Sustainable Economy Indices and their application to Austria

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Abstract: This paper presents the sustainability evaluation of the Austrian economy using the Sustainable Economy Indices (SEI) and the respective accounting system designed for it. In the first part of the paper, the backgrounds and the theoretical basis for the measuring system are outlined. Differences from existing methods of sustainability measurement and accounting are analysed.

The second part of the paper shows the SEI calculation for Austria. Following the SEI method, not only ecological sustainability but also aspects of provision of consumption, monetary exchange and eco-efficiency of trade flows are assessed. Finally, based on a novel classification of economic activities, the structure of the Austrian economy from a sustainability viewpoint is further discussed.

Keywords: economic sustainability; green accounting; sustainability indicators; Sustainable Process Index; Austria.

Reference to this paper should be made as follows: Gassner, J. and Narodoslawsky, M. (2004) 'Sustainable economy indices and their application to Austria', *Int. J. Environment and Sustainable Development*, Vol. 3, No. 2, pp.120–144.

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1 Introduction

There are a large number of indicators measuring human impact on nature at different stages of the cause-effect chain (indicators for driving forces, pressures, states, impacts and responses). Environmental economic accounting introduces ecological valuation and environmental impact assessment to economic accounting. Thereby, satellite accounting systems to the System of National Accounts, such as the System of Environmental Economic Accounts (SEEA), allow for the evaluation of (mainly) environmental pressure at the level of national economies. Environmental economic accounts can be instruments to analyse the ecological sustainability of economic systems.

Environmental economic accounts are not instruments of economic sustainability (the economic and not ecological sustainability of economies). The economic aspects of sustainability are covered by conventional accounting systems such as the System of National Accounts (SNA). The combination of environmental and economic accounts in e.g. National Accounting Matrices Including Environmental Accounts (NAMEA) represents a major data source for comprehensive evaluation of economies.

However, neither the SEEA nor the SNA has been constructed as sustainability accounts resulting in sustainability indices. They omit certain aspects that are relevant for national and regional sustainability assessment.

It is the purpose of this paper to present an application of a measuring system tailored to the economic sustainability assessment of regions and nations (the Sustainable Economy Indices). After an outline of theoretical basis for the system of indices, the Austrian economy will be analysed against the backdrop of the sustainability criteria implied by the Sustainable Economy Indices.

2 Three scarcities determining economic sustainability

2.1 Scarce natural sources and sinks

The first scarcity that economic systems are confronted with arises from the exchange of matter and energy with its natural environment. Renewable and non-renewable resources are extracted and used up or transformed in production processes. Awareness of the scarcity of natural inputs to anthropogenic systems arose long before the development of industrial systems in pre-economic times [1]. Scarcity is constituted by the fact that some resources are non-renewable on a human time scale (mineral resources) and that others are renewable at finite reproduction rates only.

Extraction and transformation as well as the use of transformed resources cause outflows from anthropogenic systems to their natural environment. The natural environment serves as sink for these emissions. Awareness of limited sink capacities has grown only recently [2,3]. Emission of substances that exceeds the natural assimilation capacities can result in degraded quality of the environmental compartments that in turn may have negative effects on other ecosystem elements.

The relevance of the scarcity of natural endowments for the sustainability of economic systems is twofold. Inputs are not infinite and economic systems have to deal with the allocation of the scarce resources. Outputs may cause the general setting of economic production to deteriorate (health problems, loss of natural amenities). Outputs may degrade the quality and reduce the quantity of inputs (forest dieback, decreased soil fertility).

2.2 Scarce consumption

The final aim of economic activity is the provision of goods and services to the final user. The amount of goods and services for final consumption is limited physically because of the finiteness of inputs and the overall efficiency of economies. But consumption is not only a question of matter and energy. Consumption implies the fulfilments of needs that are expressed in the form of consumers' demand for goods and services. Consumption measured in monetary – not in physical units – is, in principle, infinite. The value accorded to consumption goods and services can be augmented regardless of any physical boundary.

The boundary that determines the scarcity of consumption is not of a physical but of a social nature. Needs and demand are not only naturally given but social constructs. Consumption is scarce when supply cannot meet demand.

2.3 Scarce money

Money is the primordial 'resource' of every economic activity [4]. As communication medium of fully differentiated economic systems it assures the perpetuation of economic actions (actions of payment). Economic systems at every level (persons, corporations, regions, nations) need money (solvency) to 'play the economic game'. A lack of money can be counteracted by creditors and investors. In the absence of the latter a lack of money leads to insolvency (at the personal and business level) or other economic difficulties at the national and regional level.

It follows that the scarcity of money is directly relevant for the sustainability of economic systems inasmuch as insolvency entails the exclusion from economic activity. In the – within the scope of this paper more relevant – case of national and regional economies it is of indirect importance as it may cause "a sharp hike in domestic interest rates, a rapid depreciation of the domestic currency, or some other abrupt domestic or global disruption" [5].

3 How scarcities are taken into account by existing indicator systems

There are a large number of measures that make visible the scarcity of natural sources and sinks in one way or another. Single value indicators (e.g. tons of CO_2 emitted), partly aggregated indices (the CML-method [6]) as well as highly aggregated indices (e.g. the Material input per service unit – MIPS [7]) figure among the measures for the exchange between anthropogenic systems and their natural environment. Some of these measures – such as the Sustainable Process Index [8] – methodologically include the scarcity of natural resources. For instance, natural flows can serve as reference for weighting of single flows.

Consumption in national economies is measured in the System of National Accounts (SNA) [9]. The European System of National Accounts [10] defines consumption as expenditure or purchase by domestic institutional units for/of goods and services for the fulfilment of individual or collective needs.

In- and outflows of money to and from economic systems are recorded in Balances of Payments (BOP) [11]. A BOP summarises the transactions between an economy and the rest of the world (ROW).

The connection between monetary data and the (mainly) physical data on the natural environment is established in environmental economic accounting. The System of Environmental Economic Accounts (SEEA) [12] represents the state of the art in environmental economic accounting. The SEEA is the standard environmental satellite account to the SNA. In a number of additional accounts it supplements data on physical flows and stocks to the monetary data of the SNA. According to the SEEA handbook the evaluation of physical flows can be carried out by using the method of CML, the MIPS and the Ecological Footprint (EF) approach.

None of the mentioned systems has been constructed for the measurement of economic sustainability explicitly. Prima facie, a combination of the SNA, the BOP and the SEEA covers the main aspects related to the scarcities determining sustainability, though. However, there are a number of weaknesses of the existing measurement systems from the viewpoint of national and regional sustainability:

- The physical indicators for the sustainability of the exchange between economic systems and their natural environment (MIPS, CML, and Ecological Footprint) lack persuasiveness seen from an ecological sustainability perspective. They omit essential aspects related to depletion and degradation of natural sources and sinks (MIPS, EF). Their sustainability reference/goal is vague (MIPS). Their analytical soundness is weak (EF). They lack communicability (CML) [13].

- The consumption concept of the SNA comprises expenditure of a defensive nature (e.g. expenditure on the public health system, on environmental protection or on national security and defence). Defensive expenditure does not represent a surplus value for the social environment of economic systems. It rather corrects for amenity losses and degradations that are due to the ways of functioning of our economic, political and other social systems. Defensive expenditure is accounted for in the SNA in different ways. The Net Domestic Product is calculated as GDP minus depreciation. Available income calculates as national income minus current transfers (such as taxes, social insurance contribution). Satellite accounts record e.g. expenditure for the health system or environmental protection expenditure. However, a complete picture of the 'defensive sector' of an economic system (from a sustainability point of view) is lacking.

- Whilst the SEEA represents a comprehensive survey of data on physical flows of resources and residuals, it completely neglects the interrelation between trade flows and environmental pressure and more generally between trade flows and economic sustainability. The omission of data on trade flows and environmental pressure is a major drawback [14–17].

- Linking trade flows and environmental pressure opens up new views on regional and national interrelations. The development of an "environmental economic balance of payments" [18–21] can show what economic systems provide to other economic systems (money, natural sources, labour) and whether the providers are sufficiently compensated for their sacrifices. Thereby, economic sustainability analysis can point to alternative ways of ecological-economic cooperation and symbiosis that may create win-win situations for the trading partners.
- Mainly two notions orient sectoral classification in conventional economic accounting. One is the notion of the market. Classification with reference to the market yields the economic sectors of the SNA (non-financial corporations, financial corporations, general government, households, non-profit institutions serving households). The second pivotal notion is 'production'. Economic classification schemes that are built around 'production' form a primary, a secondary and a tertiary sector.

The ultimate goal of every economic system is the provision of consumption (corrected for its defensive part). For structural analyses it is useful to show which share of overall production contributes directly to consumption and which share has (only) auxiliary functions. How much value added and how many natural resources are incorporated in consumption goods and services? How much are used up in internal economic processes or for defensive activities? These are crucial questions in sustainability assessment. The answer to these questions can be given by a sector classification that differs from the conventional ones.

4 The Sustainable Economy Indices

An accounting system based on existing standardised accounting systems, but extending these in certain aspects will correct for the mentioned weaknesses. On the basis of such an accounting system indicators that help grasp the sustainability of regional and national economic systems can be formed more accurately.

The Sustainable Economy Indices (SEI) [13] are a measurement system specifically developed for the assessment of economic sustainability. The SEI ensue from a sustainability conception that sees the above-mentioned scarcities as decisive pillars of economic sustainability. In consequence, the SEI measure the sustainability of the exchanges between economic systems and their natural, social and economic environments. Three indices for the respective system-environment interfaces form the first indicator set within the SEI.

A second indicator set consists of two indices, each linking two sustainability aspects (two system-environment interrelations) in the form of efficiency ratios. The first efficiency ratio shows the overall eco-efficiency of an economic system in providing consumption. The use of natural sources and sinks refers to the generation of consumption. The second efficiency ratio shows the eco-efficiency of trade flows. It links (monetary) trade flows between economic systems to the use of natural resources related to these trade flows. (Figure 1) The indices are shown in Table 1.

Figure 1 Aspects covered by the Sustainable Economy Indices

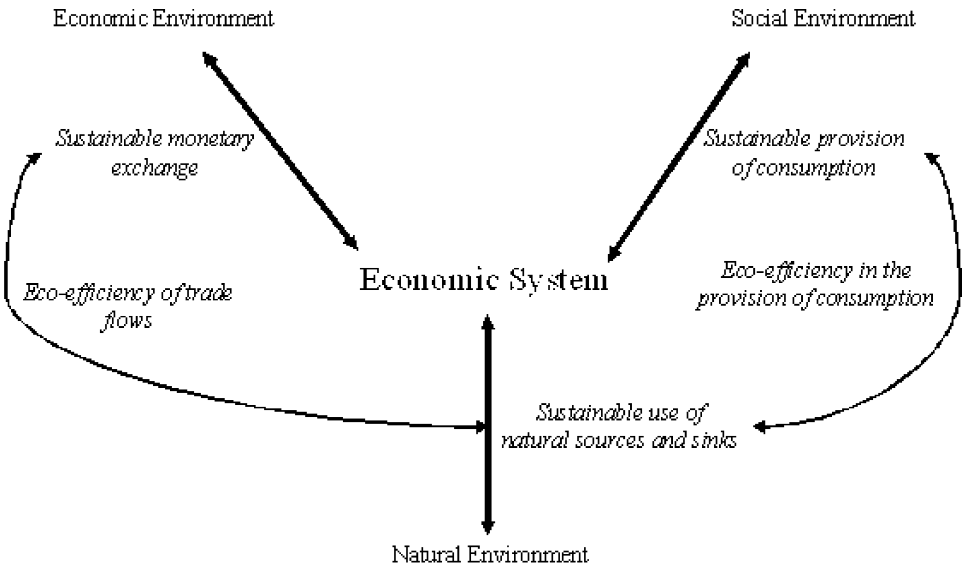


Table 1 Indices contained in the Sustainable Economy Indices

Index	*Abbreviation*	*Sustainability aspect*
Effectiveness		
Ecological Sustainability Index	ESI	Use of natural sources and sinks
Consumption Surplus Index	CSI	Provision of consumption
Economic Exchange Index	EExI	Monetary exchange
Efficiency		
Economic Efficiency Index	EEI	Eco-efficiency in the provision of consumption
Import/Export Efficiency Indices	IEfI/EEfI	Eco-efficiency of trade flows

4.1 Sustainable use of natural sources and sinks

The first index measures sustainability of the exchanges between economic systems and their natural environment. The sustainability of flows of resources from the natural environment to the economic system and flows of residuals from the economic system to its natural environment are considered. Moreover, as pressure on the natural environmental is not exerted by productive activities exclusively and ecological sustainability is a function of overall environmental pressure, flows of resources and residuals induced by consumptive activities have to be taken into account as well.

From the methods for evaluating the interaction between anthropogenic systems and surrounding ecosystems the Sustainable Process Index (a pressure index) has been chosen [13]. The SPI [8], a measure of ecological sustainability, expresses pressure on natural systems as the area needed to embed the respective activities sustainably into the ecosphere. According to the SPI methodology, pressure is put on ecosystems by flows of matter and energy over the boundaries between natural and anthropogenic systems. Input flows of (renewable and non-renewable) resources together with output flows of (solid, fluid and gaseous) emissions result in overall pressure due to flows. Flows are converted to area consumption. In addition, 'direct' area consumption in the form of sealed ground (due to e.g. installations, roads) is considered. The reference for ecological sustainability of the activities assessed is the (geographical) area available. In the particular case of national and regional accounting the reference value is given by the surface of a region or a nation. This surface can be used to generate the resources needed for the regional/national and foreign (transboundary flows) productive and consumptive activities and to dissipate the residuals from such regional/national and foreign activities.

The SPI assumes that when the area needed for the generation of resources and the disspation of residuals exceeds the area available, an activity or a number of activities is not sustainable. So, when the consumptive and productive activities of a nation/region consume an area larger than the surface of the nation/region, the nation/region has to be considered ecologically unsustainable.

The conversion of flows of resources and residuals to the area uses a system of natural reference flows:

- For renewable and fossil resources [22] the area used is calculated from the actual input flow divided by the yield per area for the resources. For fossil materials the generation process ('the yield') is sedimentation of carbon to the sea bed, which is the predominant flow to a long-term reservoir in the carbon cycle.
- SPI area for installations, buildings, streets and the like is identical with the actual surface used for such artefacts.
- Non-renewable resources do not form natural cycles. Their use is 'inherently dissipative' [8]. Accordingly, there are no natural reference flows calculated in the SPI concept for these resources. Instead, it is assumed that the area needed to supply non-renewables can be assessed from emission flows. Dissipation of products (emissions to air, water and soil) is compared to natural reproduction of the three environmental media. The flows for the compartments water and soil are calculated by multiplying natural concentrations by the rate of renewal of the media. Renewal of top soil is directly related to area, renewal of water bodies is connected to area by precipitation rates. Anthropogenous emissions to air are referred to natural emissions per area.

The SPI combines the strengths and avoids the weaknesses of the above-mentioned indices (MIPS, CML, EF) inasmuch as it:

- Relies on a clear notion of sustainability. It assesses human action against the background of natural states and flows.
- Considers inputs from the ecosphere and output flows to the ecosphere.
- Can be displayed in aggregated and disaggregated ways, which facilitates the analysis of human impact on nature on different levels of detail.
- Uses area as an aggregate – to express impact on the natural environment.

The SPI calculations within the frame of the SEI give the Ecological Sustainability Index (ESI). The ESI is the SPI calculated for a regional or national economic system. The ESI calculates as the total area consumption for a nation/region divided by the area available to the nation/region. Area consumption includes domestic (productive and consumptive) activities as well as rest of the world (ROW) activities that consume domestic area (through transboundary flows of emissions). The reference area for sustainability evaluation is the geographical surface of the domestic economic system [23].

$$ESI = \frac{\left(A_{Decon} + A_{Fecon} + A_{DHH} + A_{FHH}\right)}{S_D} \quad [m^2/m^2]$$

with ESI Ecological Sustainability Index
- $A_{D\ econ}$ Domestic area consumed by domestic production
- $A_{F\ econ}$ Domestic area consumed by foreign production
- $A_{D\ HH}$ Domestic area consumed by domestic households
- $A_{F\ HH}$ Domestic area consumed by foreign households
- S_D Geographical surface of the domestic economic system

An ESI between 0 and 1 stands for ecological sustainability of an economic system (and the domestic households). An ESI value bigger than 1 represents unsustainability, the area appropriated exceeds the area available.

Sustainability criterion: $ESI \leq 1$

4.2 Sustainable provision of consumption

To develop our measure of sustainable exchange between economic systems and their social environment (the households), we are taking Pezzey's [24] concept of survivable development as a starting point. This concept sees the reproducibility of a population assured as long as a minimum level of consumption (C^{SURV}) is available.

In contrast to Pezzey's essentially biological definition, we tend to interpret C^{SURV} against the backdrop of social and economic systems. Survivability does not (only) designate 'biological survivability of a population' but also 'survivability of anthropogenic systems', which of course includes the biological part. A single absolute level of economic and social survivability cannot be determined. The level of C^{SURV} can vary for an anthropogenic system when the system evolves. C^{SURV} comprises organisational, material and social (human and intellectual) resources. Organisational resources comprise the 'administrative' efforts certain social and economic systems require. These are different for e.g. industrial and agricultural societies. The functioning of highly industrialised societies usually requires more complex organisational structures and therefore more resources. It is evident, that industrial societies use more material resources than other cultural forms. A non-negligible share of the material resources is used to 'keep the system going'. The need for these resources is a consequence of the ways of living in general and the ways of producing and consuming in particular. For example, environmental protection services and expenditure are a necessary consequence of the pressure exerted on nature by anthropogenic activities. Reducing the pressure will decrease the need for activities such as the cleaning up of contaminated sites. The same holds true for social resources. Education is a necessary precondition for the functioning of industrialised societies. Other societies may not require accumulation of the same (e.g. technical) knowledge and skills and thereby may rely on different education systems.

The important point is that different societies need different amounts of goods and services to assure social and economic survival. The goods and services assuring survival are of a defensive nature. They are the (material, organisational, social) basis for the functioning of anthropogenic systems. The provision of these goods and services does not represent a surplus to society. It simply assures the survival of a system at its actual state. Growth of the amount of goods and services for survival is not considered an aim of economic activity but a duty that ties up resources that might be spent on the provision of a 'consumption surplus' under other circumstances. Therefore, we subtract this part of commodities from consumption. The remaining good and services (more accurately: their monetary value) represent a Consumption Surplus (C_S) to society.

An alternative measure – the Index of Sustainable Economic Welfare (ISEW) – published by Cobb and Cobb [25] subtracts (among others) defensive expenditure from consumption. In addition, the ISEW includes consumption as well as investment. The ISEW is intended to measure welfare. Consumption and investment generate welfare. We can modify the ISEW's view according to the measurement of the consumption surplus and say that consumption and investment can represent goods and services available to society once survivability requirements are met. Both (parts of) consumption and (parts of) investment are results of economic activity made available to society. It follows that the consumption surplus must comprise consumption goods as well as investment goods that are made available to the social environment of economic systems and that are not for survivability purposes.

It follows that the Consumption Surplus calculates as:

$$CSI = C_{tot} - C^{SURV} + CF_{HH} \quad [€, \$]$$

with CSI Consumption Surplus Index

C_{tot} Total consumption (domestically produced plus imported minus exported)

C^{SURV} Survivability level of consumption (domestically produced plus imported minus exported)

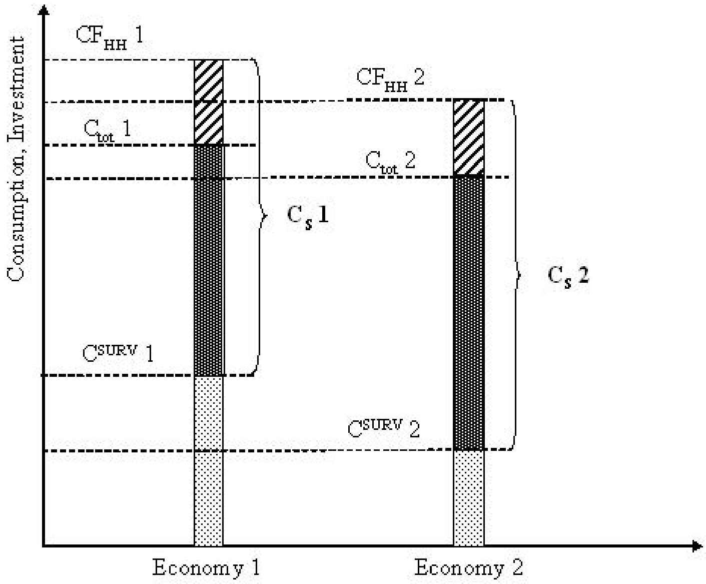
CF_{HH} Capital formation for households

C^{SURV} is determined at the product level and comprises food, energy as well as products of a defensive nature (public administration services, parts of education services, health and social work services, sewage and refuse disposal services). CF_{HH} comprises dwellings.

The CSI as such is shown in absolute terms without sustainability reference. The sustainability criterion for the provision of consumption (or utility) is usually based on the requirement of intergenerational equity. It states that consumption shall be non-declining over time [26–28]. We adopt this criterion for the Consumption Surplus:

$$\text{Sustainability criterion: } \frac{dC_s}{dt} \geq 0$$

Figure 2 Survivability level of consumption, Consumption, Capital formation for households and Consumption Surplus for two exemplary economic systems



4.3 Sustainable monetary exchange

The standard accounting system for the analysis of monetary flows between economies is the BOP. Here, we are only considering part of the balance of payments. In order to measure whether an economy is borrowing or saving, it suffices to balance imports and exports of goods and services of that economy (balance of trade, balance of services). Unrequited transfers are only indirectly related to an economy's productive and consumptive behaviour. They are a part of the national income that has been saved and is then voluntarily or obligatorily transferred to the ROW. These transfers are usually of a political or private (in the case of salary sent home by foreign workers) nature and do not give information about economic functioning. Claims and liabilities and the respective capital transactions are the result of anterior lending and borrowing and envisaged production and consumption.

It is evident that a deficit in the balance of trade and services does not necessarily lead to economically critical situations. It causes dependence on external investors and changed terms of trade. What is important from the viewpoint of 'monetary sustainability' (solvency) is that constant current account deficits may not be financed by creditors forever or may lead to prohibitive payments of interest.

There is no unanimity among economists about when a current account deficit becomes unsustainable. Some maintain that a deficit of more than 4.2% of GDP is unsustainable [5]. To interpret the possible solvency difficulties due to a current account deficit information on the size of the deficit relative to GDP, its sources [29–30], the structure of capital inflows [31] and finally, as today's foreign exchange deficit has to be settled by future income, the expected GDP growth rate (the expected rate of return of investment relative to the interest rates of foreign liabilities) are needed.

Applying a precautionary approach we hold that sustainable monetary exchange requires a positive balance of trade and services.

The Economic Exchange Index calculates as:

$$\mathrm{EExI} = \frac{V_E - V_I}{\mathrm{GDP}} \; [\%]$$

with EExI Economic Exchange Index
V_E Value of exports
V_I Value of imports
GDP Gross Domestic Product

Sustainability criterion: $V_E - V_I \geq 0$

4.4 *Eco-efficiency in the provision of the consumption surplus*

Natural resources are at the beginning of every economic activity. The provision of C_S is the final end of economic activity. To relate the source and the end of economic activity yields a major efficiency ratio from the viewpoint of economic sustainability. How many natural resources are used up to provide a unit of C_S? How can the amount of C_S generated be maximised and, at the same time, the amount of natural resources be kept at some sustainable level? These are crucial questions directly related to and derived from a ratio of overall economic efficiency.

The Economic Efficiency Index is the ratio of C_S supplied to all natural resources used by an economic system. In contrast to the Consumption Surplus Index, the Economic Efficiency Index includes domestically produced C_S only (and not produced plus imported minus exported C_S). To calculate all natural resources used by an economy, the natural resources imported with products for intra-economic use (GFCF except dwellings and, partly, streets and highways and intermediate consumption) are added to the use of natural resources for domestic production. Natural resources used for the domestic production of products that are exported for intra-economic use in the ROW economies are deducted. The use of natural resources is quantified as the incorporated SPI area [32] of products.

The Economic Efficiency Index calculates as:

$$\mathrm{EEI} = \frac{C_{Sdom}}{\left(A_{Decon} + A_{Pimpecon} - A_{Pexpecon}\right)} \; [€/m^2]$$

with EEI Economic Efficiency Index
$C_{S\,dom}$ Domestically produced consumption surplus
$A_{P\,imp\,econ}$ Area incorporated in products imported for economic use
$A_{P\,exp\,econ}$ Area incorporated in products exported for economic use

4.5 *Eco-efficiency of trade flows*

A pair of efficiency indices relates the use of natural resources to the value of imports and exports. Exporting environmentally intensive, low value products may threaten the sustainability of an economic system in two ways. Firstly, the domestic production of such goods puts pressure on the domestic environment and may lead to ecologically unsustainable situations. Secondly, the export of low value products is a possible reason for solvency problems.

> "The real prices of 'non-oil primary products' have fallen from index 100 in 1960 to index 55 in 1991, and the resulting balance of payments problems have forced many countries into the 'debt trap' [...]
>
> [...] prices have been kept low, and to increase earnings, production has been increased; in many cases exerting a great pressure on the natural environment." [33]

The ratio of exported value per pressure on the environment is crucial for the sustainability not only of producers of raw materials but also of economies engaged in the transformation of these raw materials. An economic system can become less unsustainable by exporting high value products for the production of which few resources are needed. At the same time, it will strive to import low value, environmentally intensive products. The ratio of value imported/exported to area (SPI) incorporated in goods and services imported/exported gives a combined economic-ecological picture of how trade affects the sustainability of an economic system.

The Import Efficiency Index calculates as:

$$IEfI = \frac{VA_{imp}}{A_{imp}} \ [€/m^2]$$

with IEfI Import Efficiency Index
A_{imp} Area incorporated in goods and services imported
VA_{imp} Value added incorporated in goods and services imported

The Export Efficiency Index calculates as:

$$EEfI = \frac{VA_{exp}}{A_{exp}} \ [€/m^2]$$

with EEfI Export Efficiency Index
A_{exp} Area incorporated in goods and services exported
VA_{exp} Value added incorporated in goods and services exported

5 The SEI Accounting System

Among all the accounting systems discussed within the framework of the System of Environmental Economic Accounts (SEEA) [12] the supply and use tables including environmental accounts (SUTEA) serve our purpose best. A full SUTEA contains all necessary data on monetary and physical flows needed to calculate our indices of economic sustainability. SUTEAs are based on conventional monetary supply and use tables. Monetary tables are brought together with physical supply and use tables to yield an integrated system of physical and monetary accounts.

For the calculation of our indices and economic analysis with regard to sustainability, the standard SUTEA has to be slightly rearranged and extended. Firstly, a different classification – classifying products and not activities – will be provided. The classification will be derived from the Consumption Surplus. It will allow for the calculation of the Consumption Surplus Index (CSI). Moreover, it will serve for structural analysis showing how much value added and how much SPI area appropriated is used for Consumption Surplus, for survival and for internal economic processes. Secondly, additional accounts for SPI valuations of industries and products needed to calculate the ESI, the EEI, the IEfI and the EEfI have to be included.

5.1 Economic functions

At the disaggregate level a SUTEA uses conventional classifications of industries (General industrial classification of economic activities within the European Communities – NACE) and products (Classification of products by activity – CPA). These remain unchanged, because national statistical offices collect monetary as well as physical data according to these classification systems.

Within the framework of the Sustainable Economy Indices it is especially interesting to form aggregates of value added and SPI area consumption per sector. Economic functions (sectors) can be derived directly from the notion of the Consumption Surplus.

The first economic function is the assurance of survival (*Survivability*). It comprises the final uses of all survivability products regardless of the final uses sections. In Gassner [13], it has been shown that food, energy, government expenditure on public administration, health and social work services, education services (50%) and sewage and refuse disposal services are products for social survival.

The second function is the provision of the *Consumption Surplus*. It comprises all products in the final uses section's final consumption expenditure (FCE) and valuables except survivability products. Parts of investment (gross fixed capital formation – GFCF) consist of goods and services for households as well (dwellings). These goods and services are to be included in C_S.

The third economic function comprises all products for intra-economic use. Products for intra-economic use are products in the final uses section GFCF (except dwellings). Again, survivability products are excluded. This third function will be called *Production,* (Table 2)

On basis of this allocation of final uses to economic functions, intermediate flows (in use tables) can be ascribed to economic functions. Thereby, we can ascribe values that are recorded and calculated for activities (and not products) such as value added or generation of residuals and use of natural resources (and the derived consumption of SPI area) to the economic functions.

Table 2 Allocation of final uses to the economic functions Survivability, Production and Consumption Surplus

<table>
<tr><th></th><th colspan="3">FCE</th><th colspan="5">GFCF</th><th></th></tr>
<tr><th>Products</th><th>by households</th><th>by government</th><th>by NPISH</th><th>Dwellings</th><th>Other builings and structures</th><th>Machinery</th><th>Transport equipment</th><th>Other GFCF</th><th>Valuables</th></tr>
<tr><td>P1</td><td colspan="9" rowspan="3">Survivability</td></tr>
<tr><td>P2</td></tr>
<tr><td>…</td></tr>
<tr><td></td><td colspan="4" rowspan="7">Consumption surplus</td><td colspan="4" rowspan="7">Production</td><td rowspan="7">Consumption Surplus</td></tr>
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5.2 Ecological valuation

In addition to changes in classification, accounts showing the ecological evaluation of the physical flows of natural resources, ecosystem inputs and residuals with the SPI have to be introduced.

The SPI Valuation Accounts are constructed according to SEEA [12]. In order to integrate SPI calculations with physical-monetary supply and use tables, the physical flows of resources, ecosystem inputs and residuals are multiplied by the respective SPI factors. The overall SPI area of an industry is calculated as the sum of the single areas needed to supply flows of resources and dissipate flows of residuals [34]. The sum of SPI areas per industry yields the total SPI area of an economic system. The SPI area of an economic system plus the SPI area for flows of resources and residuals due to consumptive activities (the SPI area of the Households) gives the overall SPI area of a given nation or region.

6 The Sustainable Economy Indices for Austria

6.1 Data sources

Supply and use tables represent the backbone of our system of accounts. Supply and use tables for the Austrian economy are published by Statistik Austria. The current version of the Austrian input-output tables is the ‘Input-Output-Tabelle 1995’ [35] which is in accordance with the European System of National Accounts.

Monetary data in supply and use tables are supplemented with data on industry and household related physical flows. In principle, all flows of resources and residues have to be recorded. Here, only flows of residues are taken into account. This has mainly two reasons. Firstly, no SPI weighting factors for non-renewable resources exist. Use of non-renewable resources is considered by weighting dissipative flows of emissions to air, water and soil. Secondly, the SPI area needed to supply flows of renewable resources is insignificant in relation to area needed to dissipate emissions.

Data on residue flows for Austria are recorded in NAMEA Abfall [36], NAMEA Wasser [37] and NAMEA Luft [38]. SPI weighting factors are mainly taken from Krotscheck [8]. All calculations are carried out for 1995.

6.2 Limitations

A few limitations of our study cannot go without being mentioned:

- For reasons of limited scope of our work, ROW supply and use tables have not been used. Austrian economic structure has been used to calculate e.g. SPI area incorporated in imports from ROW economies. Differences between Austria and the ROW in intermediate flows, repartition of final uses to final uses sections are omitted. Resource and residual flows per industrial output (resource and emission factors) have been corrected for Austria’s main trading partners, though.
- The EEI requires the calculation of total consumption surplus produced by the domestic economy. This includes domestically consumed as well as exported products. Domestically consumed products can be allocated to the consumption

surplus by means of the final uses sections in use tables. Exports are one final uses section. But no information on whether exported products are for intra-economic use or contribute to the consumption surplus can be found in supply and use tables. As no ROW supply and use tables are used, the repartition of domestic and imported products to the functions is applied to exports.

- For the calculation of SPI area, transboundary flows of residuals are omitted.

7 Results

The following sections will present the results of the SEI calculations for Austria. The indices outlined in Section 4 are calculated on the basis of data discussed in Section 6.

7.1 An ecologically unsustainable economic system

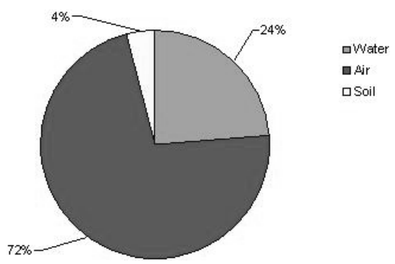
One major result of the Economic Sustainability Indices calculations is obvious and defies every contrary interpretation. The pressure exerted on the natural environment by Austria's economic system together with Austria's households cannot be sustained. The calculation of the Ecological Sustainability Index (ESI) shows that the (SPI) area appropriated by Austrian productive and consumptive activities exceeds by far the area available to embed these activities. Total SPI area of Austrian industrial plus consumptive (households) activities is 12,1 mill. km^2. From the 12,1 km^2, 8,9 km^2 are due to economic production and 3,2 km^2 to consumption by households. The Austrian geographical territory covers 83.800 km^2.

The main SPI areas are due to CO_2 emissions. CO_2 emissions have global environmental effects mainly and the area for the dissipation of global emissions calculates as land area plus the aliquot sea area available (3,4 times the land surface on a global average). It follows that the Austrian reference area for the ESI calculations amounts to S_D = 285.000 km^2.

The SPI area consumption of the Austrian economic system (12,1 mill. km^2) is 42 times the reference area (ESI = 42) [39]. The Austrian environmental pressure is at 4200% of its sustainable level. The conclusion is manifest: Austria's economic system is strictly not sustainable in the ecological sense.

From the 12,1 mill. km^2, 2,88 mill. km^2 (24%) are needed for the absorption of water emissions, 8,64 mill. km^2 (72%) for air emissions and 0,53 mill. km^2 (4%) for emissions to soil (solid waste) (Figure 3).

Figure 3 Repartition of Austria's SPI area according to environmental compartments



For most industries, CO_2 emissions cause the biggest area consumption for the medium air. The biggest water emission areas are due to flows of N (e.g. agriculture, forestry and fishing, manufacture of chemicals and chemical products) and flows of TOC (e.g. manufacture of food products and beverages, manufacture of pulp, paper and paper products, manufacture of machinery and equipment, sewage and refuse disposal services). Where data on flows of non-hazardous waste are available, these flows cause the biggest SPI areas for emissions to soil. Other solid waste areas are due to flows of 'other hazardous wastes'.

Figure 4 Industry and household related SPI area in percentage of the Austrian total

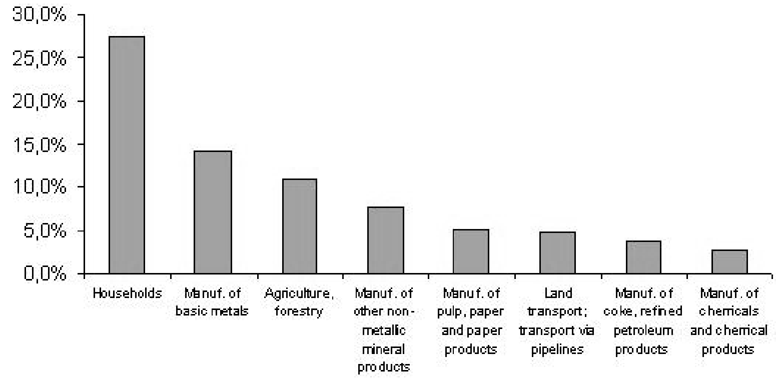


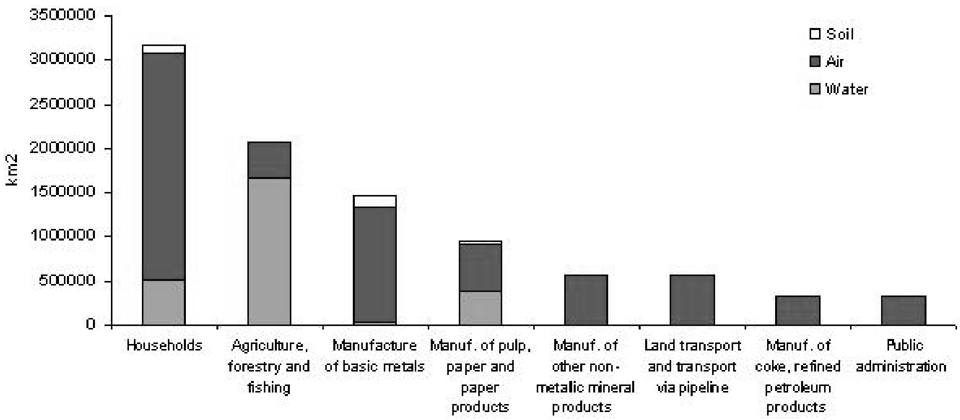
Figure 4 shows the most important area consuming activities. More than 27% of the overall Austrian SPI area is due to emissions caused by households. From these 27%, 83% fall to emissions to air (heating and car travel), that is nearly 23% of the total Austrian SPI area. The main area consuming industrial activities are manufacture of basic metals (NACE 27), agriculture, forestry and fishing (NACE 01, 02, 05), manufacture of other non-metallic mineral products (NACE 26), and manufacture of pulp, paper and paper products (NACE 21).

It is conspicuous that – with the exception of agricultural activities – emissions to air constitute the main area-consuming factor. (Figure 5)

As mentioned above, SPI areas for the medium air are dominated by area consumption due to CO_2 emissions. It follows that, according to the SPI concept, the paramount pressure on the environment and the principle cause for the unsustainability of productive and consumptive activities lie in the use of fossil energy. Sustainable use of fossil resources (which are very slowly renewing resources) is assured by a rate of exploitation that does not exceed the rate of renewal of the resource deposits (which of course holds true for every renewable resource). A rate of depletion that exceeds the rate of regeneration implies that on the output side of human activities more residuals are emitted than can be reabsorbed by the natural environment. In our particular case, one effect of such excessive emissions is their contribution to the greenhouse effect. From this point of view, the ESI points to global warming as a major threat to ecological (and therefore economic) sustainability.

Apart from Agriculture, forestry and fishing (emissions of N), Manufacture of pulp, paper and paper products (TOC) and Households (TOC) show a high share of area consumption due to water emissions.

Figure 5 Compartmental composition of SPI areas per industry/households



7.2 A steadily increasing consumption surplus

The sustainability evaluation of the economy-society interface yields a result nearly as unambiguous as the ESI calculations. The consumption surplus available to the households is increasing, thus complying with the respective sustainability criterion. As our calculations are based on supply and use tables following the NACE Rev.1 and CPA classification systems the availability of time series data were limited. The only adequate version of supply and use tables for the Austrian economy before the actual version (1995) date from 1990 [40]. This gives us two points in time for the analysis of consumption surplus development. The Consumption Surplus Index for 1990 is at 65.500 mill. €, for 1995 it is at 88.000 mill. €. This yields an average nominal growth of 6,1% per year. Real growth is at an average 2,6% per year. We can conclude that the Austrian economy is in compliance with the consumption surplus criterion for the examined period.

For further (long-term) studies of consumption surplus increases and decreases additional data (e.g. through conversion of supply and use tables following classification systems anterior to NACE and CPA) is needed. Such calculations lie beyond the scope of this paper. However, our results are confirmed by statistics that show a constant increase in real private consumption expenditure (not consumption surplus) from 1990 to 2001 at 2,3% p.a. [41].

Figure 6 shows a comparison of 1990 and 1995 for the most important goods and services within C_S. Note that only 50% of education services are ascribed to the Consumption Surplus.

During the same period (1990–95), the total amount of Survivability products shows a minor real increase of 1,2% (4,6% nominal). In absolute terms, the Survivability products account for 36.200 mill. € in 1990 and 45.300 mill. € in 1995. The value of C^{SURV} for 1990 and 1995 is 29% of the total value of final uses. The lion's share of C^{SURV} is Public administration services, Health and social work services, Food products and beverages and Education services. (Figure 7) In Austria, the social expenditure to GDP ratio has risen from about 26% in 1990 to over 29% in 1995. Since then it has remained more or less around the 1995 level [42].

Figure 6 Value of main consumption surplus products at basic prices for 1990 and 1995

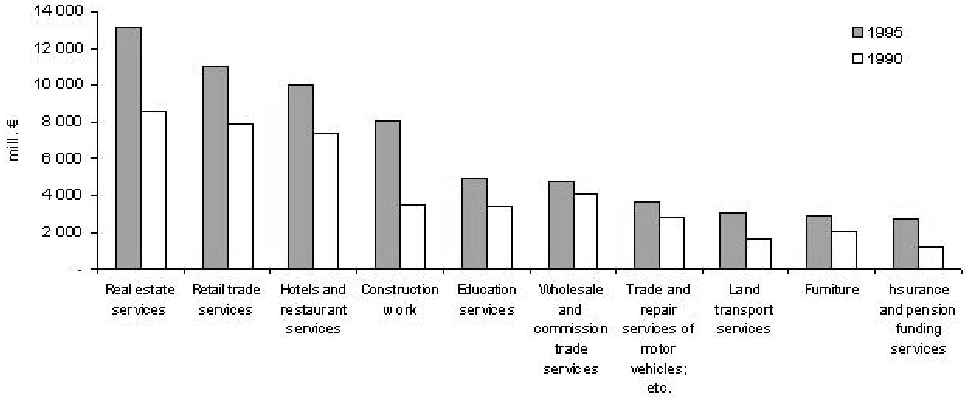
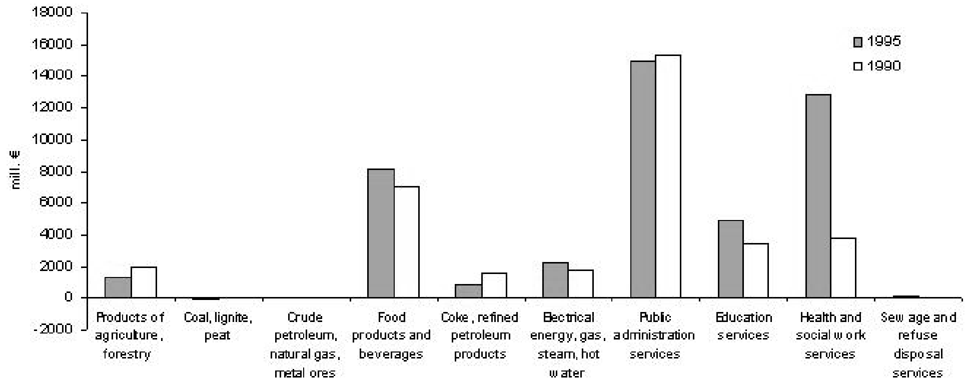


Figure 7 Value of products within C^{SURV} in 1990 and 1995



Comparison at the product level reveals a drastic rise in Health and social work services [43], a relatively important decrease in Products of agriculture and forestry and in Coke and refined petroleum products. Possible explanations for the decreases are a shift of Products of agriculture to Food products and a shift from pricier petrol to cheaper diesel [44].

7.3 A nearly balanced economic exchange

Unlike the Consumption Surplus Index and the Ecological Sustainability Index, the interpretation of the results for the Economic Exchange Index is less obvious. According to our sustainability criteria, the EExI in principle shows an unsustainable economic exchange for Austria. The Austrian economy's balance of goods and services is slightly negative, with the overall values at basic prices of imports (54.500 mill. €) exceeding the overall value of exports (49.700 mill. €). With an exchange deficit of 4.800 mill. €, the sustainability criterion for the economy-economy interface ($V_E - V_I \geq 0$) is a priori not fulfilled.

However, it must be noted that the Austrian economic exchange deficit is small in relation to the overall Austrian economic performance (2,96% of GDP) and does not represent a menace to the solvency of the economic system [45]. Traditionally, the Austrian balance of goods is negative (according to recent statistics, it has been slightly positive in 2002) whilst the balance of services is positive. The balance of goods accounts for more than 50% of the total current accounts deficit.

An analysis of the exchange with Austria's main trading partners shows that the balance of goods is positive with central and eastern European countries, whilst it is negative within the European Union (Germany, Italy). This fact is accompanied by a foreign exchange deficit in high value products such as motor vehicles and chemicals. The deficit for motor vehicles is decreasing though, due to a significant growth of the Austrian automotive industry. On the other hand, Austria sees a surplus in the exchange of medium value products such as iron and steel, pulp and paper. The same holds true for the exchange of services. Traditional services (tourism, transport, and construction) are among Austria's main export products. Innovative high value services are mainly imported.

In general, the excess of Austrian imports over Austrian exports cannot be attributed to productivity deficits or a particular weakness of the export industry. Together with structural deficits (a lack of production of high value products), a constant rise in final consumption expenditure throughout the 1990s, which made higher imports necessary, can be seen as the paramount reason for the Austrian foreign exchange deficit; a deficit that up to present has not limited the creditworthiness of the national economy.

From an integrated ecological-economic point of view it cannot be ignored that the main source of ecological unsustainability is among the principle sources for foreign exchange deficits. We have identified the consumption of fossil fuels and related emissions as the most important driving force for the excess of SPI area over geographical area available. A look at the import-export statistics reveals that the exchange of crude petroleum, natural gas and metal ores accounts for 1.300 mill. € of foreign exchange deficit. Together with the exchange of coke and refined petroleum products (41 mill. € of foreign exchange deficit) it accounts for nearly 40% of the total Austrian net foreign exchange deficit. It follows that the reliance on imported fossil fuels represents a twofold threat to economic sustainability: it causes the lion's share of SPI area appropriation and at the same time puts pressure on the current accounts.

7.4 The Economic Efficiency Index

The explicative strength of the Economic Efficiency Index lies in comparisons of efficiencies (natural resources used per consumption surplus provided) in time and space. Time series of the index show whether an economic system is gradually moving towards sustainability or away from it. Comparisons between countries may reveal potentials for improvement. Standardised time series calculations for Austria are not available as the NAMEAs for air, water and soil (1994) are the first according to the NACE Rev. 1 classification. Time series calculations as well as international comparisons at the level of detail applied lie beyond the scope of this work.

Therefore, it would be of limited explanatory power to present EEI calculations in this paper.

7.5 Import and Export Efficiency Indices

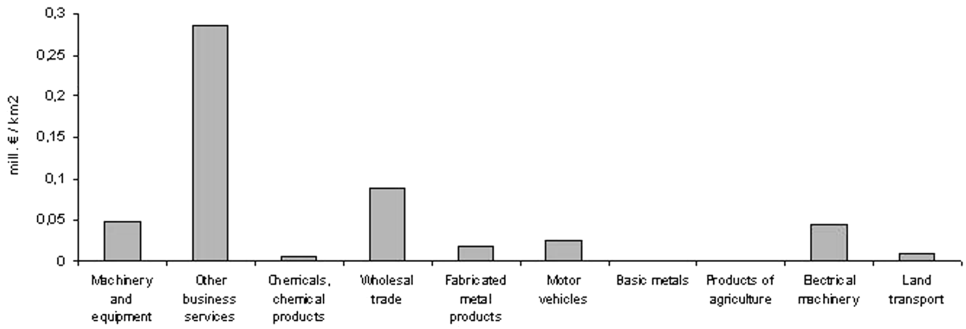
Relevant from the vantage point of the Import and Export Efficiency Indices is the relation of value added of goods and services imported and exported to area incorporated in goods and services imported and exported. Austria's exports contain 8.100 € per km^2 of SPI area whilst imports to Austria contain 7.000 € per km^2 of SPI area.

Thus, in terms of import and export efficiency it can be said that Austria is more eco-efficient than its trading partners (86% of Austrian export value added per area). The share of high value – low area products is higher in exports than it is in Austrian imports. Moreover, Austria shows advantages in production efficiency in relation to its main trading partners [46]. On a national average (emission per capita or per GDP) Austria shows higher efficiency than its main trading partners for most air emissions. Germany, Austria's principal trading partner has significantly higher relative CO_2, N_2O, SO_2 emissions. Eastern European countries such as the Czech Republic, Poland, Slovakia, Hungary and Slovenia show higher relative air emissions for most substances, though they have made tremendous advances in emission reduction throughout the 1990s.

The main imported and exported products are basically the same with a higher share of wholesale trade in Austrian exports. Whilst products of agriculture figure among the ten most important imports (in terms of value added), pulp and paper figure among the ten most important exports. Generally, many high efficiency products are virtually not traded. Education services (94.500 €/km^2) have a share of 0,2% of total trade volume, research and development services (6,2 mill. €/km^2) 0,5%, computer and related services (1 mill. €/km^2) 0,9%. The most traded products usually have significantly lower efficiency ratios. Machinery and equipment accounts for 7,8% of total trade volume (50.800 €/km^2), chemicals for 5,9% (5.100 €/km^2), fabricated metal products for 5,1 (18.200 €/km^2), basic metals for 4,6% (1.200 €/km^2). The only high value products with a significant share in total volume of trade flows are wholesale trade (7,6%; 88.700 €/km^2) and other business services (7,3%; 280.000 € / km^2).

Figure 8 shows efficiency ratios for Austria's main exports.

Figure 8 Efficiency (value added per area consumed) for main Austrian exports



What is conspicuous is that while trade flows of value added are rather evenly distributed among a number of products, trade flows of SPI area can be attributed to a large extent to only few products: basic metals (nearly one third of total traded flows of SPI area), products of agriculture, pulp and paper and chemicals.

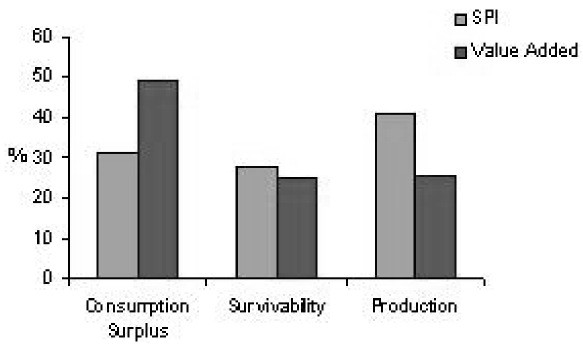
In general, Austria incurs (economic – ecological) exchange deficits because it is a net importer of high value products. This general weakness is levelled out mainly by the fact that Austria is a net importer in very low efficiency products (basic metals, chemicals and chemical products, coke and refined petroleum products) as well.

Time series calculations show that imported as well as exported SPI area decreased significantly from 1980 to 1993 and have been rising slightly since. Monetary trade flows show a steady increase during the same period. Most products show efficiency increases for this period due to emission reduction in industry. From 1995 on, efficiency increases are levelled out by increases in total trade volume.

7.6 Functional composition

The Survivability function of the Austrian economy provides 25,3% of overall value added and appropriates 28,0% of SPI area. The values for the production function are 25,8% of value added and 40,9% of SPI area. Consumption surplus is responsible for 48,9% of value added and 31,1% of SPI area appropriation. (Figure 9) When consumption is included, functional composition of SPI area is 21% Survivability, 30% Production, 23% Consumption surplus and 26% Households.

Figure 9 SPI area appropriation and value added per economic function



Differences in functional efficiency are due to the products allocated to the functions. The Consumption Surplus function comprises high efficiency products such as real estate services, wholesale trade and retail trade. The Production function is composed, to a significant degree, of low efficiency product machinery and equipment and medium efficiency product construction work. Survivability comprises low efficiency products (e.g. products of agriculture, food products) as well as high efficiency products (e.g. health and social work services, education services).

8 Conclusions

8.1 Case study conclusions

The area appropriated for the supply of resources and the dissipation of residuals exceeds by far the geographical area available. With an Ecological Sustainability Index of 42 Austria is far from a state of sustainability. Households, agriculture, the manufacture of basic metals and the manufacture of paper are responsible for the lion's share of national SPI area appropriation. The largest SPI areas are due to emission from fossil fuels.

Austria's economic system has been sustainable from a Consumption Surplus point of view during the 1990s. The rise in Survivability products was somewhat slower than the increase in Consumption Surplus. There was a significant increase in government expenditure from 1990 to 1995 that was counteracted by a decrease in products of agriculture and petroleum products.

Economic exchange is more or less balanced for Austria. A deficit of about 3% of GDP does not represent a threat to the solvency of the national economy. Structural deficits and a rise in consumption expenditure result in an import surplus in high value products. At the same time Austria is a net exporter of medium value products and services.

Austria's economic system shows export efficiency that is 15% higher than its import efficiency. Austria is strong in exporting medium value – low efficiency products and medium value – medium efficiency services.

Austria has a high efficiency Consumption surplus function, a medium efficiency Survivability function and a low efficiency Production function. A reduction in government expenditure throughout the second half of the 1990s points to changes in functional composition – the decrease of survivability products.

Implications for the Austrian economy that arise from the case study at hand are:

- The significant overuse of natural sinks must be counteracted in order to be sustainable. Two complementary measures seem necessary to achieve this goal. Firstly, technological change and optimisation are necessary to reduce further the impact of industrial activities. This includes emissions of regional and local impact (e.g. N and TOC emissions to water) as well as the predominant problem of global warming through emissions of greenhouse gases. Secondly, a change in consumer behaviour is required. A non-negligible share of the unsustainability of the Austrian economic system stems from consumptive activities. Emissions from household activities (e.g. CO_2 from traffic) are still on the rise. The reduction of these emissions cannot be tackled by technological advances alone but has to be based on more ecological design of product-service systems as well as a change in lifestyles.
- Consumption Surplus is on a steady rise. A look at the product level reveals that services make up a high share of Consumption Surplus. Further decoupling of Consumption Surplus and environmental pressure can be achieved by a shift from 'dirty services' such as transport and tourism to less environmentally intensive ones (optimise the high efficiency part). At time same time decoupling involves the optimisation of the low efficiency part of Consumption Surplus (mainly products) by measures mentioned under the first point.
- Austria's surplus in terms of Import and Export Efficiency is mainly technology driven. Austria shows lower relative emissions than most of its trading partners for a number of substances (CO_2, SO_2, N_2O). This is especially important for CO_2 emissions in Germany (by far Austria's most important trading partner) and SO_2 in the Eastern European countries. Structural advantages are minor in relation to technology differences. Possibilities to further increase the surplus are the specialisation in high value services and (for dirty products such as steel) the establishment of end of the value chain production in Austria.

8.2 Questions for further research

Conceptual research seems necessary in the field of environmental pressure incorporated in trade flows. Linking trade flows and environmental pressure opens up new views on regional and national interrelations. The development of an 'environmental economic balance of payments' can show what (solvency, natural sources, labour) economic systems provide to other economic systems and whether the providers are sufficiently compensated for their sacrifices. Thereby, economic sustainability analysis can point to alternative ways of ecological-economic cooperation and symbiosis that may create win-win situations from the viewpoint of economic sustainability. Further work is needed to make clear possible patterns of cooperation between continents, nations and regions and to explain how economically unsustainable parts can give a sustainable whole. Questions that will have to be treated are: are deficits/surpluses of the environmental trade balance necessary/desirable/justifiable? How will global environmental impacts (which are global sacrifices and not sacrifices of the trading countries) be dealt with in trade balances?

Empirical research is needed to work out the significance of the concept of functional composition and the Economic Efficiency Index presented in this paper. Here, time series for the Austrian economy as well as comparable data from other countries have to be collected and assessed. The explicative strength of the concepts can only be shown by elaborating differences in time and space.

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