) capital also contains the time of pupils and students for studying.

4 Description of the Three Types of I-O Tables

We now move to the three types of tables discussed above, and offer a description of each in turn.

4.1 General comments

In the following paragraphs, there is a brief description of the three types of I-O tables showing German economic activities in the year 1990 (see Tables 4 to 6). Comments will focus on the twelve activities which are presented in the highly aggregated tables. It has already been mentioned that the I-O tables have been compiled from 91 activities (see section 3.1). It is planned to publish the tables in this detailed classification to allow special studies, e.g. on household activities or on education services.

It is not possible to describe all supplementary tables which have been compiled in the context of the three extended I-O tables. It should be mentioned that import matrices are available for all types of I-O tables, showing the imports in a breakdown by product group as well as by using branch and final use, respectively. In Tables 4 to 6, the column totals of the import matrices are only presented as primary inputs of the respective using branches.

Several additional tables are available in the case of physical I-O tables. The data comprise detailed information on the material inputs and outputs of economic activities, which can be further subdivided into complete material balances of energy uses, water uses and other materials. Furthermore, special balances of biological metabolism of animals, plants and human beings are estimated.

In the case of physical I-O tables, it might be useful to reduce material flows for some specific analyses. There are throughput materials which do not enter economic circulation, but are only treated as primary inputs (withdrawal from non-produced natural assets) and final uses (disposal into the non-produced natural assets). The most important examples are water flows, like cooling water, which enter the natural sphere again without any further treatment. Other examples are soil materials only moved in the context of construction activities. In Table 5, throughput materials are shown in row 20. They comprise about three quarters of all material flows without having an important economic or ecological influence. Thus, it could be considered to remove them before analyzing the physical flows of economic activities in the context of physical I-O tables.

In the case of time I-O tables, additional information on the qualification structures of employed persons by branch are available. Furthermore, data on the qualification levels of the whole population can be combined with the complete range of household activities.

4.2 Extended monetary I-O table

The activities shown in columns 1 to 5 and 8 of Table 4 represent the traditional classification of production activities. Special emphasis is given to environmental protection activities which are explicitly presented in column/row 6. The environmental protection activities only comprise services which are delivered to third parties (external protection activities) whereas internal protection activities, like water treatment plants for own purposes, are not taken into account (Schäfer and Stahmer 1989; Kuhn 1996). It might be possible to “externalize” their costs by establishing separate production units, but it would be very difficult to estimate the corresponding physical flows, e.g. of waste and air pollution.

In column/row 7, there is a description of education services of government institutions, enterprises and non-profit institutions serving households. The gross output of these activities is treated as fixed capital formation and increases the stock of education (human) capital (row 7, column 18). The consumption of education capital is associated with those activities which use the accumulated knowledge of people (row 19). As far as labor inputs have monetary values (row 14), it is assumed that the value of depreciation of education capital is part of these revenues. To avoid double counting, a (negative) margin of labor and education has been introduced

Table 4 Extended monetary input-output table, Germany 1990 (billion DM)

Row No.	Uses / Supply	Input of branches								
		agriculture, forestry, fishing	mining, water and energy supply	manu-facturing	construction	market services	environ-mental protection services	education services	non-market services	household production
		1	2	3	4	5	6	7	8	9
	Product output by product group									
1	Products of agriculture, forestry, fishing	7.5	0.1	43.4	0.1	5.9	–	0.1	1.1	6.0
2	Products of mining, water and energy supply	1.8	30.8	45.0	0.5	20.7	0.7	1.6	5.7	15.4
3	Products of manufacturing	14.8	13.1	571.1	72.0	109.0	2.4	2.7	41.3	109.1
4	Construction work	0.7	3.9	7.1	4.2	23.4	1.8	1.3	7.2	1.0
5	Market services	8.2	15.9	288.6	39.6	424.5	1.7	7.8	109.1	127.9
6	Environmental protection services	0.1	0.9	5.2	2.0	1.8	4.9	0.5	1.1	2.5
7	Education services	–	–	–	–	–	–	–	–	–
8	Non-market services	0.4	0.5	5.8	0.7	4.9	1.3	0.1	66.5	2.8
9	Household production services	–	–	–	–	–	–	–	–	130.3
10	Household services related to employment	0.5	1.0	17.5	4.0	22.7	–	3.0	9.6	–
11	Household services related to education	–	–	–	–	–	–	–	–	–
12	Other household services	–	–	–	–	–	–	–	–	–
13	**Product and residual inputs, totals**	**34.0**	**66.1**	**983.5**	**123.1**	**612.8**	**12.9**	**17.1**	**241.8**	**395.0**
14	Labor inputs	28.9	47.8	581.1	120.0	793.8	5.4	78.2	211.6	853.2
15	Margin of labor and education	–1.8	–1.5	–27.8	–6.4	–37.0	–0.2	–6.1	–15.4	–39.5
	Revenues on products									
16	Non-deductible value-added tax	–	–	–	–	11.6	1.0	1.3	14.3	23.3
17	Taxes less subsidies on products	–4.5	–2.6	54.5	2.3	23.3	–	0.2	0.3	–
	Consumption of fixed produced assets									
18	Assets incl. consumer durables	11.8	20.3	72.9	5.4	170.7	6.5	8.3	12.0	33.3
19	Education (human) capital	1.3	0.6	10.3	2.4	14.3	0.2	3.1	5.7	39.5
	Withdrawal from the non-prod. natural capital									
20	Throughput materials	x	x	x	x	x	x	x	x	x
21	Other materials	x	x	x	x	x	x	x	x	x
	Imports from the rest of the world									
22	Goods	5.9	13.4	225.2	13.0	29.5	0.7	0.6	13.6	42.1
23	Services	0.4	0.7	8.6	1.0	22.9	0.0	0.9	5.7	4.8
24	**Primary inputs, totals**	**42.0**	**78.6**	**924.8**	**137.7**	**1,029.1**	**13.6**	**86.5**	**247.8**	**956.7**
25	**Gross output, balancing items**	**76.0**	**144.7**	**1,908.3**	**260.8**	**1,642.0**	**26.6**	**103.6**	**489.6**	**1,351.8**

Input of branches				Final uses								Total uses	Row No.
household services (except household production)			totals	private consump-tion	government consump-tion	fixed capital formation			disposal into the non-produced natural capital	exports to the rest of the world	totals		
services related to employment	services related to studying	other services				fixed assets (except consumer durables incl. change in stocks)	consumer durables	education capital					
10	11	12	13	14	15	16	17	18	19	20	21	22	
0.1	0.0	3.2	**67.3**	–	–	2.8	–	–	x	5.9	**8.7**	**76.0**	1
0.4	0.2	18.4	**141.3**	–	–	–0.7	–	–	x	4.1	**3.4**	**144.7**	2
7.6	1.5	116.1	**1,060.6**	–	–	184.7	73.3	–	x	589.7	**847.7**	**1,908.3**	3
0.1	–	2.4	**53.1**	–	–	205.1	–	–	x	2.5	**207.7**	**260.8**	4
20.1	10.1	403.4	**1,457.1**	–	–	32.6	40.7	–	x	111.6	**184.9**	**1,642.0**	5
0.2	0.1	7.2	**26.5**	–	0.1	–	–	–	x	–	**0.1**	**26.6**	6
–	–	–	–	–	–	–	–	103.6	x	–	**103.6**	**103.6**	7
0.3	2.2	20.7	**106.2**	18.7	361.9	1.1	–	–	x	1.8	**383.4**	**489.6**	8
–	17.4	922.1	**1,069.8**	282.0	–	–	–	–	x	–	**282.0**	**1,351.8**	9
–	–	–	**58.4**	–	–	–	–	–	x	–	–	**58.4**	10
–	–	–	–	–	–	–	–	42.2	x	–	**42.2**	**42.2**	11
–	–	–	–	1,775.4	–	–	–	–	x	–	**1,775.4**	**1,775.4**	12
28.7	**31.6**	**1,493.6**	**4,040.2**	**2,076.0**	**361.9**	**425.6**	**114.0**	**145.8**	**x**	**715.6**	**3,839.0**	**7,879.2**	13
–	–	–	**2,720.0**	–2,720.0	–	–	–	–	x	–	**–2,720.0**	–	14
–	–	–	**–135.8**	135.8	–	–	–	–	x	–	**135.8**	–	15
3.0	1.1	50.3	**106.0**	–	–155.0	27.7	17.9	–	x	3.4	**–106.0**	–	16
–	–	–	**73.4**	–	–73.4	–	–	–	x	–	**–73.4**	–	17
14.0	2.5	76.1	**433.9**	–	–	–307.9	–126.0	–	x	–	**–433.9**	–	18
5.4	4.7	51.1	**138.6**	–	–	–	–	–138.6	x	–	**–138.6**	–	19
x	x	x	x	x	x	x	x	x	x	x	x	x	20
x	x	x	x	x	x	x	x	x	x	x	x	x	21
5.0	1.0	70.2	**420.1**	–	–	66.3	31.9	–	x	–518.3	**–420.1**	–	22
2.2	1.4	34.0	**82.7**	–	–	0.1	0.1	–	x	–82.9	**–82.7**	–	23
29.6	**10.7**	**281.7**	**3,839.0**	**–2,584.2**	**–228.4**	**–213.7**	**–76.1**	**–138.6**	x	**–597.8**	**–3,839.0**	–	24
58.4	**42.2**	**1,775.4**	**7,879.2**	**–508.2**	**133.5**	**211.8**	**37.9**	**7.1**	x	**117.8**	–	**7,879.2**	25

(row 15) which also counterbalances the intermediate inputs of household services related to employment (row 10).

It is assumed that all household activities are productive. Nevertheless, the use of the term "household production" is limited to the case of household activities which meet the third-person criterion (column/row 9). The gross output of household production is compiled as the total of the value of intermediate consumption products, depreciation of consumer durables and the value of the time spent for household production. The depreciation of education capital is counterbalanced by the mentioned margin (row 15, column 9). Household production services are partly used as intermediate inputs of other household activities (row 9, columns 9, 11 and 12). The remaining values leave the economic circulation and are treated as private consumption (row 9, column 14).

The household services (except household production) (columns/rows 10 to 12) represent household activities for own purposes which cannot be carried out by third persons. Thus, a suitable valuation of the time spent for these activities seems to be impossible. The gross output of these services comprise only intermediate inputs and consumption of fixed produced assets, including the depreciation of education capital which has not to be counterbalanced in this case. Household services related to employment (column/row 10) are used by the branches employing the respective persons. Household services related to studying (column/row 11) comprise learning activities of pupils and students. The costs of these activities are treated as investment in education capital (row 11, column 18). All other household services (column/row 12) are used for consumption purposes only (row 12, column 14). These activities comprise e.g. social activities and activities for physiological regeneration (eating, sleeping etc.).

4.3 Physical I-O table

The physical I-O table (Table 5), shows a completely different picture of the economy. The activities producing material goods play a much more important role, while service branches, with their immaterial outputs, have a relatively low importance.

The production activities of agriculture, forestry and fishing (column/row 1) also comprise balances of plants and animals as far as they belong to the controlled economy. Thus, an analysis of the biological metabolism of living beings is possible.

The production activities of mining, water and energy supply (column/row 2) especially contain the withdrawal of raw materials from nature and their transformation into marketable goods. In comparison to the other flows of materials, water inputs and outputs dominate the description of these activities. As mentioned already, it seems to be preferable to allow a suitable reduction of these flows to facilitate the analysis of material flows. In row 20/column 2, most of the water flows are shown as throughput materials (e.g. cooling water) which represents about a half of all material flows of the economy.

In manufacturing and construction (columns/rows 3 and 4), the transformation of material goods into other material goods is described. Of course, these transformation processes require further inputs of raw materials withdrawn from nature, and they produce not only goods but also residuals. As far as soil is only moved but not used as material input of buildings etc., the respective material flow (row 20, column 4) is shown as throughput material.

In the case of market services (column/row 5), education services (column/row 7) and non-market services (column/row 8), material product inputs are normally transformed into residuals only. Apart from some exceptions (e.g. preparing meals in restaurants), the product output of services is immaterial.

Important material flows can be observed in environmental protection activities (column/row 6). Wastes and waste-water of other branches are treated and transformed into other types of residuals, which could be safely stored in controlled landfills, or which could be disposed of into nature without severe damages to ecosystems.

The material balances of household activities (columns/rows 9 to 12) are similar to those of the other service branches. Apart from preparing meals, no material product output is shown. The output of household services normally consists of residuals only. Some raw materials (e.g. oxygen and water) are taken into account in the case of the biological metabolism of human beings.

4.4 Time I-O table

The comments given to the extended monetary I-O table (section 4.2) could be applied for the interpretation of the time I-O table (Table 6) to a great extent. All values of the monetary table have been transformed into time values by the labor inputs directly or indirectly necessary to produce the respective products.

The additional primary inputs of household services (except household production) (columns/rows 10 to 12) cause the only major difference between the time and the monetary I-O table. In the extended monetary tables, the direct inputs of time of these activities have not been valued. Thus, the output is compiled only as the sum of intermediate inputs and depreciation. In the time I-O table, the direct inputs of time of all household services are taken into account. These amount to more than half of the value of time of all outputs of the whole economy (425 billion hours in comparison to 810 billion hours).

In the case of services related to employment (column/row 10), the additional inputs of time are linked with the traditional branches of the economy. The time spent traveling to the work place is now an additional intermediate input of the branches

Table 5 Physical input-output table, Germany 1990 (million tonnes)

Row No.	Uses / Supply	Input of branches								
		agriculture, forestry, fishing	mining, water and energy supply	manu-facturing	construction	market services	environ-mental protection services	education services	non-market services	household production
		1	2	3	4	5	6	7	8	9
	Product output by product group									
1	Products of agriculture, forestry, fishing	98.3	0.2	80.3	0.8	0.8	27.3	0.0	0.1	8.5
2	Products of mining, water and energy supply	64.5	2,084.7	1,343.9		109.9	111.4	51.2	310.5	741.5
3	Products of manufacturing	20.7	6.7	494.5	550.8	84.5	1,180.2	0.5	14.2	32.7
4	Construction work	–	–	–	0.0	28.5	21.7	0.0	6.0	–
5	Market services	4.7	–	47.8	20.7	1.8	112.1	0.0	0.1	0.5
6	Environmental protection services	–	0.4	–	–	6.0	4.7	–	–	–
7	Education services	–	–	–	–	0.1	49.1	–	–	–
8	Non-market services	–	–	–	–	0.5	298.6	–	–	–
9	Household production services	–	–	–	–	2.6	652.2	–	–	–
10	Household services related to employment	–	–	–	–	0.3	59.8	–	–	–
11	Household services related to education	–	–	–	–	0.1	32.0	–	–	–
12	Other household services	–	–	–	–	3.6	1,897.0	–	–	–
13	**Product and residual inputs, totals**	**188.2**	**2,091.9**	**1,966.5**	**589.7**	**238.7**	**4,446.0**	**51.8**	**330.9**	**783.2**
14	Labor inputs	x	x	x	x	x	x	x	x	x
15	Margin of labor and education	x	x	x	x	x	x	x	x	x
	Revenues on products									
16	Non-deductible value-added tax	x	x	x	x	x	x	x	x	x
17	Taxes less subsidies on products	x	x	x	x	x	x	x	x	x
	Consumption of fixed produced assets									
18	Assets incl. consumer durables	–	1.9	15.1	21.0	0.0	–	0.0	0.0	1.1
19	Education (human) capital	x	x	x	x	x	x	x	x	x
	Withdrawal from the non-prod. natural capital									
20	Throughput materials	–	31,428.0	5,346.1	113.2	–	3,500.0	–	–	–
21	Other materials	606.9	6,797.1	1,138.5	67.9	118.0	9.8	14.8	89.7	62.3
	Imports from the rest of the world									
22	Goods	10.4	49.2	238.9	28.1	13.3	0.2	0.3	2.4	18.5
23	Services	–	–	0.0	0.0	0.0	–	0.0	0.0	0.3
24	**Primary inputs, totals**	**617.4**	**38,276.2**	**6,738.6**	**230.2**	**131.4**	**3,510.0**	**15.1**	**92.1**	**82.2**
25	**Gross output, balancing items**	**805.6**	**40,368.1**	**8,705.1**	**819.9**	**370.1**	**7,956.0**	**66.9**	**423.0**	**865.3**
	Supplementary information:									
26	Product outputs	251.4	6,961.0	1,361.4	540.3	99.4	0.4	–	16.8	35.5
27	Residual outputs	554.2	33,407.2	7,343.7	279.6	270.7	7,955.6	66.9	406.3	829.8

Input of branches				Final uses									
household services (except household production)			totals	private consump-tion	government consump-tion	fixed capital formation			disposal into the non-produced natural capital	exports to the rest of the world	totals	Total uses	Row No.
services related to employment	services related to studying	other services				fixed assets (except consumer durables incl. change in stocks)	consumer durables	education capital					
10	11	12	13	14	15	16	17	18	19	20	21	22	
0.1	0.0	4.8	**221.3**	x	x	47.1	–	x	526.9	10.2	**584.3**	**805.6**	1
66.7	35.7	2,099.0	**7,036.3**	x	x	–0.3	–	x	33,305.6	26.5	**33,331.8**	**40,368.1**	2
4.5	0.7	34.6	**2,424.5**	x	x	13.9	4.4	x	6,106.4	155.9	**6,280.6**	**8,705.1**	3
–	–	–	**56.3**	x	x	534.2	–	x	229.4	0.0	**763.6**	**819.9**	4
0.0	0.0	5.7	**193.5**	x	x	–0.3	–	x	163.8	13.2	**176.7**	**370.1**	5
–	–	–	**11.1**	x	x	–	–	x	7,942.8	2.1	**7,945.0**	**7,956.0**	6
–	–	–	**49.1**	x	x	–	–	x	17.7	–	**17.7**	**66.9**	7
–	0.0	0.2	**299.3**	x	x	16.6	–	x	107.1	–	**123.7**	**423.0**	8
–	–	35.5	**690.3**	x	x	–	–	x	173.2	1.8	**175.0**	**865.3**	9
–	–	–	**60.1**	x	x	–	–	x	22.5	0.1	**22.6**	**82.7**	10
–	–	–	**32.0**	x	x	–	–	x	8.4	0.0	**8.5**	**40.5**	11
–	–	–	**1,900.6**	x	x	–	–	x	507.9	2.8	**5,10.7**	**2,411.3**	12
71.4	**36.4**	**2,179.8**	**12,974.5**	**x**	**x**	**611.3**	**4.4**	**x**	**49,111.7**	**212.7**	**49,940.1**	**62,914.5**	13
x	x	x	x	x	x	x	x	x	x	x	x	x	14
x	x	x	x	x	x	x	x	x	x	x	x	x	15
x	x	x	x	x	x	x	x	x	x	x	x	x	16
x	x	x	x	x	x	x	x	x	x	x	x	x	17
0.5	0.1	2.5	**42.2**	x	x	–40.8	–4.1	x	2.7	–	**–42.2**	–	18
x	x	x	x	x	x	x	x	x	x	x	x	x	19
–	–	–	**40,387.3**	x	x	–	–	x	–40,387.3	–	**–40,387.3**	–	20
6.9	3.4	208.2	**9,123.5**	x	x	–	–	x	–9,123.5	–	**–9,123.5**	–	21
4.0	0.6	17.0	**383.0**	x	x	7.4	2.7	x	–	–393.1	**–383.0**	–	22
0.0	0.0	3.8	**4.1**	x	x	–	–	x	–	–4.1	**–4.1**	–	23
11.3	**4.0**	**231.6**	**49,940.1**	x	x	**–33.4**	**–1.4**	x	**–49,508.1**	**–397.2**	**–49,940.1**	–	24
82.7	**40.5**	**2,411.3**	**62,914.5**	x	x	**577.9**	**3.0**	x	**–396.4**	**–184.5**	–	**62,914.5**	25
–	–	–	**9,266.1**										26
82.7	40.5	2,411.3	**53,648.4**										27

Table 6 Time input-output table, Germany 1990 (billion hours)

Row No.	Uses / Supply	Input of branches: agriculture, forestry, fishing (1)	mining, water and energy supply (2)	manu-facturing (3)	construction (4)	market services (5)	environ-mental protection services (6)	education services (7)	non-market services (8)	household production (9)
	Product output by product group									
1	Products of agriculture, forestry, fishing	0.44	0.00	2.50	0.00	0.27	–	0.00	0.06	0.35
2	Products of mining, water and energy supply	0.05	1.09	1.29	0.01	0.55	0.03	0.04	0.14	0.41
3	Products of manufacturing	0.50	0.40	17.97	2.20	3.39	0.09	0.09	1.29	4.21
4	Construction work	0.02	0.13	0.24	0.14	0.80	0.08	0.04	0.23	0.04
5	Market services	0.26	0.49	8.68	1.18	21.71	0.06	0.21	3.58	3.65
6	Environmental protection services	0.00	0.03	0.15	0.06	0.11	0.13	0.01	0.03	0.10
7	Education services	–	–	–	–	–	–	–	–	–
8	Non-market services	0.02	0.02	0.25	0.03	0.20	0.08	0.01	2.87	0.12
9	Household production services	–	–	–	–	–	–	–	–	10.56
10	Household services related to employment	0.13	0.24	4.41	1.01	5.71	0.00	0.76	2.43	0.00
11	Household services related to education	–	–	–	–	–	–	–	–	–
12	Other household services	–	–	–	–	–	–	–	–	–
13	**Product and residual inputs, totals**	**1.43**	**2.41**	**35.50**	**4.64**	**32.75**	**0.47**	**1.16**	**10.62**	**19.43**
14	Labor inputs	2.04	0.74	13.82	3.33	17.40	0.26	1.83	6.84	82.31
15	Margin of labor and education	x	x	x	x	x	x	x	x	x
	Revenues on products									
16	Non-deductible value-added tax	x	x	x	x	x	x	x	x	x
17	Taxes less subsidies on products	x	x	x	x	x	x	x	x	x
	Consumption of fixed produced assets									
18	Assets incl. consumer durables	0.38	0.65	2.31	0.17	5.24	0.11	0.28	0.32	1.02
19	Education (human) capital	0.20	0.08	1.52	0.35	2.10	0.04	0.44	0.86	6.67
	Withdrawal from the non-prod. natural capital									
20	Throughput materials	x	x	x	x	x	x	x	x	x
21	Other materials	x	x	x	x	x	x	x	x	x
	Imports from the rest of the world									
22	Goods	0.22	0.33	7.12	0.41	0.90	0.02	0.02	0.43	1.67
23	Services	0.01	0.02	0.27	0.03	0.72	0.00	0.03	0.18	0.20
24	**Primary inputs, totals**	**2.84**	**1.83**	**25.05**	**4.29**	**26.36**	**0.43**	**2.59**	**8.63**	**91.87**
25	**Gross output, balancing items**	**4.27**	**4.24**	**60.55**	**8.93**	**59.11**	**0.90**	**3.75**	**19.25**	**111.30**

Input of branches				Final uses									Total uses	Row No.
household services (except household production)			totals	private consump-tion	government consump-tion	fixed capital formation			disposal into the non-produced natural capital	exports to the rest of the world	totals			
services related to employment	services related to studying	other services				fixed assets (except consumer durables incl. change in stocks)	consumer durables	education capital						
10	11	12	13	14	15	16	17	18	19	20	21	22		
0.00	0.00	0.18	**3.82**	–	–	0.12	–	–	x	0.33	**0.45**	**4.27**	1	
0.01	0.01	0.48	**4.12**	–	–	–0.03	–	–	x	0.15	**0.11**	**4.24**	2	
0.15	0.04	3.38	**33.71**	–	–	5.86	2.43	–	x	18.56	**26.84**	**60.55**	3	
0.00	–	0.08	**1.83**	–	–	7.02	–	–	x	0.09	**7.10**	**8.93**	4	
0.71	0.32	11.80	**52.65**	–	–	0.99	1.61	–	x	3.86	**6.46**	**59.11**	5	
0.01	0.00	0.28	**0.90**	–	–	–	–	–	x	–	**–**	**0.90**	6	
–	–	–	**–**	–	–	–	–	3.75	x	–	**3.75**	**3.75**	7	
0.01	0.10	0.83	**4.54**	0.84	13.76	0.04	–	–	x	0.07	**14.72**	**19.25**	8	
–	1.41	75.27	**87.24**	24.06	–	–	–	–	x	–	**24.06**	**111.30**	9	
–	–	–	**14.69**	–	–	–	–	–	x	–	**–**	**14.69**	10	
–	–	–	**–**	–	–	–	–	18.25	x	–	**18.25**	**18.25**	11	
–	–	–	**–**	505.09	–	–	–	–	x	–	**505.09**	**505.09**	12	
0.90	**1.87**	**92.30**	**203.49**	**530.00**	**13.76**	**13.99**	**4.04**	**22.01**	x	**23.05**	**606.85**	**810.34**	13	
12.25	15.43	397.83	**554.10**	–554.10	–	–	–	–	x	–	**–554.10**	**–**	14	
x	x	x	x	x	x	x	x	x	x	x	x	x	15	
x	x	x	x	x	x	x	x	x	x	x	x	x	16	
x	x	x	x	x	x	x	x	x	x	x	x	x	17	
0.41	0.07	2.40	**13.36**	–	–	–9.45	–3.91	–	x	–	**–13.36**	**–**	18	
0.93	0.79	8.67	**22.65**	–	–	–	–	–22.65	x	–	**–22.65**	**–**	19	
x	x	x	x	x	x	x	x	x	x	x	x	x	20	
x	x	x	x	x	x	x	x	x	x	x	x	x	21	
0.11	0.03	2.39	**13.64**	–	–	2.06	1.03	–	x	–16.73	**–13.64**	**–**	22	
0.09	0.05	1.50	**3.10**	–	–	0.00	0.01	–	x	–3.11	**–3.10**	**–**	23	
13.79	**16.38**	**412.79**	**606.85**	**–554.10**	**–**	**–7.39**	**–2.87**	**–22.65**	x	**–19.84**	**–606.85**	**–**	24	
14.69	**18.25**	**505.09**	**810.34**	**–24.10**	**13.76**	**6.60**	**1.17**	**–0.65**	x	**3.21**	**–**	**810.34**	25	

where the commuting persons are employed. These additional inputs are not counterbalanced, but are treated as part of the gross output of the traditional branches.

According to the extended concept of inputs of time, the hours spent by pupils and students for studying are now an important part of the outputs of the household services related to studying (column/row 11). In comparison to the outputs of education services (column 7), the household activities have now a substantially increased importance as part of the investment in education capital (see column 18: 18 billion hours in comparison to 4 billion hours of education services).

The other household services (column/row 12) have a higher value of gross output than all other activities shown in the time I-O table (505 billion hours in comparison to 305 billion hours). This output (e.g. social and leisure activities, physiological regeneration) can be interpreted as a final goal of all activities. The outputs are treated as private consumption (row 12, column 14) amounting to five-sixths of all final use.

5 Applications

This article has presented three different types of I-O tables, using differing units of presentation. For facilitating comparisons, the same concepts of production and capital as well as primary inputs and final use have been applied. Furthermore, the same classifications of activities have been used. The presentation aimed at providing arguments for a combined use of these tables. Each type can only show specific aspects of economic activities, while all three types together can achieve an almost complete description. The heated debate on physical I-O tables since 2003 has shown that they offer important specific applications but have limited benefits for integrated environmental and economic analysis (cf. Hubacek and Giljum 2003; Giljum and Hubacek 2004; Dietzenbacher 2005; Hoekstra and Van den Bergh 2006; Weisz and Duchin 2006). A thorough analysis of possible uses of the three types of I-O tables is provided in Minx (2007).

The I-O tables shown are highly aggregated. This aggregation level might be not sufficient for many applications. Detailed tables with further conceptual explanations were published in 2003 in volume 1, part 1 of the publication series "Sozio-ökonomisches Berichtssystem für eine nachhaltige Gesellschaft" (Socio-economic reporting system for a sustainable society) of the Federal Statistical Office of Germany (Stahmer et al. 2003a). In volume 1, part 2 of this series, Reiner Stäglin and Joachim Schintke discuss—with many examples—possible applications of the three input-output tables (Stäglin and Schintke 2003). These and other volumes of the publication series can be ordered from the Federal Statistical Office free of charge.

Experiences with linking physical or time use data with the results of monetary I-O analysis have a long tradition (cf. e.g. Leontief 1973). Extensive uses of these linkages have been made by Dutch statisticians who combined their Social Accounting Matrices with physical data, e.g. information on residuals of the production processes (cf. e.g. de Boer et al. 1996 and the overview in Eurostat 2008: 424–426).

Furthermore, it is possible to merge parts of the three types in hybrid unit tables. Such procedure is particularly useful if a high level of price differentiation of specific products is observed. Examples of such merging procedures are energy I-O tables with physical data for energy flows and monetary data for the remaining flows (cf. Beutel and Stahmer 1982), the analysis of metal production and use (cf. Hawkins et al. 2007; Nakamura et al. 2008) and the discussion of waste management problems (cf. Nakamura and Kondo 2002; Takase et al. 2005). Furthermore, models with mixed time and monetary units in an I-O framework were discussed (cf. Minx and Baiocchi 2009).

In more sophisticated econometric models, simultaneous use of different units of presentation could be introduced. Such procedure is possible if functional dependencies between time, physical and monetary data of the same elements of the tables could be estimated (see e.g. the Osnabrueck model in Meyer et al. 1999).

6 Modeling of the Half-Day Society

The conceptual discussion leading to the Magic Triangle of I-O tables and the further development of these concepts were described in my "Rückblick eines Gesamtrechners" (Retrospection of a national accountant) (Stahmer 2009b; see also the version on my homepage www.carsten-stahmer.de). Especially for integrated economic and social analysis, I felt that an estimate should be attempted to show the interrelationships between the time delivered and the time directly or indirectly received of population groups. Such considerations had been stimulated by a study "Zeit für Kinder" (Time for children) which had been undertaken by the German Federal Statistical Office financed by the "Deutscher Arbeitskreis für Familienhilfe" (cf. Stahmer et al. 2003; see also a colored version on my homepage].

A first estimation of interrelationships of population groups in time units was presented in March 2002 in Halle, Germany (cf. Stahmer 2003; see also my homepage). Detailed tables were published two years later (cf. Stahmer et al. 2004). An English version of such "Sozio-ökonomische Input-Output-Tabellen" (SIOT) was presented as "Social accounting matrix based on input-output analysis" (SAMIO) at an OECD meeting (cf. Stahmer 2004). The concepts are also described in Eurostat's I-O handbook (Eurostat 2008: 424–445, available on the internet). According to the Magic Triangle of I-O tables, the presentation of SIOT is not limited to a framework in time units but also comprises the corresponding tables in monetary and physical units.

The first SIOT show origin and destination of time units for three age groups of the population. Special emphasis of later studies was laid on further disaggregation of the population groups by gender and by their level of education (see Schaffer 2008). As a by-product of this research, estimates of the contribution of men and women to traditional and extended Gross Domestic Product became available (cf. Schaffer and Stahmer 2006; Schaffer 2007).

In a second step, the SIOT was used to analyze changes of time patterns of the population. In September 2002, I presented—together with Alexander Opitz—the model of a "Half-day society" ("Halbtagsgesellschaft"), a concrete utopia for a sustainable society (see this first unpublished version and later publications on my homepage). The development of this concept had been especially stimulated by the work of André Gorz and Ulrich Beck (see e.g. Gorz 1989; Beck 1992). In particular, five social goals are to be pursued (see Stahmer 2009a, available on the internet):

1. Distributing the available paid work—with the same average amount of working hours—among all persons fit for employment.
2. Ensuring equal social status for paid and unpaid work.
3. Ensuring equal participation of both men and women in paid and unpaid work.
4. Strengthening social networks.
5. Increasing professional and social capacities.

The concept of the half-day society does not mean that part-time work becomes the rule. Rather, all those capable of working—men and women alike—would spend, averaged over the long-term, one half of their time for paid work while devoting the other half to unpaid domestic and social work in various forms (e.g. caring for children, the ill and elderly, volunteering in social institutions). This distribution of time could imply, for example, that a period of full-time, paid work is followed by an equal period dedicated to unpaid social work. In addition, there would be phases of education and training as well as continuous learning to ensure that paid and unpaid social work can be performed to high standards. As women and men would have the same employment pattern, differences in career paths and in the level of remuneration should dwindle.

In a developed country like Germany, the achievement of these requirements would lead—on average—to a substantial decrease of paid working hours for men and a slight increase of paid working hours for women (see also the discussion of reducing paid working hours in Schor 2005). As a corollary the unpaid working hours of women would decrease, those of men substantially increase. The total sum of paid working hours would diminish while the total amount of unpaid work would increase.

In order to support that equal social importance is attributed to unpaid and paid work, time units are introduced as complementary currency for unpaid services provided for third parties. In this context, each hour is valued equally. The time units accumulated could be saved or used to get services from other persons. A new type of banking system would be necessary to guarantee the long-term and supra-regional use of these time units. By establishing such complementary currency, the dominant position of money could gradually be weakened.[2]

Strengthening small informal social networks and supporting regional markets could counterbalance insecurities arising from global, largely unregulated markets and curtail international trade with its negative environmental impacts. Of course, additional national and supranational government instruments are necessary to further an agenda of sustainable development. Regulation and taxation pertaining to products hazardous to the health or damaging the environment and taxes on financial flows are amongst such instruments capable of reducing negative impacts of current processes of globalization.

Notes

1. I wish to thank Heinz Dieterich for encouraging me to update my "Magic Triangle." Many thanks also go to Jan Minx and Christine Zumkeller who have been very helpful in revising my paper.
2. A comprehensive concept of using units of working time for economic valuation has been proposed by Arno Peters and Heinz Dieterich (see the description of an equivalence economy in Dieterich 2006: 103–125).

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