The Sustainable Economy Indices

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Measuring the Sustainability of National

and Subnational Economic Systems

Doctoral Thesis

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Länger als Glück ist Zeit, und länger als Unglück

Heiner Müller

Abstract

Throughout this thesis, a set of indices for the measurement of economic sustainability is developed. The basic concept for the development of the indices sees economic sustainability co-determined by the natural and social environment of economic activity as well as by the operational principles of economic systems. From the sustainability concept elaborated, indices of economic sustainability (effectiveness) and auxiliary indices of economic efficiency are presented. Data collection for and calculation of the indices is done within a framework of environmental-economic accounts (supply and use tables including environmental accounts) that are extended by accounts for ecological evaluation. Economic functions are derived by aggregation of the basic data. A regional as well as a national economic system are used to examine the applicability and explicative strength of the indices.

Kurzfassung

Im Rahmen dieser Dissertation wird ein System von Indizes zur Messung von ökonomischer Nachhaltigkeit entwickelt. Das vorangestellte Konzept ökonomischer Nachhaltigkeit versteht diese als Funktion der Austauschbeziehungen von ökonomischen Systemen und deren sozialen und natürlichen Umwelten. Es wird davon ausgegangen, dass ökonomische Nachhaltigkeit zusätzlich durch die grundlegenden Operationen ökonomischer Systeme mitbestimmt ist. Auf dem Konzept aufbauend werden Nachhaltigkeitsindizes (Effektivität) und Hilfsindizes, die die Effizienz ökonomischer Systeme messen, entwickelt. Datensammlung und Berechnung der Indizes basiert auf einem System von kombinierten umweltökonomischen Konten. Ein standardisiertes Kontensystem wird um Konten zur Bewertung von Umweltwirkungen erweitert. Die Ausgangsdaten werden weiters zu ökonomischen Funktionen aggreggiert. Ein regionales und ein nationales ökonomisches System werden mithilfe der Indizes abgebildet. Die Anwendbarkeit und Aussagekraft des Indikatorsystems werden so geprüft.

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Abbreviations

AOX	Adsorbable Organic Halogens
ATS	Austrian Schilling
BOD	Biological Oxygen Demand
BOP	Balance of Payments
BS68	Betriebssystematik 1968
CML	Centrum voor Milieukunde Leiden
COD	Chemical Oxygen Demand
COICOP	Classification of Individual Consumption by Purpose
CPA	Classification of Products by Activity
CSI	Consumption Surplus Index
CV	Contingent Valuation
DPSIR	Driving Force, Pressure, State, Impact, Response
EE	Ecological Economics
EEfI	Export Efficiency Index
EEI	Economic Efficiency Index
EPEA	Environmental Protection Expenditure Account
ESI	Ecological Sustainability Index
ESVG	Europäisches System Volkswirtschaftlicher Gesamtrechnung
EExI	Economic Exchange Index
FCE	Final Consumption Expenditure
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GNP	Gross National Product
IEfI	Import Efficiency Index
ISEW	Index of Sustainable Economic Welfare
ISIC	International Standard Industrial Classification
LCA	Life Cycle Assessment
MFA	Material Flow Analysis
MIPS	Material Intensity per Service Unit
NACE	General Industrial Classification of Economic Activities within the European Communities
NAMEA	National Accounting Matrix Including Environmental Accounts
NDP	Net Domestic Product
NMVOC	Non-methane Volatile Organic Carbon
NPISH	Non-profit Institutions Serving Households
PIOT	Physical Input Output Table
ROW	Rest for the World
SCI	Survivability Consumption Index
SEEA	System of Environmental Economic Accounts
SFA	Substance Flow Analysis
SNA	System of National Accounts
SNI	Sustainable National Income
SPI	Sustainable Process Index
SSE	Steady State Economy
SUTEA	Supply and Use Tables Including Environmental Accounts
TMR	Total Material Requirement
TOC	Total Organic Carbon
WCED	World Commission on Environment and Development

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1 Introduction

The motivation for this thesis ensues from the answers to three questions.

Why Sustainability?

The use of the term sustainability is inflationary these days. From economic policy to environmental protection, from management practices to psychological treatment – results have to be sustainable or to use the not more concrete German term “nachhaltig”. At the beginning of the recent sustainability inflation is the scientific evidence or the very personal feeling, or something in between, that things are not sustainable the way they are. The proto-feeling of unsustainability, the original fear that things might not last has been nourished by the first pieces of evidence of continued degradation of our natural surroundings that have come to light a few decades ago. What is at stake, according to these first warnings of unsustainability – is nothing less than the survival of the human race and its natural resource base. All other sustainability efforts are sprung from this “primal fear”.

Ecological sustainability, the survival of some “structure and identity” of eco-systems, is at the beginning and still at the centre of sustainability theories and practices. In the light of an ever increasing pressure exerted by anthropogenous systems on their natural environment the concerns of the proponents of ecological sustainability are not less justifiable today than thirty years ago.

Why Economic Sustainability?

Economic activity has a most prominent part in sustainability considerations. This is due to the fact that most sustainability considerations focus on the health and viability of ecological systems and that the lion’s share of pressure on ecological systems is related to economic production and the consumption of goods. On the other hand, economic theory and practice at all times has been concerned with the survival and development of economic systems as such. The first approach (the theoretical and practical look on economic pressure on nature) concentrates on the natural environment rather than economic functioning. The second approach (economic theory and practice) tends to omit the natural environment of economic processes.

The evidence that economic activity endangers its natural surroundings and that in turn degraded quality of environmental media and depleted natural resources may endanger economic development makes it necessary to bring together both perspectives. The combination of both approaches has given birth to disciplines such as Environmental and Resource Economics or the multi-disciplinary Ecological Economics. These disciplines go beyond economic sustainability, they treat issues that are of importance from the viewpoint of economic sustainability. But explicit approaches to economic sustainability are rare. Most concepts content themselves with according a more or less prominent part to nature within economic considerations.

Economic sustainability is more than resource management and environmental protection. The “ecological part” of economic sustainability is widely accepted and abundantly examined. The genuinely economic aspects of economic sustainability can be found in conventional economic theory rather than Environmental or Ecological Economics. It is the aim of this thesis to combine aspects of the economic and the ecological part of sustainability. Both economic and ecological considerations must be part of economic sustainability.

Why Indicators?

Sustainability needs indicators. The detection of sustainability or its absence usually lies beyond our naturally given perceptive faculties. Indicators help perceive complex facts and are therefore indispensable instruments for shaping development paths that can be sustainable.

Starting Points

The number of sustainability concepts is large. Most concepts – at least implicitly – understand sustainability as ecological sustainability. Genuine concepts of economic sustainability do virtually not exist. The existing concepts (e.g. the Steady State Economy) have not been used to serve as basis for the development of indicators.

The instruments of economic and environmental-economic accounting are well developed. There are numerous economic indicators as well as physical and monetary indicators of the human impact on nature. Very few existing systems of indicators are meant to measure economic sustainability.

Economic and environmental-economic accounting is carried out at the national level rather exclusively. Ecological sustainability – as natural capacities differ regionally – has to be evaluated against the backdrop of regional environmental situations. Important sustainability efforts are initiated at the regional and local level (e.g. Local Agenda 21).

Goals

The main goals of the thesis at hand can be derived directly from the enumerated starting points:

We shall analyse existing concepts of economic sustainability and if necessary extend or modify existing concepts. Thereby, the conceptual groundwork for indicators and accounts in the field of economic sustainability shall be enlarged. The concept to develop shall serve as a basis for the development of indicators of economic sustainability.

Existing indicators of different nature shall be scrutinised. By extending and modifying existing measures, a comprehensive set of indicators of economic sustainability shall be elaborated. The indicators shall be applicable on economic systems of different size (above all on nations and regions). They shall combine the strength of both widely accepted standardised systems of accounts and indicators and alternative measures that open up different perspectives on sustainability.

The applicability of the indicators shall be tested in case studies.

Chapter Overview

Chapter 1: Introduction

Chapter 2:Threats to Human Development and the Concept of Sustainability

A general introduction to Sustainability and Sustainable Development is given. The treatment of the natural environment in economic theory from the Physiocrats to Ecological Economics is briefly outlined. In the following, concepts of economic sustainability are discussed.

Chapter 3: Interfaces

The exchange between economic systems and their environment is analysed from a systems theoretical point of view. Moreover the operational principles of economic systems are outlined.

Chapter 4: A Concept of Economic Sustainability

Strengths and weaknesses of existing concepts of sustainability are evaluated in the light of the findings of Chapter 3. The conceptual basis for the development of indices is laid by extending and modifying the concepts.

Chapter 5: Indicators of Economic Sustainability

Existing indicators and accounting systems are scrutinised against the backdrop of the sustainability concept elaborated in Chapter 4. Necessary extension of existing indicators are presented.

Chapter 6: The Sustainable Economy Indices and the Underlying System of Accounts

A system of indices for the measurement of economic sustainability is presented. The blueprint of the data base of the indices in the form of modified environmental-economic accounts is developed.

Chapter 7: Case Studies and Calculations

The calculation of the indices from the data base of the accounts is described in detail. The indices are calculated for Austria and the Feldbach district.

Chapter 8: Conclusions

Chapter 9: References

Chapter 10: Appendix

Working Hypotheses

Hypothesis 1:

Economic systems have specific structures and identities. As long as structure and identity are intact (within certain boundaries) an economic system is sustainable. The sustainability of economic systems is co-determined by their social and natural environments as well as by the operational principles of economic systems.

Hypothesis 2:

Economic sustainability is measurable. Indicators are necessary to inform about economic sustainability. Indicators have to reflect the aspects determining the sustainability of economic systems.

Hypothesis 3:

National economic systems are the main object of economic statistics. Indicators of economic sustainability must be applicable on the national level. Regional economic systems are essential for the implementation and evaluation of economic sustainability. Indicators of economic sustainability must be applicable at the regional, sub-national level.

Hypothesis 4:

The implementation of sustainability needs acceptance from the main actors. A system of indicators of economic sustainability has to be based on standardised, regularly updated data sources. It must be easy to communicate and understand for the main actors.

2 Threats to Human Development and the Concept of Sustainability

Life is a creative process. At the same time, all life is inherently destructive. It consumes to generate the new. Resources of energy and materials are used and allow for growth and development. Every living species lives at the expense of, but nevertheless co-evolves with, other species. Mankind has been very effective in taking advantage of nature's creative potentials and has been using ever increasing shares of natural production. Creation and consumption are organised in an economic system that at first glance is highly efficient and effectively provides support to human living. Within economic systems natural resources are used and transformed to commodities for the consumption of households. The world economy's output of goods and services increases steadily.

But is it possible that euphoria about this creative fury has made us forget about the prerequisites of economic production and consumption? It is a few decades already since concern about human impact on nature has first been raised. From the early seventies on, the natural environment of economic activities has been on the political agenda.[1] Depletion and degradation of natural resources, pollution of environmental media, the ongoing loss of biodiversity and climate change have become issues of increasing importance and priority. The consequences of human pressure exerted on natural systems has been identified to be a major threat to the viability of the systems absorbing anthropogenous emissions and supplying natural resources.

Obviously, the relationship between anthropogenous[2] and natural systems is not uni-directional and so we have to ask, what the consequences of destruction of natural systems for cultural, man-made systems can be. What are the consequences of our impact on nature? What is economic output worth, when it relies on overuse and persistent destruction? And will there be economic output tomorrow when we forget about economic input (the natural prerequisites of economic activity) today?

> Climate change, for example, is likely to raise sea levels, threatening island economies and low-lying countries such as Maldives and Bangladesh. Climate change also jeopardises agricultural production in developing countries. The Russian Federation and parts of Africa could see dramatic reductions in their crop yields by 2050. The overall impact of a doubling of carbon dioxide in the atmosphere would be to reduce the gross domestic product (GDP) of developing countries by an estimated 2-9 percent.[3]

Overuse of natural sources and sinks represents a threat to anthropogenous systems at the global as well as the regional level. While global environmental problems, such as the depletion of the ozone layer and the greenhouse effect, may adversely affect the

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[1] See e.g. Meadows et al. 1972, Carson 1962

[2] The term "anthropogenous system" as it is used in this thesis is meant to stand for economic as well as other social systems.

[3] The International Bank for Reconstruction and Development / The World Bank 2000, p. 87

environmental conditions for a number of people and countries all over the globe, other problems are of geographically more limited scale. For instance, pollution of water and soil or the depletion of natural resource stocks (e.g. coal, metal ores) usually have a direct influence on local, regional or national anthropogenous systems only.

The second threat to human development (unlike the interference of human activities with the functioning of ecosystems) does not endanger the development of the global anthropogenous system but that of specific anthropogenous subsystems within the global system. Prosperity is not an ubiquitous phenomenon. Aggregate global production is increasing, but neither production as such nor the gains from it are evenly distributed among economies. There is no evidence for a general reduction of the inequalities between anthropogenous systems.[4] Underdeveloped economies in some parts of the world seem to catch up with more developed ones, others still stay behind.[5]

What is endangered by the destruction of natural environments and uneven repartition of wealth and productive facilities is development in general. Development of the global economy and all its national and regional subsystems is inherently linked to the health of the surrounding natural systems. Development of single economic systems from the national to the personal level relies on the distribution of material wealth and creative industrial capacities. Ways have to be found that allow for longevity of mankind in general and the global economy in particular. Moreover, stability and progress of single economies – the developed and the developing – have to be assured.

Growing awareness of the threats to natural viability, economic convergence (the equalisation of economic wealth) and social equity have called into being a number of practical countermeasures such as environmental protection efforts and economic development programs and an underlying body of conceptual work that starting from reflections about the negative effects of mankind on nature focuses on longevity and qualitative development of natural and anthropogenous systems.

2.1 Sustainability and Sustainable Development

Is humanity on a path that is endangering social, natural and economic systems' ability to survive? In the light of ecological problems such as global warming, depletion of the ozone layer etc., and against the backdrop of social and economic inequality we tend to answer that no, we are not on a path that can be perpetuated.

Such scepticism has led to the renaissance[6] and spread of theories and practical efforts that deal with what can be subsumed under the term "sustainability". The number of definitions of sustainability is large. From a very general point of view it can be said that sustainability of a

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[4] Ekins et al. 1994, p.6

[5] The World Bank 2001, p.51

[6] „Nachhaltigkeit" has a lasting tradition in German and Austrian forestry.

system can be interpreted as survival and reproduction of a certain systemic "integrity and structure"[7], while nevertheless allowing for evolution and development.

A definition of sustainability in this spirit is given by Costanza and Patten:

> A sustainable system is a renewable system which survives for some specified (noninfinite) time.[8]

This definition applies to all sorts of systems in all possible contexts. It simply states that whenever the integrity and structure of a system exist for a certain time, the system is sustainable for that period of time. If the period of the survival of a system can be specified has to be questioned, though. The concepts of sustainable development treated in this thesis do not determine such periods (see quote 26).

In the light of the ecological and social problems discussed, sustainability can take more concrete shape. By coupling the notion of sustainability with the notion of development (of anthropogenous systems mainly) value free definitions such as Costanza and Patten's are supplemented with explicitly normative content. "Sustainable development" – as development is always purposeful and inherently linked to (normative) goals - implies that it does make a difference what kinds of system survive and how they survive.

A central definition in this respect is provided by the World Commission on Environment and Development (WCED)[9]. This anthropocentric definition of sustainable development shifts the focus from general longevity to the fulfilment of human needs:

> Sustainable development is development that meets the needs of present generations without compromising the ability of future generations to meet their own needs.

With its definition of sustainable development the Commission goes a step further from Costanza and Patten's general notion of systemic structure and integrity (sustainability). It restricts sustainable development to pathways that make intergenerational and intragenerational equity and the fulfilment of needs possible. Seen from this teleological perspective, sustainable development is not only a possible state or way of evolution of an arbitrary system. It is made an ethical imperative.[10]

Definitions of sustainability and sustainable development (normative and positive) can be applied on different scales (global, regional, local) and with different scopes. Usually three spheres (economic, social, ecological) of sustainable development can be derived. Against the backdrop of e.g. the WCED's definition the three spheres become visible. Human needs – at least some - are met by economic activity. Equity in distribution of the gains from economic activity may be achieved by social interaction. Longevity of anthropogenous as well as natural systems is assured by consideration of natural capacities that are prerequisites for life in general and economic activity in particular. (Fig.2.1)

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[7] Cleveland et al. 1995, p. 2

[8] Costanza and Patten 1995

[9] World Commission on Environment and Development 1987, p.43

[10] Ott 2001, p.57 and Perman et al. 1999, p.50

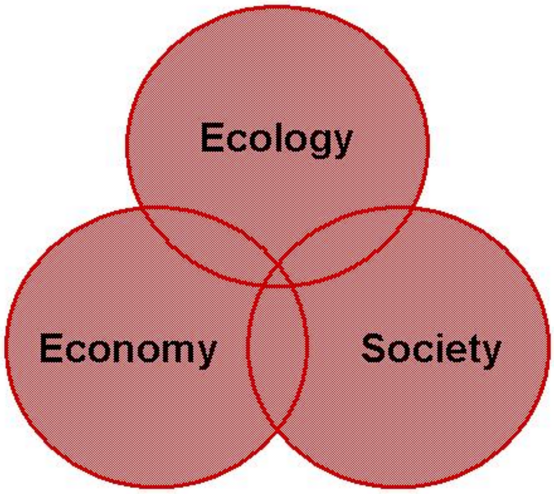

Figure 2.1: The economic, ecological and social dimension of sustainable development

It is evident that the three spheres of sustainable development are closely linked. Sustainable development in one sphere can be a necessary condition for sustainable development in another – always dependent on the definitions applied. The primordial function of ecological sustainability is evident as soon as it is accepted that every human activity relies on basic natural life support. Neither economic nor social sustainable development are possible when natural capital is overused. Other relations are less deterministic. Social and economic sustainable development strongly interact, but sustainability in one sphere is not a prerequisite for sustainability in the other. Tradeoffs of sustainability in the different spheres are possible. Economically desirable behaviour may limit the possibilities for sustainable development of social and natural systems. Ecological sustainability is of course possible without social and economic sustainability.

Sustainability in the economic sphere is at the centre of this thesis. In consequence, we will restrict our overview of concepts of sustainability to concepts of economic sustainability. Whenever economic sustainability involves or relies on sustainability of the ecological and the social systems, corresponding concepts will be discussed as well. A number of concepts of economic sustainable development consider the natural basis of economic activity. Thus, it seems useful to give an outline of the treatment of nature in economic theory before addressing economic sustainability concepts as such.

2.2 Nature and Economics – From Primacy to Neglect to Respect

At the time, when the first schools of economic thinking developed, life was strongly attached to its natural basis. Most of the economic production of that time – the 18th century – was agricultural, a fact that is reflected by the theoretical bodies of these early economic schools.

The Physiocrats base their economic theory on the notion, that land is at the origin of all wealth. The only economic activity considered to create value added as such is agricultural cultivation. All subsequent activities, such as manufacturing, wholesale trade and retailing are seen as unproductive transformations and ought to be reduced to a minimum.[11]

The classical economic theories of e.g. Malthus and Ricardo are inspired by the Physiocrats' "materialistic" approach. In accordance with the Physiocrats, Malthus states that only land - "the machinery of the land"[12] – can produce and that every other economic process is simple transformation of natural capital.

The primacy of natural creation over human production determines the physiocratic and classical notion of production. Production is depicted as a sequence of activities from natural production to transformation and distribution. The – in contemporary terminology – "process chain approach" to production describes the relationship between natural and man-made goods. They are distinct and complementary outputs of sequential creative processes (natural creation and economic production). Complementarity of natural and man-made goods implies that manufacture of capital can not be increased independently from supply of natural resources.[13]

The classicals claim that land is limited in quality and quantity.[14] Malthus derives scarcity from exponentially growing populations compared to only arithmetically increasing surface of arable land. Resource scarcity in turn will lead to overuse of available land and finally to the regulatory mechanisms of war, disease and starvation. Ricardo explains, why land provides its owners with a rent. With populations growing, the productive quality of cultivated land would diminish. Increased cost of cultivation and intensified use of better soil yield a rent.

Malthus as well as Ricardo recognise limited availability of natural resources and draw conclusions for demographic, political and geographic issues. There is an essential difference though between scarcity in the Malthusian and the Ricardian sense. Resources in a Malthusian world are limited in quantity. To Ricardo the limiting factor is not quantity but quality of resources. In other words, in a Ricardian world resources per se are infinite in supply while quantity of high quality resources is limited. Ricardo's scarcity is the relative scarcity "of a particular resource relative to another resource [...]. Absolute scarcity, by contrast, refers to the scarcity of resources in general, the scarcity of ultimate means."[15] Malthus in his work refers to absolute scarcity in quantity of resources.

It can be seen that the Physiocrats as well as the exponents of classical economics pay tribute to the primordial function of nature for economic production. Relative (Ricardian) scarcity has found its way into the theoretical body of neoclassical economics, while absolute scarcity of natural resources is excluded from it. The lack of the notion of absolute scarcity significantly affects how natural resources are treated in neoclassical economics.

[11] see Costanza et al. 2001, p.27

[12] Malthus 1815, 1836

[13] see Christensen 1989, p.21

[14] Costanza et al. 2001

[15] Daly 1991, p.39

Neo-classical economics focuses on exchange rather than production. Economic activity takes place inside a closed cycle of exchange of commodities. What is circulating is not goods and services as such – these would be used up while running in circles - but exchange value. In this idealised model of circular flows, there is no place for environmental aspects such as natural resources, technology and taste. They are treated as exogenously given factors.

Neo-classical production theory presumes independently given, homogenous factors of production. There seems to be no complementarity between capital, labour and land. Neither man-made capital nor human labour depend in any way on natural prerequisites. Natural resources are usually excluded from production functions. Like agricultural harvest in classical thinking, all factors of neo-classical production theory are created out of nothing.[16]

Consequently, the neo-classical solution to the problem of (resource) scarcity does not reside in the interaction between nature and the economic system. It is exchange – in its institutionalised appearance of the market – that makes scarcity a temporary difficulty. With a resource's scarcity growing, its price will rise. The rise in prices will trigger a number of feedback mechanism, such as exploration, substitution or recycling. Investment and concurrent technological innovation will increase efficiency of resource use, extraction and processing and finally bring alternative technologies and products to the market.[17] An example for the functioning of this mechanism is the substitution of capital for more expensive human labour. This mechanism of substitution is limited to marketable goods though. It is unable to grasp environmental media such as water and air as long as there are no prices set for clean water and unpolluted air.

Important parts of the natural environment are neglected by neoclassical economic theory. Ecosystem services of all kinds (natural resources and other) are excluded from neoclassical production theories. Limited availability of resources is neutralised by technological progress and the market mechanism.

The discipline of Environmental and Resource Economics strives to correct for this neglect. It applies mostly neo-classical economic methodology to environmental issues. Its focus lies on research topics such as pollution and other externalities, instruments for environmental protection (regulatory standards, market mechanisms such as taxes and tradable permits), optimal depletion of non-renewable and optimal use of renewable resources.

A transdisciplinary approach to the economy-nature interrelations is Ecological Economics (EE). Developed since the 1980's, it "addresses the relationships between ecosystems and economic systems in the broadest sense."[18]

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[16] One could argue that capital is used as an input to the production of capital. But with natural resources ignored, the output of the first step in the sequence of production of capital is always created without (material) input.

[17] Cleveland 1991, p.292

[18] Costanza 1989, p.1

Sprung from increasing concern about human effects on nature and increasing discontent with the answers of conventional economics to the respective questions, EE finds its sources and instruments in disciplines so diverse as Ecology, Thermodynamics or Evolutionary Economics. Ecological Economics is not a clear cut scientific discipline based on a homogenous theoretical body. It lies far beyond the scope of this thesis to give a comprehensive survey of all theories and practices it makes use of. We will briefly discuss only the aspects of EE which will be of further use in the course of this thesis.

EE treats the question of human impact on nature and of its consequences for the development of anthropogenous systems. In addition, in accordance with aspects of some important definitions of sustainable development, EE addresses the questions of distribution of wealth and development. It critically challenges the paradigm of economic growth and confronts it with the notion of (qualitative) development.

> By “growth” I mean quantitative increase in the scale of the physical dimensions of the economy; [...] By “development” I mean the qualitative improvement in the structure design and composition of physical stocks and flows, that result from greater knowledge, both of technique and of purpose.[19]

Growth and the limits to it are necessarily related to the question of relative and absolute scarcity. Substitution and complementarity of man-made and natural capital are a crucial question in this regard. Unlike neo-classical economic theory, EE emphasises the natural resource base of economies.[20] One out of a number of approaches applied within EE is a biophysical approach to production[21] that identifies solar energy as the primary input to all life and distinguishes raw materials, intermediate inputs and products.

Besides ecosystems, biodiversity, population growth and ecological carrying capacity, the measurement of welfare and sustainability and the critical scrutiny of traditional economic indicators is, among other issues, at EE’s agenda. Measures such as the GDP are questioned in the light of the sustainability paradigm and enriched knowledge about nature-economy-society interactions.

Unlike Environmental and Resource Economics, EE does not exclusively apply neo-classical methodology, but the wide range of methods of social and natural sciences (in particular of economics and ecology)[22]. These are e.g. systemic analysis of material and energy flows through natural and economic systems, environmental assessment techniques or the application of biological concepts in the analysis of co-evolution of natural and social systems[23]. Here, methods that are of importance within the scope of this thesis are briefly outlined:

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[19] Daly 1987, p. 323

[20] see Costanza et al. 2001

[21] Christensen 1989, p.27

[22] see Norgaard 1989, p. 51

[23] see Costanza et al. 2001, p.61

- System Theory and Analysis

Classical reductionist science analyses isolated causal relationships. This approach is adequate when interaction between the analysed phenomenon and its environment are weak or linear[24]. Complex natural and social systems usually show strong and non-linear interactions between its elements.

System Theory focuses on the structure of interactions between different elements of systems and the interrelations of systems and their environments. Systems Analysis can be applied on different hierarchical levels – an enterprise, an economic sector, a local, regional, national economy can be considered a "system" – and in different scientific fields. It claims that in diverse systems, such as ecosystems or economic and social systems, similar structures of interaction can be detected. The systemic view opens up the possibility of integrated analyses of natural and social systems and can thereby help to re-integrate nature into economic thinking and re-define economy as a subsystem of the global natural system.

- Thermodynamics

Thermodynamics has been introduced to economics by Nicholas Georgescu-Roegen. He applied the entropy law to economics and described production processes with regard to degradation of available energy. Although the practical implications of his findings are not evident, the theory of "The Entropy Law and the Economic Process"[25] directs the attention to the fact that solar energy is the only genuine energetic input to natural as well as social systems and calls for a change from fossil to renewable energy resources.

- Social Metabolism

Transfer of mass and energy across the boundaries between natural and social systems has been proven to be the source of most actual environmental problems. Thus, analysis of material and energy flows between social systems and ecosystems is an important instrument to assess and control environmental impact of human activity.

Environmental and Resource Economics as well as EE are efforts to foster the conviction that economic activity relies on a natural basis. Their considerations are based on respect for our natural environment or, more pragmatically, on the acknowledgement of the importance of natural resources for production.

EE in general, and the methods described here (Systems Theory, Thermodynamics, Social Metabolism) in particular, represent the theoretical foundation of this thesis. They will be applied directly or indirectly as they are parts of other methods used (e.g. methods of ecological evaluation).

EE and Environmental and Resource Economics deal with issues that are relevant for ecological and in turn economic sustainability. The study and control of the use of natural sources and sinks is of utmost importance in this respect. But neither EE nor Environmental

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[24] see Costanza et al. 2001, p.61

[25] Georgescu-Roegen 1971

and Resource Economics are sustainability concepts as such. Their scope is wider than that of pure sustainability. Sustainability concepts may be derived from their theories.

2.3 Sustainability in Economics

2.3.1 Concepts of Economic Sustainability

The main concepts of economic sustainability are based on a general agreement on the desirability of “some acceptable state of human well-being to be maintained over an indefinite period of time”[26]. They are concepts of sustainable economic development. Most of the concepts are output- or input-oriented[27] which is to say that sustainability is sought to be determined through the output from economic activity or the input to economic activity. Perman et al.[28] present six concepts of sustainability. Five of the six concepts deal with economic resources and outcomes:

- A sustainable state is one in which utility (or consumption) is non-declining through time.

This first concept claims that economies are sustainable when utility or consumption is constant or increasing over time. A difference between utility and consumption lies in the possible breadth of the concepts. While consumption is limited to marketable commodities, utility may be derived from public, non-market goods and services, too. When utility depends on consumption exclusively, both forms of the concept are equivalent. While future development of utility or consumption are determined, the concept makes no indications about initial levels of consumption or utility.

- A sustainable state is one in which resources are managed so as to maintain production opportunities for the future.

This concept approaches the question of intergenerational equity from a different vantage point. In contrast to the first concept, sustainability is assured by maintenance of opportunities for production. Thus, the focus of this concept lies on the input side of economic activities. Opportunities for future production are natural capital, man-made capital, human capital (the skills of the workforce) and intellectual capital (disembodied skills). This input-oriented concept is linked to the first (output-oriented) concept inasmuch as

> Maintenance of the productive potential of the economy will be achieved if the levels of L [labour], K_H [man-made, human and intellectual capital] and K_N [natural capital] change only in ways that allow the output to be non-declining over time.[29]

[26] Perman et al. 1999, p.50

[27] see Pezzey 1989, p.13

[28] Perman et al. 1999, p.52

[29] Perman et al. 1999, p.57

- A sustainable state is one in which the natural capital stock is non-declining through time.

This concept follows from the former when it is assumed that natural capital cannot be substituted for by other forms of capital and that it represents the only factor limiting future production potentials. The concept can be based on the notion of one homogenous stock of natural capital, thus implying substitutability between different forms of natural capital. A stricter version of the concept requires non-declining stocks of single components of natural capital.

- A sustainable state is one in which resources are managed so as to maintain a sustainable yield of resource services.

This concept links economic sustainability to the productive capacities of natural systems. It sees sustainability determined by flows of services from resource stocks maintained at some definite level over time. To assure sustainability the level of extracted flows must not exceed the rate of reproduction of (renewable) natural resources. Once again, the requirements can be applied to aggregate flows of services or to single subsets of services. Aggregation of resources with different rates of reproduction is not straightforward, though.

> What does 'maintaining a flow of resource services constant' mean when the flow is made up of heterogeneous elements? Does it mean that each different element must be kept constant, or rather that some weighted sum should be maintained?[30]

What is conspicuous is that most concepts of economic sustainability are inseparably related to some notion of sustainability of natural systems. The concepts discussed above rely on the sustainability of stocks of natural capital or sustainability of flows of services from natural resource stocks. They define economic sustainability largely as ecologically sustainable use of natural resources for economic purposes. According to the degree of substitutability of man-made for natural capital assumed, economies are thought to depend upon natural capital and the service flows from it. Concepts of strong sustainability dismiss the idea of substituting man-made for natural capital (e.g.: A sustainable state is one in which the natural capital stock is non-declining through time). Concepts of weak sustainability advocate at least limited substitutability (e.g.: A sustainable state is one in which resources are managed so as to maintain production opportunities for the future).

Concepts of strong sustainability that do not regard natural resources as inputs to economic activity only but consider additional functions of natural system which are of no direct economic use can be called concepts of ecological sustainability. These concepts – though they still deal with the impacts of economic activity on natural systems – focus on sustainability of ecosystems as such (and not only as a resource basis for economic systems).

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[30] Perman et al. 1999, p.61

One such concept is among those outlined by Perman et al.[31].

- A sustainable state is one which satisfies minimum conditions of ecosystem stability and resilience through time.

Sustainability according to this concept is given, when ecosystems are resilient, which means that they can return to their initial state after disturbances. The initial state of an ecological system is determined by its integrity and structure. Perman et al. argue that the resilience of ecosystems cannot be predicted and that in consequence, if ecological sustainability is desirable,

> economic affairs should be organised so as to keep to a reasonably low level the likelihood that disturbances alter the system's parameters to a point where the resilience of the whole ecosystem is threatened.[32]

As they are of importance throughout this thesis it is worth discussing two approaches to sustainability that can be seen as substantiations of one of the above concepts.

- The Steady State Economy[33]

Daly's "Steady State Economy" can be seen as an interpretation of the fourth concept discussed (A sustainable state is one in which resources are managed so as to maintain a sustainable yield of resource services.).[34] The Steady State Economy (SSE) is an economy with constant stocks of capital. Capital consists of two physical "populations" embedded in a larger natural system – bodies and artefacts (man-made capital). On the one hand, both yield services to the "consumer". On the other hand they need maintenance and replacement in case of death and deterioration. Resources needed for these means are the necessary throughput of an economic system.

While intermediate transactions can be cancelled out – they do not yield net services as money has to paid for the purchase of goods – two "uncancelled fringes"[35] exist at the very beginning and at the very end of the economic process. At the input side the fringe is the "unpaid inputs from nature" because "we do not pump money into a well as we pump oil out of it". On the output side, what is left, when all intermediate transactions are cancelled out, is "psychic income" provided by capital to the final consumer.[36]

The throughput needed to maintain and replace capital is, on the input side, taken in the form of low-entropy resources from the environment and, on the output side, emitted in the form of high-entropy emissions and wastes to the environment. Throughput is the final cost, the

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[31] Perman et al. 1999, p.61

[32] Perman et al. 1999, p.63

[33] Daly 1991

[34] It should be noted that the SSE is not limited to the question of resource services. Other issues are addressed as well. Still, sustainability of resource services is a central point of the SSE.

[35] Daly 1991, p.32

[36] Fisher 1906

uncancelled fringe of resources consumed. Psychic income is the final benefit, the net services to the final consumer. These services are provided by an economy's capital stock.

Strategies to attain a steady state are threefold:

> For stocks, the indicated mode of behaviour is *satisficing,* choosing some level of stocks that is sufficient for a good life and sustainable for a long future. Throughput is to be *minimized*, subject to the maintenance of the constant stocks. Service is to be *maximized*, subject to the constant stocks.[37]

- The concept of Moser et al.

Much like the SSE, the concept of Moser et al. can be seen as an interpretation (and extension) of the fourth concept discussed. In contrast to the ecosystem resilience concept it does not see sustainability determined by the state of a natural system but by the pressure exerted on natural systems by human activities. Human activity may accelerate (or augment) the degeneration of natural resources and the deposition of substances and thereby may overuse natural regenerative and assimilative capacities. The emission of substances and materials degrades the quality of the natural media air, water and soil. In addition, the consumption of non-renewable resources may empty natural reservoirs. Thus, within this concept, the exchange of matter and energy between anthropogenous and natural systems is identified as one major threat to ecological sustainability. But functioning of ecosystems is not exclusively based on the quality of its elements alone. It relies just as much on the harmonised interactions of the latter. Human actions (resource depletion, land use) may affect mutual dependence and balance of ecosystem elements on a structural basis. Examples of this are roads (that cut ecosystems and impede migration), massive excavations and mining (that move large amounts of material and change the ground water systems), and deforestation (that changes landscapes and destroys habitats).

The concept at hand focuses on these anthropogenous impacts on nature. Industrial metabolism (the exchange of matter and energy with natural systems) and structural change are at its centre.[38] Sustainability criteria that help operationalising the concept are provided by Moser et al.[39]:

- Anthropogenous material flows must not exceed the local assimilation capacity and should be smaller than natural fluctuations in geogenic flows.
- Anthropogenous material flows must not alter the quality and the quantity of global material cycles.
- Renewable resources can only be extracted at a rate that does not exceed the local fertility.
- The natural variety of species and landscapes must be sustained or improved.

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[37] Daly 1991, p.37

[38] see Gassner and Narodoslawsky 2001

[39] Moser et al. 1993

After having introduced different concepts of economic sustainability and related concepts of ecological sustainability, we will have to assess the strengths and weaknesses of the concepts against the backdrop of the aim of this thesis, the development of indicators of economic sustainability. But first, we are going to provide a general analysis of economic sustainability and the threats to it that will serve as groundwork for the assessment.

3 Interfaces

An economic system is first surrounded by a social and natural environment. The social environment of economic systems consists of other fully differentiated systems such as the political, the religious or the legal system. The natural environment is formed by ecosystems. Furthermore, subsystems of the global economic system are surrounded by other economic subsystems (national economies are surrounded by other national economies, companies by companies). Therefore, the environment of an (non-global) economic system is natural, social and economic.

Exchange of matter and energy takes place between the economic system and the environmental systems. Natural resources are extracted and subsequently used up in production processes, residues from these productive activities (and the usage of goods and services within the social environment) are emitted and have to be absorbed by surrounding eco-systems. Economic goods and services are provided to other economic subsystems and the social environment. Households operate at the boundary between the economic system and its social environment. On the one hand, they buy economic goods and services and are part of the economic system. On the other hand, the use of the goods and services purchased is non-economic and takes place within the social environment of economic systems. It follows that economic systems are open systems with regard to the exchange of matter and energy.

In addition to the exchange of matter and energy, economic systems are engaged in symbolic exchange with other economic systems. Symbolic exchange (communication) – in the form of actions of payment[40] - takes place between different economic units. Economic systems are closed systems with regard to communication. Money can neither be transferred to the natural nor to the social environment. Other social systems (legal, religious, etc.) are constituted by their own code. Once again, households, in their function of purchasers and users, form the boundary between economic systems and their social environment. They pay money to purchase and thus take part in economic communication. At the same time they have functions which are independent from economic communication (actions of payment). (Fig.3.1)

[40] The binary code of economic communication is to pay/not to pay. The medium of communication within economic systems is money.

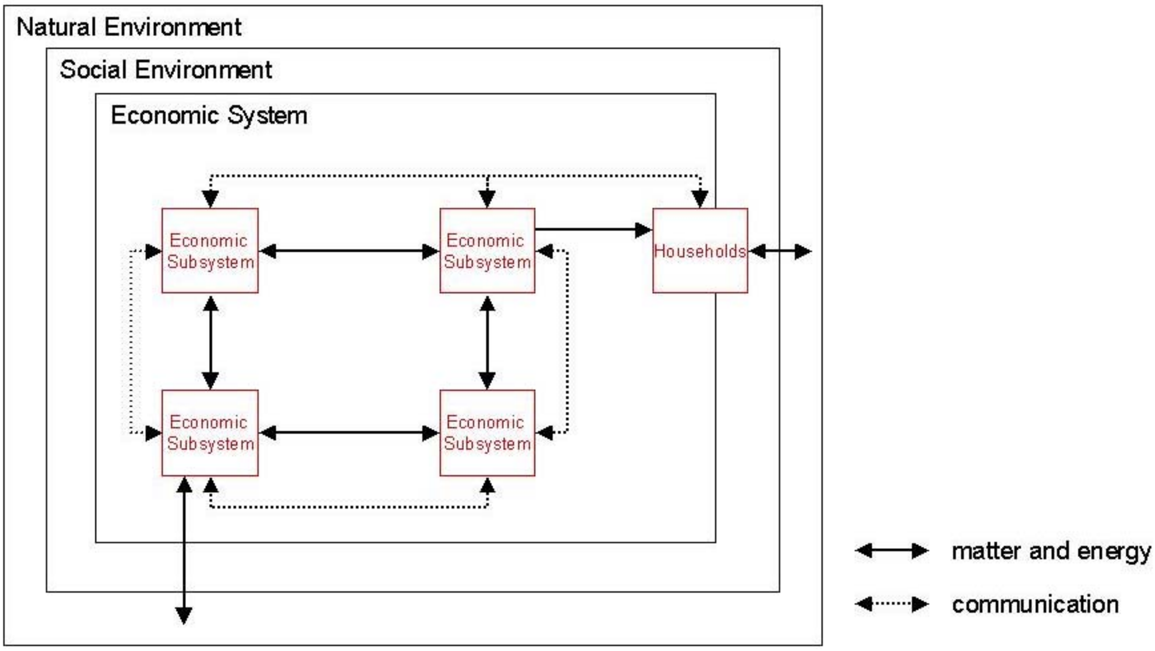

Figure 3.1: The exchange between economic and other systems

To some extent, economic systems depend upon and are co-determined by the exchange with other systems. But economies, like all systems, are not entirely determined by their environment. Natural, economic and social environments define boundary conditions for the functioning of economic systems. Natural boundaries appear in material form, when, for instance, resource deposits are used up or geomorphologic situations limit the spread of industrial buildings. Social boundaries appear in the form of criteria (ethical, legal, etc.) and expectations of economic functioning. Economic boundaries can be of material and communicative nature when e.g. materials cannot be supplied and money cannot be paid.

In this section we have to answer the question when the exchange between economic and other systems represents a menace to the sustainability of an economic system. The answers will provide criteria for the evaluation of the concepts of sustainability outlined in Section 2.3.1.

3.1 The Exchange between Nature and Anthropogenous Systems

Anthropogenous (economic and social) and natural systems are in a state of mutual exchange. Social and economic strategies such as production and living are influenced by their natural environment. On the other hand, these social and economic characteristics leave their mark on nature. Fischer-Kowalski et al. describe sustainable development through the dynamic interplay of natural with social (including economic) systems.[41] (Fig.3.2)

[41] Fischer-Kowalski et al. 1997, p.25

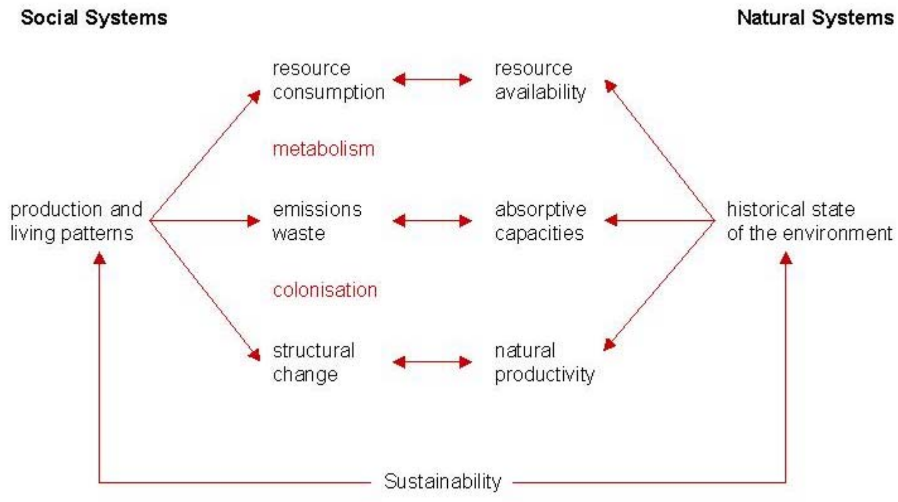

Figure 3.2: Sustainable Development and the interplay of nature and society (Source: Fischer-Kowalski et al. 1997)

Anthropogenous systems depend upon the exchange of materials and energy with nature, their social metabolism[42]. Metabolism problems change natural environments and altered environments, in turn, act back on anthropogenous systems. Production, reproduction and availability of natural resources together with the capability of social and economic systems to organise these elements in accordance with their environment – together with other factors - allow for the survival of societies.

Resource use is determined by production strategies and the size of anthropogenous systems. Population size, in turn, is dependent on the existence of natural resources and the ability to harness these resources. Exploitation of natural resources relies on preceding colonisation of natural systems.[43] Colonisation strategies and metabolism have evolved with cultures and have made cultures evolve.

The metabolism of hunter-gatherer societies is limited by the biophysical needs of its population. These cultures live on plants and animals, instruments are made of stone, wood or bones. The limiting factor for hunter-gatherer populations is food availability. Human nutrition is dependent on natural regenerative cycles. Survival strategies are migration and conscious limitation of population size, e.g. infanticide.

First colonisation strategies emerge with agricultural societies. The metabolism of these first sedentary societies is still dominated by the consumption of renewable resources, such as wood (for construction of dwellings), other plants and animals. The spectrum of non-renewable resources is extended by the use of salt and metals. On the one hand, the

[42] The term social metabolism describes exchange of economic and social systems with natural systems.

[43] Here, colonisation signifies the transformation of natural processes by mankind for economic and social purposes (e.g. agriculture). See Fischer-Kowalski et al. 1997, p.25

quantitative change in the metabolism of agricultural societies with regard to the preceding hunter-gatherer communities is due to the need for housing. On the other hand, the social domain is enlarged by the domestication of animals. These animals, though they are still natural creatures, live within social systems and, in consequence, their metabolism is social. The change from hunter-gatherer to agricultural societies brings increased efficiency of the exploitation of natural resources, higher demand and a shift of the boundaries of the social system.

While agricultural societies still depend on the current inflow of solar energy that is transformed to biomass, chemical transformation of biomass is made a less limiting factor by the use of non-renewable fossil resources. The metabolism of industrial societies is based on the exploitation of first coal and today mainly petroleum. Abundant deposits of fossil and mineral resources together with the invention and dissemination of machines frees the industrial society from its ancestors' dependence on natural regenerative periods and capacities. Industrialisation of agriculture and animal husbandry make population growth seemingly independent from renewable natural resources. In contrast to earlier cultures, the industrial culture relies to a large extent on the exploitation of non-renewable resources, be it energetic or material. The lion's share of the social metabolism is no longer congruent with the biophysical one of man and animal. Most of the industrial societies' throughput can be allocated to the production, use and maintenance of artefacts.

There is no question about the fact that social and economic activity may endanger its natural environment. Phenomena of ecological change, such as ozone depletion, climate change and loss of biodiversity, are to a large extent adaptations of natural systems to pressure exerted on them by mankind.

If we assume that economies are independent from nature, social metabolism and the degradation of natural systems that results from it can be excluded from the list of economic sustainability issues. It is true that various dependencies of society from nature have been alleviated. Heated houses keep us from freezing in winter, trade and preservation make all sorts of food available throughout the year, human and animal labour has been replaced by machines. But yet, economic throughput of natural resources is bigger than ever. And our economies seem no less dependent from petroleum than hunter-gatherer societies have been from animals to hunt and plants to gather. Massive exploitation may cause the depletion of such resources. In addition to our dependency on nature as a source, we are dependent on its capacity to absorb the unwanted outputs of our productive and consumptive activities. It has already been mentioned that the emission of substances and materials may degrade the quality of the natural media air, water and soil and that emissions may be the cause for global environmental problems such as the greenhouse effect and the depletion of the ozone layer.

It follows that as long as economic systems are dependent on the functioning of their natural environment as a source for material and energetic input and as a sink for solid, gaseous and fluid emissions, the exchange between natural and anthropogenous systems is a question of sustainability for the global economic and social systems as well as for economic and social subsystems.

3.2 The Exchange between Economic Subsystems and between Economic Systems and their Social Environment

We have seen above in this chapter that economies are open systems with regard to their natural environment. Exchange of matter and energy takes place and this interaction influences economic systems as well as the natural environment in a reciprocal way. We have detected the intensity and extent of change as a factor determining ecological and in consequence economic sustainability. But the harmonised exchange between economic systems and their natural environment is not the sole determinant of economic sustainability. It is a necessary but not a sufficient precondition for sustainable economic activity. On our quest for further requirements for economic sustainability it is useful to consult Niklas Luhmann.

Luhmann[44] defines economic systems, like all social systems, as systems of communication. The most important social systems structure their communication according to binary codes. Science operates under the code of true/false, the judicial system under right/wrong. The primary code of economic systems is derived from the central notion of ownership (to have/not to have). Modern economies' secondary code is derived from the functions of money (to pay/not to pay). The medium of the code to pay/not to pay is money.[45] Among the most important features of money is the fact that it is suitable for the operations of economic systems only. Money cannot be imported from the systemic environment to the economic system and it cannot be exported from the economic system to its environment.[46] There is no modern economic system without money and wherever money occurs is economic activity. Communication constitutes economic systems and economic activity is where the code of economic activity is applied. Money constitutes closed (with regard to the medium), circular and self-referential systems. It creates actions of payment that require ability to pay and in turn reproduce ability to pay. Economy is where sequences of payment take place (or not).

Actions of payment per se are bare of meaning. To introduce meaning, the code has to be superposed by programs. Simplistically speaking, programs are criteria that determine whether it is sensible to pay or not to pay.

Luhmann[47] discerns two different classes of programs to determine soundness of payment. The first class of programs articulates criteria of the environment of an economic system (e.g. goals of industrial restructuring, investment, consumption preferences). The second class does not deal with economy-environment relations. It refers directly to the processes of payment (no payment) that constitute economic systems. In the following, we will call the first class of criteria "external criteria" and the second class "internal criteria". It is worth mentioning that external criteria such as consumer needs and preferences cannot be treated

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[44] Luhmann 1988a, p.102

[45] for a more extensive treatment of the functions of money see Luhmann 1988b

[46] It goes without saying that money in its material form is taken from and deposited in its environment. Here we are of course concerned with its communicative functions.

[47] Luhmann 1988b, p.250

directly within the economic system. What is needed is a programming of the systemic operations as such. Programming of the payment operations is realised through prices.

External criteria are manifold. They can comprise, for instance, ecological soundness of economic activity or investment programs. Environmental disturbances can be made present in economic systems when they result in a change of actions of payment. When environmental services and products help to open up new markets, when negative ecological effects result in a change of prices, social metabolism and the related pressure on the environment becomes a matter to be dealt with in economic operations.

In the context of this thesis, the definitions of sustainable development determine external criteria. It is e.g. the WCED's emphasis on present and future needs that determines requirements (external criteria) for development to be called sustainable. Other concepts of economic sustainability require the provision of utility or consumption goods. A non-fulfilment of these external (sustainability) criteria accordingly represents a state of unsustainability.

The second class of criteria is self-referential, it refers to the functioning of the economic system as such and not to its environment. It consists of criteria to maintain solvency. Payment takes place between economic subsystems. Continuation of the payment processes requires solvency (available money) of the economic subsystems. A subsystem that is not able to pay, can be excluded from the processes of payment (insolvency). Continued solvency is the prevailing criterion for e.g. companies. For a company it is sensible to pay, every time the action of payment prolongs its ability to pay (and additionally yields a profit). In contrast, households do not "pay/not pay" to keep up their solvency. Their primary criterion for sensibility of payment/absence of payment is the satisfaction of needs. It is nevertheless evident that households need money to participate in the economic sequence of payment actions. Solvency is a prerequisite for every economic unit and as households – as purchasers – are part of the economic system, the criterion of solvency applies to them as well.

Internal criteria come down to one essential common denominator, durable ability to pay or the prolongation of payment actions. With emphasis on the counterpart of every payment one could say: prolongation of exchange – of goods, services, rights, and so on - between economic subsystems. Keep up your solvency! Thus is the internal imperative for economic systems from nations to companies and single human actors.

Insolvency is a term and state of importance for civil and criminal law.[48] Insolvency is synonymous for long-term or constant inability to settle one's debts due to the lack of means of payment.[49] Its juridical opposite "solvency" can be defined as the "ability of a company to fully comply with its financial obligations".[50] The term with all its juridical connotations can be applied to private entities and firms. It does not apply to national economies. A national economy cannot be insolvent in the juridical sense.

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[48] The exact juridical connotations of the term are of no use for our further observations.

[49] Matzen 1993, p.26, translation by the author

[50] Matzen 1993, p.28, translation by the author

National and regional economic system will be at the centre of our interest in the subsequent sections of this treatise. Thus, it is of importance to define a state and find the respective term that is near to Luhmann's notion of insolvency and applies to national and regional economic systems as well as to companies and individuals. Insolvency is the result of accumulated, constant debts that cannot be settled. The term "debt" may be applied to all kinds of economic systems. Therefore, it seems sensible in the context of this work to use "accumulated, excessive debt" as a proxy for "insolvency".

How does an economic system run into debt? When expenses exceed income. When a person spends more money on consumption than the sum he earns every month, he will be obliged to take out a loan. When a company enlarges its production capacities it might borrow to finance investment. Much like single households, national and regional economic systems run into debt when consumption exceeds income. Consumption in this regard may be seen as the sum of goods and services used. As the "consumer" is here a national/regional economy, this includes consumption as well as investment goods. Income in this context is the value added (in consumption and investment goods) of the national/regional economy in a certain period. When in this period consumption exceeds income (value added) the nation/region must import goods from trading nations/regions. This point requires further attention.

The goods and services produced by an economy can be utilised in the economy or sold to trading economies. What is not exported together with what is imported by an economy is what is consumed and invested by the domestic economy and the domestic households. If what an economy saves from what it produces (exports) is less than what it imports from trading economies the economy incurs debts.

In other words foreign trade creates claims and liabilities of an economy vis-à-vis its trading partners. Exports are claims of an economy, imports represent liabilities. When claims exceed liabilities an economy is saving in relation to other economic systems. When liabilities exceed claims an economy is incurring debts. Therefore, export surplus equals net savings, import surplus equals net debts. To incur debts means to live of stocks. As continuous dissavings will impoverish an economy, constant import surplus over export cannot be sustainable.

> Finally, if sustainability is to mean anything for trading and manufacturing nations, it will not make sense to focus solely on a nation's own resource stocks; what will matter is maintaining balanced trade and the productivity of its physical and human capital, possibly in the face of rising real prices for resource inputs it needs to buy on world markets.[51]

Liabilities are not a priori a problem. Investment is done and debts are incurred with the perspective of future profit, of a return on invest that is sufficient at least to pay back. It is durable and accumulated debt burden that may cause problems. We have seen that at the level of national economies debt is incurred by current account deficits (import that exceeds export). In the context of current accounts, Reisen[52] states:

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[51] Pezzey 1989

[52] Reisen 1997, p.5

> Since large current account deficits will not be financed by foreigners forever, authorities need to know the required magnitude and time profile of the subsequent adjustment back to payments balance. [...] It is thus not only important to know the sources of the current account deficit, but also the size and the time profile of the balancing adjustment.

Unlike companies, nations and regions cannot be excluded from the sequence of payments. There is no definite level of debt that would cause a nation/region to go bankrupt. Import surplus causes an outflow of money (a loss in solvency) from an economic system to other economic systems. But a lack of solvency can be solved by an inflow of money (credit, investment) to the respective economic system. The mechanism counteracting an import surplus and fostering the readjustment to balanced exchange is the depreciation of the currency of the net importing country. Depreciation makes export goods of the respective country “cheap” for the rest of the world. This in turn will increase the amount (and the overall value) of goods and services exported and thereby reduce the import surplus. Within currency areas (where no relative depreciation is possible) exchange deficits result in decreased real wages for the net importing region. In any case, exchange deficits worsen the terms of trade for the nation or region in deficit (the value of export goods decreases in relation to the import goods). Another drawback national and regional economies encounter when indebted is dependence on the creditor/investor. Loss of creditworthiness and investor confidence and the subsequent outflow of money may cause serious economic problems. We follow Luhmann[53] in his argument that “danger” to an economic system is coming from its environment while “risk” is attributed to internal systemic actions. Risk is calculable, danger is not. In this regard, for an economic system to have money means to transform “danger” to “risk”. To have money ensures self-determination and enlarges an economy’s opportunities in the face of adverse situations. As strategies for sustainable development must strive to minimise the potential dangers, to have or not to have money is a question of economic sustainability.

3.3 Concluding Remarks on the Exchange between Economic Systems and Their Natural, Social and Economic Environment

On the basis of our systemic analysis, we have identified the natural, social and economic environments as factors determining boundary conditions for the functioning of economic systems. Boundaries appear in physical and symbolic form. It is essential for the evolution of economic systems to create room for manoeuvre within these boundaries, to become as independent as possible from environmental restrictions. An example for this is the shift from the exclusive use of renewable resources to the use of non-renewables which lead to an increased decoupling of productive and consumptive habits from natural reproductive and regenerative cycles. As a consequence, today other limiting factors of the natural environment come into play (e.g. assimilative capacities).

Neglect of environmental boundaries may reduce the ability of economic systems to evolve and, at worst, endanger its survival. Therefore, the recognition of environmental boundaries

[53] Luhmann 1988b, p.269

becomes one possible precondition for the development and viability of economic systems. Concepts of economic sustainability have to take this fact into account.

4 A Concept of Economic Sustainability

In this chapter, we will examine the concepts of sustainability discussed in Section 1.3.1 with reference to the analysis of the different forms of exchange between economic systems and their social, natural and economic environments. We will further lay the conceptual basis for the development of indicators of economic sustainability.

4.1 Discussion of Existing Concepts

The question that has actually to be answered is whether and how the physical and communicative exchanges discussed in Chapter 2 are taken into consideration by the different conceptual approaches to sustainability. The answers will help determine whether existing concepts or parts of concepts represent a suitable basis for the aim of this thesis, the development of indices for economic sustainability.

- A sustainable state is one in which utility (or consumption) is non-declining through time.

This definition of sustainability concentrates on the provision of consumption or utility to households. While economic theory considers the households to be part of the economic system, we have seen that from a system theory's point of view they form the border between the economic system and its social environment. In consequence, the concept at hand understands economic sustainability as a function of the exchange between the economic system and its social environment. The amount of utility or consumption provided to the social system over time determines whether an economic system is on a sustainable path or not. In other words, the concept defines an external criterion for economic systems to be sustainable. The strictness of the criterion can vary. It can require steadily increasing utility or consumption or, less strictly, some increasing (long or middle-term) average value of utility or consumption – which is the result of increasing and decreasing short-term levels of utility or consumption. Moreover, additional criteria such as minimum or survivability levels of consumption or utility can be introduced.
The other forms of exchange with an economic system's environment are not considered. Neither exchange with economic subsystems nor the use of natural sources and sinks is explicitly touched upon. The availability of money and natural resources only indirectly referred to, but is not the central criterion. From the viewpoint of the aim of this thesis this represents a non-negligible drawback.

The requirement of constant, increasing or non-decreasing consumption or utility is a call for the availability of the resources that allow for the production of the respective output. But the production of goods and services may deteriorate the resources it relies upon and in turn have a negative effect on future production potentialities. An accounting system exclusively based on the explicit requirements of this concept runs the risk of detecting sustainability where the provision of consumption and utility deteriorates resources. Deterioration of resources in turn may impede future possibilities for such provisions. Considering only outputs is a case of myopia for the future. Output sustainability can grasp the consequences of resource depletion only when it has already resulted in decreased production potentials.

Measures of input sustainability indicate symptoms of human activity, too. But the time lag between cause and the measured effect is normally smaller and it is easier to infer the cause from the effect. Exploitation of natural capacities may impede production many decades from today. To allow for proactive strategies, indicators of sustainability must measure pressure on the environment rather than symptoms of environmental degradation that occur in the long run only.

Solvency much like resources is a precondition for the production of output. For some time output can be generated in a way that violates the criterion of solvency. For instance, production may be financed by external creditors and investors. Analogous to the overexploitation of resources, debt (which in its accumulated form may lead to insolvency or loss of self-determination) does not necessarily prevent an economy from the production of output immediately. Foreign investment in many cases is desirable (when it is used to enhance production potentials that in turn allow for the payback of the liabilities incurred). In other cases it may be not. In these cases the effects of long-term borrowing may come to the surface with delay. Thereby, debt today can diminish future economic potentials.[54] The advantages of an explicit consideration of resource consumption apply to debt as well. Possible problems can be detected earlier, measurement is “closer” to the cause of such problems.

- A sustainable state is one in which resources are managed so as to maintain production opportunities for the future.

Sustainability according to this concepts is not determined by the actual provision of utility or consumption but by the potential to provide utility or consumption. In consequence, it concentrates on the factors of economic production (natural, physical, human and intellectual capital) and not its output. The sustainability criterion is not a non-declining stock of different sorts of capital but non-declining production opportunities. This in principle allows for substitution between the different sets of capital.
Solvency, the need for financial capital, is not (an explicit) part of the concept. In principle however, solvency is a prerequisite for production and therefore implicitly present in this concept but not explicitly. In this respect, the critique of the former concept applies to this concept as well. The accumulation of physical, intellectual and human capital can be based on borrowing from other economic systems. The liabilities incurred can in turn reduce future opportunities for production.
If it is assumed that the provision of utility or consumption is inherent to economic sustainability (what the concept might do implicitly), the omission of the exchange between economic systems and their social environment represents a weakness of the concept. In principle, economic systems that are richly endowed with all sorts of capital may fail to provide consumption or utility.

[54] In this particular respect the exchange between different economic subsystems shows analogies to the exchange of economic systems with their natural environment. Overusing natural sources and sinks can be regarded as “incurring liabilities” vis-à-vis the natural environment. Liabilities – provided that no irreversible effects occur – are desirable when they are invested in order to reduce the future use of natural resources.

Serious problems arise when it comes to quantifying criteria for and measurement of sustainability according to this concept. Approaches to the measurement of physical (man-made) capital and natural capital exist. In contrast, quantifying human and intellectual capital, finding measures for “stocks of learned skills, embodied in particular individuals, which enhances the productive potential of those people” and for “stock[s] of useful knowledge” that “reside in books and other cultural constructs”[55] seems very difficult.

- A sustainable state is one in which the natural capital stock is non-declining through time.

In principle, this concept is purely ecological. Its definition of sustainability does not explicitly include the existence of an economic system. Non-declining natural capital stocks may or may not exist with or without the existence of economic systems.
When it is assumed that the concept understands natural stocks as resources for economic activity, it can be concluded that it is concerned with the economy-nature exchanges. The concept omits exchange among economic subsystems as well as between economic systems and their social environment. The criterion of a non-declining stock of natural capital can be applied to an aggregate stock of capital (and thereby allowing for substitution of different forms of natural capital) or to subsets of natural capital.
Methods for the measurement of natural stocks exist.

- A sustainable state is which satisfies minimum conditions of ecosystem stability and resilience through time.

This is a purely ecological concept, as well. Ecosystem stability and resilience alone cannot give any indication about economic functioning, impact etc. (and is not supposed to do so within this concept). In contrast to the concept of a non-declining stock of natural capital, no widely accepted method of quantification of ecosystem resilience exists.

- A sustainable state is one in which resources are managed so as to maintain a sustainable yield of resource services.

In contrast to the concepts of a non-declining capital stock and ecosystem resilience this approach presupposes the existence of an economic system making use of natural resource services.
The concept is purely input-oriented and consequently omits exchange between economic subsystems as well as between the economic system and its social environment. As long as solvency is not needed to maintain a sustainable yield of resource services and as long as external criteria such as the provision of goods and services are not thought to be inherent parts of economic sustainability the concept per se is coherent.
Approaches to the measurement of sustainability of resource flows exist, they will be presented in the course of this thesis.

The concept of Moser et al. and the concept of a SSE are once again regarded as derived from the concept of a sustainable yield of resource services.

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[55] Perman et al. 1999, p.56

- The concept of Moser et al.

When the notion of resource services is not limited to sources but comprises the absorptive functions of natural systems as well, main aspects of the concept of Moser et al. are congruent with the concept of a sustainable yield of resource services. A possible difference is that the concept presented by Moser et al. applies to elements of natural systems without direct use for anthropogenous systems while the concept of a sustainable yield of resource services is of more anthropocentric nature.
In contrast to the ecosystem resilience concept, this concept defines ecological sustainability by means of the human impact on nature. It considers impact in the form of flows and structural change. It comprehensively covers the exchange between anthropogenous systems and their natural environment. Here, the exchange (and not the state of an ecosystem) determines ecological sustainability. Economic sustainability is not part of the concept.
The main criteria of this concept are based on anthropogenous flows. Adequate approaches to the measurement of anthropogenous flows and their impact on natural systems exist (they will be discussed later in this section). In principle, measurement of the natural variety of species and landscapes is possible as well.

- The Steady State Economy

The concept of a Steady State Economy takes into account the exchange between economic systems and their natural and social environments. Thereby, it combines approaches of input sustainability and approaches of output sustainability. Daly does not determine concrete criteria for economic sustainability. He presents the already mentioned strategies of satisficing stocks, minimising throughput for the maintenance of stocks and maximising services provided by the stocks.

4.2 The Conceptual Basis for Indicators of Economic Sustainability

The starting point for our conceptual considerations is the hypothesis that economic sustainability is determined by the exchange between economic systems and their natural, social and economic environments (Chapter 3). The previous section has shown that parts of these physical and symbolic interactions are taken into account by existing concepts of economic or ecological sustainability. A more profound discussion of the different aspects of the concepts enumerated will help shaping the conceptual basis for indices of economic sustainability.

First, the different forms of the existing concepts of dealing with the nature-economy linkage shall be examined. Different (not necessarily complementary) questions concerning the nature-economy interface are posed by the concepts:

- Can natural capital be substituted for by physical, human and intellectual capital?
- Can subsets of natural capital be substituted for by other subsets of natural capital?
- Are only natural resources of direct economic use to be considered? Are natural resources without direct economic use to be considered as well?

- Has the throughput (input of resources and output of emissions) of economic systems to be minimised?[56]
- Does uncertainty about the behaviour of ecological systems call for prudent behaviour in order to minimise the likelihood of a threat to ecosystem resilience and stability?[57]

Neoclassical economic theory's answer to the problem of dependency on natural resources is substitution. When resources become scarce, the reasoning goes, their prices will rise and at a certain price difference between a resource and its possible substitute, substitution will be initiated by the forces of the market. Moreover, not only the substitution of one natural resource for another is advocated, but the replacement of natural resources by man-made capital. If substitution is infinitely possible

> a depleting stock of resources does not present a problem for sustainable development since economic output can be maintained or even increased indefinitely through substitution. [58]

Others question perfect substitutability of man-made capital for natural resources.[59] By requiring non-declining stocks of natural capital or non-declining resource flows, most of the sustainability concepts discussed do so as well. It is true that goods and services can be provided by different combinations of natural and man-made capital.

> First, productive potential can in some circumstances be maintained in the face of falling availability of non-renewable resources if these can be substituted for by rising quantities of physical capital. Second, knowledge appears to be a good substitute for non-renewable resources, and so it may well be the case that falling quantities of non-renewable resources could be more than compensated for by increasing human and intellectual capital.[60]

It is nevertheless evident that production of man-made capital will always rely on a certain amount of natural resources. The ultimate source of life on earth is solar energy. Ecosystems live of solar energy. Ecosystem components are utilised in the form of labour and natural capital in the economic process.

> Practically everything on the earth can be considered to be a direct or indirect product of past and present solar energy... Fossil fuels and other natural resources represent millions of years of embodied sunlight. Environmental flows (such as winds, rains, rivers) represent embodied sunlight of more recent origin.[61]

The possibility of substitution of man-made for natural capital today is limited. Possibility of substitution in the future is limited by the need for (transformed) solar energy. Actual inter-dependence and the impossibility of future independence of man-made and natural capital determine the future need for natural resources.

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[56] This question is derived from Daly's possible means to attain a SSE.

[57] This question is derived from the precautionary considerations mentioned in Perman et al. 1999 in the context of the sustainability concept of ecosystem stability and resilience.

[58] Victor 1991

[59] Pearce and Turner 1990 and Pearce et al. 1988

[60] Perman et al. 1999, p.57

[61] Costanza 1980

It is further true that natural resources can replace other natural resources in economic processes to some extent. For instance, wood in its different functions of construction and combustible material has been replaced by minerals and petroleum and plastic products.

If we open our view to natural functions that are of (seemingly) no direct economic use (e.g. life support functions) as inputs to economic processes, further critical points on substitutability occur. First, there are functions of our natural environment that seem irreplaceable by man-made capital. The climate or the protecting function of the ozone layer, up to this point, cannot be substituted for by any form of non-natural capital. The degradation of such functions may in turn impede the functioning of economic systems (see footnote 3). Thus, it seems sensible to extend our protective efforts on natural functions without directly visible economic purpose. This point leads us back to the substitutability of one natural resource for another. The depletion of natural resource stocks may influence such life support functions. Massive deforestation does not represent a problem from the viewpoint that possible substitutes for the direct economic functions of wood can be found. But inasmuch as deforestation may change the local and global climate, it represents a possible threat to economic systems. The same holds true for petroleum, that as a fuel can be replaced by other resources. But the combustion of fossil fuels causes emissions that are, at least to some part, responsible for global warming (climate change). It follows that a concept of economic sustainability has to consider resources of direct economic purpose as well as functions of natural systems of no direct economic use. Which indirect resources (life support functions) have to be considered and how this has to be done cannot be decided upon with certainty. The interdependencies of ecosystem elements are still not fully understood. Which ecosystem functions will be affected by the exploitation and subsequent substitution of a resource cannot be predicted with certainty.

On the basis of the latter arguments, we agree with the calls for prudent behaviour and the minimisation of throughput that is presented by Daly as one cornerstone of a SSE. To serve as a basis for the development of indicators of economic sustainability these two requirements have to be concretised. A possible way of putting these limitations in concrete terms is proposed by Sustain[62]:

- Anthropogenous material flows must not alter the quality and the quantity of global material cycles.

This criterion sets limits for the exploitation of reservoirs within material cycles (e.g. fossil resources). It claims that materials from such reservoirs be exploited at a rate that does not exceed their regeneration rate.
It further calls for a minimisation of immissions on reservoirs such as groundwater reserves in order to assure future usability of the resources.

[62] Sustain 1994, p.15

- Anthropogenous material flows must not exceed the local assimilation capacity and should be smaller than natural fluctuations in geogenic flows.

While the first criterion mainly restricts the use of inputs to anthropogenous systems, the second criterion requires limit values for immissions on ecosystems. Immissions must not exceed the natural assimilative capacities. Sustain argues that ecosystems are far more sensitive to immissions that exceed assimilative capacities than they are to exploitation of non-renewable (mineral) resources that exceeds regeneration rates. In consequence, they refrain from setting limits for the exploitation of non-renewable resources. This gives way to exploitation and substitution of natural resources within the limits of assimilation capacities for emissions due to the use of the resources.

- Renewable resources can only be extracted at a rate that does not exceed the local fertility.

This criterion claims that the use of renewable resources must not degrade the fertility of the soil and has to respect local climatic and ecological circumstances.

- The natural variety of species and landscapes must be sustained or improved.

This criterion sets limits to anthropogenous structural change (excavation, road construction, etc.). It claims that areas of widely untouched nature are essential for ecological evolution.

The above criteria substantiate what sustainability means for the exchange between anthropogenous systems and their natural environment. For renewable resources, the variety of species and landscapes and assimilative capacities, the criteria are equivalent to the criterion of a non-declining stock of natural capital, when quantity as well as quality of stocks are required to be non-declining and substitutability between different subsets of natural capital is assume to be zero. The concept of Moser et al. does not set limits for the exploitation of non-renewable resources. In this respect, the concept of a non-declining capital stock is stricter as it calls for compensation of the declining stock of non-renewables by increasing stocks of other forms of natural capital (when substitutability is assumed). Both concepts can be in accordance with the concept of ecosystem stability and resilience (according to the degree of substitutability applied) when they are applied to single ecosystems (and not e.g. to the global or to national natural environments). The criteria of Moser et al. and the criterion of a non-declining stock of natural resources can serve as a part of the conceptual basis for the indicators of economic sustainability to develop (resilience is dismissed for lack of measurability). Which of the two concepts will finally be applied will result from the analysis of strengths and weaknesses of indicators that quantify the respective criteria.

Second, we have to make clear what sustainability of the exchange between economic systems and their social environment means. Only one concept of economic sustainability explicitly deals with this system-environment linkage. It claims that

- Utility or consumption provided must be non-declining through time.

The term utility is rather ambivalent. On the one hand, it is meant to stand for the desire and wants of people. On the other hand, utility is used as a synonym for welfare or the actual ability to satisfy desire.

When economic systems are defined as being limited by the application of the binary code to pay/not to pay only a small part of “satisfaction, pleasure, happiness, or whatever the stuff of welfare is thought to be”[63] lies within the economic sphere. Economic activity ends with the last in a sequence of payments, the purchase of goods and services for final consumption by the households. The use of these commodities is, according to our definition, non-economic. It is not intended to create ability to pay and yield profits. Whether the consumer is happy with what he has bought or not is not an economic question. And whether he is happy at all even less. The mental condition of the labour force can of course influence the functioning of an economic system. But what is crucial here, is that the economy does sell neither happiness nor welfare. Therefore, an external criterion of non-declining utility (=welfare) represents a misplaced requirement for the exchange between an economic system and its social environment. The fulfilment of such a criterion cannot be achieved by an economic system alone. Other factors (health, family, religion) co-determine welfare and satisfaction of desires. In consequence, we limit the obligation of our economies to the provision of consumption goods and services.

The term utility can be used to express the desire of the purchaser for a commodity. The objective expression for utility in this sense is the price the purchaser is willing to pay. The actual price may differ from the willingness to pay. Consumer surplus measures express the difference between how much the consumer is willing to pay for a good or a change of situations and how much he actually has to pay. The area to the left of the demand curve between the initial and the final price indicates aggregate consumer surplus or utility change. consumer surplus measures are used in applied welfare economics. They are mainly intended to indicate utility changes by public projects. As consumer surplus measures are not used in accounting, with the aim of this thesis in mind, it does not seem practicable to use the external criterion of non-declining utility to determine sustainability of economy-society exchange.

The measurement of consumption is part of standard macroeconomic accounting. Measures of final consumption expenditure are provided by conventional systems of national accounts. This is why in the context of this thesis we prefer the external criterion of non-declining consumption through time to determine sustainability of economy-society interactions. But we intend to slightly modify this criterion.

We have mentioned that the criterion at hand can be supplemented by the requirement for a minimum survivability level of consumption.

> You will recall that the symbol C_{SURV} [the survivability level of consumption] was used there to denote the minimum level of consumption consistent with reproducibility of a population of some given size.[64]

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[63] Viner 1925, p.301

[64] Perman et al. 1999, p.57

In contrast to this 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 an economic system and its social environment", which of course includes the biological point of view. A single absolute level of economic and social survivability cannot be determined. C_{SURV} is a function of the (anthropogenous) system (functions, structures and processes) which of course is influenced by its environment. The level of C_{SURV} can vary for the same anthropogenous system when the system evolves. C_{SURV} comprises organisational, material and social (human and intellectual) resources. Organisational resources comprise the "administrative" efforts given 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 our ways of living in general and our ways of producing and consuming in particular. E.g. environmental protection is a necessary consequence of the pressure exerted on nature by anthropogenous activities. Reducing the pressure will decrease the need for activities such as the clean-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.

One could argue that industrialised societies are better off compared to other societies because industrialised anthropogenous systems are what they are. And one could further argue that the high level of C_{SURV} is justified by the incredible amount of goods and services that are at the disposal of industrialised societies. It may be true that industrialised societies are better off or it may be false. Anyway, we cannot prove it and, more important from our point of view, we cannot measure it.

The important point is that different societies need different amounts of goods and services to assure social and economic survival. Goods and services that are not used up for the purpose of survival represent a surplus available to society. It is this surplus that we will use to define sustainability of the exchange between economic systems and their social environment. The respective criterion of sustainability is non-declining consumption surplus (total consumption minus survivability level of consumption).

$$C_S = C_{tot} - C_{SURV}$$

$$dC_S/dt \geq 0$$

with
C_S Consumption surplus
C_{tot} Total consumption
C_{SURV} Survivability level of consumption

After having concretised our notion of sustainability of the exchanges between economic systems and their natural and social environment, we will now turn our attention to the exchange between subsystems of the global economic system.

Economic systems exchange goods, services, unrequited transfers and capital. When economies use[65] more than they produce, the difference between usage and production has to be imported. The economy is a net importer. Net importing can be financed by borrowing from the rest of the world or by reduction of domestic stocks. Net importing runs an economy into debt as soon as domestic stocks are exhausted. In certain circumstances, that will have to be defined more clearly in the course of this work, debt can diminish an economy's potential for the future fulfilment of needs. Although this holds true for every economic system, we will confine ourselves to discussing the exchange at the level of national and sub-national economic systems.

National income is defined as

$Y = C + I + (X - M)$

with	Y	National income
	C	Consumption
	I	Investment
	X	Export
	M	Import

The savings of an economic system calculate as national income minus consumption.

$Y - C = I + (X - M)$

Considering investment as a form of intra-economic use of national income the balance of imports and exports yields the savings of a national economy.

$Y - C - I = S$

with S Saving

$S = X - M$

With other words, when an economy's expenditures on consumption and investment exceed national income, imports exceed exports and the economic system is borrowing from the rest of the world. The sustainability criterion for the exchange between economic subsystems claims that the value of imports to a given economic system must not exceed the value of exports from the given economic system.

The criteria represent requirements for the interactions of an economic system with its social, natural and economic environment to be sustainable. The interaction between an economic system and its natural environment is covered by the set of criteria proposed by Sustain:

- Anthropogenous material flows must not alter the quality and the quantity of global material cycles.

[65] We are referring to total economic consumption of goods and services and not final consumption by households.

- Anthropogenous material flows must not exceed the local assimilation capacity and should be smaller than natural fluctuations in geogenic flows.
- Renewable resources can only be extracted at a rate that does not exceed the local fertility.
- The natural variety of species and landscapes must be sustained or improved.

The interaction between an economic system and its social environment is covered by the criterion of non-declining consumption surplus. The criterion for the interaction between an economic system and its economic environment states that the value of imports must not exceed the value of exports. The set of criteria puts in concrete terms the concept of economic sustainability that will in the following serve as basis for the development of indicators of economic sustainability and an underlying system of accounts.

In the next chapter, after some general reflections about indicators and accounts, we are going to assess whether existing indicators and accounting systems represent appropriate instruments for the measurement of economic sustainability according to the concept discussed in this chapter.

5 Indicators of Economic Sustainability

What are indicators? The answer to this question is often sought in metaphors. Indicators are called "signposts that can point the way"[66], "guideposts in a complex world"[67] or a "widened sensorium"[68]. These metaphors suggest that without the help of indicators we would hardly find our way through a world that in its full complexity is not perceivable with our biological senses.

And indeed, indicators are signifiers of facts that would have passed unseen had they not been highlighted by the signifier. Perceiving e.g. the Gross National Product or the Biological Oxygen Demand lies beyond our naturally given faculties. Thus, indicators provide supplementary information about reality. One can go a step further and say that, in the case of indicators, the signifier may precede the signified. Has there been a thing like the Gross National Product before the measuring of it? The relationship between indicators and the reality they point to is inherently ambivalent. On the one hand, indicators display reality in the form of data. On the other hand, reality is shaped according to information gained from indicators. Not only is reality influenced by indicators, but the development of indicators is determined by reality. Specific historical circumstances give birth to specific indicators. The system of national accounts as we know it today has been shaped by the need for "wartime planning of resource allocation between the public and private sectors and for other policy matters"[69] after the United States of America entered World War II. The proliferation of sustainability indicators at the end of the twentieth century would not have occurred had we not found out about the increasing threat that our activities represent for natural systems. But indicators are not only developed in response to how things are. Indicators respond to how things are and how they should be.[70] How we imagine things to be is determined by our values. An ecologically sensitive person may come to the conclusion that natural resources are overused and ecosystems endangered. As exploitation and deterioration of natural systems deviates from that person's vision and values, he/she may want to get more precise information about the state of the environment and the distance between the actual and the target state. In consequence, he or she will construct an indicator and the indicator will convey the person's system of values.

Dealing with indicators we should bear in mind a few essential questions that follow from the above and can help determine the nature and usefulness of the measure:

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[66] United Nations 1997, p.1

[67] Bossel 1996, p.193

[68] Narodoslawsky 2000, p.5

[69] Kendrick 1995, p.9

[70] Of course, the same is true for perception in general. Our "widened sensorium" as it is purely cultural is simply a more evident example of the social construction of perception than our biological one.

- What part of reality is displayed by an indicator?

What kind of data is used and how is it treated by the indicator (denotation of an indicator)? What is the indicator intended to stand for (connotation of an indicator)? GNP, for instance, is the aggregate value of economic output of marketable goods and services (denotation). A common opinion about GNP is that it indicates wealth, well-being and welfare of a society (connotation).

- Which are the underlying values of the indicator?

The value assumptions of an indicator are present in its construction and more overtly in its connotations. A person convinced that maximisation of economic output is good will use an indicator such as GNP to make clear whether an economy is advancing in this respect or not. A person thinking that excessive speed of cars is dangerous and that exposing other drivers to danger is not desirable will use a speedometer to determine car speed and drive faster than it is allowed or reasonable. Persons indifferent about speed/aggregate economic output will probably not make use of a tachometer/GNP.

- How can the indicator shape reality?

Can the indicator contribute to decision making processes? What are the decisions it will possibly trigger? A faulty tachometer may spur someone on to drive faster than he is allowed to. Speeding in turn can represent danger for the driver and his environment. This is to say that inappropriate indicators or flawed ways of calculating and measuring may trigger actions that are not in accordance with a person's or society's intentions.

5.1 Indicators and Accounts

From the vast array of data about activities that modern societies process, indicators strive to filter what is relevant and thereby provide useful, interpretable information about these activities. As a way of filtering, organising and aggregating data, indicators must depend on the collection and standardised recording of data. In the field of economic statistics, the database for the development of indicators are accounting systems.

> As economies become larger and more complex, it is increasingly important to have good economic statistics organised in an analytically meaningful way to provide an empirical counterpart of those economies across time and space. Economic accounts have evolved to become the centrepiece of such a system of statistics enabling decision makers to see where the economy has been and its recent status as background for projections of where it may be going and the kinds of policies necessary for governments and private groups or individuals to achieve their objectives.[71]

Accounts provide a structural framework for the collection of data on economic activities. Data are subsequently aggregated to yield indicators such as the Gross Domestic Product. But it would be an underestimation of the role of economic accounts to see them as sole databases for the formation of indicators. The less aggregated data of accounts serve a

[71] Kendrick 1995, p.2

purpose in their own right. While indicators are mainly "used for policy target setting, monitoring and conveying information to a broader public [...] accounts are mostly used in research and policy assessment"[72].

Accounts are the less communicable counterpart of indicators. Economic analysis may require more detailed information than the consumer price index or the rate of inflation. In cases such as sectoral analysis of supply and demand, economic accounts are the instrument of the statistician's choice.

In the context of this treatise it seems necessary to analyse whether existing sets of indicators can inform about economic sustainability according to our conceptual framework. In addition to that, we shall have a look behind the economic accounts that are the platform of indicators and a source of information about sustainability in their own right.

5.2 Discussion of Existing Indicators and Accounting Systems

5.2.1 The System of National Accounts

In this section, we make reference to the most recent system of national accounts which is the System of National Accounts 1993 (SNA 1993) submitted to the U.N. Statistical Commission in 1993 and published in early 1994.[73] The European System of National Accounts 1995[74] is in accordance with SNA 1993.

The SNA 1993, like all systems of national accounts, is a framework for the organisation of data on stocks and flows of an economy. Stocks and flows are one of two building blocks of SNA 1993.[75] The second one are economic units or accounting entities. Flows are transactions between economic units (purchase and sale) or within one economic unit (production for one's own use). Flows that are not related to transactions (other flows in the SNA 1993) are due to changes in value of assets and liabilities. Flows can be further categorised with regard to their economic function or activity. SNA classifies flows in four groups: production, consumption, investment and income distribution. Stocks are flows accumulated over time.

The basic elements of a system of national accounts are accounts. An account structures and displays a number of related stocks or flows. An account organises stocks and flows from two different vantage points, one is input and the other output oriented. In SNA 1993 we find three types of accounts.

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[72] The London Group on Environmental Accounting 2001, p.3/3

[73] United Nations, Commission of the European Communities, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations and World Bank 1993

[74] Europäische Kommission 1996

[75] see Carson 1995, p.31

Transactions that are related to production and distribution and use of income are recorded in current accounts. On the one hand, the balanced items are presented as “uses”, “debits” and “outgoings”. All of these stand for transactions that reduce the economic value of the economic unit. On the other hand, current accounts list the “resources”, “credits” or “incomings” representing an increase in economic value of an economic unit.

Accumulation accounts record changes in financial and non-financial assets and liabilities that are due to transactions and other flows. Balance sheets represent stocks of financial and non-financial assets and liabilities. A sequence of accounts taken from Carson[76] is presented in Table 5.1.

[76]Carson 1995, p.36

Table 5.1: Sequence of accounts for the total economy (Source: Carson 1995)

CURRENT ACCOUNTS		
Uses		Resources
Total Economy	Transactions and balancing items	Total Economy
Production Account		
	Output	
	Intermediate consumption	
	Taxes less subsidies on products	
	Gross Domestic Product	
	Consumption of fixed capital	
	Net Domestic Product	
Generation of Income Account		
	Net Domestic Product	
	Compensation of employees	
	...	
Allocation or Primary Income Account		
	...	
Secondary Distribution of Income Account		
	...	
Use of Income Account		
	...	
ACCUMULATION ACCOUNTS		
Changes in assets		Changes in liabilities/net worth
Total Economy	Transactions, other flows and balancing items	Total Economy
Capital Account		
	Saving, net	
	Gross capital formation	
	Consumption of fixed capital	
	...	
Financial Account		
	Net lending (+)/ Net borrowing (-)	
	Net acquisition of financial assets	
	Net incurrence of liabilities	
Other Changes in Volume of Assets Account		
	...	
Revaluation Account		
	...	
Balance Sheets		
Assets		Liabilities and net worth
Total Economy	Stocks and balancing items	Total Economy
	Nonfinancial assets	
	Financial assets	
	Liabilities	
	Net worth	
Closing Balance Sheet		
	Nonfinancial assets	
	Financial assets	
	Liabilities	
	Net worth	

Beside their grouping into accounts, stocks and flows in the SNA 1993 are classified into economic sectors according to their principal function. These are[77]

- Nonfinancial corporations: legal entities that are principally engaged in the production of market goods and nonfinancial services;

[77] Carson 1995, p.42

- Financial corporations: legal entities that are principally engaged in financial intermediation or in auxiliary financial activities;
- General government. Legal entities that, in addition to fulfilling their political responsibilities and their role of economic regulation, produce principally nonmarket services for individual or collective consumption and redistribute income and wealth;
- Households: individuals or groups of individuals who supply labour, engage in final consumption, and, if owners of an unincorporated enterprise, engage in the production of market goods and services;
- Nonprofit institutions serving households: legal entities that are principally engaged in the production of nonmarket services for households.

For each of the sectors the sequence of accounts is present in SNA 1993. In order to comprehend the transactions between domestic and foreign economic units, a sixth sector – the Rest of the World account - is introduced in a way similar to the five other sectors. The Rest of the World account records e.g. imports and exports of goods and services.

Within the structure of SNA 1993, indicators (aggregates) are derived in two ways. First, the aggregation of stocks and flows for all institutional sectors yields indicators for the total economy such as GDP or consumption expenditure. Second, balancing items - that make the two sides of the accounts equal – across sectors and the Rest of the World can be relevant indicators. One such item is the external balance of goods and services that makes import and export of goods and services balance.

The most important aggregate of SNAs is the Domestic Product. Net and Gross Domestic Product (NDP and GDP) cover value added by resident producer units. NDP and GDP can be calculated in three different ways based on either production, demand or income. Other aggregates are, for instance, national income, national disposable income and national expenditure.

In addition to the data described above, SNA 1993 records data on flows of goods and services between “establishments”. In contrast to institutional units, an economic establishment is defined by its principal productive activity. Establishments are grouped to form industries. Accordingly, flows are subdivided and recorded as the outcome of the respective activities of the industries. Data on the transactions between industries are displayed in supply and use tables. These tables present a production and a generation of income account for each industry and a goods and services account by product. They are usually referred to as input-output-tables.

The SNA 1993 is market oriented. It comprises those activities that produce for the market and records income earned from sale and purchase on the market. Which activities lie within the production boundaries of SNA changes with time. A number of goods and services produced for and purchased at the market have not been marketable fifty years ago. Childcare, cooking and psychological treatment are among the activities that were excluded from SNA and have at least to some extent become services traded on markets. Thus, while explicitly constant, the production boundaries of SNA are shifted by historical changes of production and consumption habits. For some purpose, it may be necessary to extend the boundaries explicitly. The overall value of public sector services, the value of household production and other aggregates cannot be gained from standard SNAs because the respective activities lie partly or completely outside the accounting systems' boundaries.

Inclusion of non-market activities into the SNA without change of the conventional system's structure is achieved by the implementation of satellite accounts. Satellite accounts allow for "the use of complementary or alternative concepts [...] when needed to introduce additional dimensions to the conceptual framework of national accounts."[78] The European System of National Accounts[79] recommends satellite accounts for tourism, health, household production, research and development, environment etc. A satellite account of particular interest in the context of this work is of course the environmental account.

5.2.2 The System of Environmental Economic Accounts

The standard environmental satellite account is the System of Environmental Economic Accounts (SEEA) published by the United Nations in 1992.[80] A new version of SEEA – the SEEA 2000 – is currently being prepared. In the following, we will refer to a draft version of SEEA 2000.[81]

SEEA 2000 adds data on the interactions between economies and their natural environment to standard SNA. While the core set of accounts within SNA comprises exclusively flows and resulting stocks within an economy, SEEA integrates flows of materials and substances from natural systems to economies and vice versa that are not traded on markets. The basis for the extensions provided by SEEA are physical flow accounts. SEEA distinguishes flows of products, natural resources, ecosystem inputs and residuals.

> Products are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world. Natural resources cover mineral and energy resources and biological resources. Ecosystem inputs cover air and the gases necessary for combustion and the water to sustain life. Residuals are outputs from the economy which have zero price and may be recycled or are discharged into the environment.[82]

Natural as well as man-made flows are recorded in supply and use tables in physical units. The accounts can have the form of material flow analysis (MFA), substance flow analysis (SFA) and physical input-output tables (PIOT).

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78 United Nations, Commission of the European Communities, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations and World Bank 1993, p.489

79 Europäische Kommission 1996, p.6

80 United Nations 1992

81 The London Group on Environmental Accounting 2001

82 The London Group on Environmental Accounting 2001, p.2/5

The main sectors of economic activity within the SEEA 2000 are production, consumption and capital accumulation. Further disaggregation of the production and consumption sector according to classification standards such as the International Standard Industrial Classification (ISIC) and the classification of individual consumption by purpose (COICOP) is recommended. In analogy with SNA, a Rest of the World account is developed as well.

From the physical representation of economic activities, a number of indicators can be derived. SEEA 2000 suggests distinct indicators for input, output, consumption and balancing. These are[83]

- Direct Material Input: aggregate input of materials of economic value to activities of consumption and production.
- Total Material Requirement: Direct Material Input plus materials flows that occur along the lifecycle of imported products.
- Domestic Processed Output: the total mass of outputs from production and consumption to the environment. Emissions into air, water and land.
- Total Domestic Output: Domestic Processed Output plus disposal of unused domestic extraction.
- Direct Material Output: Domestic Processed Output plus exports.
- Total Material Output: Total Domestic Output plus exports.
- Domestic Material Consumption: total amount of material directly used in an economy, excluding hidden flows.
- Total Material Consumption: total primary material requirement of consumption.
- Net Additions to Stock: physical growth rate of an economy.
- Physical Trade Balance: import minus exports in physical units.

The physical accounts are brought together with economic accounts as presented in SNA 1993. This is done within the framework of hybrid input-output tables, supply and use tables including environmental accounts (SUTEA) and the comprehensive national accounting matrices including environmental accounts (NAMEA).

SUTEAs integrate monetary and physical supply and use tables. Monetary product flows and their physical equivalent are juxtaposed in matrix form. Supplementary data is recorded in tables for use of natural resources and ecosystem inputs as well as supply and use of residuals. All of the latter enter in physical units only. Table 5.2 shows an exemplary SUTEA. Monetary data is shaded.

[83] The London Group on Environmental Accounting 2001, p.3/51

Table 5.2: Supply and use tables including environmental accounts (Source: The London Group on Environmental Accounting 2001)

	Products	Industries	Capital	Consumption	Exports	Residuals
Products		Products used by industry	Products converted to capital	Products consumed by households	Products exported	
Industries	Products made by industry					Residuals generated by industry
Capital						Residuals generated by capital
Consumption						Residuals generated by households
Imports	Products imported					Residuals imported
Value added		Value added by industry				
Monetary totals	*Total products supplied*	*Total industry inputs*	*Total capital supplied*	*Total household consumption*	*Total exports*	
Natural resources		Natural resources used by industry		Natural resources consumed by households		
Ecosystem inputs		Ecosystem inputs used by industry		Ecosystem inputs consumed by households	Ecosystem inputs exported	Ecosystem inputs imported
Residuals		Residuals reabsorbed by industry	Residuals going to landfill		Residuals exported	
Other information		Employment Energy use		Energy use		

Physical data can be further processed by classification according to environmental themes such as the greenhouse effect, ozone layer depletion and eutrophication.[84] Weighting by substance-based quantity units makes aggregation of single substance environmental effects possible and allows for the formation of theme specific indices. It is suggested that these indices be compared with economic data (value added) on the sector, industry and national level.

A NAMEA extends what is recorded in SUTEAs by the comprehensive integration of accounts used in SNAs. The full sequence of accounts from generation of income via distribution to consumption and capital formation is displayed and concatenated with physical flow accounts. Additional data such as the value of environmental protection services, environmental expenditures of industries as well as additional accounts such as tax accounts including separately identified environmental taxes or environmental expenditure accounts can be included into the flexible framework of a NAMEA. Environmental accounts strive to grasp the overall environmental pressure put on the domestic environment by domestic industries as well as by transboundary transport of residuals. The capital account of SNA is extended by data on changes in environmental assets and liabilities.

[84] The London Group on Environmental Accounting 2001, p.4/16

Another satellite system of accounts presented in SEEA 2000 is the environmental protection expenditure accounts (EPEA). It tries to determine environment related industrial activities such as environmental protection, resource management and to derive the so-called “environment industry”[85]. Starting from this notion of an environmental industry and the goods and services it provides, supply and use tables for such services are constructed. The aim of these accounts is to assess national environmental expenditure and its financing by administrative and other economic units.

In addition to data on flows of natural resources, stocks of natural resources are treated in SEEA asset accounts. In contrast to SNA, SEEA does not only treat resources of direct economic interest. By introducing the notion of indirect-use values “which are not directly related to a separate payment for this aspect of using the environment”[86] and existence value the scope of assets recorded in SEEA is widened to all natural resources. Changes in assets of

- natural resources (mineral, energy, water, biological)
- land and surface water
- ecosystems
- memorandum items (intangible assets such as licenses, permits)

are accounted for in physical units. A full SEEA asset account integrates produced and natural non-produced assets. Table 5.3 shows an example of such an account. Changes due to transactions concern mainly produced assets and land. Transactions in this context are formation or production of fixed capital, changes in inventories (stocks held by producers intended for sale), consumption of fixed capital and sale/purchase of non-produced assets. Environmental appearance and disappearance record changes in quantity and quality of produced and non-produced assets. Other changes due to catastrophes, valuation changes and change in ownership may be applied to natural as well as man-made assets in a similar way.

[85] The London Group on Environmental Accounting 2001, p.5/12

[86] The London Group on Environmental Accounting 2001, p.6/6

Table 5.3: SEEA asset account (Source: The London Group on Environmental Accounting 2001)

	Produced assets	Natural resource stocks				Land
		Mineral and energy	Water	Biological resources		
				produced	non produced	
Opening stocks						
Changes due to transactions						
Gross fixed capital formation						
of which land improvement						
Changes in inventories						
of which work in progress on cultivated assets						
Consumption of fixed capital						
Sale/purchase of non-produced assets						
Environmental appearance						
Discoveries						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Natural growth						
Environmental disappearance						
Extraction of natural resources						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Unforeseen obsolescence/degradation						
Other changes						
Catastrophic losses/uncompensated seizure						
Valuation changes						
Change in ownership/structure						
Closing stocks						

The quantity of natural resources is usually counted in different physical units. To bring together produced assets counted in monetary units and natural resources calls for monetary valuation of the latter. This represents an easy task where market prices for the resources exist. When this is not the case, SEEA suggests that the net present value of the assets – "the sum of all the discounted rents throughout the life of the asset"[87] - be estimated.[88]

Further, flow accounts correcting generation of income for the use of environmental assets are proposed. By taking into account the consumption of natural resources and the returns they provide an extended generation of income account is realised. (Tab.5.4)

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87 The London Group on Environmental Accounting 2001, p.6/27

88 For a more extensive exposition of the calculation of net present value see The London Group on Environmental Accounting 2001, p.6/29

Table 5.4: Extended generation of income account (Source: The London Group on Environmental Accounting 2001)

Gross value added	
	less compensation of employees
equals gross operating surplus	
	less services of produced biological fixed capital
	less services of other fixed assets
	plus returns of produced biological fixed capital
	plus returns of other fixed assets
equals net operating surplus	
	less extraction of natural resources
	plus natural growth of non-produced biological assets
	plus enhancement to the value of subsoil resources
	plus returns to natural resources
equals depletion adjusted operating surplus	

Beside the valuation of (quantitative) resource depletion, SEEA presents a number of attempts to accord monetary value to changes in quality of the natural environment.

> The 'product' we are trying to value here is clean rather than contaminated environmental media. The task is thus to attribute a notional value to the decline in the quality rather than the quantity of a resource.[89]

Cost based techniques of valuation such as avoidance costs or restoration costs are presented together with damage cost approaches such as revealed preferences (market prices, travel costs, hedonic price analysis) and stated preferences (contingent valuation, conjoint analysis) as methods of imputing monetary value to environmental functions. The extension of conventional macro-economic indices by inclusion of cost based measures can yield environmentally adjusted indices of GDP and NDP. In analogy to that, damage-adjusted measures of income can be developed.

SEEA in its 2000 version is a most comprehensive dat basis for environmental analysis and policy. The indicators that can be derived from SEEA and the policy issues they are meant to support are as diverse as the disaggregated data sources. Physical flow accounts provide data for the generation of indicators for single substance flows as well as for environmental themes and highly aggregated indices such as the above mentioned measures of aggregate mass flows. Of course, SEEA can be used as a data source for all kinds of valuation methods based on inventories of flows of natural resources and residuals, for instance the ecological footprint methods. Environmental protection and resource management accounts are the groundwork for monetary indicators such as environmental protection expenditure, environmental taxes and subsidies and the like. Asset accounts help monitor the change of stocks of natural resources over time, both in physical and monetary units. Indicators such as the overall value of produced and non-produced assets and per capita national wealth in non-produced and produced assets can be derived.

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[89] The London Group on Environmental Accounting 2001, p.8/1

Among the indicators of sustainable development[90], SEEA counts physical indicators of macro-economic performance and standard accounting aggregates that are adjusted for the environmental effects of economic activity. The first are indicators of (strong) ecological sustainability. The second comprise the already mentioned environmentally adjusted measures of GDP and NDP, genuine income and genuine saving (depletion adjusted measures of income and saving). The latter support the notion of weak sustainability.

Another approach that is discussed within the framework of SEEA 2000 is Hueting's Sustainable National Income (SNI).[91] The SNI is the level of national income that can be perpetuated for a theoretically infinite period of time. In Hueting's concept this is the maximum level of income that can be achieved without causing vital environmental functions to degrade or disappear. Availability of environmental functions can be expressed in physical terms. By imputing the cost of maintenance and restoration of different levels of these functions, a supply curve for environmental functions is constructed. The cost of elimination measures comprise

- cost of technical measures to reduce environmental burden
- cost of a shift from environmentally harmful to less harmful production activities
- cost of decreasing the scale of the economy
- cost of a decrease in population.[92]

The corresponding demand curve displays the preferences of the households for environmental functions. Constructing the demand curve calls for valuation of environmental functions. As Hueting is sceptical about the possibilities to express consumer preferences for environmental functions in monetary units, he postulates a common desire for a level of environmental functions that assure sustainability regardless of the cost restoration and maintenance. Then, the SNI is defined as the actual level of national income minus the cost for achieving sustainability standards for environmental functions. The optimal combination of technical and other measures to achieve maximum sustainable income are calculated in a general equilibrium model of consumption and production.

5.2.3 Alternative Indicators of Economic Sustainability

While the SEEA seems to hold a somewhat official position in environmental accounting, there are other accounts and indicators that have not achieved a status of similar importance. One reason for their staying behind on the road to official political recognition of their explanatory merits is the greater distance of these methods from conventional economic accounting. But to see that as the only explanation of marginality of these approaches in their more or less unconventional methodology would mean underestimating the differences in premises, content and aim between these alternative measures and the SEEA.

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[90] The London Group on Environmental Accounting 2001, p.8/1

[91] Dieren 1995, p.206

[92] see The London Group on Environmental Accounting 2001, p.9/55

5.2.3.1 The Index of Sustainable Economic Welfare

A first approach of rather conventional methodology – in the sense of SEEA – is the Index of Sustainable Economic Welfare (ISEW) published by Cobb and Cobb.[93] The aim of ISEW is, as the name of the indicator shows, to measure economic welfare. It tries to do so by accounting for the benefits and losses inflicted on the households by economic activity. Adding up all the benefits and then subtracting all the losses is a method that we are familiar with after having studied SNA and SEEA. The SEEA asset accounts provide in quite the same way – focusing on stocks and not on flows – an aggregation of positive and negative economic results.

Measuring economic welfare, the ISEW starts by counting the value of personal consumption in the period considered. Following the reasoning that "an additional thousand dollars in income adds more to the welfare of a poor family than it does to a rich family"[94], consumption expenditure is weighted by a factor for inequality of income distribution. From this measure of weighted personal consumption a number of welfare decreasing components are deducted. Some are in accordance with SEEA (e.g. cost of air pollution, depletion of resources, loss of farm land), others, such as the costs of urbanisation, commuting and car accidents, are not. Among the welfare increasing elements of economic activity the ISEW counts services of household labour, streets and highways, consumer durables and the like. A factor that has to be highlighted in the context of this thesis is "the change in net international position". From an American vantage point, it

> measures the amount that Americans invest overseas minus the amount invested by foreigners in the United States. The annual change in the net international position indicates whether the U.S. is moving in the direction of net lending (if positive) or net borrowing (if negative).[95]

Finally, the ISEW is calculated as the sum of all aggregates accounting for welfare increase or loss.

5.2.3.2 Efficiency in the Steady State Economy

In Section 2.3.1 Daly's concept of a Steady State Economy (SSE) has been outlined as an essential precursor of Ecological Economics. Elaborating on efficiency in his visionary economy, Daly takes a position far from mainstream economic accounting that has nevertheless entered – in a very crude form – indicator considerations of the SEEA. While orthodox economic accounting is the art of adding up different stocks and flows, the indicators meant to lead the way to a SSE are efficiency ratios. Efficiency in a SSE is interpreted as a benefit-cost ratio. We have already pointed out that in a SSE benefit is equal to artefact services gained, cost corresponding to ecosystem services sacrificed. Decomposing the main input-output ratio, four ratios of efficiency are derived:[96]

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[93] Cobb and Cobb 1994, p.31

[94] Cobb and Cobb 1994, p.31

[95] Cobb and Cobb 1994, p.75

[96] Daly 1991, p.78

artefact services gained / ecosystem services sacrificed =
artefact services gained / artefact stock *
artefact stock / throughput *
throughput / ecosystem stock sacrificed *
ecosystem stock sacrificed / ecosystem service sacrificed

The four ratios represent four dimensions of efficiency in a SSE. The first, artefact service efficiency, is dependent on allocation (the basket of commodities provided) and distribution of the commodities among the households. Artefact maintenance efficiency refers to durability of and the possibility to recycle and repair commodities. Ecosystem maintenance efficiency depict depletion of natural stocks, ecosystem service efficiency the ecological impact of depletion. All ratios are closely related to aggregates of the accounting systems described earlier. Obviously, efficiency one has as a counterpart the measure of weighted personal consumption in the ISEW framework. Similarities with the other ratios can be found in the SNA (consumption of fixed capital) and SEEA (degradation and depletion of natural resources).

5.2.3.3 Orientors of Sustainable Development

A framework for indicators of sustainable development that is not restricted to economies but encompasses all possible sorts of systems goes back to Bossel.[97] According to this concept, to be viable a system has to be adapted to its environment. Thus, systemic environmental properties are determined and to each of the properties a basic orientor is related. The system of orientors indicates the viability of a given system within its environment. The properties are[98]

- Normal environmental state: actual environmental state and variations around this state.
- Scarce resources: resources that are necessary for the survival of a system within its environment and are not abundantly available.
- Variety: different environmental properties and patterns.
- Variability: variations far from the actual state.
- Change: the actual state may change to another state of the environment.
- Other systems: other systems may change the environment of a given system.

The respective orientors are shown in Table 5.5.

[97] Bossel 1996, p.195

[98] Bossel 1996, p.196

Table 5.5: Environmental properties and related orientors of system viability (Source: Bossel 1995)

Environmental property	Orientor
Normal environmental state	Existence
Scarce resources	Effectiveness
Variety	Freedom of action
Variability	Security
Change	Adaptability
Other systems	Coexistence

For sentient beings the orientor "psychological needs" is added. To assure system viability, a certain minimum level of fulfilment must be achieved for each of the orientors. On the basis of the compliance with survivability requirements, satisfaction of single orientors can be enhanced. The orientors are applied to six subsystems of the global system (Infrastructure; Economic system; Social system; Individual development; Government; Resources, environment, future) and form a frame for a number of single indicators per subsystem. The ascribed indicators are chosen among an extensive list of indicators for the fields of ethics, psychology, qualification, organisation, living conditions, welfare, material resources use, finance and economics, dependence and environmental burden. The indicator values are qualitative (4=excellent, 3=good, 2=fair, 1=deficient, 0=fail). Orientor satisfaction is calculated as the aggregate of the single indicators per subsystem and orientor.

5.2.4 Physical Indicators of the Human Impact on Nature

The interaction between man and nature can be assessed at different stages of a cause-effect chain. The OECD proposes a framework structuring the successive steps from cause to effect that serves as a classification scheme for indicators in the respective fields.[99] The elements of the framework are driving forces of environmental impact (e.g. transport, industry), pressures exerted on the environment (e.g. emissions), state of the environment, impacts of a certain environmental state and societal responses to the impacts, such as regulations and taxes. (Fig.5.1)

[99] OECD 1994, UNCSD 1996

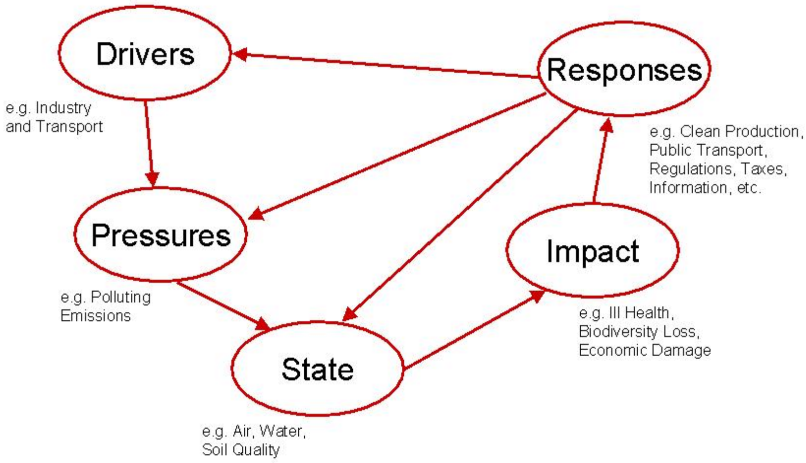

Figure 5.1: The Driving Force-Pressure-State-Impact-Response Framework (DPSIR) for Reporting on Environmental Issues (Source: OECD 1994 and UNCSD 1996)

For each of the five steps in the cause-effect chain a number of indicators exist. But for a number of reasons most indicators of sustainability are measures of pressures on the environment. Such measures reflect an early stage in the causal chain from drivers to impacts and thereby may induce protective activity before the environmental damage has occurred. An additional advantage of pressure measuring lies in the possibility to ascribe pressures directly to activities.[100]

The number of pressure indicators is large. Single value measures of emissions and immissions have to be counted among them as well as highly aggregated indices such as the Material Intensity per Service Unit (MIPS).[101]

There are numerous studies comparing different measures of the human impact on nature and we refer the reader to these studies for a comprehensive overview of current methods.[102] We are not going to add another comparison to an already exhaustive list. Nonetheless, there are a few methods of evaluation of human impact on natural systems discussed in the context of environmental economic accounting and it seems appropriate here to briefly discuss these concepts. They are the

- MIPS – Material Input per Service Unit and TMR – Total Material Requirements
- Ecological Footprint
- CML – Method
- Sustainable Process Index (SPI)

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[100] Eder 1996, p.22

[101] see Schmidt-Bleek 1993, p.407

[102] see, for instance, Sage 1993, Krotscheck 1995 or Hofer et al. 2000

MIPS[103] and TMR calculate how much material – counted as mass flows – a system consumes per time or service. The measures can be used to assess material inputs to national and sub-national economies[104] as well as the life-cycle wide material intensity of the provision of goods and services. Disaggregation of the indices yields input categories such as biotic, fossil and mineral raw materials, soil, water and air.

The Ecological Footprint[105] illustrates how much area is needed to support final consumption of sub-national and national regions. Areas for housing, transport, food etc. are aggregated and form the ecological footprint of consumption within a region. Beside the “real” areas needed for the provision of goods, the “virtual” area of fossil energy use can be calculated. The comparison of a region’s ecological footprint with the carrying capacity of that region is supposed to give information about whether consumption patterns are sustainable or not.

The CML (Centrum voor Milieukunde Leiden) – Method is a comprehensive set of indicators for categories of environmental effects. Emissions and resource consumption flows[106] are ascribed to a number of categories such as resource consumption, depletion of the ozone layer, global warming. Then, the flows are weighted according to their contribution to the effect of a category and aggregated to one single value. Further aggregation can be done by weighting of the categories.

An index that is based upon some of the ecological sustainability presented by Moser et al. is the Sustainable Process Index (SPI). The SPI[107] is a measure that converts, in principle similar to the Ecological Footprint, environmental pressures to areas necessary to embed these pressures. Pressure on the environment in the sense of the SPI is exerted by consumption of renewable and non-renewable resources and emission of substances to air water and soil. These flows are expressed in areas and together with direct area for installations and other buildings form the area used by a process, a process chain or an economic system. Sustainability of e.g. a region is given, when the area consumed does not exceed the geographical surface of the region. Conversion of flows to areas is done on the basis of a reference system of natural flows.

- For renewable and fossil resources[108] the area used is calculated from the actual input flow divided by the yield per area for the resources.
- SPI area for installations, buildings, streets and the like is identical with the actual surface used for such items.

[103] Schmidt-Bleek 1994

[104] for calculations of Total Material Requirements of the USA, the Netherlands, Germany and Japan see Adriaanse et al. 1997

[105] Wackernagel et al. 1993

[106] Other elements of environmental impact can be considered, but usually analysis is limited to flows from the anthroposphere to nature.

[107] Krotscheck 1995, p.63

[108] Within the SPI concept, fossil resources are treated as what they are – slowly renewable resources.

- Non-renewable resources do not form natural cycles. Their use is "inherently dissipative"[109]. Accordingly, there are no natural reference flows calculated in the SPI concept for these resources. Instead, it is assumed that the area needed supply non-renewables can be assessed from emission flows. Dissipation of products (emissions to air, water and soil) is opposed to natural flows of substances in the three environmental media. The flows for 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.

Single values can be aggregated to areas for raw materials, energy, infrastructure and dissipation.

5.3 Evaluation of the Existing Indicators and Accounting Systems from the Viewpoint of Economic Sustainability

In Section 4.2 our concept of economic sustainability has been explained. Evaluating whether existing indicators and accounting systems (or which parts of indicators and accounting systems) are in accordance with this concept, we have to ask whether and how they cover the exchanges between economic systems and their environment.

5.3.1 Evaluation of the System of National Accounts

First, we are going to answer the question of how the exchange between economic systems and their social environment is covered within the SNA.

As a measure of overall economic activity, GDP naturally includes value added of the production of goods and services for final consumption. But GDP as such comprises value added of the production of commodities for economic use (investment) as well. The measurement of consumption is not an aim of GDP.

NDP subtracts depreciation of man-made capital from overall domestic value added. Depreciation is compensated for by investment. When depreciation equals investment, NDP is equivalent to consumption. This holds true only for economies with constant man-made capital. When the man-made capital of an economic system is growing or decreasing, NDP differs from consumption.

Within the SNA consumption as such is shown in the "Use of income account" where individual and collective consumption are recorded per economic sector (nonfinancial corporations, financial corporations, general government, households, nonprofit institutions serving households). The European System of National Accounts[110] defines consumption as

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[109] Krotscheck 1995, p.93

[110] We refer to the German version "Europäisches System Volkswirtschaftlicher Gesamtrechnung – ESVG 1995"

expenditure or purchase by domestic institutional units for/of goods and services for the fulfilment of individual or collective needs.[111] It comprises individual and collective consumption or expenditure by households, government and non-profit institutions. Individual consumption includes goods and services received by households. Collective consumption includes goods and services provided to the whole or parts of the whole domestic population. The use of the latter goods is usually passive and non-competitive. All consumption expenditure of the households and non-profit institutions is part of individual consumption. Government consumption expenditure is partly ascribed to individual and partly to collective consumption. Individual consumption comprises expenditure on

- the public educational system
- the public health system
- social security institutions
- sports and recreational activities
- cultural activities
- housing (partly)
- disposal of waste and waste water (partly)
- road and railway networks (partly).

Collective consumption comprises spending on

- administration
- national security and defence
- law and order
- environmental protection
- infrastructure and funding.

Consumption expenditure does not include purchase of investment goods (e.g. apartments).

The treatment of the exchange between economic systems and their social environment (in standard economic terms: the provision of goods and services for final consumption) within the SNA does not include anything like C_{SURV}. Therefore, the notion of consumption within the SNA cannot directly be applied according to our concept of economic sustainability. Necessary extensions and corrections will be discussed in section 4.3.5.

We will now answer the question of how the exchange between economic systems and their economic environment is covered.

The balance of payments is not part of the SNA. Nevertheless, it is closely linked to the SNA and provides data for the transactions of an economy with the rest of the world that are used within the SNA. Thus, for expositional reasons, it seems sensible to discuss it here.

[111] Europäische Kommission 1996, p.55

> Conceptually, balance of payments accounts and related data on the international investment position are closely linked to a broader system of national accounts [...] The international standard for such a frame work is the System of National Accounts (SNA) [...] linkage of the balance of payments and the SNA is reinforced by the fact that, in almost all countries, balance of payments and international investment position data are compiled first and subsequently incorporated into national accounts.[112]

The exchanges between economies at the national level is recorded in balances of payments (BOP). A BOP is "a statistical statement that systematically summarises, for a specific time period, the economic transactions of an economy with the rest of the world"[113]. Table 5.6 shows the structure of a BOP according to the International Monetary Fund (IMF).[114]

Table 5.6: Standard components of the balance of payments (Source: IMF 1993)

1. Current Account			
	A. Goods and services		
		a. Goods	
			1. General merchandise
			2. Goods for processing
			3. Repairs on goods
			...
		b. Services	
			1. Transportation
			2. Travel
			3. Communications services
			...
	B. Income		
			1. Compensation of employees
			2. Investment income
	C. Current transfers		
			1. General government
			2. Other sectors
2. Capital and Financial Account			
	A. Capital account		
			1. Capital transfers
			2. Acquisition/disposal of non-produced, nonfinancial assets
	B. Financial account		
			1. Direct investment
			2. Portfolio investment
			3. Other investment
			4. Reserve assets

To each credit recorded in the accounts corresponds a debit (import/export) so that the BOP necessarily balances. Surpluses and deficits occur at the level of partial balances. A surplus of one part of the overall BOP is compensated for by a deficit of another part. The partial balances are

- balance of trade

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112 International Monetary Fund 1993, p.10

113 International Monetary Fund 1993, p.6

114 see International Monetary Fund 1993, p.43

- balance of services
- balance of unrequited transfers
- balance of capital transactions
- balance of foreign exchange transactions.

The balance of trade records imports and exports of goods. The balance of services includes the provision of services by residents to non-residents and vice versa, travel expenditure, transportation, income of residents working abroad and capital yield (interest earnings and dividends). The balance of unrequited transfers comprehends foreign aid to developing countries, contributions to and payments from international organisations. The balance of capital transactions records transactions that change claims and liabilities of a country vis-à-vis the rest of the world. The balancing item for the balances of trade, services, unrequited transfers and capital transactions is the balance of foreign exchange transactions. It records the claims and liabilities of national banks (currency reserves, foreign currency). The balance of current accounts (trade, services, unrequited transfers) plus the balance of capital transactions equal the balance of foreign exchange transactions.

Parts of the BOP correspond to our criterion of sustainability for the exchange between economic systems and their economic environment. The balance of trade and the balance of services cover the value of imports and the value of exports of an economic system. The values of imports and exports of goods and services are appropriate expressions of our criterion of sustainability for economy-economy exchanges and will be used as part of our accounting system.

To answer the question of how the exchange between economic systems and their natural environment is covered within the SNA, we have to turn our attention to the SEEA, a satellite account of the standard system of accounts.

5.3.2 Evaluation of the System of Environmental Economic Accounts

SEEA corrects for the blind spot of an accounting system that in its substance neglects natural sources and sinks. It represents the frame for a comprehensive record of interactions between the economy and its natural environment. Flows to an from the natural environment as well as stocks of natural resources are shown within the different accounts. In principle, the SEEA can contain all necessary data on anthropogenous flows according to our criteria for the nature-economy interface. Data on natural variety of species and landscapes can be entered in accounts for biological and ecosystem function assets.[115] This comprehensive data basis is used to construct mainly two sorts of indicators that consider aspects of nature-economy interactions in the handbook to SEEA 2000. First, physical indicators for stocks and flows are presented within the SEEA 2000. Some of these are combined with standard economic measures such as the GDP (in the form of e.g. environmental pressure per GDP). Second, stocks and flows are valued in monetary terms. The combination of indicators such

[115] The London Group on Environmental Accounting 2001, p.6/9

as the GDP or NDP with monetary values for environmental assets and flows yields measures such as the environmentally adjusted GDP and NDP or damage adjusted income.

5.3.2.1 Evaluation of Physical Indicators Presented in the SEEA 2000

Physical indicators based on flows are possible measures for sustainability according to (three of the four) criteria by Moser et al. The main physical indicators based on flow accounts within the SEEA are the MIPS/TMR, the Ecological Footprint and the CML-Method.

MIPS and the related TMR have a most prominent position among the candidates for integrated environmental-economic accounting. This is due to some obvious strengths of the methods. MIPS and TMR are easy to understand and thereby well suited for the communication of goals for environmental policy. The striking slogans of “Factor 4” or “Factor 10” are examples of such communicative efforts. As they are directly calculated from mass flows, the integration of TMR and MIPS with physical environmental accounts is rather simple. However, simplicity, a major strength of the methods, seems to be their most fundamental weakness at the same time.

First of all and most important, the exclusion of emission flows to air, water and soil is a major drawback. For the last decades the lion’s share of environmental protection efforts was focused on outputs from production and consumption to the natural environment. To neglect the probably most important environmental issue of today narrows the possibilities of strategic policy and planning significantly. It is not surprising that the only strategies for achieving sustainability suggested by the proponents of these indices are efficiency in production and life styles (sufficiency). Furthermore, no difference is made between mass flows of different quality. Therefore, the impacts of technological change are difficult to assess and the methods may yield misleading results.[116] Moreover, we agree with the authors of the SEEA handbook in their critique of the notion of sustainability of measures such as TMR and MIPS.

> The TMR does not differentiate materials by their environmental impact; highly toxic materials are simply added to materials like timber or gravel that may be much less environmentally damaging. Consequently, the sustainability goals set under this framework, such as Factor 4, appear rather vague to be used as guides to policy on their own, and require more detail to be interpreted correctly.[117]

The last is true for every highly aggregate measure. Analysis and planning will always be done relying on more detailed data and not on the basis of one summary indicator. But what must be held against TMR and MIPS is that their vision of sustainability is unclear and the standards and targets based thereon are, to say the least, arbitrary. With reference to our criteria for economy-nature exchange we can summarise that MIPS and TMR

[116] For example in the comparison of material intensive energy systems based on biomass and less intensive systems relying on fossil resources.

[117] The London Group on Environmental Accounting 2001, p.9/44

- consider flows of non-renewable and renewable resources. While our criteria limit the extraction of such resources by their natural rates of regeneration (not for non-renewables), the calculation of MIPS and TMR is done against the backdrop of limits for overall mass flows of resources (Factor 4, Factor 10).
- do not consider flows of solid, gaseous and fluid emissions to the natural environment. MIPS and TMR cannot indicate whether assimilative capacities are exceeded or not.
- do not consider the natural variety of landscapes and species.

Some of the advantages of MIPS and TMR apply to the Ecological Footprint in the same way. It is an easily calculable measure that uses a strong metaphor to express anthropogenous environmental impact. It is an adequate index for communication with a broad public and for policy-making. Nevertheless, there are important weaknesses of the approach. Much like the MIPS concept, the Ecological Footprint omits important environmental pressures exerted by human activity. Emissions (except CO_2) are completely left out from calculation. Most footprint calculations are limited to the life cycles of products and services for final consumption (thereby excluding environmental pressure from the production of investment goods). Industrial production that lies outside this life cycles is not taken into account. As the production of investment goods is to be made responsible for a non-negligible part of the overall environmental impact of a region, its omission seriously diminishes the explicative power of the Ecological Footprint in sustainability assessment. An additional weakness is that footprints are calculated on the basis of very rough data about existing technologies. Therefore, the method is insensitive with respect to technology variations between regions and technology changes over time. As “there is not much attention paid to the analytical soundness of the model”[118] the possibility for standardised usage of the Ecological Footprint in an accounting framework seems limited. It

- considers flows of non-renewable and renewable resources. Uses a reference system of natural carrying capacities to assess the ecological impact of these flows.
- does not consider flows of solid, gaseous (except CO_2) and fluid emissions to the natural environment. It cannot indicate whether assimilative capacities are exceeded or not.
- does not consider the natural variety of landscapes and species.

The CML-Method comprises all relevant environmental effects. CML can be integrated with physical accounts. Aggregation and disaggregation are possible to a certain extent. Usually, the categories of environmental effects are not aggregated to one single index of environmental pressure. Thus, the CML-Method lacks the communicative strength of MIPS and the Ecological Footprint. It is appropriate for detailed analysis rather than policy making and “ecological advertisement”. The indices are less appealing for politicians and less communicable to other social actors. Another shortcoming of the method is its lack of reference to natural flows and assimilative capacities. In other words it has no clear cut notion of and no goals for sustainability of the economy-nature exchange. It

[118] Eder 1996, p.41

- considers flows of non-renewable, renewable resources and emissions to air, water and soil.
- does not refer to assimilative and regenerative capacities.
- considers the natural variety of landscapes and species.

Physical indicators of stocks are possible measures for sustainability as it is defined by the requirement of non-declining stocks of natural capital. Within the SEEA they are presented as simple aggregates of different subsets of natural capital the monitoring of which can inform about the development of national wealth in such capital.

5.3.2.2 Evaluation of Monetary Indicators Presented in the SEEA 2000

In order to integrate the physical measures with monetary measures, physical stocks and flows have to be valued in monetary terms. The resulting indicators correct e.g. GDP for the value of depletion of natural resources and pollution damage to human health (=damage adjusted income). The extended notion of capital within SEEA calls for deduction of consumption of man-made as well as natural capital from gross measures of production and capital formation to arrive at “real” ones. The sustainability principle such measures are based upon is “weak sustainability”. They are in accordance with the criteria of a non-declining stock of different forms of capital. Unlike approaches of strong sustainability which require constancy or an increase in the aggregate stock of natural capital or, even more restrictive, of specific parts of the total stock, weak sustainability concentrates on the stock of natural capital plus man-made capital. As long as the aggregate stock of natural and manufactured capital is not decreasing, the reasoning goes, an economy is on a sustainable path. There are essential differences between the sustainability concept expressed by environmentally adjusted measures and our criteria outlined in Section 4.2.

Natural and man-made items are aggregated to one single measure. Aggregation in this case may foster the conviction that the depletion of natural resources can be offset by an increase in man-made capital. We have already set out our position concerning substitution in Section 4.2. As we see risk aversion as an integral part of sustainable development we opt for a more secure strategy of preserving natural resources allowing for the exploitation of non-renewable resources within certain limits (set by assimilative capacities of natural systems) though. In this respect, we are in line with Bossel who articulates that

> a certain minimum satisfaction must be obtained separately for each of the basic orientors. A deficit in even one of the orientors threatens long-term survival. [...] Only if the required minimum satisfaction of all basic orientors is guaranteed is it permissible to try to raise system satisfaction of individual orientors further – if conditions, in particular other systems, will allow this.[119]

In contrast to our view, weak sustainability does not exclude the growth of one basic element at the expense of another as long as the gains exceed the losses.

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[119] Bossel H. 1996, p.198

If it is assumed that aggregation of different forms of capital within one indicator does not necessarily imply the right to substitute one form for the other, integrated measures such as environmentally adjusted GDP can be in accordance with criteria such as non-declining stocks of natural capital. Then, monetisation and aggregation serves the aim of constructing one single index instead of a number of indicators in physical, monetary or other units. But in our view, monetary valuation of natural stocks and flows encounters a number of difficulties. These difficulties may not be outweighed by the sole advantage of having one index instead of a set of indicators.

A very general objection to monetisation is that analysis of and knowledge about nature is to a large extent quantified in physical terms. Ecologists as well as engineers express themselves in physical terms. Environmental quality as well as engineering efficiency is depicted in kilograms and square meters rather than in Dollars and Euros. Once it is accepted that economic sustainability is among others a matter of ecological soundness and technological efficiency there is good reason not to blur knowledge of natural and technical sciences by monetising non-marketable natural stocks and flows.

In addition, there are a number of other difficulties of methods of monetary valuation. The SEEA presents mainly three methods (for non-marketable goods):

- Net present value:

> When market prices do not exist, the next choice is to estimate the net present value of future benefits accruing from holding or using the asset.[120]

The net present value is calculated as the aggregate discounted rent yielded by a resource throughout its lifetime. Calculations are based upon estimation of the resource rent, determination of the life length and the discount rate. Net present value techniques do not allow for a comprehensive treatment of the economy-nature exchange according to our concept and the derived criteria. They consider natural source and sink functions only if they are (public or private) property and their use has to be paid. The SEEA 2000 is even more restrictive in this respect:

> [...] attention is restricted to the case of mineral and energy deposits, biological resources, both cultivated and non-cultivated, and land since these are the only assets where it is likely to be practical to compile a full asset account in monetary terms.[121]

Other valuation methods allow for a more comprehensive coverage of ecosystem functions. Cost based pricing techniques assess the cost of preventing environmental degradation (avoidance costs) or the cost of reversing it (restoration costs). Degradation occurs as assimilative capacities of the environmental media for anthropogenous substances are exceeded. In consequence, cost based techniques take into account ecosystems' sink functions. Avoidance of environmental degradation can be achieved through structural adjustment (change in productive and consumptive habits) and abatement (technological measures). Cost based techniques usually value the avoidance of degradation due to

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[120] The London Group on Environmental Accounting 2001, p.6/26

[121] The London Group on Environmental Accounting 2001, p.6/37

emissions (and subsequent immissions). Avoidance costs are calculated on the basis of data on emissions per economic activity and technical characteristics of production processes and data on available abatement techniques (technical and cost data).

Cost based pricing techniques do not measure how far the environment is from a sustainable state in ecological terms, but how easily society can correct for degradation and depletion and achieve an ecologically sustainable state. Measures of environmental protection, such as increased efficiency in energy consumption, can be of zero cost or even benefiting. In consequence, these methods may overestimate certain ecological problems which are difficult to counteract at the expense of more pressing ones. Moreover, cost based valuation focuses on defensive environmental activities. However, it is often difficult to determine which part of expenditures should be treated as reaction to environmental problems.

Damage pricing techniques (according to the SEEA) consist of a number of methods. Revealed preference pricing techniques, which are part of damage pricing techniques, comprise market prices, hedonic pricing and the travel cost method. Stated preference techniques (a subset of damage pricing techniques) comprise contingent valuation and conjoint analysis approaches.

Market valuation of environmental damage tries to identify “loss of production and changes in the market value of assets [...]”[122]. Market valuation is of limited applicability for the assessment of sustainability of economy-nature exchange as “much environmental damage cannot be associated with a marketed good directly”[123]. Hedonic pricing estimates the value of environmental services as the price of a proxy good that is marketable. The travel cost method determines the value of natural places of interest by assessing how much people actually pay to get to these places. Both hedonic pricing and the travel cost method can cover only a very limited number of environmental functions.

Another method among damage pricing techniques is contingent valuation.

> The contingent valuation (CV) method presents hypothetical situations to a representative sample of the relevant population designed to elicit statements about how much they would be willing to pay for specific environmental services. [...] CV studies can be conducted as in-person or telephone interviews or mail surveys. [...] valuation methods based on conjoint analysis differ from contingent valuation because they do not directly ask people to state their values in monetary terms. Instead, values are inferred from the hypothetical choices or trade-offs that people make. The respondent is asked to state a preference between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost.”[124]

[122] The London Group on Environmental Accounting 2001, p.8/14

[123] The London Group on Environmental Accounting 2001, p.8/14

[124] The London Group on Environmental Accounting 2001, p.8/17

Damage pricing techniques are usually applicable to a very limited number of local and regional environmental issues. To serve in national accounting, local estimates need to be aggregated, which is a rather intricate task. Willingness to pay requires informed and affected test persons. The farther – in geographic and emotional terms – a topic, the more speculative the answers will be. Independent from distances is the highly subjective character of willingness to pay methodology. Questionnaires about the same environmental issues may bring to light incompatible answers according to the design of the elicitation format, the individual's interests and mood.

Against the backdrop of our concept of economic sustainability and the applicability within a corresponding accounting system, the main caveats against the methods of monetary valuation discussed above are:

- Market prices and net present value techniques are applicable to a small part of the possible aspects of the exchange between anthropogenous systems and their natural environment only. They cannot be applied to value essential natural functions such as assimilative capacities.
- Cost based valuation methods may emphasise costly - but from the viewpoint of the protection of natural resources not so important – environmental problems. Cost based techniques express speculations. They tell how much the solution of an environmental problem would cost if society undertook the necessary measures to counteract the problem. In contrast, standard accounting within the SNA records e.g. how much (in monetary terms) has been produced, has been invested or has been consumed. The SNA is an ex post analysis. the underlying rationale of cost based techniques is that of an ex ante approach.
- Damage pricing techniques are best applied within a limited (geographical) context. Aggregation of regional results to national accounts is difficult. Much like cost based techniques, some damage pricing methods are speculative (not so hedonic pricing and the travel cost method). Contingent valuation asks how much people would be willing to pay and does not record how much they actually pay. In addition, contingent valuation may underestimate (from the point of view of the protection of natural resources) not well known or not fully understood environmental problems. As for cost based valuation, the rationale of damage pricing is not that of standard accounting.

In the light of this critical assessment of monetary valuation, we conclude that the advantage of one single index instead of a set of indicators does not outweigh the numerous difficulties and weaknesses. In consequence, we opt for physical indicators to describe sustainability at the economy-nature interface.

5.3.3 Evaluation of the Alternative Indicators of Economic Sustainability

The ISEW is a socially and environmentally adjusted measure of economic welfare and much of what has been said about weak sustainability indicators above holds true for the ISEW as well. It allows for trade-offs between different elements constituting overall welfare. It encounters the problem of valuing non-marketable items. It relies on the concept of "real" welfare and does not refer to standards of ecological sustainability. Apart from these weaknesses, the ISEW – as a measure of welfare – is very helpful as it asks for what is generating societal welfare (in the terms of this thesis: what is part of consumption surplus) and what is not. By negatively counting e.g. defensive private expenditures on health and education, costs of commuting and urbanisation, it corrects conventional macroeconomic measures and thereby goes a long way to make clear what can be counted as consumption surplus for the households. Finally, as the ISEW has been invented as an indicator of welfare it is not able to serve as an instrument for planning of economic sustainability. Essential data needed for the latter purpose, such as information on inter-industry relations or value added per economic activity, is absent from its accounting framework.

Daly's efficiency ratios for a Steady State economy are only a rough sketch of indicators for a sustainable economy and are not supported by an accomplished accounting system. It is nevertheless worth considering some of their aspects. The two poles of efficiency (ecosystem services and artefact services) can be found in our definition of a sustainable economy. In addition to this not surprising similarity, what seems important to us, is that Daly, in contrast to the other accounting systems excepting the combination of TMR/MIPS and GDP, introduces efficiency ratios and outlines increases in efficiency as a major strategy to achieve sustainability. Furthermore, Daly's efficiency ratios give a rough picture of the sequence of economic processes (from the natural resource to the commodities for final consumption).

Bossel's clarifying view on system-environment interactions and environmental properties is important. His approach of defining orientors for system viability seems sensible. The problems arise when it comes to determining the indicators for the orientors. Bossel chooses an exhaustive number of indicators for each of them. His merit is to fit single indicators into a systems-theoretical frame. Thereby he tries to ensure balance and completeness in coverage of the indicators. But on the other hand, he cannot avoid other deficiencies of such indicator sets that he is nevertheless aware of. Even a systematic set of single indicators strongly reflects the "specific expertise and research interest of their authors"[125]. Even within a systematic framework indicators may stress some aspects more than others. Moreover, single indicators within one set are susceptible to double counting. They often account for the same thing twice and on different levels in the cause-effect chain. Bossel's set of indicators for coexistence of the infrastructure system, for instance, comprises[126]

- environmental footprint vs. permissible sustainable footprint
- rate of change of environmental footprint
- rate of change of key environmental indicators (pollution, desertification, depletion)
- rate of foreclosure of important options (environmental resources, regional development): Rate of conversion of fertile agricultural land to infrastructure, accumulation of persistent wastes

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[125] Bossel 1996, p.195

[126] Bossel 1996, p.212

Aggregation of these indicators is definitely a case of double counting and may lead to overestimation of certain effects. The environmental footprint measures environmental pressures such as resource depletion. In an indirect way, it is also an indicator of how a society handles its potentials and options for the future. Generally, the orientor concept may add up indicators and indices that comprehend the same facts at different levels of detail and aggregation. Moreover, it not only tends to horizontal but also vertical double counting, as it indicates the same facts at multiple levels of the cause-effect chain. A comprehensive environmental footprint approach must grasp flows of wastes and convert them into area used. A set of key environmental indicators should comprise flows of waste as well. To integrate these indicators with, as it is shown in the example at hand, the rate of accumulation of persistent wastes, which is definitely an effect of waste flows means aggregating a cause and the related effect.

5.3.4 Evaluation of the SPI

The SPI is an index of sustainability that has been derived directly from the criteria of Moser et al. It applies the criteria for flows of non-renewable and renewable resources and emission flows directly. Flows of renewable resources are weighted with reference to natural regenerative capacities. Fossils are considered as renewable resources. This sets very strict limits to their exploitation, a fact that expresses the conviction that the perhaps most pressing environmental problem of today (global warming) can be attributed to the consumption of fossil fuels. In contrast, mineral resources (which are renewable on a geological time scale as well) are considered as non-renewables. The limits for sustainable outputs of emissions are determined by assimilative capacities.

The only criterion of the criteria of Moser et al. not included in the SPI concept is sustained variety of species and landscapes. The SPI assesses sustainability of flows between anthropogenous systems and natural systems only. The concept is flow-based exclusively and therefore cannot cover pressure on the environment exerted by factors other than flows (structural change, colonisation). As the natural variety of species and landscapes is to a large extent determined by structural change, these aspects of the sustainability concept of Moser et al. are not taken into account by the SPI.

5.3.5 Applicability of Existing Indicators and Necessary Extensions

5.3.5.1 Measuring the Consumption Surplus

The notions of a consumption surplus or a (social and not biological) survivability level of consumption are absent from conventional macroeconomic accounting systems. The underlying rationale of C_{SURV} is that different economic and social systems rely on different systemic elements and different structures (interrelations between the elements). The elements and structures require different amounts of material, organisational and human resources to be able to operate. The amount of resources required is C_{SURV}.

The calculation of the ISEW is based on similar considerations about goods and services of defensive nature.

> [...] we have not included government expenditures as adding to welfare because they are largely defensive in nature. That is, the growth of government programs does not so much add to net welfare as prevent deterioration of well-being by maintaining social security, environmental health, and the capacity to continue commerce.[127]

The quoted passage shows similarities with our notion of organisational resources required to make social and economic systems operate. The same similarities can be found in the treatment of expenditures on education within the ISEW (human resources). There are other aspects of the ISEW that make clear the difference in starting points between the ISEW and our approach. The ISEW intends to measure welfare. It answers the question of how much (economic) welfare is at a societies disposal. In contrast, what we are trying to develop, is an indicator for sustainability of economic systems and our definition of economic activity is determined by communication through actions of payment. The question that we are trying to answer is: How much consumption is available to society once the basic requirements for the functioning of given economic and social systems are met? Aspects such as services of (unpaid) household labour (which is crucial for the results of the ISEW calculations) are not within the scope of our approach. Furthermore, as has been explained in the previous chapters, we refrain from aggregating man-made and natural capital.

The ISEW includes consumption as well as investment. This is due to the fact that – referring to what the ISEW intends to measure – consumption and investment generate welfare. We modify this view according to what we intend to measure and say that consumption and investment can represent goods and services available to society once the basic requirements for the functioning of given economic and social systems are met. Both (parts of) consumption and (parts of) investment are results of economic activity made available to society. This leads us to the following definition of the consumption surplus:

$$C_S = C_{tot} - C_{SURV} + CF_{HH}$$

with CF_{HH} Capital formation for households

Which parts of overall capital formation are ascribed to capital formation for households and which parts of consumption to C_{SURV} will be determined in Section 6.3.3.3.

> In sum, the vision is that of a physical open system, a fund of service yielding assets maintained by a throughput that begins with the depletion of nature's sources of useful low entropy and ends with the pollution of nature's sinks with high entropy waste. There are two physical magnitudes, a stock of capital (people and artefacts) and a flow of throughput. There is one psychic magnitude of service or want satisfaction that is rendered by the stocks and is of course their reason to be. [128]

[127] Cobb and Cobb 1994, p.52

[128] Daly 1991, p.16

If Daly is correct and all services are rendered by stocks[129] - and we do think that he is right – should we not measure stocks of man-made capital in order to indicate economic sustainability? Measuring welfare or the satisfaction of wants we certainly should. But is the economic system to be hold responsible for non-declining stocks of man-made capital and thus non-declining service flows from this stock? We think that it is not. Imagine that by some disaster brought about by natural or human circumstances (e.g. war, flooding, volcano eruption) the stock of man-made capital at society's disposal decreases significantly. A look at the stocks will reveal decreased welfare or satisfaction of wants. Imagine further that the economic system has not been touched by the disaster and produces steadily. Then is the economic system as such unsustainable, is it functioning worse than before the disaster? No, because it is providing as much goods and services to the households as before. Welfare and the satisfaction of wants are changed by a change in stocks, the functioning of the economic system (its sustainability) is determined by flows of goods and services from the economic system to its social environment.

We conclude that the external criterion for economic sustainability will be measured in the form of flows of goods and services from the economic system to the social environment as defined above (C_S).

5.3.5.2 Measuring the Sustainability of Interactions between Anthropogenous Systems and Their Natural Environment

The issue of measuring stocks or rather flows has to be addressed for the interface of anthropogenous and natural systems just as much as for the exchange between economic and social systems. It has to be made clear that here our considerations include the exchange between economic systems and the natural environment and between social systems and the natural environment. In other words, pressure exerted on natural systems by productive and consumptive activities has to be taken into account in order to determine sustainability of natural sources and sinks.

We have seen that in principle stocks and flows can be used to determine sustainability according to our concept. The requirement of (a) constant stock(s) of natural capital and that of flows limited to natural reference flows are both appropriate. Indicators and accounts exist for both concepts. The SEEA lays the groundwork for records of all sorts of natural capital and all sorts of flows between nature and the economy. The main advantages of measuring flows rather than stocks have already been outlined in Section 5.2.4.

Within the DPSIR framework, measuring stocks corresponds to measuring states or impacts. States are e.g. depleted deposits or contaminated environmental media, an impact is, for instance, a resulting loss of biodiversity. The respective pressures could be the use of flows of non-renewable resources and the emission of substances to water, air and soil. The advantage of measuring flows is, that pressure (e.g. emissions, extractions) can be directly attributed to productive and consumptive activities. On the other hand, the activities responsible for a loss of biodiversity are usually difficult to determine. First because

[129] Daly subsumes all artefacts regardless of their life length in stocks.

deterministic cause-effect relationship between pressures and states do not necessarily exist. And if they exist, they are, in many cases, virtually impossible to determine. Also because, and this leads us to the second weakness of measuring stocks, the time lag between pressures and states/impacts can be large. It is a long way from emissions or structural change to biodiversity loss. Therefore, measuring stocks points to problems when the damage has already occurred. It can only trigger defensive activities of restoration of quality and quantity of resources. In contrast, the measurement of pressures cannot directly deduce states and impacts from pressures. In some cases it may lead to exaggerated precautionary measures. But it can induce actions before damage has occurred and these actions are not necessarily of defensive nature only. We consider it one essential feature of indicators to point out to problems before damage occurs. In the light of these considerations, we opt for measuring flows to determine sustainability of the exchange between anthropogenous systems and their natural environment.

From the flow-based methods discussed, the SPI meets our requirements best. It

- relies on a clear notion of sustainability which is directly derived from the criteria of Moser et al.. It assesses human action against the background of natural states and flows.
- includes 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 – like the Ecological Footprint – area, a concrete and communicable measure - to express impact on the natural environment.
- bases its calculations on flows of emissions and resources. It can easily be calculated from data of e.g. NAMEAs.

There is one criterion of Moser et al. that is not taken into account by the SPI (variety of species and landscapes). Sustainability according to this criterion cannot be measured by means of flows. There are no flows of species and landscapes as there are flows of resources and emissions. The SEEA comprises land and ecosystem accounts that can be used to account for variety of species and landscapes.
A basic set of land cover/land use accounts consists of matrices that relate land cover (ecosystems such as forests, dry land) to land use (land underlying buildings, agriculture etc.) and land use to economic activities. Records of land cover changes shows increases or decreases in different ecosystems.[130] In supplementary accounts, biotope types can be ascribed to land cover types and biodiversity indicators can be developed for the biotope types. The integration of quality aspects (classification of ecosystems according to factors such as health of trees or state of the soil) is feasible in principle but difficult in practice.

> There are no concise breakdowns by complex quality classes of land or ecosystems types which are scientifically sound.[131]

[130] The London Group on Environmental Accounting 2001, p.7/26

[131] The London Group on Environmental Accounting 2001, p.7/34

Apart from this difficulty – part of the quality aspect (quality of environmental media) is covered by the SPI – a combination of the SPI and land and ecosystem accounts according to the SEEA allow for a comprehensive assessment of the sustainability of the interaction between nature and anthropogenous systems. In the course of this thesis, we will nevertheless refrain from including land and ecosystem accounts mainly for reasons of scope and labour intensity of such an inclusion.

5.3.5.3 Measuring the Sustainability of Interactions between Economic Systems and Their Economic Environment

The measure for sustainability of the exchange between economic systems and their economic environment is directly derived from 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 rest of the world. These transfers are usually of political or private (in the case of foreign workers that send part of their salary home) nature and do not give information about whether consumption (consumption and investment) in a period exceeds national income. Claims and liabilities and the respective capital transactions are the result of anterior lending and borrowing and envisaged production and consumption. A country that has lived beyond its means in the past, e.g. because it has invested in the industrial sector, may have to pay back the debt incurred. It will do so by liquidating recent savings. Capital transactions tell more about past and future production and consumption activities than about today's. Time series of balances of trade and services can serve the same purpose in our particular case.

5.3.5.4 Additional Indicators

The indicators developed in Sections 5.3.5.1 – 5.3.5.3 tell whether an economic system is sustainable or not. They are indicators of effectiveness. For the analysis of strengths and weaknesses of economic systems from a sustainability vantage point according to our concept, it can be useful to provide additional information. The linkage of indicators for the different interfaces can provide such information. The linkage of indicators for the exchange between economies and their natural environment and indicators for the exchange between economies and their social environment can show how efficiently economic systems or subsystems are providing consumption surplus from natural resources. To link indicators of economy-economy exchange with indicators for economy-nature exchange can inform about how much resources are used up for the production of goods and services for exports/imports and about the claims and liabilities that result from these exchanges. Such (efficiency) indices can help to make economic sustainability problems visible and different economies comparable. Thus, they can point the way to sustainability as measured by the indicators of effectiveness.

6 The Sustainable Economy Indices and the Underlying System of Accounts

On the basis of our concept of economic sustainability and our reflections on measurement of economic sustainability, we will now develop a set of indices intended to measure economic sustainability.

The indices fall into two classes. The first class indicates whether an economic system is sustainable or not (effectiveness). The second class of indices helps to identify strengths and weaknesses of an economy from a sustainability vantage point (efficiency). It makes palpable potentials for improvement in technologies and economic structure.

6.1 Sustainability and Survivability Indices

The first group of indices measures sustainability and survivability of the economy. It is developed in analogy to the criteria of our concept of economic sustainability developed in Section 4.2. A fourth index expressing the survivability level of consumption (C_{SURV}) completes the first set.

To assess the ecological aspect of economic sustainability it is necessary to indicate the use of domestic natural sources and sinks. Domestic sources and sinks can be exploited by both domestic and foreign economies (and households). The analysis of the impact of the rest of the world economies on domestic eco-systems calls for a recording of transboundary environmental effects such as foreign emissions to air and water that are immitted on domestic natural systems. Domestic and foreign use of domestic natural resources come to overall pressure on the domestic environment. When natural sources and sinks are overused – be it by domestic or foreign activities – the domestic economy is not in a state of sustainability.

Sustainability of the use of natural resources is assessed with the SPI. The area (in terms of the SPI) needed to contain the domestic economy and the domestic households plus the domestic area needed to contain foreign economic activities and the foreign households is compared to the geographical surface of the nation/region considered. When the area needed is larger than the geographical surface, it is assumed that the economy is not ecologically sustainable.

Ecological Sustainability Index: $A_{D\ econ} + A_{F\ econ} + A_{D\ HH} + A_{F\ HH} / S_D$ $[m^2/m^2]$

with	$A_{D\ econ}$	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

Ecological sustainability criterion: $A_{D\ econ} + A_{F\ econ} + A_{D\ HH} + A_{F\ HH} / S_D \leq 1$

The geographical surface of the domestic economic system is calculated including sea area available for exploitation. For global environmental effects the area available to contain anthropogenous flows is larger than the aggregate geographical surface of the economies. The surface of the oceans has to be considered in the determination of the surface available for the containment of anthropogenous flows. The inclusion of the oceanic surface (70,8 % of the globe) - on an average global level - yields a less strict ecological sustainability criterion:

$A_{D\ econ} + A_{F\ econ} + A_{D\ HH} + A_{F\ HH} / S_D \leq 3{,}4$

When the area consumed exceeds the overall surface of the globe (3,4 times the global land area), as long as we are not capable of outsourcing resource provision and assimilation of residues to other planets, mankind induces flows that are larger than their natural reference flows. It may thereby overuse natural resources and jeopardise their future availability. In the absence of irreversible effects, a one time overuse of sources and sinks does not necessarily cause the collapse of the ecosystem overused. When present resource consumption is used to “finance” more sustainable behaviour in the future[132], the long-term effects of a short-term overuse may be positive. Time series of the SPI and analysis of the use of natural resources on the disaggregate level will give a clearer picture of the future unsustainability of past and present behaviour. What can be said with certainty is that an SPI that lies constantly above 1 (or 3,4 for global environmental effects) indicates the overuse of natural capacities that results in changed (deteriorated) environmental conditions. It thereby indicates unsustainability of the activities examined.

The consumption surplus includes goods and services for final consumption by households and capital formation for households. Commodities for survival and intra-economic use are excluded. Domestically produced as well as imported goods and services conduce to the fulfilment of needs. Domestic production plus imports minus exports make the amount of goods and services available to the domestic households. The goods and services available to the households in a given period valued at basic prices indicate the value of C_S in that period. An economic system is on a sustainable path as long as this value is not decreasing.

Consumption Surplus Index: $C_S = C_{tot} - C_{SURV} + CF_{HH}$ [€, $]

with C_S Consumption surplus (domestically produced plus imported minus exported)

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 (domestically produced plus imported minus exported)

[132] Technological change of wide range is likely to provoke increased resource consumption in the phases of construction of a new technology and replacement of old technologies and may result in lower resource consumption thereafter (in the phase of the operation of a new technology).

The absolute level of sustainable consumption surplus cannot determine sustainability. Consumption habits are relative to cultural conditions. Cultural conditions in turn change with time. If we assume that the basis for an assessment of the sustainability of economic systems is their present functioning and that minimum requirements for C_S are determined by present consumption habits a decrease of C_S is equivalent to unsustainability. So even if we cannot determine absolute levels of sustainability for this index, we can say that a diminishing level of the Consumption Surplus Index points to unsustainability. As with the SPI, real unsustainability has to be determined on the basis of time series. A short-term decline in C_S that results in increased future C_S can be desirable.

Consumption surplus criterion: $dC_S/dt \geq 0$

Whether an economy is saving or incurring debts can be measured by balancing imports and exports of goods and services. When the value of imports (basic prices) exceeds the value of exports an economic system runs into debt. Here, the value of all goods and services is taken into account.

Economic Exchange Index: $V_E - V_I$ [€], [$]

with V_E value of goods and services exported

V_I value goods and services imported

Economic exchange criterion: $V_E - V_I \geq 0$

It is evident, that a current account deficit 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 the solvency criterion is that constant current account deficits (even if financed by import of capital) may lead to prohibitive payments of interest. To interpret the possible solvency difficulties due to a current account deficit information on the size of the deficit relative to GDP, its sources[133], the structure of capital inflows[134] 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) is needed.

It should be noted that foreign exchange surpluses are considered economically problematic as well. Under the assumption of fully flexible currency exchange rates constant current account surpluses lead to an appreciation of the currency of the exporting country. The appreciation rises (relative) prices of export products. Higher prices in turn result in decreased exporting possibilities and a subsequent adjustment to a balanced current account. In order to avoid currency deprecation or structural economic adjustments which usually are accompanied by negative effects on other important economic goals economic

[133] "The first principle is that current account deficits should be seen to finance productive investment, preferably into the exporting sector in order to prepare for the amortisation of rising foreign liabilities, which is inevitable." Reisen 1997, p. 14

[134] Capital in the form of Foreign Direct Investment (FDI), for instance, is less volatile than other investment forms (portfolio).

theory calls for balanced current accounts ($V_E – V_I = 0$). A look at the statistics[135] shows that mainly rich industrialised countries – Japan and European countries such as France, Italy, Switzerland, Belgium – produce large current account surpluses. These surpluses seem to represent only insignificant threats to the economic stability and not threat at all to the solvency of these countries. Therefore, we stick to the economic exchange criterion that the value of exports must be equal or bigger than the value of imports.

C_{SURV} can be expressed by the amount of products necessary to lay the basis for the operation of social systems. Which products are included in the calculations of the Survivable Consumption Index is explained in Section 6.3.3.3.

Survivability Consumption Index: $C_{SURV\,D} + C_{SURV\,I} – C_{SURV\,E}$ [€], [$]

with $C_{SURV\,D}$ value of domestically produced products for survivability

$C_{SURV\,I}$ value of products for survivability imported

$C_{SURV\,E}$ value of products for survivability exported

There is no criterion of sustainability for the Survivability Consumption Index. The level of C_{SURV} influences economic sustainability inasmuch as it uses up resources, but it does not determine economic sustainability. What is of interest is the amount of goods and services needed to assure survivability of a given anthropogenous (economic and social) system.

6.2 Efficiency Indices

Efficiency indices set values in relation to other values. In our case, natural inputs will be related to economic outputs and parts of economic activity will be related to overall economic activity.

Natural resources are at the beginning of every economic activity. The provision of C_S is the final end of economic activity (according to our concept of economic sustainability). To relate the source and the end of economic activity yields a major efficiency ratio from the viewpoint of economic sustainability. How much 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 all natural resources used by an economic system, on the one hand, and, on the other hand, C_S supplied by means of these resources. in contrast to the Consumption Surplus Index, the Economic Efficiency Index includes domestically produced C_S (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 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-

[135] The International Bank for Reconstruction and Development 2000, p. 258

economic use in ROW economies are deducted. The use of natural resources is quantified as the incorporated SPI area[136] of products.

Economic Efficiency Index: $C_{S\ dom} / (A_{D\ econ} + A_{P\ imp\ econ} - A_{P\ exp\ econ})$ [€/m^2], [\$/m^2]

with $C_{S\ dom}$ Domestically produced consumption surplus

$A_{P\ imp\ econ}$ area incorporated in products for economic use imported

$A_{P\ exp\ econ}$ area incorporated in products for economic use exported

A second efficiency index 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. First, the domestic production of such goods puts pressure on the domestic environment and may lead to ecologically unsustainable situations. Second, the export of low value products is a possible reason for current account 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' [...][137]

> [...] prices have been kept low, and to increase earnings, production has been increased; in many cases exerting a great pressure on the natural environment.[138]

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.

> Eastern Europe, followed by Latin America and the Caribbean, are currently the two regions with the highest concentration of dirty goods [metals, petroleum, paper] as these products account for over one fifth of total exports. As far as trends are concerned, there is rather clear evidence of a relative decline in the importance of these products in industrial countries' exports, while increases are observed in Eastern Europe, Latin America and West Asia.[139]

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.

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[136] The area (the consumption of resources and the generation of residuals valued with the SPI) used for the production of a good.

[137] Ropke 1994, p.14

[138] Ropke 1994, p.18

[139] Low and Yeats 1992, p.93

Import Efficiency Index: VA_I / A_I [€/m^2], [$/$m^2$]

with A_I area incorporated in goods and services imported

VA_I value added incorporated in goods and services imported

Export Efficiency Index: VA_E / A_E [€/m^2], [$/$m^2$]

with A_E area incorporated in goods and services exported

VA_E value added incorporated in goods and services exported

Additional indices can be composed in order to point to structural strengths and weaknesses of an economy. The size of the part of an economy providing $C_{S\ dom}$ and $C_{Surv\ dom}$ (domestically produced goods and services for the survivability level of consumption) in relation to the whole economy can help to detect such structural particularities. The shares of value added in total value added and of SPI area consumed in total area consumed indicates the size of these economic segments in economic and ecological terms.

Functional Composition Indices: VA_S / VA_D [€/€], [$/$]

with VA_S value added of the part of the domestic economy providing C_S

VA_D value added of the domestic economy

A_S / $A_{D\ econ}$ [m^2/m^2]

with A_S SPI area of the part of the domestic economy providing C_S

$A_{D\ econ}$ SPI area of the domestic economy

VA_{SURV} / VA_D [€/€], [$/$]

with VA_S value added of the part of the domestic economy providing C_{SURV}

VA_D value added of the domestic economy

A_{SURV} / $A_{D\ econ}$ [m^2/m^2]

with A_{SURV} SPI area of the part of the domestic economy providing C_{SURV}

$A_{D\ econ}$ SPI area of the domestic economy

6.3 An Accounting System for the Analysis of Economic Sustainability

While indices are of importance for purposes such as policy communication, target setting or the comparison between regional or national economies, they are unsuitable instruments for more detailed analysis of economic functioning and structure. Interdependencies of economic activities, strengths and weaknesses of single activities in relation to the whole economy, strongly exporting and heavily polluting activities have to be scrutinised at a more disaggregate level. The necessary data for such investigations is provided in systems of accounts.

Two requirements for an accounting system for economic sustainability analysis can be determined. First, it has to provide all necessary economic and environmental data that is needed for the composition of the indices developed. Disaggregation of the indices has to be made possible. Second, the accounting system has to be of standardised format. It is indispensable that the accounting system can be derived from regularly updated and widely accepted data sources.

Among all the accounting systems discussed in Section 5.2.2 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.

6.3.1 Monetary Supply and Use Tables

Monetary supply and use tables are matrices of economic activities and products that describe domestic production and transactions with the rest of the world.[140] Supply tables show output of economic activities and imports classified in groups of products. Use tables show the use of goods and services classified in groups of products and types of usage (intermediate consumption, consumption by households, investment and export). In addition, use tables show gross value added per industry. Simplified supply and use tables are given in Tables 6.1 and 6.2.

Table 6.1: Simplified supply table

	Industries	**Imports**	**Total Supply**
Products	Output per industry and product	Imports per product	Total supply per product
Total	Output per industry	Total imports	Total supply

[140] Europäische Kommission 1996, p. 223

Table 6.2: Simplified use table

	Industries	Final Uses			Total Use
Products	Intermediate consumption per industry and product	Final consumption expenditure per product	Gross fixed capital formation per product	Exports	Total use per product
Value Added	Value added per industry				
Total	Input per industry				

There are two important identities for supplies and uses. First, for each industry, total output equals intermediate consumption plus value added. Second, total supply (domestic output plus imports) of one product equals total use (intermediate consumption plus exports plus final consumption plus capital formation) of the product.

Supply and use tables can be integrated to one combined supply and use table. To do so, use tables are supplemented by columns for products and rows for industries and imports. Supply tables are transposed. (Table 6.3)

Table 6.3 Simplified combined supply and use table

	Products	Industries	Rest of the World	Final Consumption	Gross Capital Formation	Total
Products		Intermediate consumption	Exports	Final consumption expenditure	Gross fixed capital formation	Total use
Industries	Output					Total output
Value Added		Value added				
Rest of the World	Imports					
Total	Total supply	Total input				

In the European Systems of National Accounts, industries are classified according to the General Industrial Classification of Economic Activities within the European Communities (NACE Rev.1). Products are classified according to the Classification of Products by Activity

(CPA).[141] NACE Rev.1 and CPA are fully co-ordinated classification systems. For every industry and at every level of detail according to NACE Rev.1 CPA shows the corresponding products.

Flows of goods and services in supply and use tables can be valued at either basic or purchasers prices. Basic prices correspond to purchasers prices minus taxes plus subsidies minus transport and profit margin:

basic prices = purchasers prices – value added tax – import duties – other taxes on products + subsidies on products – profit margin – transport margin

Imports are shown in values including costs of insurance and transport to the import border (cost, insurance, freight – cif.). Exports are shown in export border values (free on board – fob.). Value added is shown in basic prices. It is the difference between output at basic prices and intermediate consumption at purchasers prices.

6.3.2 Physical Supply and Use Tables

Physical supply and use tables are the physical equivalent to the monetary supply and use tables outlined in the previous section. They record flows of products supplied by the domestic economy or imported and their use by industries (intermediate consumption) for consumption, capital formation and export. All flows are entered in physical units (e.g. million metric tons). In addition to the flows recorded in monetary supply and use tables, physical supply and use tables show flows from the natural environment to the economy and vice versa and inter-environmental flows. They comprise flows of natural resources and ecosystem inputs[142] that are used for production and consumption as well as flows of residuals such as emissions to air, water and soil that are generated by production, consumption and capital formation and discharged to the environment. Flows from the domestic environment to the domestic economy and vice versa are displayed as well as flows from the domestic environment to the rest of the world environment and vice versa (cross boundary environmental flows) and flows from the domestic economy to the rest of the world environment and from the rest of the world economy to the domestic environment.

Use tables for natural resources and ecosystem inputs, supply and use tables for products and supply and use tables for residuals are formed. While supply tables for residuals display the generation of emissions per industry, consumption, capital formation and the rest of the world, use tables record the re-absorption of residuals by industries (recycling, waste collection and treatment), capital formation (disposal to landfill sites) and the rest of the world. Emissions from capital formation (e.g. methane emissions and washing-out of substances to groundwater from landfill sites) are treated as residuals. The tables can be integrated to one comprehensive system of physical flow accounts. Similar to the

[141] NACE Rev.1 and CPA classifications are shown in the Appendix.

[142] "These are the inputs from the environment such as the gases needed for combustion and production processes as well as air and water for living things. Hydro, wind, and solar power

construction of the combined monetary supply and use table, a matrix format is used. Classification of industries and products can be done according to the systems used in monetary tables. Table 6.4 shows a combined physical supply and use table.

contributing to energy sources may also be included here as well as, potentially, nuclear and biomass energy." Vorburg draft on SEEA 2001, p.3-9

Table 6.4: Combined physical supply and use table

			Products				Residuals				
		Products	Industries	Capital	Consumption	ROW	ROW economy	National environment	ROW environment	Material balance	Total use
	Products		Products used by industry	Products used for capital	Products used for consumption	Products used by ROW					
Products	Industries	Products supplied by industry						Residuals generated by industry	Residuals generated in ROW		
Products	Capital							Residuals generated by capital		Net material accumulation by capital	
Products	Consumption							Residuals generated by consumption	Residuals generated in ROW	Net material accumulation by consumption	
Products	ROW	Products supplied by ROW								Net material accumulation of products by ROW	
Residuals	ROW-economy							Residuals generated by ROW		Net flow of residuals from ROW economy	
Residuals	National environment		Recycled products supplied to industry	Waste to landfill site					Cross boundary environmental flows to ROW	Net flow of residuals from the national economy	
Residuals	ROW environment							Cross boundary environmental flows from ROW		Net cross border flow of residuals	
	Natural resources		Raw materials supplied to industry		Raw materials supplied to consumption					Accumulation of natural resources in the environment	
	Ecosystem inputs from national environment		Ecosystem inputs to industry		Ecosystem inputs to consumption		Ecosystem inputs to ROW			Accumulation of ecosystem inputs in the environment	
	Ecosystem inputs from ROW environment		Ecosystem inputs to industry		Ecosystem inputs to consumption					Accumulation of ecosystem inputs in the ROW	
	Total supply										

6.3.3 Supply and Use Tables Including Environmental Accounts (SUTEA)

A SUTEA is a combination of physical and monetary supply and use tables. In principle one is free to decide which accounts to show in monetary or physical units. For our purpose it is sensible to use a monetary supply and use table as presented in Section 6.3.1 and to supplement it with data not included in conventional economic accounts (flows of natural resources, ecosystem inputs and residuals). The latter will be entered in physical units. An example of a SUTEA has already been presented in Table 5.2.

For the calculation of our indices and economic analysis with regard to sustainability, the standard SUTEA has to be slightly rearranged and extended. First, calculations of C_S and C_{SURV} have to be realised within the framework of the supply and use tables. Second, additional accounts for SPI valuations of industries and products have to be included. But before discussing the necessary extension, the definition of boundaries between economic systems and nature and between economic systems and their economic and social environment shall be briefly outlined.

6.3.3.1 The Boundary between Anthropogenous Systems and their Natural Environment

The range of social metabolism - input from natural to social systems and output from social to natural systems – is determined by the allocation of elements (humans, animals, artefacts) to the social and economic or the natural sphere.

It is evident, that the virgin Amazon rain forest together with its flora and fauna is part of nature. Yet, this assignment becomes less clear as soon as man takes possession of parts of the forest and transforms it according to social purpose. Everything social has once been natural. Every artefact consists of natural materials. It is the degree of transformation from the natural to the social that makes the allocation more or less difficult. Untouched nature is natural and on the other end of the gamut no one would hesitate to assign a car to the social system. But what about domestic animals and useful plants? What about human beings and the forest path that we walk on? And on the other hand, are artefacts from cars to credit cards not part of (changed) nature?

The simple answer is that various elements are both social and natural and that there is no unambiguous general allocation possible. What is natural and what is not has to be defined at the level of the specific analysis.

The analysis of economic sustainability has to strive to seize among others the (over)use of natural sources and sinks by man. The boundaries between natural and anthropogenous systems have to be set in this particular regard:[143]

- Artefacts that are produced and maintained by human activity such as machines, buildings, consumption goods are part of anthropogenous systems. Thus, energy and

[143] see Fischer-Kowalski et al., p.62

raw materials for the production of artefacts can be treated as inputs from nature to anthropogenous systems. Residuals generated by the use of artefacts are treated as outputs from anthropogenous systems to nature. Artefacts, that are discharged to landfill sites in the form of waste are still part of anthropogenous systems. Otherwise, emissions from landfill sites would represent inter-environmental flows and not be recorded in environmental economic accounts.

- Domesticated animals are considered as part of the anthropogenous systems. Otherwise, fodder and pharmaceuticals used in cattle breeding would be output to nature. Overgrazing would not be taken into account as a man-made problem, as the flow of grass from the pasture to the cattle would be an inter-natural one. Animal products like meat and milk, that today are produced in a highly industrialised way, would be inputs to society and not inter-social transfers.
- Wild animals and plants are ascribed to nature so that flows of residuals and their effect on animal and vegetable health can be recorded.
- Useful plants are part of the natural system. Consumption of biomass is an input to society. When plants are assigned to society, their respective input – CO_2 and O_2 – would be a virtually immeasurable input to society. On the other hand, fertilisation would be a inter-society problem and not be taken into account.
- Human beings are part of the social sphere. Everything that is used for maintenance and reproduction of human beings (food) and the respective pressure on the environment is to be taken into account in economic sustainability analysis.
- Air, water and soil are part of nature. Thus, the consumption of the media in production can enter environmental-economic accounts as an input to anthropogenous systems, contamination of the media as an output from society to nature.

6.3.3.2 The Boundary between Economic Systems and Their Economic and Social Environments

In Chapter 3 we have characterised economies as the sphere of actions of payment. Thus, the boundary between economic and other social systems separates the realm of money from the one where no actions of payment take place. This boundary is constituted by the last of a sequence of actions of payment. It has to be set where payment is not meant to guarantee future payment but to provide consumption goods. Therefore, the households represent the boundary between economic systems and their social environment.

The boundary between different economic systems is not determined by differences of code and medium.[144] These boundaries are less economic than institutional, political, functional, legal and biological. They are political, where the economic behaviour of politico-historical constructs such as nations is examined. They are institutional and functional, when economic sectors which are usually built around some notion of economic function and institutional

[144] This is not true when considerations are extended to comprise non-monetary economies, but this is not the case here.

position (the government sector represents an institutional more than a functional unit) are of interest. They are legal, when at the microeconomic level companies and other economic organisations form the subsystems of a greater economic system. And finally the boundaries are of biological nature when single persons take part in economic activity in their role of final consumers.[145]

At the centre of this work is the analysis of regional and national economic systems. Detailed analysis of these macroeconomic systems requires further disaggregation and we are going to use mainly functional criteria for the cut off between economic subsystems. Further, a natural environment will be ascribed to the regional and national economic systems examined. In most cases, it will match the political territory of nations and regions. But in principle, a region can be defined according to other criteria, such as geographical or cultural characteristics.

6.3.3.3 Definition of Economic Functions

At the disaggregate level the conventional classifications of industries and products (NACE and CPA) remain unchanged. This is necessary, because monetary as well as physical data is collected according to these classification systems by national statistical offices. In order to determine the consumption surplus and the survivability level of consumption, economic functions will be determined. These functions serve as starting point for the calculation of accounting aggregates reflecting the notion of C_S and C_{SURV}.

Sectoral classification in conventional economic accounting is oriented by mainly two notions. One is the notion of the market. Classification with reference to the market yields the economic sectors already enumerated in Section 5.2.1 (nonfinancial corporations, financial corporations, general government, households, nonprofit 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 primary sector (exploitation and processing of raw materials, energy, water and food supply) is prior to industrial production processes. The secondary sector (manufacturing industry) is at the centre of industrial production while the tertiary sector (services such as retailing, insurance, banking, health and education, research and development) is only indirectly related to industrial production as such.

The ultimate goal of an sustainable economic system is the provision of consumption surplus. The classification of economic activities into sectors or functions must be done with reference to this main goal. Neither of the conventional classification schemes meets this requirement.

In order to analyse an economy’s structure and ability and corresponding efficiency to provide C_S, we have to separate the activities not directly aimed at the final goal. These

[145] As every action of payment is economic, the role of the households is double. They find themselves at both sides of the boundary between economic and other social systems. At the economic side when they buy and at the “social” side when they make use of the items purchased.

activities are nevertheless indispensable contributions for the functioning of the economic whole. This is not meant to say that they are indispensable as such. Some activities are. Others are necessary because the economic world is what it is. They are consequences of our ways of living in general and our ways of producing and consuming in particular. Environmental protection, for instance, is a necessary consequence of the pressure exerted on nature by anthropogenous activities. Reducing the pressure will decrease the need for activities such as the clean-up of contaminated sites.

Economic functions/aggregates are determined by a repartition of final uses in use tables and subsequent allocation of intermediate flows according to the use tables.

The first economic function/aggregate is the provision of products for survival (**Survivability level of consumption** - C_{SURV}). The level of C_{SURV} cannot be determined in absolute terms. A highly developed industrial society may require more products to survive than an agricultural one. We assume however, that it can be determined which products compose C_{SURV}. These products, by their nature, assure the basic functioning of societies.

- The initial interpretation of C_{SURV} focuses on the biological survival of populations (of animals or human beings). The main product assuring biological survival is food. Ingestion allows for the functioning of animal and human bodies. Food is the primary energy source for what within the concept of a SSE represents the first "physical population".
- Daly claims that the second physical population (the artefacts) represents extensions of the human body. Others attribute the evolution of technology as such to a lack of biological organs.[146] Both see artefacts as replacements and reinforcement of human (biological) features. The cultural extension of a purely biological C_{SURV} must include the survival of the second physical population of artefacts. Much as biological bodies, artefacts consume energy in order to function. Energy used by artefacts consists mainly of fuels and electrical energy. Together with food, other energy sources represent the main source for cultural survival (the functioning of the physical populations of bodies and artefacts).[147]

We identify the provision of energy to bodies and artefacts as one essential part of C_{SURV}. The second part of C_{SURV} comprises defensive services mainly. First, these services maintain the two physical populations of bodies and artefacts. Second, they provide and restore the necessary (organisational and other) basis for the functioning of societies.

- Beside energy for everyday functioning, the physical populations of bodies and artefacts need maintenance. Maintenance of bodies is achieved through health services. Signs of wear and tear of biological bodies are counteracted by medical treatment for humans and animals. Health services are mainly defensive and help assuring the biological survival.

[146] Gehlen 1957, p.8

[147] Daly's population of artefacts comprises all artefacts (consumption and investment goods). As we are concerned with C_{SURV} here, we consider artefacts for consumption (and their energy use) only.

- Maintenance of artefacts is more difficult to determine at the product level. National supply and use tables' product classification (at the two digit level) does not distinguish between sale, repair and maintenance of products. Explicitly mentioned (at the 4 digit level) is only the repair and maintenance of motor vehicles. Other services such as plumbing or the work of electricians or bricklayers are partly defensive as well. But there is no way of isolating this defensive part within the frame of a SUTEA. Therefore, we will not include maintenance of artefacts with C_{SURV}.
- Government expenditures which are part of collective consumption are included in C_{SURV} as well.

  > [...] we have not included government expenditures as adding to welfare because they are largely defensive in nature. That is, the growth of government programs does not so much add to net welfare as prevent deterioration of well-being by maintaining security, environmental health, and the capacity to continue commerce. [148]

  At the product level, government expenditure consists of Public administration services, Health and social work services, Sewage and refuse disposal services and Education services.

  > [...] it would be inappropriate to count education as consumption [surplus, the author] because most schooling appears to be defensive. In other words, people attend school because others are in school and the failure to attend would mean falling behind in the competition for diplomas or degrees that confer higher incomes and recipients.[149]

  The viewpoint of a survivability level of consumption concerning education is somewhat different. What is of importance is not so much the opportunity to have higher incomes but the possibility to survive within a specific cultural context. We assume that the level of education that is supposed to assure survival in this respect is represented by compulsory education. Inability to write, read and count to ten excludes a person from a number of activities of knowledge based societies. Profound knowledge of astrophysics, medieval Chinese poetry or the course of the Hundred Years' War is less essential for most people. It seems sensible to include compulsory education with Survivability consumption activities and to exclude higher education, which is ascribed to consumption surplus. In Austria about 50 % of expenditure on education go to higher education. The other half goes to compulsory education. We are going to count the 50 % of compulsory education among C_{SURV}.

On the level of the (2 digit) CPA classification, C_{SURV} comprises the following products:

- Products of agriculture, hunting and related services (CPA 01)
- Products of fishing, operation of fish hatcheries and fish farms; related services (CPA 05)
- Coal, lignite; peat (CPA 10)
- Crude petroleum and natural gas; related services (CPA 11)

[148] Cobb and Cobb 1994, p.52

[149] Cobb and Cobb 1994, p.53

- Food products and beverages (CPA 15)
- Coke, refined petroleum products, nuclear fuel (CPA 23)
- Electricity, gas, steam and hot water (CPA 40)
- Public administration services (CPA 75)
- Education services (CPA 80) (50 %)
- Health and social work services (CPA 85)
- Sewage and refuse disposal services etc. (CPA 90)

The second economic function/aggregate is the provision of the **consumption surplus** (C_S). C_S comprises mainly final consumption expenditure. In standard use tables the final uses section is subdivided into

- Final consumption expenditure (FCE) by households
- Final consumption expenditure by government
- Final consumption expenditure by NPISH (non profit institutions serving households)
- Gross fixed capital formation / Dwellings
- Gross fixed capital formation / Other buildings and structures
- Gross fixed capital formation / Machinery
- Gross fixed capital formation / Transport Equipment
- Gross fixed capital formation / Other GFCF (gross fixed capital formation)
- Valuables
- Changes in inventories

FCE by households, by government and by NPISH are the main elements of C_S and the provision of the products ascribed to these final use sections is attributed to the respective function/aggregate. Products for C_{SURV} as defined above are subtracted from total FCE. The provision of these products is not part of the consumption surplus aggregate/function. Parts of GFCF consist of goods and services for households as well. These goods and services are to be included in C_S.

- Dwellings are entirely for the use of households. Therefore, all products in the final uses section GFCF/Dwellings and their provision are ascribed to the consumption surplus aggregate/function. Part of construction work (and therefore part of the construction of dwellings) is certainly defensive in nature (e.g. restoration of buildings). The difficulties in determining the defensive part of construction are the same as for overall maintenance of artefacts. The defensive part cannot be deduced from a standard SUTEA. With the need for standardisation of the calculation of our indices in mind we omit the defensive part of the provision of dwellings and ascribe the whole final uses section (dwellings) to C_S.
- Another GFCF section including products for the use of households is the Other buildings and structures section. This section includes the construction of streets and highways which are partly used by the households. Cobb and Cobb estimate that about three fourth

of all vehicle miles are for non-commuting travel and therefore contribute to welfare.[150] Studies for Austria[151] show that up to 50 % of overall passenger traffic (in person kilometres) is non-professional. About 20 % of the Other buildings and structures section can be attributed to the construction of streets and highways. If we assume that the lion's share of freight travel is for professional purpose, between 10 % (Austrian studies) and 15 % (Cobb and Cobb) of the Other buildings and structures section is for the use of households. Moreover, the main part of maintenance and restoration work of streets and highways must be attributed to (professional) freight transport that is responsible for most wear and tear of the respective infrastructure. For reasons of clarity and standardisation of calculations we will not include streets and highways with the consumption surplus function/aggregate.

- Valuables are of minor importance compared to other final uses sections. Only few products (of little aggregate value) are ascribed to that section usually. As valuables are definitely not of intra-economic use we shall to treat them in analogy to consumption goods and ascribe this section to C_S.

After the consumption surplus and the survivability level of consumption functions/aggregates that comprise all final uses for households, the rest of the final uses in use tables (GFCF except dwellings and changes in inventories) and the allocated intermediate flows form the third function/aggregate. This economic function provides goods and services for intra-economic use (e.g. machinery, industrial construction, transport equipment). It will be called **production**. Table 5.5 shows how final uses are ascribed to the three economic functions/aggregates.

Table 6.5: Allocation of final uses to economic functions/aggregates

Survivability	Production	Consumption surplus
Food, energy and products of defensive nature	GFCF/Other buildings and structures	FCE by households (except Survivability)
	GFCF/Machinery	FCE by government (except Survivability)
	GFCF/Transport equipment	FCE by NPISH (except Survivability)
	GFCF/Other GFCF	GFCF/Dwellings (except Survivability)
	Changes in inventories	Valuables

We have identified the use of natural sources and sinks as on major criterion of economic sustainability. In consequence, economic sustainability accounting has to record flows from the economic system to the natural system and vice versa. Limiting our view to economic activities would omit an essential factor of environmental pressure. Households emit a non-negligible amount of substances to air, water and soil. To leave out this source of environmental pressure would yield a gravely distorted picture of the use of anthropogenous

[150] Cobb and Cobb 1994, p.53

[151] König 1998

systems' natural resources. Moreover, it would foster misleading interpretations of the health and viability of an economic system's natural environment. The natural environment of economic systems is the same as that of other social systems. Whether the environment is degraded by economic or other social activity is irrelevant for the sustainability of economic systems. Economic sustainability relies on the ecological soundness of all – and not only economic – activities. In order to grasp all ecologically adverse effects, we have to add another function/aggregate to the three genuinely economic functions/aggregates.

This additional function/aggregate of a sustainable economic system comprises the activities of the households. It includes activities that are related to the economic system by consumption of goods and services as well as activities with no reference to the economic system.[152] It will be called **households**.

6.3.3.4 Allocation of Exports to the Economic Functions/Aggregates

Exports cannot be allocated to economic functions/aggregates on the basis of information from domestic supply and use tables. In use tables no specifications are made about use of exports in the ROW. Whether they are used for economic purposes (and allocated to the Production function) or final consumption (and allocated to the Consumption surplus function) cannot be decided from information of domestic use tables. Therefore, other ways of allocation have to be found.

First, the use of exports can be determined by consulting the use tables of the respective importing countries. If it is assumed that a product imported is used to the same share for the different functions whatever its nation of origin might be – neglecting that product A from economy A can be used for survivability mainly while product A from economy B can be used for consumption surplus only – the average share of functions in a certain product can be determined for a certain importing economy. Unfortunately, in use tables no indications are given concerning the destinations of exports. Whether an export goes to economy A rather than economy B cannot be decided. This problem could be solved by consultation of other data sources. But even if we know where the domestic products are exported to and which economies' supply and use tables to include in our calculations, going this way is lengthy and rather intricate.

A second way of computation that is less accurate but of more moderate effort relies on the assumption that products are used to the same share for survivability, consumption surplus and intra-economy purposes in the ROW as they are used in the domestic economy. Final use of products in the domestic economy has been described above. To determine the share of a product used by the three economic functions, we take domestic final uses as a starting point. In contrast to the calculation of domestic uses we do not restrict our considerations to domestically produced goods and their use, imports are included. From domestic final uses of domestically produced plus imported goods and services the total share of a product used per function within the domestic economic system can be calculated (final uses for

[152] The digestion of home grown food is responsible for the emission of waste water as much as the digestion of food bought at the supermarket.

survivability, consumption surplus and intra-economy and allocation of intermediate flows). Then, the repartition of domestic and imported products to the functions is applied to exports. By allocating domestic final uses of domestically produced goods and services to the functions and by subsequent repartition of domestically produced exports to the three functions, all final uses of domestic products are ascribed to functions/aggregates.

6.3.3.5 Inclusion of SPI Valuation Accounts

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 first step of the calculation of the Sustainable Process Index yields weighting factors for natural resources, ecosystem inputs and residuals to air water and soil. On the input side, these factors represent the inverse of flows of resource per area and year. Accordingly, their dimension is m^2*a/kg. On the output side, the factors are calculated as the inverse of the mass of residuals that can be absorbed per area and year. They are of the same dimension as the input factors.[153] In a second step, the SPI factors are multiplied by flows of inputs from the environment and outputs to the environment [kg/a]. The product of weighting factor and flow gives the area needed to contain this resource or residual flow. 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. This is done for all physical flows that transgress the ecosphere-anthroposphere boundary regardless of whether the flows' origin and destination lies within the domestic economy or in the Rest of the World.

Monetary flows and area needed for the provision of inputs and the absorption of outputs represent the basic data needed for the calculation of our indices and further analysis at the more detailed level. It is useful to include additional accounts that are derived from the primary data presented up to this point, though.

Direct exchange of ecosystem inputs and residuals are recorded in physical supply and use tables as presented in Table 6.4. Flows of residuals and ecosystem inputs to and from the Rest of the World are included as well as cross boundary flows of residuals (from the domestic environment to the ROW environment). Our efficiency indices contain data on indirect imports and exports of SPI area. In this context, indirect exchange between economic systems refers to the area needed to contain the production of commodities imported and exported. The manufacture of a good in the ROW consumes ROW resources and makes use of the absorptive capacities of the ROW environment. Calculation of the SPI area needed for the production of the good in the ROW and the transport of the good to the

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[153] This is a rudimentary explanation of how the SPI's weighing factors are calculated. For further instructions we refer the reader to Krotscheck 1995.

national border give the incorporated area of the imported good. Incorporated area of exported goods is calculated analogously.[154]

In contrast to Life Cycle Assessment (LCA), environmental accounting ascribes environmental pressure to industries (activities) and not products. In Fig.5.1 the squares represent industries, the arrows flows of resources from the environment to the industries and flows of residuals from the industries to the natural environment.

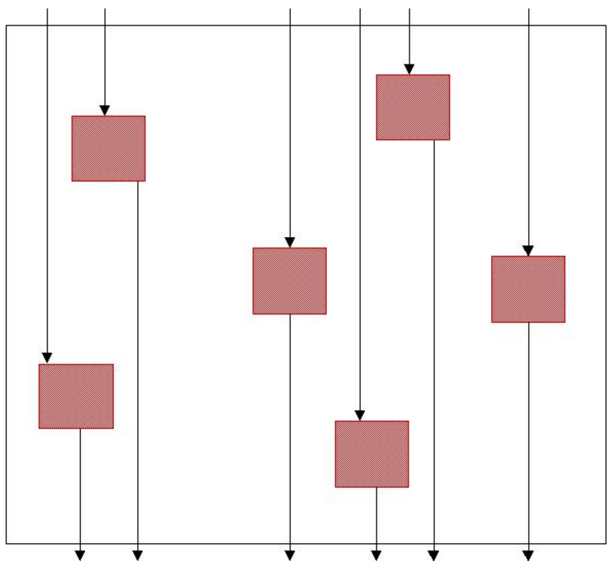

Figure 6.1: Resource inputs and residual outputs per industry

Thus, the incorporated area of goods and services cannot directly be derived from the SPI values for flows in physical supply and use tables. Additional information on the linkage of industries that contribute to the production of a good is needed. This information on the physical interrelation of industrial activities can be found in physical use tables (products used by industries). Calculation of an industry's contribution to the production of a good is done in the same way as for classification of industries (following the intermediate flows shown in use tables). Thus, SPI area used by an industry can be allocated to products for final uses according to the contribution of the industry to the provision of the products. The sum of areas contributed by industries gives the incorporated area of a product.

From the allocation of SPI areas per product and the allocation of products to the economic functions/aggregates, the SPI areas per function/aggregate can be derived.

[154] In analogy to monetary valuation, incorporated area of imports is calculated including transport to the import border. Incorporated area of exports is shown as "export border area".

Ideally, incorporated area of imported goods and services should be calculated from data of the respective exporting Rest of the World economies. Area consumed by transportation should be added as well. Data on transportation from the exporting to the importing country can be found in neither domestic nor ROW supply and use tables. They are provided by e.g. LCA studies of imported products.

An accounting system including the corrections discussed above is shown in Table 6.6. It can be seen that starting with the allocation of products to the three economic functions according to final uses, industries have been grouped to the economic functions as well. Single industries and products are not always allocated to only one function. Values per function will be shown on the aggregate level only (e.g. value added per function, SPI area needed per function). On the disaggregate level we will stick to the NACE Rev.1 classification. Final uses include consumption plus capital formation. Accounts for SPI area per industry and function have been supplemented. Unshaded cells show monetary blocks as they can be found in conventional supply and use tables. and environmental accounts (flows of resources and residuals in physical units). Shaded cells show area consumption calculated with the SPI.

To complete the SUTEA according to the matrix shown in Table 6.6 accounts for flows from the domestic economy to the ROW environment, from the ROW economies to the domestic environment, cross boundary environmental flows, ecosystem inputs to ROW and flows of residuals to the domestic economy (recycled products, waste to landfill site) have to be added (see Tab.5.2).

Table 6.6: SUTEA for the calculation of indices of economic sustainability

	Products	**Industries**	**Domestic Final Uses**		**Exports**		**Residuals**	**Sustainable Process Index**
Products		Products used by industry	Final uses of survivability products		Export of survivability products			
			Final uses of production products	Final uses of consumption surplus products	Export of production products	Export of consumption surplus products		
Industries	Products made by industry						Residuals generated by industry	Area (SPI) needed by industry for generation of residuals
Final Uses							Residuals generated by households	Area (SPI) needed by households for generation of residuals
Imports	Products imported							
Value added		Value added by industry						
Monetary totals	Total products supplied	Total industry inputs	*Total final uses*		*Total exports*			
Natural resources		Natural resources used by industry	Natural resources consumed by households					
Residuals								
Sustainable Process Index		Area (SPI) needed by industry for use of natural resources	Area (SPI) needed by households for use of natural resources					

6.4 Interpretation of the Sustainability Criteria

In the previous chapters, a concept of economic sustainability has been elaborated and a system of indices of economic sustainability has been developed together with related criteria determining sustainability. In this section, we will discuss the rationale of the criteria presented in order to provide – on the basis of this discussion – help for the interpretation of the measures.

Most generally, it can be said that our concept of sustainability can be classified as a strong sustainability approach. It identifies complementary prerequisites of economic sustainability in the form of natural resources, goods and services for final consumption and money for continued actions of payment. By establishing distinct measures for the different prerequisites, we imply that minimum conditions for each of the prerequisites must be fulfilled to assure sustainability. From that point of view, the concept underlying the Sustainable Economy Indices advocates strong sustainability. From another point of view, our concept goes beyond what is usually the central issue of strong versus weak sustainability confrontations. Within these confrontations, (economic) sustainability is determined by according to natural resources a more (strong sustainability) or less (weak sustainability) prominent part in economic considerations. Against this backdrop, accounting for economic sustainability comes down to the question of whether aggregate measures of man-made and natural capital valued in monetary terms are acceptable or separate indices for the different classes of capital are needed.[155] Focusing on the elementary forms of exchange between economic systems and their natural, social and economic environment rather than the natural appendix to economic activity, we extend the scope of economic sustainability accounting mainly by introducing solvency as one major precondition for economic sustainability.

Similar to most precursory concepts, we determine sustainability through constraints on economic activity.[156] Constraints - in our concept – are determined on the level of the exchange between economic systems and their environments. The three constraints for the exchange with the natural, social and economic environment are of different nature. The sustainability criteria for the exchange with the social and the natural environments are determined by (alleged) particularities of the environments. The criterion for the economy-nature interface is represented by natural productive and assimilative capacities in the form of a system of reference flows of materials and substances. From this system of reference flows the criterion of an area consumption that does not exceed the area available is derived. It relies mainly on scientific knowledge about an economic system's natural environment (measurement and calculation of natural reference flows). The sustainability criterion on the economy-society interface is built on the conviction that it is the final aim of every economic activity to provide goods and services that yield a consumption surplus and on the assumption that future generations are going to demand as many goods and services (more precisely: as much value of goods and services) as the present generation. Its basis is less

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155 see Bartelmus and Vesper 2000, p.19

156 see Perman et al. 1999, p.51

scientific than ethical. It is strongly influenced by claims for intergenerational equity. The reference for the assessment of sustainability is the respective actual state of the exchange between the economy and its social environment. The third criterion is derived from the operational principles of economic systems (the exchange of money between subsystems of the global economic system). Its reference value is a balanced foreign exchange or in other words, the reference for consumption plus investment is income. It can be seen that much like the reference of current provision of goods and services for consumption surplus, the reference of balanced exchange is co-determined by the actual state of the economic system (actual production represents the reference for actual investment plus consumption and vice versa). The comparison of the actual state of the exchanges between an economic system and its environments with the reference values is thought to indicate sustainability or unsustainability for a given point in time. Anthropogenous flows of resources and emissions that exceed natural reference flows, flows of goods and services for consumption surplus that fall behind anterior flows and import values that exceed export values are rated unsustainable. Every year of non-compliance with the three criteria is a year of unsustainability.

But there is one aspect inherent to sustainability that necessarily influences the interpretation of our indices – time. Sustainability always points into the future. Sustainability today is always sustainability for the future. A sustainable present always implies prospects of the future. This means that present activity must not only be assessed against the backdrop of its present impacts but with its consequences for future activity in mind. It follows for the interpretation of our indices that sustainability at one point in time can cause unsustainability at an ulterior point in time and that present unsustainability can be necessary to assure future sustainability. First, this calls for the use of time series data for the different indices in sustainability analysis. Second, this makes our sustainability criteria less strict.

A SPI value of more than 100 very likely cannot be sustained in the long run without significant depletion and degradation of natural resources. But the meaning of a SPI value of 100 can be very different for the (future) sustainability of economic systems according to the reasons for the anthropogenous flows induced. Flows and environmental pressure related to the production and installation of new technologies can be desirable from a long term perspective provided that the SPI area used is “invested” in relatively more environmentally sound technologies. A short term increase in SPI values is then accepted to “finance” a long term reduction of SPI area used. The blue line in Figure 6.2 shows hypothetical time series data for such an investment path. The red line shows a scenario of constantly increasing SPI area consumption without investment in future sustainability. It follows that unsustainability can be desirable when it is a transitory state leading to a more sustainable future (what implies the absence of irreversible effects).

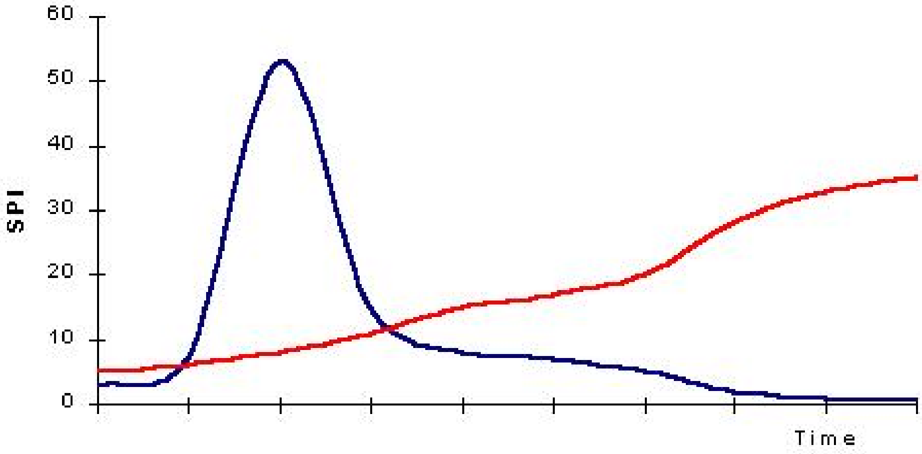

Fig. 6.2: Hypothetical development paths for SPI area consumption

Similar reflections hold true for the other interfaces as well. Long periods of investment (and the respective foreign exchange deficits) can be necessary to enhance future production capacities. Periods of reduced production of goods for consumption surplus can be desirable to assure future potentials to provide such goods (through e.g. investment in goods for intra-economic use). It is beyond the scope of this thesis to analyse sustainability or unsustainability of investment periods (and the related debts in money and SPI area) and their effect on future development of economic systems. What is of importance here, is to note that our sustainability criteria are made less strict by the considering present activities' effects on the future. In consequence, sustainability judgements are highly influenced by the length of the period of analysis. Short-term unsustainability can be part of a trend of long-term sustainability and vice versa. (Fig.6.3) This does not discredit our criteria of sustainability but points out the fact that they should be seen as guiding principles for economic sustainability built on precautionary considerations concerning the exchange between economic systems and their environments.

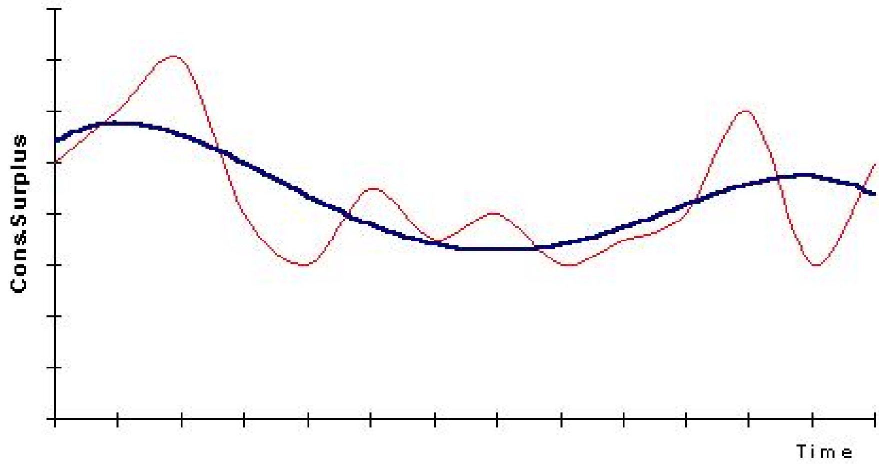

Fig. 6.3: Hypothetical time series of consumption surplus (red) and trend (blue)

It is obvious that the result of sustainability assessments is relative to space just like it is relative time. What seems to be sustainable for a region may reveal unsustainable in the greater context of e.g. a nation. Unsustainable regions may fulfil essential functions for the sustainability of a greater whole. The rural hinterland of an agglomeration, for instance, may serve as reservoir of natural resources (sources and sinks) for the city while the city region provides the necessary consumption surplus for the hinterland. Together the city and its hinterland may represent a relatively more sustainable area than the city and the hinterland alone. In addition to the strengths and weaknesses of single regions/nations, the opportunities for the alleviation of weaknesses and the weakening of strengths through exchange with other regions/nations has to be considered. Our indices of economic exchange, import efficiency and export efficiency can provide the necessary data in this respect. They can be used to show, what sustainability/unsustainability in one region/nation means for regions/nations that trade goods and services and thereby exchange natural resources as well as money. Thereby , these indices put into a wider perspective sustainability judgements on single regions/nations and may point out possible threats to sustainability related to activities induced in other regions/nations (such as depletion of resources in other countries or, more generally, global environmental effects).

Case studies show that for most regions the quotient of area consumed for supply of resources and dissipation of emissions exceeds by far the area available. On the basis of such results one could conclude, that for industrialised anthropogenous systems it is impossible to live within the constraint of natural reference flows and that therefore, the sustainability criterion for the economy-nature interface is unachievable and in consequence irrelevant. It is true that with results for area consumption that amount to 100 times the area available attaining a state of sustainability seems beyond the reach of every technology and life-style changing effort. There are two major arguments against these objections, one is theoretical, the other empirical. The theoretical argument holds that however far a goal is, it may still be sensible, rewarding etc. to try to achieve it. The obvious fact that developed countries live way beyond their ecological means does not discredit the aim of ecological sustainability as such. The empirical argument holds that the lion's share of area consumption is due to our ways of using fossil resources. A drastic change in the composition of energetic resources used (from fossil to renewable resources) may result in drastically reduced area consumption (up to 75 % of total area consumption can be attributed to the use of fossil resources) according to the SPI concept. Concepts for the substitution of fossil resources on a large scale exist.[157]

So even if an SPI of 1 cannot be achieved, significant SPI reductions are possible.

[157] Stöglehner 2000

The criterion of a SPI value of 1 is directly derived from the SPI reference system of natural flows of resources and emissions. There is another essential function of reference systems in assessing human impact on nature – they underline specific environmental problems at the expense of others. Even if a Sustainable Process Index of 1 seems illusory for most developed economies, the reference system of natural flows is essential inasmuch as it is used to weight flows of resources and emissions. Weighting of anthropogenous flows highlights problems and points to ways of reductions of pressure on the environment. Applying different reference systems means stressing different environmental problems and indicating different ways to (possibly different) states of sustainability. In contrast to other physical measures of the human impact on nature, that use socially or politically co-determined reference systems, the SPI relies on a system of reference values determined on the basis of scientific knowledge (which of course is also co-determined by social factors). While political reference systems (e.g. emission limit values) may change rapidly[158], the SPI reference values are invariable and therefore seem more appropriate to support the long-term strategies of sustainable development.

[158] A recent example are the envisaged national emission limit values for greenhouse gases according to the Kyoto protocol.

7 Case Studies and Calculations

So far, the conceptual background of our accounting system and the system of indices based thereupon have been outlined. Starting from general reflections, we have defined criteria for economic sustainability that later in the course of this thesis have served as cornerstones for indices and accounts. The construction of the accounts and the calculation of the indices have not been treated down to the last detail. First, because part of the theories that we have made use of are laid out extensively in other publications.[159] We have strived to confine ourselves to the innovatory – and not the library – aspects of our work, to the insight added by recombination and extensions of existing theories and methods. Second, because part of the methodological background the reader needs in order to apply this system of measures of economic sustainability is best given understanding of in combination with the description of a concrete application.

Thus, in this chapter, the explicative strength of our concept will be tested in two case studies. In parallel to the applications on the regional and the national level (Austria and the Austrian political district of Feldbach) calculations will be explained in more detail.

7.1 Data Sources

7.1.1 Monetary Supply and Use Tables and Physical Flow Accounts

An extended SUTEA serves as point of departure for our calculations. In consequence, 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”[160] which is in accordance with the European System of National Accounts. It comprises supply and use tables at basic prices as well as purchasers prices. Industrial activities are classified according to NACE Rev.1. Products are classified according to CPA. The Austrian versions of NACE Rev.1 and CPA the ÖNACE and the ÖCPA classifications systems show aggregate values for NACE and CPA 01, 02, 05 (02, 05 are not shown separately because of limited data availability) and for NACE and CPA 11, 13 (13 is not shown for reasons of secrecy). Flows are shown in millions of Austrian Schilling (mill. ATS). NACE Rev.1 and CPA classifications are shown in Tables A1 and A2 in the appendix.

Monetary data in supply and use tables are supplemented with data on industry 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. First, as described in Section 5.2.4, 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. Second, SPI area needed to supply flows of renewable resources is

[159] see e.g. Krotscheck 1995, Statistik Austria 2001, Cobb And Cobb 1994

[160] Statistik Austria 2001

insignificant in relation to area needed to dissipate emissions. The results of our calculations would only slightly be changed by a consideration of renewable resource flows (a somewhat higher SPI area for agriculture, forestry and fishing). Although data on flows of renewables are available, they are not yet published in standardised format. In consequence to the lack of significance and standardisation of data we have decided not to include flows of renewable resources in our system of accounts.

Data on residue flows for Austria are recorded in NAMEA Abfall[161], NAMEA Wasser[162] and NAMEA Luft[163]. NAMEA Abfall (waste) contains data on flows of waste per industrial activity. Data on flows of hazardous waste are provided by regional administrative bodies (every transport and disposal of hazardous waste in Austria has to be recorded). Data on non-hazardous waste flows are taken from the Austrian Federal Waste Management Plan 1995 and 1998 (Bundesabfallwirtschaftsplan) which is largely based on data for 1993. In addition to that, sectoral waste management concepts (Branchenkonzepte) for 1991-1996 have been taken into account. According to the authors of NAMEA Abfall, quality of data on flows of non-hazardous waste from industrial activities is limited.

NAMEA Abfall records flows of hazardous and non-hazardous waste per industry according to NACE Rev.1. NACE 01, 02, 05 and 11, 13 are recorded separately. To fit with Statistik Austria’s monetary supply and use tables, data of these industries will be aggregated. Flows of hazardous waste are broken down to

- Halogenic solvents
- Non-halogenic solvents
- Colours and varnishes
- Waste oil
- Other hazardous wastes.

Flows are recorded in metric tons per year.

NAMEA Wasser (water) records flows of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD_5), Total Organic Carbon (TOC), Nitrogen (N), Ammonium Nitrate (NH_4-N), Phosphor (P), Adsorbable Organic Halogens (AOX), Zinc (Zn), Copper (Cu), Cadmium (Cd), Lead (Pb), Chromium (Cr), Nickel (Ni) and Mercury (Hg). COD, BOD_5, TOC, N, NH_4-N and P are shown in tons per year, the other parameters in kilogram per year.

Industrial emissions have been calculated as emissions from industrial processes plus waste water emissions due to personnel. Emissions from industrial processes have been calculated from measurement data and – if not available - from official notifications (Bescheidwerte) and sectoral water emission ordinances (branchenspezifische Abwasseremissionsverordnungen). Calculations of waste water flows due to personnel have been based on assumptions for the number of working days per year (200), water

[161] Wolf 2000

[162] Fürhacker et al. 1999

[163] Ahamer et al. 1998

consumption per day and capita (67 l) and emission flows[164]. In addition to industrial emissions, emissions from households have been calculated. A daily water consumption of 200 l per capita has been assumed as well as emission flows for substances and summary parameters. Flows of household wastewater and wastewater from personnel are reduced by the degree of purification of wastewater treatment facilities for the different substances. The same applies to emissions from industrial processes which are not directly discharged.

NAMEA Luft (air) records data on atmospheric emissions of Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), Non-methane Volatile Organic Carbon (NMVOC), Methane (CH_4), Carbon Monoxide (CO), Dinitrogen Oxide (N_2O), Ammoniac (NH_3) and Carbon Dioxide (CO_2). CO_2 is shown in 1000 tons, all other substances in tons. NACE 01 comprises emissions flows from NACE 01, 02 and 05. NACE 31, 32, 33 comprise the emission flows of NACE 30 which is not shown separately. The emission flows of NACE 75, 80 and 85 are subsumed under “public services” according to the older BS68 classification[165]. In our calculations, the emissions of “public services” are allocated to NACE 75, 80 and 85 in proportion of the industries’ value added. It follows that the overall SPI area of

- NACE 30 is undervalued,
- NACE 31, 32, 33 is overvalued.

The main data source for the calculation of emissions to air are industrial energy balances. Multiplication of consumption of different energy sources by emission factors for different fuels and technologies of combustion yields emission flows. For our calculations we have chosen records where emissions from company cars are ascribed to industries. Land transport (NACE 60) comprises only emissions from activities creating value added by transport (railway and road and other transport of persons and cargo). Emissions from energy provision (NACE 40) are ascribed to energy consuming industrial activities as well. Only energy consumption for its own use and electricity network losses are ascribed to NACE 40.

Data on emissions to air and soil have been adjusted (to 1995 production) by means of production indices.

Monetary supply and use tables for Austria are shown in Tables A3 and A4 in the appendix. Physical supply tables are shown in Table A5.

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[164] Fürhacker et al. 1999, p.15

[165] Betriebssystematik 1968

7.1.2 Sustainable Process Index Weighting Factors

SPI weighting factors are shown in Table 7.1.[166]

Table 7.1: SPI weighting factors

Compartment	Flow	Weighting Factor	Dimension
Water	COD	0,00014	m2 a / mg
	BOD	0,00021	m2 a / mg
	TOC	0,02778	m2 a / mg
	N	0,03571	m2 a / mg
	NH4-N	0,02778	m2 a / mg
	P	0,09259	m2 a / mg
	AOX	0,09259	m2 a / mg
	Zn	0,00056	m2 a / mg
	Cu	0,02778	m2 a / mg
	Cd	0,55556	m2 a / mg
	Pb	0,06944	m2 a / mg
	Cr	0,05556	m2 a / mg
	Ni	0,09259	m2 a / mg
	Hg	2,77778	m2 a / mg
Soil	Halogenic solvents	46,80000	m2 a / kg
	Non-halogenic solvents	46,80000	m2 a / kg
	Colours and varnishes	46,80000	m2 a / kg
	Waste oil	46,80000	m2 a / kg
	Other hazardous wastes	66,00000	m2 a / kg
	Non-hazardous wastes	33,00000	m2 a / kg
Air	SO2	0,00392	m2 a / mg
	NOx	0,00725	m2 a / mg
	NMVOC	0,00015	m2 a / mg
	CH4	0,00022	m2 a / mg
	CO	0,00010	m2 a / mg
	N2O	0,04348	m2 a / mg
	NH3	0,00500	m2 a / mg
	CO2	0,00014	m2 a / mg

SPI weighting factors are multiplied by the respective flows in physical tables to yield SPI area needed to supply and dissipate the flows.

166 The factors are partly taken from Krotscheck 1995 and from personal information given by Christian Krotscheck.

$$A_{xiy} = F_{xiy} * WF_{xy}$$ [m²]

with	A_{xiy}	SPI area for flow of substance x from industry i to compartment y	[m^2]
	F_{xiy}	Flow of substance x from industry i to compartment y	[kg/a]
	WF_{xy}	Weighting factor for substance x in compartment y	[m^2a/kg]

In the SPI concept it is assumed that the same area of a compartment can absorb flows of different substances at the same time. For instance, 1 m^2 of water surface (renewal of the water body by precipitation on 1 m^2) can be used to absorb flows of copper and flows of zinc at the same time. Thus, to calculate the overall SPI area for the three environmental media single substance areas are not added. Overall SPI area for a medium calculates as the biggest single substance area for that medium. The (biggest) single substance area is thought to contain all other single substance flows as well. In consequence, aggregation – and we are using aggregated flows per industry – yields an underestimated SPI when flows of different substances cause the biggest areas for subsystems at the disaggregate level.

$$A_{iy} = \max A_{xiy}$$ [m²]

with	A_{iy}	SPI area for flows from industry i to compartment y	[m^2]

The overall SPI area per industry calculates as the sum of the SPI areas for air, water and soil.

$$A_i = \sum_y A_{iy}$$ [m²]

with	A_i	SPI area for industry i	[m^2]

The SPI area for all industries within an economic system is obtained as

$$A_{D\,econ} = \sum_i A_i$$ [m²]

with	$A_{D\,econ}$	SPI area for domestic production	[m^2]

The SPI area for households is calculated analogously. The total SPI area of an economic system and the respective households calculates as

$$A_{D\,tot} = A_{D\,econ} + A_{D\,HH}$$ [m²]

with	$A_{D\,tot}$	Total domestic SPI area	[m^2]
	$A_{D\,HH}$	SPI area of domestic households	[m^2]

7.1.3 Regional Supply and Use Tables

Supply and use tables are usually available for national economies only. As input-output tables exist for only few sub-national economic systems, in our search for maximum standardisation of calculations we will have to rely on data from the national level and a method to break down national data to the regional level.

The conversion of Austrian supply and use tables to regional supply and use tables is done by multiplying Austrian supply (of products by industries) and Austrian use (of products by industries and of products for final use) by reduction factors. Reduction factors for supply and intermediate use are calculated as the ratio of the number of employees in an industrial sector (according to NACE Rev.1) in a region to the national number of employees in the sector.

$$RF_i = \frac{E_{Ri}}{E_{Ni}}$$

with RF_i Reduction factor for industry i

E_{Ri} Number of employees in industry i in the region

E_{Ni} National number of employees in industry i

Reduction factors for final consumption expenditure are based on the ratio of regional inhabitants to national inhabitants. The ratio of regional to national inhabitants is furthermore weighted by the ratio of median gross regional income per capita to its national counterpart.

$$RF_{fce} = \frac{I_R * MGI_R}{I_N * MGI_N}$$

with RF_{fce} Reduction factor for final consumption expenditure

I_R Number of inhabitants in the region

I_N National number of inhabitants

MGI_R Median gross regional income

MGI_N Median gross national income

Reduction factors for gross fixed capital formation (GFCF) calculate as the ratio of regional value added to national[167] value added.

$RF_{gfcf} = VA_R / VA_D$

with RF_{gfcf} Reduction factor for gross fixed capital formation

VA_R Regional value added

VA_D Domestic value added

[167] Only domestic economic units are taken into account. The nationality concept of national accounting is not applied.

The reduction factors help determine total regional final and intermediate uses and total regional supply.

$S_{R\,ji} = S_{D\,ji} * RF_i$

with $S_{R\,ji}$ Regional supply of product j by industry i

$S_{D\,ji}$ Domestic supply of product j by industry i

$U_{R\,ji} = U_{D\,ji} * RF_i$

with $U_{R\,ji}$ Regional use of product j by industry i

$U_{D\,ji}$ Domestic use of product j by industry i

$U_{R\,fce\,j} = U_{D\,fce\,j} * RF_{fce}$

with $U_{R\,fce\,j}$ Regional use of product j for FCE, dwellings and valuables

$U_{D\,fce\,j}$ Domestic use of product j for FCE, dwellings and valuables

$U_{R\,gfcf\,j} = U_{D\,gfcf\,j} * RF_{gfcf}$

with $U_{R\,gfcf\,j}$ Regional use of product j for GFCF except dwellings

$U_{D\,gfcf\,j}$ Domestic use of product j for GFCF except dwellings

Total regional supply and use per product calculate as

$S_{R\,j} = \Sigma_i S_{R\,ji}$

with $S_{R\,j}$ Total regional supply of product j

$U_{R\,j} = \Sigma_i U_{R\,ji} + U_{R\,fce\,j} + U_{R\,gfcf\,j}$

with $U_{R\,j}$ Total regional use of product j

Reduction factors cannot indicate the repartition of regional supplies to industries and final uses (how much of regionally supplied product i is used by industry h and for final uses). Regional intermediate (inter-industry) exchange may of course diverge from the national average. Unfortunately, data on regional intermediate flows is virtually never readily available. To avoid excessive data collecting efforts for the composition of our indices and accounts we opt for the application of average national data on inter-industry exchange at the regional level. This means that the relative repartition of uses of regionally supplied product i to industries and final uses is set congruent with the repartition of uses of nationally supplied product i. The share of uses of industry h in total uses of nationally supplied (not imported) product i is constant.

7.2 The Sustainable Economy Indices for Austria

All index calculations are based on the system of accounts shown in the Appendix.

7.2.1 The Ecological Sustainability Index for Austria

The results of the Ecological Sustainability Index calculations at the industry level (NACE Rev.1) are shown in Table 7.2. SPI valuation accounts are shown in Table A6 in the appendix.

Table 7.2: SPI area per industry/households and compartment in km^2

Industry NACE Rev.1	Water	Air	Soil	Total
01	1670585	390697	12918	2074200
10	10	34277	1	34279
11	36	19920	123	20079
13	13	11453	1	11468
14	14	174556	34	174604
15	54560	154931	41816	251307
16	0	7767	1	7768
17	15501	52139	31	67671
18	861	6891	282	8034
19	5142	4704	4449	14295
20	4445	109410	122283	236137
21	385114	528429	24818	938361
22	389	35841	124	36354
23	2972	325777	382	329131
24	82133	211128	729	293991
25	278	101900	14	102192
26	3445	572634	186	576265
27	29752	1308493	138717	1476963
28	1306	106595	844	108745
29	389	57918	285	58592
30	30	0	17	47
31	429	37647	282	38357
32	2056	25098	0	27154
33	56	6	33	95
34	333	44892	638	45863
35	56	7875	181	8111
36	167	404	30	601
37	0	0	1241	1241
40	464	21254	8693	30411

41	56	4035	79185	83275
45	3778	170647	444	174869
50	1028	36558	1069	38655
51	2361	108464	3403	114228
52	3195	96412	430	100037
55	23641	153623	500	177764
60	1806	549882	667	552355
61	83	27395	5	27483
62	62	23222	3	23287
63	333	28166	152	28651
64	667	25081	36	25784
65	972	20795	26	21793
66	417	9597	2	10016
67	67	1600	37	1703
70	583	12713	24	13320
71	71	1271	7	1348
72	83	1271	9	1363
73	73	0	7	80
74	1195	23117	124	24435
75	7640	118714	1120	127474
80	111	93852	27	93990
85	750	98203	401	99354
90	63561	45695	217	109473
91	0	0	111	111
92	417	56677	5	57099
93	472	28	67	567
95	95	0	0	95
99	99	0	5	104
Households	505207	2577512	87599	3170318
Total	**2879357**	**8637105**	**534837**	**12051359**

Total SPI area of domestic industrial plus domestic consumptive (households) activities is 12,1 mill. km^2. From the 12,1 km^2, 8,9 are consumed by economic production and 3,2 by consumption by households.

$A_{D\ econ}$ = 8881041 km^2

$A_{D\ HH}$ = 3170318 km^2

$A_{D\ tot}$ = 12051359 km^2

Transboundary flows of emissions to air, water and land are not considered in our calculations as they seem of minor importance compared to flows of domestic origin.

A_F = 0 km^2

Evaluation of the ecological sustainability is done by referring the SPI area to the Austrian geographical surface (S_D = 83800 km^2).

ESI = 12051359 / 83800 = 144

with ESI Ecological Sustainability Index

The main SPI areas for due to CO_2 emissions. CO_2 emissions have global environmental effects mainly and the area for the dissipation of global emissions is 3,4 times the land surface of the Austrian economy. Therefore, the Austrian SPI calculates as follows:

ESI = 12051359 / 285000

ESI = 42

It can be seen that the area consumed by the Austrian economy and the Austrian households is 42 times the surface available.[168] It follows that Austria's economic system is strictly not sustainable in the ecological sense. From the 12,05 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 7.1)

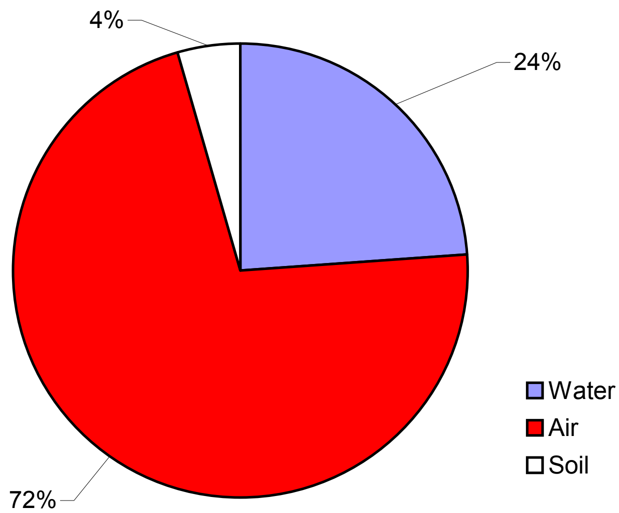


Figure 7.1: Repartition of Austria's SPI area according to environmental compartments

For most of the 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).

[168] This underestimates the SPI area of the mainly local emissions to water and soil for which – at least in Austria – no oceanic surface is available for dissipation.

Where data on flows of non-hazardous waste are available[169], these flows cause the biggest SPI areas for emissions to soil. Other solid waste areas are due to flows of “other hazardous wastes”.

Figure 7.2 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), Manufacture of pulp, paper and paper products (NACE 21).

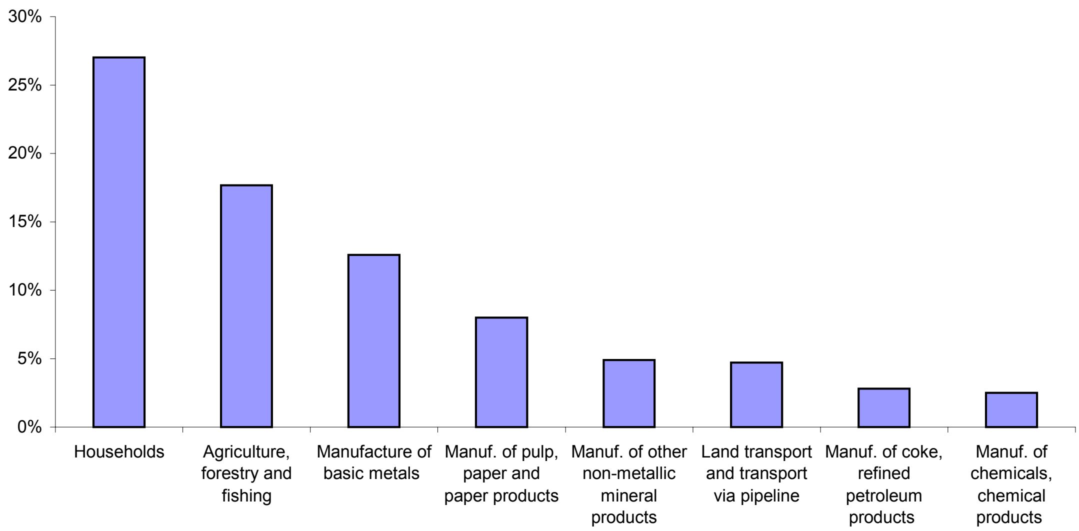


Figure 7.2: Industry and household related SPI area in percent of the Austrian total

Figure 7.3 shows the compartmental composition of the SPI areas of the most important activities. It is conspicuous that – with the exception of agricultural activities – emissions to air constitute the main area consuming factor. 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 lies in the use of fossil energy. Sustainable use of fossil resources (which are slowly renewable 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 SPI concept points to global warming as a major threat to ecological (and therefore economic) sustainability.

[169] NACE Rev.1: 01, 15, 18, 19, 20, 21, 27, 41, 45, 85 and households

Activity based analysis confirms that area consumption of industries relying to a large extent on energy consumption (e.g. Land transport) is caused by emissions to air exclusively. 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.

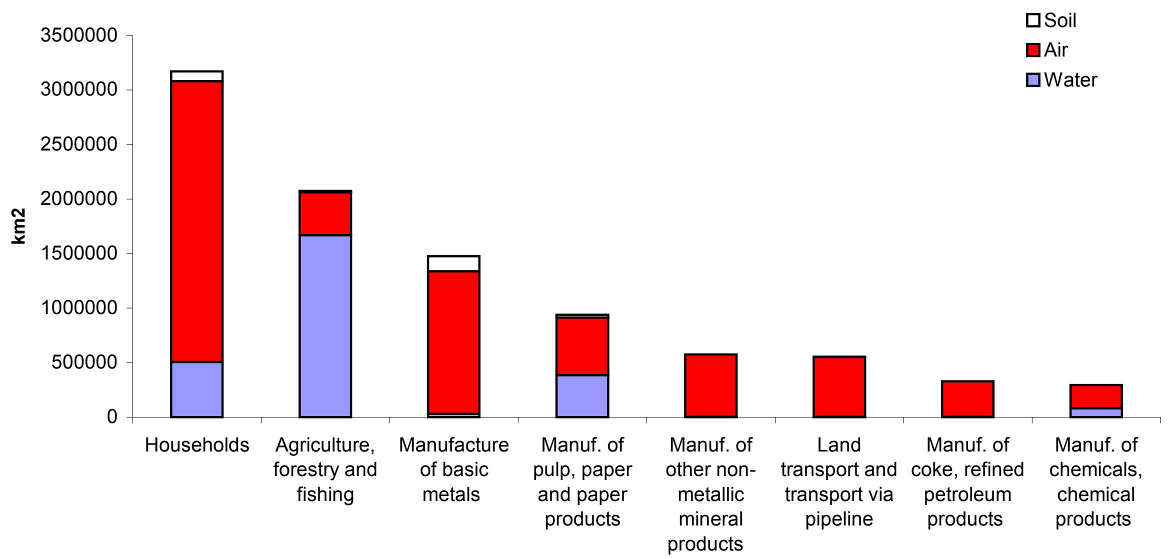


Figure 7.3: Compartmental composition of SPI areas per industry/households

7.2.2 The Consumption Surplus Index for Austria

To assess the compliance with the consumption surplus criterion of non-declining C_S available to society time series data are needed. The last supply and use tables for the Austrian economy before the actual version (1995) date from 1990.[170] To have at least two points in time for comparison of societal value available over time, we are going to analyse the 1990 supply and use tables together with the tables from 1995 which are generally used throughout this work.

Table 6.5 shows that all products from the final uses sections Final consumption expenditure (FCE) by households, Final consumption expenditure by government, Final consumption expenditure by NPISH, Gross fixed capital formation / Dwellings, Valuables are ascribed to the Consumption surplus function. Excepted from the calculation of C_S are all products for C_{SURV} (CPA 01, 02, 05, 10, 11, 15, 23, 40, 75, 80 [50 %], 85, 90). The classification of final uses in the 1990 supply and use tables is slightly different from that of 1995. Classes are

- Private consumption expenditure
- Public consumption expenditure (transformed)

[170] Österreichisches Statistisches Zentralamt 1999

- Consumption expenditure by NPISH
- Public consumption expenditure (not transformed)
- GFCF/Dwellings
- GFCF/Road construction
- GFCF/Other surface and underground engineering
- GFCF/Machinery
- GFCF/Transport equipment
- Low value products
- Changes in inventories
- Exports.

Calculation of the Consumption Surplus Index for 1990 will include Private consumption expenditure, Public consumption expenditure, Consumption expenditure by NPISH, and GFCF/Dwellings. Products for C_{SURV} remain unchanged.

CSI_{1990} = 901087 mill. ATS

CSI_{1995} = 1211895 mill. ATS

with $CSI_{1990, 1995}$ Consumption Surplus Index for 1990, 1995

Detailed calculations of C_S are shown in Table A7.

It can be seen that the value at basic prices for C_S has increased by more than 300000 mill. ATS from 1990 to 1995. We can conclude that the Austrian economy is in compliance with the consumption surplus criterion for this period.

The average growth in C_S per year for the considered five year period is at 6,1 %. The average growth of all final uses for the same period is at 5,3 %. Figure 7.4 shows a comparison of 1990 and 1995 for the most important goods and services within C_S. Not surprisingly, the products contributing most to C_S are the same for 1990 and 1995. These are not goods as such but services of market infrastructure (trading, letting, buying, selling) and other services (Education services, Hotel and restaurant services, Land transport services).

Figures 7.5 and 7.6 show changes in C_S per product.

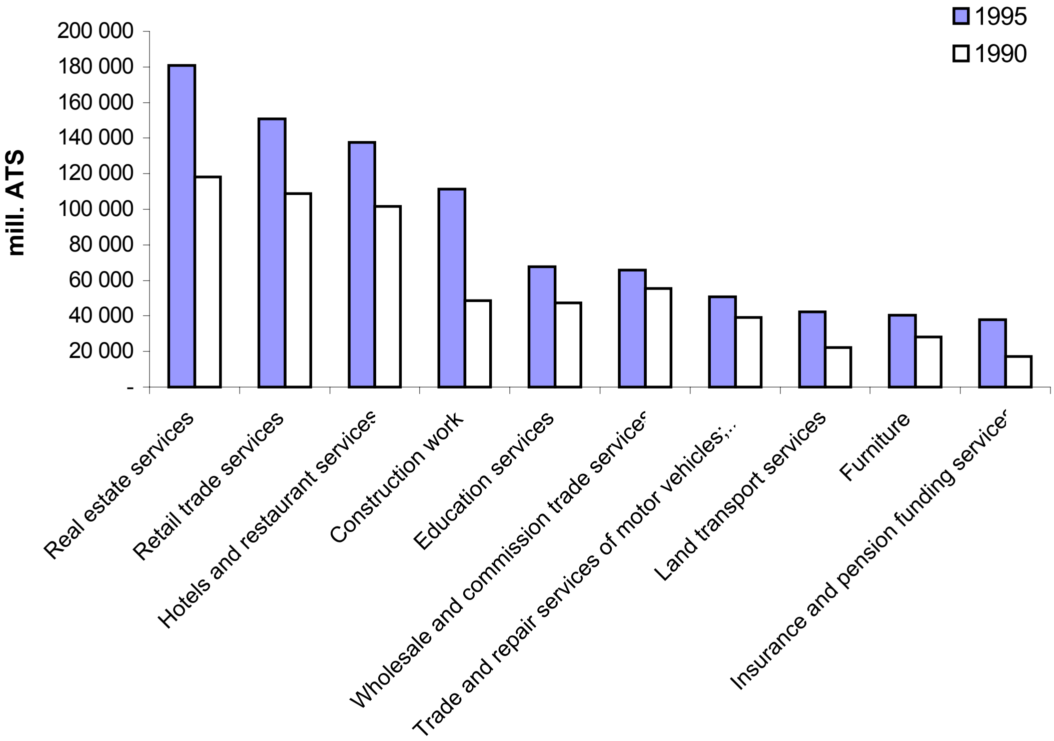


Figure 7.4: Value of main consumption surplus products at basic prices for 1990 and 1995

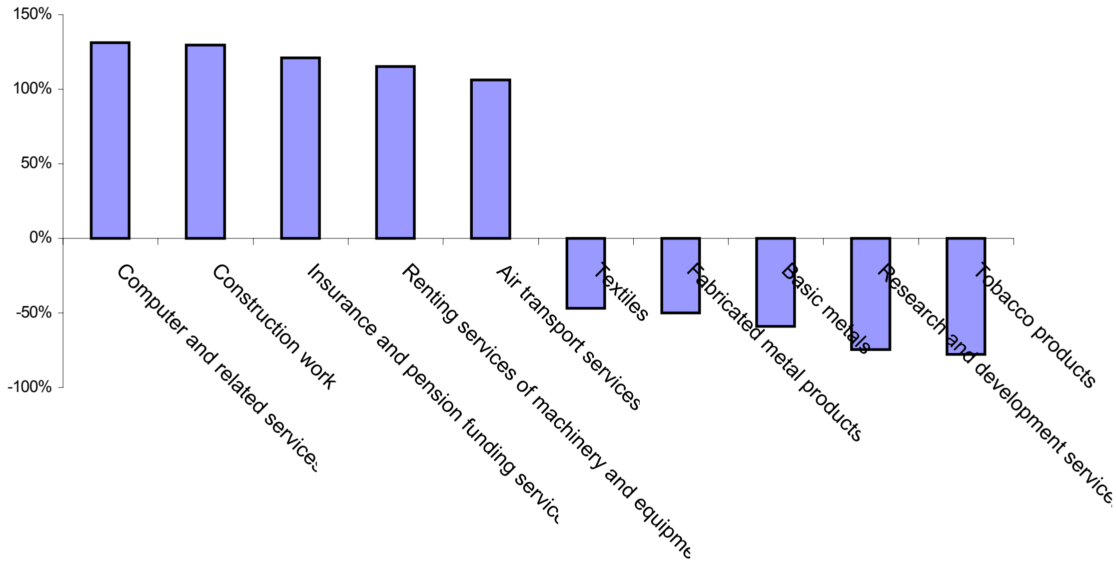


Figure 7.5: Increase or decrease in value per product in percent of 1990 value

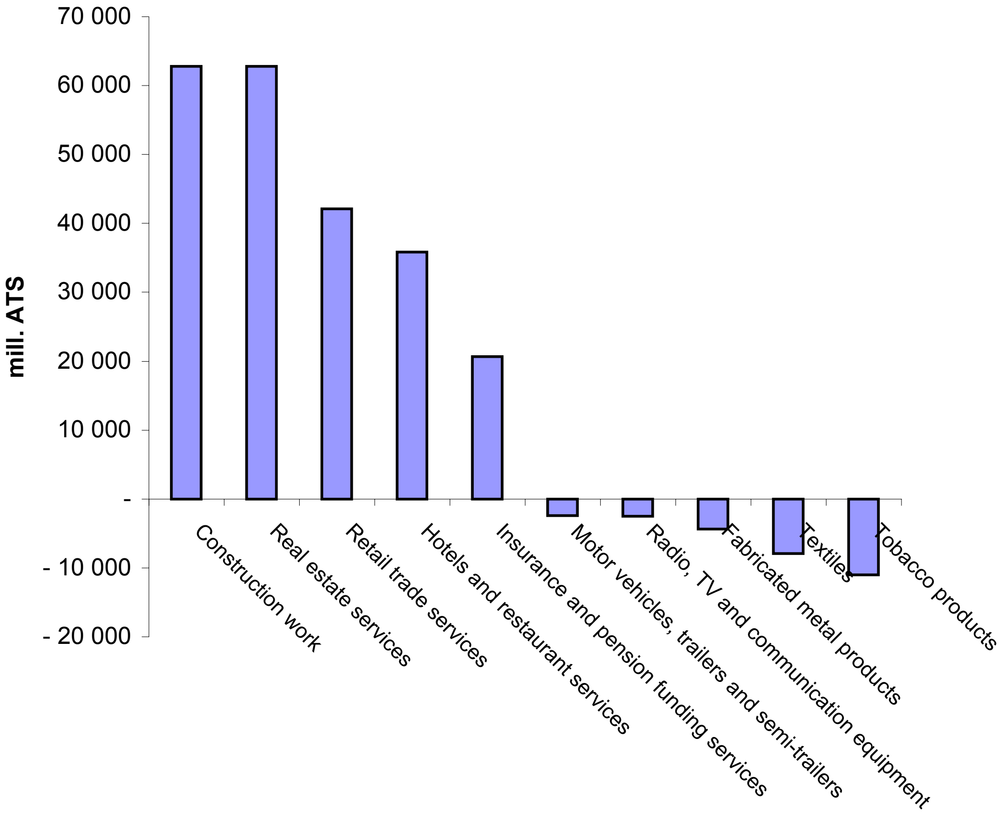


Figure 7.6: Increase or decrease in value per product in absolute value

7.2.3 The Economic Exchange Index for Austria

The Economic Exchange Index is calculated as the value of exports from minus the value of imports to the Austrian economy. In contrast to the Consumption Surplus Index, all exchanged goods are taken into account. The overall values at basic prices of goods and services exported and imported to the ROW for 1995 are

V_E = 683292 mill. ATS

V_I = 749821 mill. ATS

It follows that with

EExI = $V_E - V_I$ = -66529 mill. ATS

with EExI Economic Exchange Index

the Economic exchange criterion ($V_E - V_I \geq 0$) is 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 %) and does not represent a menace to the solvency of the economic system.[171] Traditionally, the Austrian balance of goods is negative while the balance of

[171] Ditlbacher 2000

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 while 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, 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 nineties, that made higher imports necessary, can be seen as the paramount reason for the Austrian foreign exchange deficit. A deficit which up to today does not limit the creditworthiness of the national economy.

Figure 7.7 shows foreign exchange surpluses and deficits per product. It can be seen that among products with export surplus both goods and services figure while products with import surplus consist of goods only.[172]

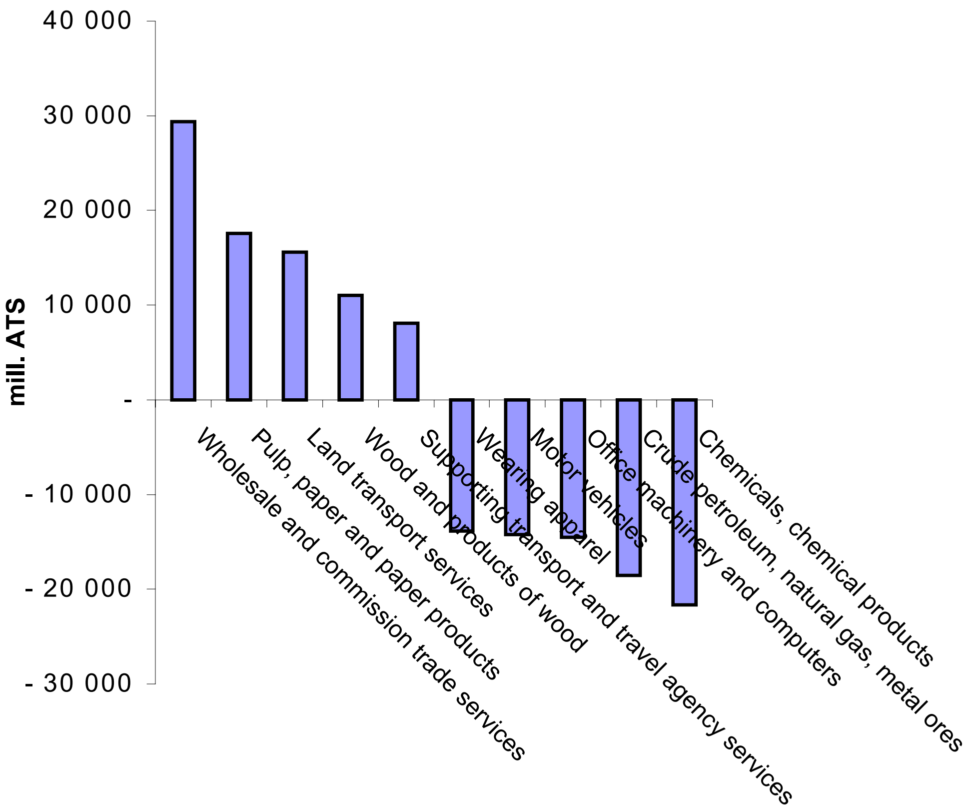


Figure 7.7: Foreign exchange deficit and surplus per product

[172] With reference to the tourism sector it must be noted that in the 1995 supply and use tables Hotel and restaurant services cause a significant export deficit of 11339 mill. ATS.

From an integrated ecological-economic point of view it cannot go without saying 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 18537 mill. ATS of foreign exchange deficit. Together with the exchange of Coke and refined petroleum products (7823 mill. ATS of foreign exchange deficit) it accounts for nearly 40 % of the total Austrian net foreign exchange deficit.

7.2.4 The Survivability Consumption Index for Austria

The Survivability Consumption Index calculates as the total value at basic prices of final uses of products for C_{SURV} as defined in 6.3.3.3. Domestically produced and imported products are considered. As the notion of C_{SURV} applies to production as well as to households all categories of final uses (FCE, GFCF and others) are taken into account. One main point of interest from the viewpoint of social survivability is the amount of value needed in order to assure survivability relative to the total value of products used by the economy and the households. Further splitting makes visible the share of C_{SURV} products in products provided to households and in products for intra-economic use. As with the Consumption Surplus Index, we are going to use 1990 supply and use tables and 1995 data.

The total amount of C_{SURV} products used according to 1990 and 1995 use tables is:

SCI_{1990} = 497773 mill. ATS

SCI_{1995} = 623698 mill. ATS

with $SCI_{1990,1995}$ Survivability Consumption Index for 1990 and 1995

Detailed calculations of C_{SURV} are shown in Table A8.

It follows that the average growth per year of C_{SURV} (4,6 %) equals the average growth of all products for the same period of time. 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} are Public administration services, Health and social work services, Food products and beverages and Education services. (Fig.7.8)

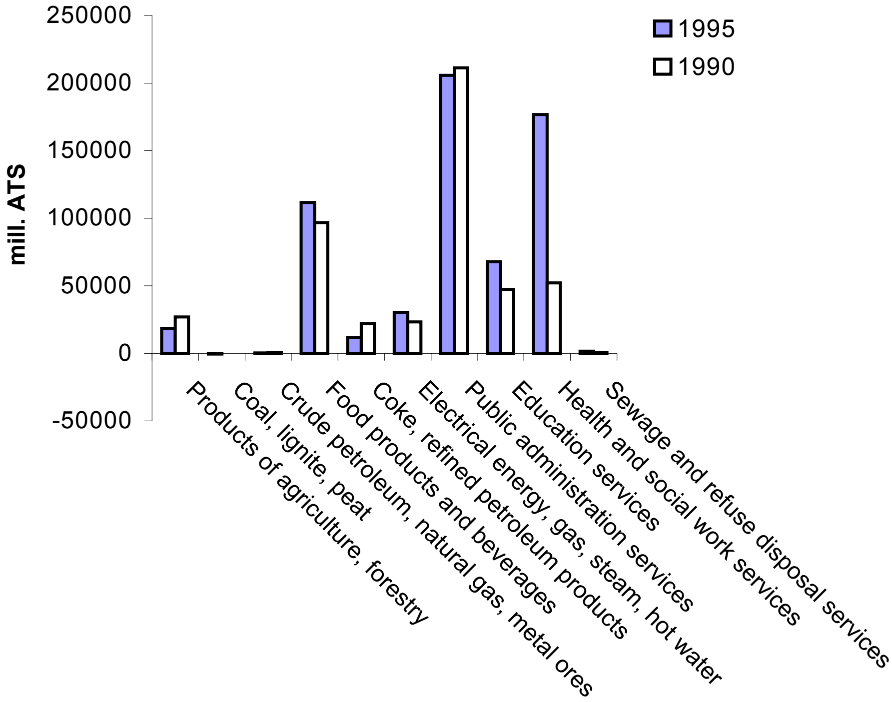


Figure 7.8: Value of products within C_{SURV} in 1990 and 1995

Coal, lignite, peat, Crude petroleum, natural gas and metal ores directly fulfil survivability functions to a very limited extent (values of up to 1500 mill. ATS, not visible in Fig. 7.8) only. They are for intermediate consumption mainly. Intertemporal comparison reveals a drastic rise in Health and social work services, 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[173].

The rise in value of Health and social work services is partly due to changes in allocation between the 1990 and the 1995 use tables. Social transfers that in the 1990 use tables have been recorded as intermediate uses are shown as final uses in the 1995 version.

- 1990: Intermediate consumption 62482 mill. ATS
  Final uses 52162 mill. ATS
- 1995: Intermediate consumption 5944 mill. ATS
  Final uses 176761 mill. ATS

The remaining difference is still more than 68115 mill. ATS (+9 % p.a.).

Changes are made clear by a comparison of the composition of products for Survivability between the two accounting periods (Fig.7.9).

[173] From 1993 to 1995 Austria saw a rise in the overall consumption of diesel from 112000 Terajoule (TJ) to 121000 TJ. In the same period, the consumption of petrol decreased from 109000 TJ to 102000 TJ.

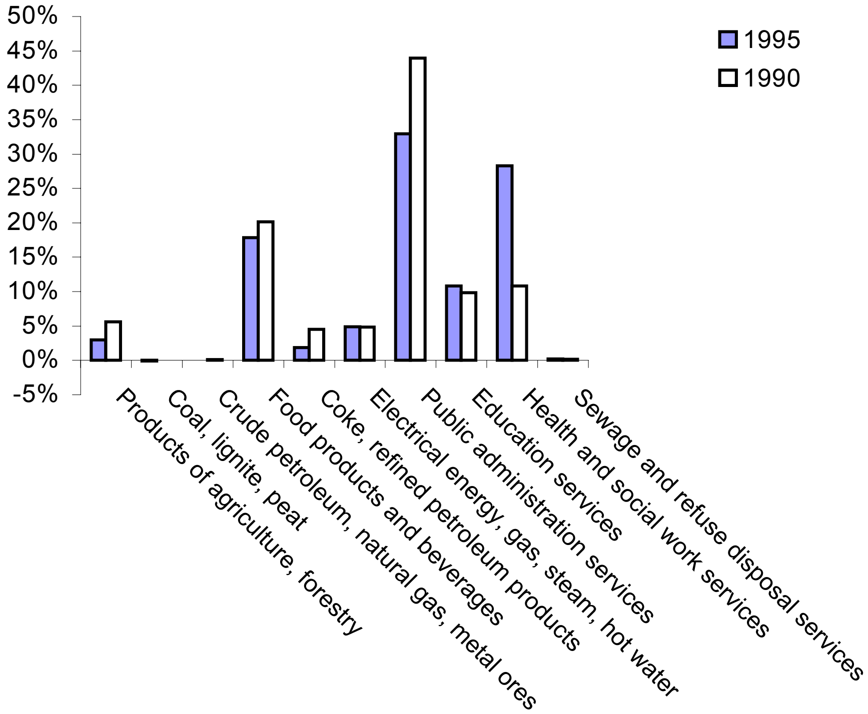


Figure 7.9: Composition of C_{SURV} per product in percent, 1990 and 1995

According to our classification of final uses for households on the one hand and final uses for production on the other hand

- 33,9 % (1995) and 34,6 % (1990) of products for households are part of C_{SURV}
- 0,4 % (1995) and 1,6 % (1990) of products for economic production are ascribed to C_{SURV}.

However, it has to be noted that major parts of C_{SURV} which in use tables figure under final consumption expenditure by government (and in consequence are ascribed to the Value function) are of non-negligible use for production as well (Health and social work services, Public administration services, Education services).

7.2.5 The Economic Efficiency Index for Austria

The explicative strength of the Economic Efficiency Index lies in comparisons of efficiencies (natural resources used per value 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. Standardized time series calculations for Austria are not available as the NAMEAs for air, water and soil (1994) are the first following 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. A one year calculation of the index for only one economic system yields little evidence. Therefore, the focus of this section is on the description of the necessary steps for the calculation of the index.

The Economic Efficiency Index opposes the consumption surplus produced by an economic system (value of C_S produced at basic prices) and the amount of natural resources used by economic production (SPI area consumed). Starting point for the calculations is the SPI area consumed per product i (A_{Pi}). Transboundary flows of residuals are neglected. Basically, it is assumed that industry i produces product i only and that the area consumption of industry i can fully be ascribed to the production of product i (A_i = A_{Pi}). When industry i produces products other than product i the SPI area of the industry has to be allocated to the different products in order not to overvalue the ecological intensity of products and undervalue the intensity of others. For the main area consuming activities the following optimisations have been carried out:

- Manufacture of basic metals: 93 % of the output of Manufacture of basic metals are basic metals. 2,8 % are Fabricated metal products. 0,9 % is Machinery and equipment. 0,8 % are Chemicals and chemical products. The rest are service activities. The SPI area of Manufacture of basic metals is proportionally ascribed to the different products. It is assumed that service activities do not consume SPI area.
- Agriculture, forestry: 92 % of the output of Agriculture and forestry are Products of agriculture and forestry. 4,2 % are Food products and beverages. 2,1 % is Construction work. 1,4 % are Hotel and restaurant services. The SPI area of the industry is proportionally ascribed to the different products.
- Manufacture of other non-metallic mineral products: 90 % of the output are Other non-metallic mineral products. 2,4 % are Other mining and quarrying products. 2,1 % is Construction work. 1,8 % are Wholesale and trade services. The SPI area of the industry is proportionally ascribed to the different products. It is assumed that service activities do not consume SPI area.
- Manufacture of coke and refined petroleum products: 85 % of the output are Coke and refined petroleum products. 5,2 % are Land transport and transport via pipelines services. 4,3 % are Supporting transport services. 100 % are proportionally ascribed to Coke and refined petroleum products and to Land transport.
- Public administration: 91 % of the output are public administration services. 1,9 % are Real estate services. 1,6 % are Printed matter and recorded media. 1 % are Other business services. 0,8 % is Construction work. 100 % are proportionally ascribed to the different products.
- Manufacture of wood and products of wood: 91 % of the output are Wood and products of wood. 3,4 % is Furniture. 1,2 % is Construction work. 100 % are proportionally ascribed to the different products.

These corrections yield the following SPI areas per product (Table 7.3):

Table 7.3: Domestic Austrian SPI area per product

Product CPA	Name	SPI area [km^2]
01	Products of agriculture, forestry and fishing	1927853
10	Coal and lignite; peat	34279
11	Crude petroleum, natural gas, metal ores	20079
13	Metal ores	11455
14	Other mining and quarrying products	189573
15	Food products and beverages	338423
16	Tobacco products	7768
17	Textiles	67671
18	Wearing apparel; furs	8034
19	Leather and leather products	14295
20	Wood and products of wood	224802
21	Pulp, paper and paper products	938361
22	Printed matter and recorded media	37884
23	Coke, refined petroleum products	310041
24	Chemicals, chemical products	305807
25	Rubber and plastic products	102192
26	Other non-metallic mineral products	548604
27	Basic metals	1409023
28	Fabricated metal products	151577
29	Machinery and equipment n.e.c.	71885
30	Office machinery and computers	45
31	Electrical machinery and apparatus	38357
32	Radio, TV and communication equipment	27154
33	Med., precision, opt. instruments; watches, clocks	95
34	Motor vehicles, trailers and semi-trailers	45863
35	Other transport equipment	8111
36	Furniture; other manufactured goods n.e.c.	9102
37	Recovered secondary raw materials	1241
40	Electrical energy, gas, steam and hot water	30411
41	Water; distribution services of water	83275
45	Construction work	222281
50	Trade and repair services of motor vehicles etc.	38655
51	Wholesale and comm. trade serv., ex. of motor vehicles	114228
52	Retail trade serv., repair serv., exept of motor vehicles	100037
55	Hotel and restaurant services	206803
60	Land transport and transport via pipeline services	571445
61	Water transport services	27483
62	Air transport services	23281

63	Supporting transport services; travel agency services	28651
64	Post and telecommunication services	25784
65	Financial intermediation services (ex. insurance serv.)	21793
66	Insurance and pension funding services	10016
67	Services auxiliary to financial intermediation	1692
70	Real estate services	15869
71	Renting services of machinery and equipment	1333
72	Computer and related services	1363
73	Research and development services	63
74	Other business services	25710
75	Public administration services etc.	120463
80	Education services	93990
85	Health and social work services	99354
90	Sewage and refuse disposal services etc.	109473
91	Membership organisation services n.e.c.	111
92	Recreational, cultural and sporting services	57099
93	Other services	567
95	Private households with employed persons	56

With the assumption of a homogenous production per product, the division of A_{Pi} by the value at basic prices of the total domestic supply of product i (S_{Di}) yields the specific area consumption per unit of product.

$A_{P\ spec\ i} = A_{P\ i} / S_{D\ i}$ [km^2/mill. ATS]

with $A_{P\ spec\ i}$ Area consumption per unit of product i

$A_{P\ i}$ Domestic area consumption for the production of product i

$S_{D\ i}$ Value at basic prices of domestic supply of product i

Calculations of $A_{p\ spec}$ are shown in Table A10.

With the assumption of constant $A_{Pi\ spec}$ for the home economy and the ROW, the SPI area imported and exported with products can be calculated.

$A_{P\ imp\ econ\ i} = A_{P\ spec\ i} * V_{imp\ econ\ i}$

with $A_{P\ imp\ econ\ i}$ Area incorporated in product i imported for economic use

$V_{imp\ econ\ i}$ Value at basic prices of product i imported for economic use

$A_{P\ exp\ econ\ i} = A_{P\ spec\ i} * V_{exp\ econ\ i}$

with $A_{P\ exp\ econ\ i}$ Area incorporated in product i exported for economic use

$V_{exp\ econ\ i}$ Value at basic prices of product i exported for economic use

Import and export of products and the SPI area related to their production occurs in two ways. First by directly importing or exporting product i. Second because product i can be used for the production of product h. SPI area for the production of product i is then “indirectly” imported or exported with product h.

$V_{imp\ econ\ i} = V_{imp\ dir\ econ\ i} + V_{imp\ indir\ econ\ i}$

with $V_{imp\ dir\ econ\ i}$ Value at basic prices of product i directly imported for economic use

$V_{imp\ indir\ econ\ i}$ Value at basic prices of product i indirectly imported for economic use

$V_{exp\ econ\ i} = V_{exp\ dir\ econ\ i} + V_{exp\ indir\ econ\ i}$

with $V_{exp\ dir\ econ\ i}$ Value at basic prices of product i directly exported for economic use

$V_{exp\ indir\ econ\ i}$ Value at basic prices of product i indirectly exported for economic use

The value of products directly imported and used within the economic system can be taken from use tables. All imported products for GFCF (except Dwellings) and all imported products for intermediate consumption are counted as direct imports to the domestic economic system. No difference is made between products allocated to C_{SURV} and production. The value of indirectly imported product i calculates as the value of intermediate consumption of product i for the production of product h multiplied by the share in total output of product h directly imported. Values are taken from domestic use tables. Homogeneity of intermediate flows in the domestic economy and the ROW is assumed.

$V_{imp\ indir\ i} = \sum_h U_{ih} * V_{imp\ dir\ econ\ h} / S_{D\ h}$

with U_{ih} Value of intermediate consumption of product i for the production of product h

This is a simplified way of calculating intermediate flows. It considers one step in the process chain only. In order to avoid significant negligence of intermediate flows (product i which is used for production of product h which in turn is used for production of product j which is imported) we include a second step of the process chain in calculations of indirect import for the main area consuming products (CPA 27, 01, 26, 21, 60, 23, 75, 24, 20, 16, 28 – 80 % of total industrial SPI area).

The share of exports used within the economic systems of the ROW cannot be determined on the basis of domestic use tables as no specifications are made whether exports are for FCE, GFCF or intermediate consumption. For imports the share of total imports of a product that is used for intra-economic purposes (GFCF and intermediate consumption) can be calculated.[174]

$P_{imp\ econ\ i} = V_{imp\ dir\ econ\ i} / V_{imp\ i}$

[174] In the equations above only imports and exports for intra-economic use are considered.

with $P_{imp\ econ\ i}$ The share of product i imported for economic use in percent of the total imports of product i

$V_{imp\ i}$ Total value of imports of product i

Calculations of $P_{imp\ econ}$ are shown in Table A9.

Under the assumption that exports are used within the economic systems of the ROW to the same share as imports are used within the domestic economic system, the value of exports for intra-economic use can be determined.

$P_{imp\ econ\ i} = P_{exp\ econ\ i}$

with $P_{exp\ econ\ i}$ The share of product i exported for economic use in percent of the total exports of product i

$V_{exp\ dir\ econ\ i} = P_{exp\ econ\ i} * V_{exp\ i}$

with $V_{exp\ i}$ Total value of exports of product i

Indirectly exported products are calculated analogously to indirectly imported products.

$V_{exp\ indir\ econ\ i} = \Sigma_h\ U_{ih} * V_{exp\ dir\ econ\ h} / S_{D\ h}$

From $V_{exp\ econ\ i}$, $V_{imp\ econ\ i}$ and $A_{P\ spec\ i}$ SPI area imported and exported with product i for economic use can be calculated. Total area imported and exported are calculated as

$A_{P\ imp\ econ} = \Sigma_i A_{P\ imp\ econ\ i}$

with $A_{P\ imp\ econ}$ SPI area imported with products for economic use

$A_{P\ exp} = \Sigma_i A_{P\ exp\ econ\ i}$

with $A_{P\ exp\ econ}$ SPI area exported with products for economic use

It follows that

$A_{tot\ econ} = A_{D\ econ} + A_{P\ imp\ econ} - A_{P\ exp\ econ}$

with $A_{tot\ econ}$ Total area used by the domestic economy for the provision of Consumption Surplus

Calculations of $A_{tot\ econ}$ are shown in Table A12.

Total value of C_S supplied (domestically produced, imports are not included) by the domestic economy can be derived from domestic use tables. It calculates as the sum of domestically supplied products in the final uses sections FCE, GFCF/Dwellings, Valuables and Exports. The share of C_S in exports is total exports multiplied by (1- $P_{exp\ econ\ i}$). The rest of the exports are products for economic production and are not taken into account in the calculation of total value of the consumption surplus. C_{SURV} is excluded.

$$C_{S\ dom} = U_{D\ FCE} + U_{D\ Dwellings} + U_{D\ Valuables} + U_{D\ Export} *(1- P_{exp\ econ\ i})$$

with $U_{D\ FCE}$ Value of domestically produced products for final consumption expenditure

$U_{D\ Dwellings}$ Value of domestically produced products for GFCF/Dwellings

$U_{D\ Valuables}$ Value of domestically produced valuables

$U_{D\ Export}$ Value of domestically produced exports

Calculations of $C_{S\ dom}$ are shown in Table A11.

The Economic Efficiency Index follows as

$$EEI = C_{S\ dom} / A_{tot\ econ}$$

with EEI Economic Efficiency Index

The results for the Austrian economy are:

$A_{D\ econ}$ = 8,88 mill. km^2

$A_{P\ imp\ econ}$ = 4,49 mill. km^2

$A_{P\ exp\ econ}$ = 4,31 mill. km^2

$A_{tot\ econ}$ = 9,06 mill. km^2

$C_{S\ dom}$ = 1190267 mill. ATS

EEI = 0,13 mill. ATS / km^2

Austria's productive activities consume 9,06 mill. km^2. From the 8,88 mill. km^2 used by domestic production 4,31 mill. km^2 are exported with products that are used for economic production in the rest of the world. 4,49 mill. km^2 are imported with goods and services that are in turn used in domestic production activities. Together with a domestically produced consumption surplus of 1190000 mill. ATS this gives an economic efficiency of 0,13 mill. ATS of C_S per km^2 used for economic production. A more detailed analysis of the Austrian economic system's efficiency is provided in Section 7.3.6 where the Austrian efficiency is compared to the Feldbach region's efficiency.

7.2.6 The Import and Export Efficiency Indices for Austria

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. In contrast to the Economic Efficiency Index calculations, what is of interest here is not total area incorporated in products used by economic systems, but "area added"[175] by the trading economic systems. Exported products contain only domestic SPI area added by domestic productive activities. Imported products contain SPI area added by productive activities of the trading partner. For imports from the ROW, area added equals total area incorporated in the products, when it is assumed that the size of the ROW's trading partner is insignificant in relation to the ROW and that in consequence all productive activities are carried out within the ROW economic system. For Austria this means that only Austrian area (area consumed by Austrian economic activities) incorporated in exports is considered and not total area. Money flows are treated analogously to flows of SPI area. Not total value added incorporate in products (prices) exchanged is considered but only value added by the trading partners. Once again, for the ROW value added equals total value added (basic prices). For Austrian exports, only Austrian value added is taken into account. Calculated as such, the indices give a good picture of whether an economic system trades relatively high value - low area products with regard to its trading partners or not. Thereby, they reflect the influences of trade on solvency and ecological sustainability of an economic system.

Calculations are as follows:

In addition to area consumption per unit of product i ($A_{Pi\ spec}$), value added per unit of product is determined. (Tab.7.4)

[175] Term used in analogy to "value added".

Table 7.4: Austrian value added per product (Source: Statistik Austria 2001)

Product CPA	Name	Value added [mill. ATS]
01	Products of agriculture, forestry and fishing	56281
10	Coal and lignite; peat	468
11	Crude petroleum, natural gas, metal ores	1296
14	Other mining and quarrying products	6059
15	Food products and beverages	58883
16	Tobacco products	1313
17	Textiles	11836
18	Wearing apparel; furs	6780
19	Leather and leather products	3377
20	Wood and products of wood	21756
21	Pulp, paper and paper products	20254
22	Printed matter and recorded media	21550
23	Coke, refined petroleum products	5761
24	Chemicals, chemical products	22816
25	Rubber and plastic products	16228
26	Other non-metallic mineral products	26792
27	Basic metals	23243
28	Fabricated metal products	38463
29	Machinery and equipment n.e.c.	47498
30	Office machinery and computers	293
31	Electrical machinery and apparatus	23358
32	Radio, TV and communication equipment	19429
33	Med., precision, opt. instruments; watches, clocks	8697
34	Motor vehicles, trailers and semi-trailers	15835
35	Other transport equipment	4841
36	Furniture; other manufactured goods n.e.c.	24105
37	Recovered secondary raw materials	614
40	Electrical energy, gas, steam and hot water	56815
41	Water; distribution services of water	3874
45	Construction work	175410
50	Trade and repair services of motor vehicles etc.	47336
51	Wholesale and comm. trade serv., ex. of motor vehicles	139882
52	Retail trade serv., repair serv., exept of motor vehicles	114434
55	Hotel and restaurant services	91457
60	Land transport and transport via pipeline services	81057
61	Water transport services	730
62	Air transport services	6205

63	Supporting transport services; travel agency services	21620
64	Post and telecommunication services	53140
65	Financial intermediation services (ex. insurance serv.)	-731
66	Insurance and pension funding services	30413
67	Services auxiliary to financial intermediation	3510
70	Real estate services	181709
71	Renting services of machinery and equipment	31422
72	Computer and related services	19555
73	Research and development services	5374
74	Other business services	100935
75	Public administration services etc.	140067
80	Education services	122573
85	Health and social work services	129916
90	Sewage and refuse disposal services etc.	19846
91	Membership organisation services n.e.c.	18851
92	Recreational, cultural and sporting services	32123
93	Other services	12562
95	Private households with employed persons	5878

With the assumption of a homogenous production per product, the division of the value added by product (VA_{Pi}) by the value at basic prices of the total domestic supply of product i (V_{Di}) yields the specific value added per unit of product.

$VA_{P\ spec\ i} = VA_{Pi} / S_{Di}$ [mill. ATS/mill. ATS]

with $VA_{P\ spec\ i}$ Value added per unit of product i

VA_{Pi} Domestic value added with the production of product i

S_{Di} Value at basic prices of domestically supplied product i

Calculations of $VA_{p\ spec}$ are shown in Table A10.

With the assumption of constant $VA_{P\ spec\ i}$ for the home economy and the ROW, the value added imported and exported with products can be calculated.

$VA_{P\ imp\ i} = VA_{P\ spec\ i} * V_{imp\ i}$

with $VA_{P\ imp\ i}$ Value added incorporated in product i imported

$V_{imp\ i}$ Value at basic prices of product i imported

$VA_{P\ exp\ i} = VA_{P\ spec\ i} * V_{exp\ i}$

with $VA_{P\ exp\ i}$ Value added incorporated in product i exported

$V_{exp\ i}$ Value at basic prices of product i exported

Direct and indirect import and export are calculated analogously to the Economic Efficiency Index. All imported and exported products are included (no calculation of $P_{imp\ econ\ i}$ and $P_{exp\ econ\ i}$). Differences to the Economic Efficiency Index occur with the calculations of $V_{imp\ indir\ i}$ and $V_{exp\ indir\ i}$. While for the EEI calculations U_{ih} includes all intermediate flows (domestic plus imported), $V_{imp\ indir\ i}$ is calculated by using flows of the trading partner and $V_{exp\ indir\ i}$ by using domestic flows only. Imports from the ROW can be calculated with domestic plus imported flows as all intermediate flows are assumed to be of ROW origin (no imports). The same optimisation of the calculation of indirect import and export (the consideration of a second step in the process chain is carried out for the main area consuming and value adding products).[176]

From $V_{exp\ i}$, $V_{imp\ i}$ and $VA_{P\ spec\ i}$ value added imported and exported with product i can be calculated. Total value added imported and exported are calculated as

$VA_{P\ imp} = \Sigma_i VA_{P\ imp\ i}$

with $VA_{P\ imp}$ Value added imported

$VA_{P\ exp} = \Sigma_i VA_{P\ exp\ i}$

with $VA_{P\ exp}$ Value added exported

SPI area exchanged is calculated in the same way as value added (replace $VA_{P\ spec\ i}$ by $A_{P\ spec\ i}$). The efficiency indices calculate as

$IEfI = VA_{P\ imp} / A_{P\ imp}$

with IEfI Import Efficiency Index

$EEfI = VA_{P\ exp} / A_{P\ exp}$

with EEfI Export Efficiency Index

The results for Austria are:

$A_{P\ imp}$ = 5,86 mill. km^2

$A_{P\ exp}$ = 3,84 mill. km^2

[176] For nearly 90 % of total industrial SPI area and 85 % of total value added.

$VA_{P\ imp}$ = 607538 mill. ATS

$VA_{P\ exp}$ = 430918 mill. ATS

IEfI = 0,104 mill. ATS / km^2

EEfI = 0,112 mill. ATS / km^2

Calculations of import and export of SPI area and value added at the product level are shown in Table A13.

It can be seen that Austria's exports contain 0,112 mill. Austrian Schillings per km^2 of SPI area while imports to Austria contain 0,104 mill. Austrian Schillings per km^2 of SPI area. Thus, in terms of import and export efficiency it can be said that Austria is more efficient than its trading partners (92,9 % of Austrian exports' value added per area). For reasons of interpretation it must be stressed that country specific differences in efficiency of production (area consumption per output of product) are not included in the calculations.[177] Differences in import and export efficiency are due to differences in the composition of imports and exports. The share of high value - low area products is higher in exports than it is in Austrian imports. Figures 7.10 and 7.11 show efficiency ratios for Austria's main imports and exports. Directly and indirectly exchanged products are shown.

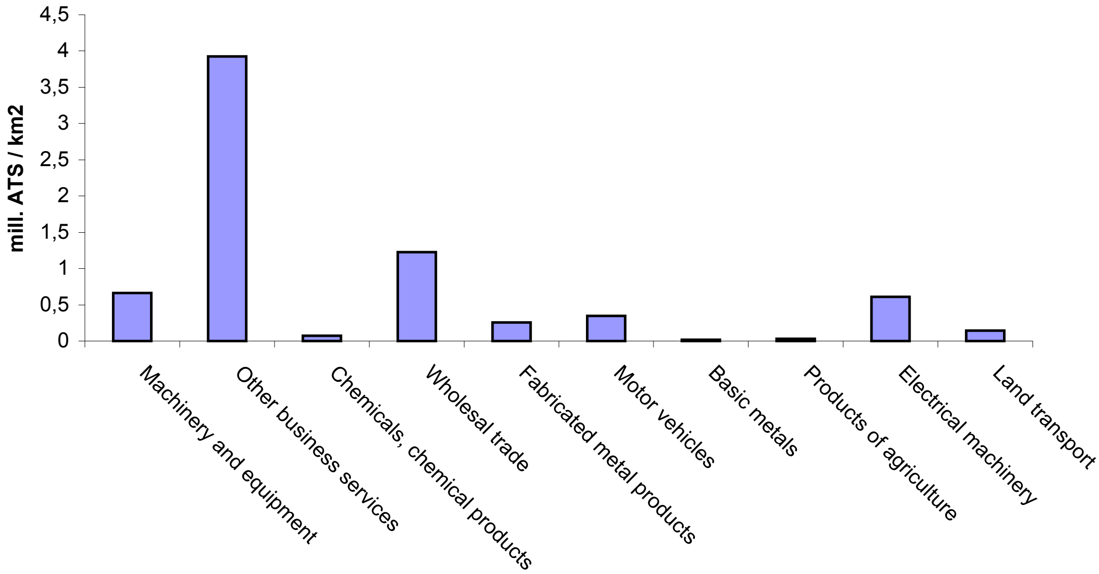


Figure 7.10: Efficiency (value added per area consumed) for main Austrian imports (in order of value added imported)

[177] 70 % of Austrian trade flows are exchange with EU countries. Differences in productive efficiency between EU countries are assumed to be insignificant.

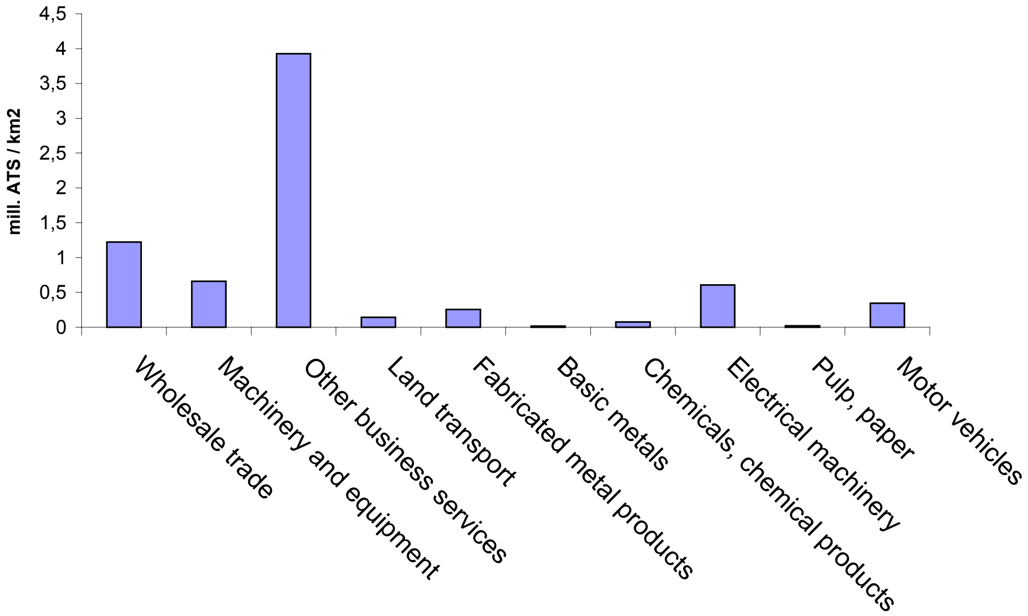


Figure 7.11: Efficiency (value added per area consumed) for main Austrian exports (in order of value added exported)

The main imported and exported products[178] are basically the same with a higher share of Wholesale trade in Austrian exports. While Products of agriculture figure among the ten most important (in terms of value added) imports, Pulp and paper figure among the ten most important exports. Generally, many high efficiency products are virtually not traded. Education services (1,3 mill. ATS / km^2) has a share 0,2 % of total trade volume, Health and social work services (1,3 mill. ATS / km^2) 0,1 %, Research and development services (85 mill. ATS / km^2) 0,5 %, Computer and related services (14 mill. ATS / 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 (0,7 mill. ATS / km^2), Chemicals for 5,9 % (0,07 mill. ATS / km^2), Fabricated metal products for 5,1 (0,25 mill. ATS / km^2), Basic metals for 4,6 % (0,016 mill. ATS / km^2). The only high value products with a significant share in total volume of trade flows are Wholesale trade for (7,6 %; 1,22 mill. ATS / km^2) and Other business services (7,3 %; 3,9 mill. ATS / km^2). Exports of Wholesale trade consists of direct as well as indirect flows to about the same extent. In contrast, import of this product is mainly indirect import. Other business services are directly as well as indirectly imported and exported. In general, services tend to not be directly traded. When services are traded, they are incorporated intermediate flows of directly traded goods.

Imports and exports of value added and SPI area in absolute numbers are shown in Figures 7.12 and 7.13. 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 Basic metals (nearly one third of total traded flows of SPI area), Products of agriculture, Pulp and paper and Chemicals. Most products that show significant exchange

[178] It must be made clear once again, that we are talking about products imported and exported and intermediate flows incorporated in these products.

deficits in terms of value added show significant deficits in SPI area as well (Basic metals, Chemicals, Products of agriculture). The same holds true for the products which account for exchange surpluses. The exchange of these products does not significantly affect the Austrian import and export efficiency ratio. Products the exchange of which creates surpluses (deficits) in terms of value added but does not result in exchange of high SPI area values (or vice versa) have to be highlighted. Among them are Wholesale trade (more or less balanced exchange), Motor vehicles (exchange deficit), Other business services (deficit), Machinery and equipment (deficit). It becomes visible that in general Austria incurs (economic – ecological) exchange deficits due to an imbalance of the exchange of high value products. This general weakness is levelled out mainly by an exchange deficit in very low efficiency products (Basic metals, Chemicals and chemical products, Coke and refined petroleum products).

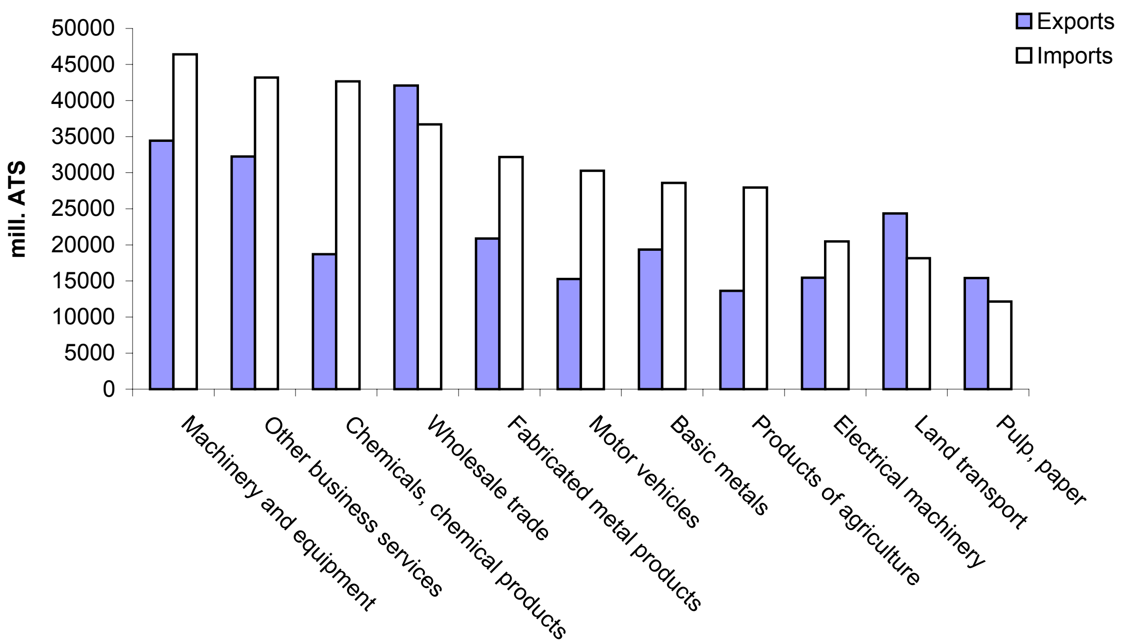


Figure 7.12: Value added per product imported and exported

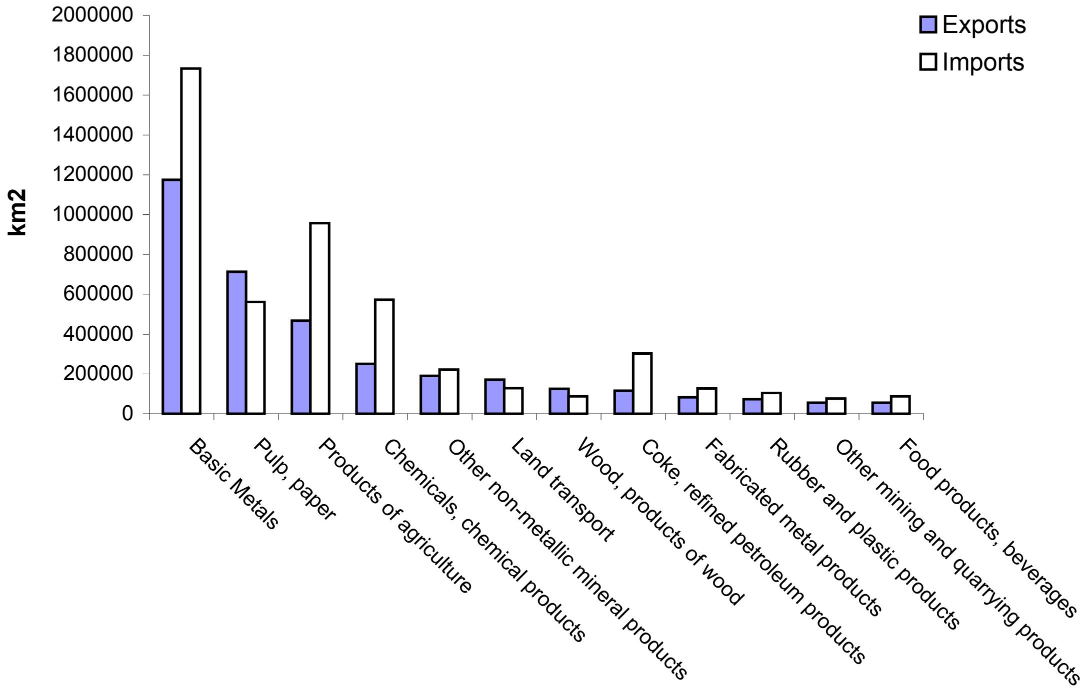


Figure 7.13: SPI area consumed per product imported and exported

7.2.7 The Functional Composition Index for Austria

The calculation of the Functional Composition Index starts with the classification of products for final use. According to Table 6.5 final uses are ascribed to the three economic functions Survivability, Production and Consumption surplus. For all calculations of functional composition only domestic flows (no imported flows) are considered. Thereby we get the directly ascribable value of products ($U_{S\ dir}$, $U_{P\ dir}$, $U_{C\ dir}$). Calculation of indirectly ascribable flows is done in analogy to calculations of indirect imports and exports. Only domestic intermediate flows are considered.

$U_{S,P,C} = U_{S,P,C\ dir} + U_{S,P,C\ indir}$

with $U_{S,P,C}$ Value of uses of goods ascribed to Survivability (S), Production (P) or Consumption surplus (C)

$U_{S,P,C\ dir}$ Value of final uses ascribed to S, P or C

$U_{S,P,C\ indir}$ Value of intermediate uses ascribed to S, P or C

Together with $VA_{P\ spec\ i}$ and $A_{P\ spec\ i}$ the share of domestic value added by and SPI area used for Survivability, Production or Consumption surplus can be determined.

$VA_{P\ S,P,C\ i} = VA_{P\ spec\ i} * V_{S,P,C\ i}$

with $VA_{P\ S,P,C\ i}$ Value added incorporated in product i ascribed to S, P or C

$V_{S,P,C\ i}$ Value at basic prices of product i ascribed to S,P, or C

$VA_{P\ S,P,C} = \Sigma_i VA_{P\ S,P,C\ i}$

with $VA_{P\ S,P,C}$ Value added ascribed to S, P or C

SPI area used by the three functions is calculated in the same way as value added (replace $VA_{P\ spec\ i}$ by $A_{P\ spec\ i}$). The Indices calculate as

$FCI_{VA\ S,P,C} = VA_{P\ S,P,C} / VA_{D\ econ}$

with $FCI_{VA\ S,P,C}$ Functional Composition Index for value added

$VA_{D\ econ}$ Value added of the economic system

and

$FCI_{A\ S,P,C} = A_{P\ S,P,C} / A_{D\ econ}$

with $FCI_{A\ S,P,C}$ Functional Composition Index for SPI area

$A_{D\ econ}$ Area consumption of the economic system

The results for Austria are:

$FCI_{VA\ S}$ = 25,3 %

$FCI_{VA\ P}$ = 25,8 %

$FCI_{VA\ C}$ = 48,9 %

$FCI_{A\ S}$ = 28,0 %

$FCI_{A\ P}$ = 40,9 %

$FCI_{A\ C}$ = 31,1 %

Calculations of functional allocation at the product level are shown in Table A14.

Apparently, products of the production aggregate are supplied with a higher share of low efficiency products than products of the consumption surplus aggregate. Efficiency ratios of products of the survivability function lie between those of production and consumption surplus products. This is due to the fact that Education services (50 %) and Health services (100 %) are ascribed to C_{SURV}. Most other products within C_{SURV} have comparatively low efficiency ratios. A look at the functional composition at the product level shows that a high share of services contributes to the provision of consumption surplus products (Real estate services 89 %, Other services 96 %, Insurance and pension funding services 87 %, Services auxiliary to financial intermediation 86 %, Post and telecommunication services 69 %). The generally high efficiency ratios of services explain why only 45 % of area consumed is incorporated in consumption surplus products while 56 % of value added can be ascribed to these products.

When consumption is included, functional composition of SPI area is 21 % Survivability, 30 % Production, 23 % Consumption surplus and 26 % Households.

7.3 The Sustainable Economy Indices for the Feldbach Region

7.3.1 The Feldbach Supply and Use Tables

As mentioned in Section 7.1.3, regional supply and use tables are constructed by multiplying domestic supply and use by reduction factors. Reduction factors are defined for intermediate supply and use, for final consumption expenditure and for gross fixed capital formation. Data for reduction factors for intermediate flows are taken from regional and national employment statistics. Employment statistics for Austria following the NACE Rev. 1 classification are readily available at the national level and at the level of the “Bundesländer”. Districts are the next size down in Austrian administrative units.[179] At the district level employment statistics follow another classification system (Kammersystematik). Data on Feldbach employment according to the “Kammersystematik” have been provided by the Styrian[180] chamber of commerce. Data according to the Kammersystematik had to be converted to the NACE Rev.1 classification system. Where district data was not available (service activities mainly) a Bundesland average according to NACE Rev.1 has been used. For NACE Rev.1 75, 91 and 95 the reduction factors are calculated as the ratio of district inhabitants to national inhabitants. The reduction factors per industry are shown in Table 7.5. Bundesland average values are marked “*”. Average national inhabitant values are marked “**”.

[179] For our calculations the Feldbach region is set equivalent to the Feldbach district.

[180] The Feldbach district is part of the Bundesland Styria.

Table 7.5: Reduction factors per industry for the Feldbach district in percent of the Austrian total

Industry NACE	Name	RF_i [%]
01	Agriculture, forestry and fishing	1,07
10	Mining of coal, lignite and peat	0,00
11	Extraction of crude petroleum, natural gas, metal ores	0,00
14	Other mining and quarrying	2,15
15	Manufacture of food products and beverages	1,16
16	Manufacture of tobacco products	0,00
17	Manufacture of textiles	0,77
18	Manufacture of wearing apparel	1,70
19	Tanning and dressing of leather	9,24
20	Manufacture of wood and products of wood	2,67
21	Manufacture of pulp, paper and paper products	0,00
22	Publishing, printing and reproduction of recorded media	0,08
23	Manufacture of coke, refined petroleum products	0,02
24	Manufacture of chemicals, chemical products	0,13
25	Manufacture of rubber and plastic products	0,14
26	Manufacture of other non-metallic mineral products	0,83
27	Manufacture of basic metals	0,01
28	Manufacture of fabricated metal products	0,45
29	Manufacture of machinery and equipment n.e.c.	0,58
30	Manufacture of office machinery and computers	7,14
31	Manufacture of electrical machinery and apparatus	0,16
32	Manufacture of radio, TV and communication equipment	1,96
33	Manufacture of med., precision, opt. instruments; watches, clocks	0,92
34	Manufacture of motor vehicles, trailers and semi-trailers	0,26
35	Manufacture of other transport equipment	3,07
36	Manufacture of furniture; other manufactured goods n.e.c.	1,12
37	Recycling	0,00
40	Electrical energy, gas, steam and hot water supply	0,28*
41	Collection, purification and distribution of water	0,24*
45	Construction	0,76
50	Sale, maintenance and repair of motor vehicles etc.	0,38
51	Wholesale and comm. trade, ex. of motor vehicles	0,61
52	Retail trade, repair, except of motor vehicles	0,71*
55	Hotels and restaurants	0,42
60	Land transport and transport via pipeline	0,17
61	Water transport	0,00

62	Air transport	0,00
63	Supporting transport activities; activities of travel agencies	0,40*
64	Post and telecommunications	0,05*
65	Financial intermediation	0,65*
66	Insurance and pension funding	0,58*
67	Activities auxiliary to financial intermediation	0,69*
70	Real estate activities	0,36*
71	Renting of machinery and equipment	0,72
72	Computer and related activities	0,01
73	Research and development	0,00
74	Other business activities	0,09
75	Public administration and defense ; compulsory social security	0,84**
80	Education	0,50
85	Health and social work	0,60
90	Sewage and refuse disposal etc. activities	2,83
91	Activities of membership organisations n.e.c.	0,84**
92	Recreational, cultural and sporting activities	0,10
93	Other service activities	2,07
95	Private households with employed persons	0,84**

The reduction factor for final consumption expenditure, valuables and dwellings is calculated as follows:

I_R = 67600

I_N = 8090000

I_R / I_N = 0,0084

MGI_R = 18480 ATS

MGI_N = 22670 ATS

MGI_R / MGI_N = 0,82

RF_{fce} = 0,0069

The reduction factor for GFCF (except dwellings):

$VA_{Ri} = VA_{Di} * RF_i$

with VA_{Di} Domestic value added by industry i

$VA_R = \Sigma_i VA_{Ri}$

$VA_D = \Sigma_i VA_{Di}$

with VA_R Total regional value added

VA_D Total domestic value added

VA_R = 13116 mill. ATS

VA_D = 2133789 mill. ATS

RF_{gfcf} = 0,006

The Feldbach district's supply and use tables are then derived from the national ones (Tables A15, A16 and A17). For intermediate flows, regional supply and use is domestic supply and use multiplied by RF_i. Final uses for FCE, dwellings and valuables are calculated by multiplication of national values by RF_{fce}, final uses for GFCF (except dwellings) by multiplication by RF_{gfcf}. For supply, no imports to the domestic economy are considered. For use, domestic flows plus imports to the domestic economy are taken into account.

7.3.2 The Ecological Sustainability Index for Feldbach

The regional Ecological Sustainability Index is calculated by multiplying domestic Austrian industry-related area consumption by the respective reduction factors.[181]

$A_{Ri} = A_i * RF_i$

with A_{Ri} Regional SPI area consumption by industry i

$A_{R\ econ} = \Sigma_i\ A_{Ri}$

with $A_{R\ econ}$ Regional SPI area consumption by regional economic activities

Total area consumption of all productive and consumptive activities of the Feldbach district is

$A_{R\ econ} = 77554\ km^2$

Detailed Calculations are shown in Table A18.

With the Feldbach geographical surface of 727 km^2 the Ecological Sustainability Index amounts to

ESI = 106

[181] Reduction factor for SPI area consumed by households is RF_{fce}.

In analogy to the calculations for Austria, we assume that emissions to air have mainly global environmental impacts and that the area for the dissipation of global emissions is 3,4 times the land surface of the Feldbach economy, the Feldbach SPI calculates amounts to:

ESI = 31

Compared to the Austrian ESI of 144 (42), the Feldbach economic system and the Feldbach households are nearer to a state of ecological sustainability. On a very general level this can be attributed to the fact that the Feldbach economic and social systems are comparatively smaller in relation to the district's surface than the Austrian economic and social systems are in relation to the national surface. Austria's population density is at about 100 persons per km^2. The same value for Feldbach is 92 persons per km^2. Austrian value added per surface is considerably higher than Feldbach value added per surface (factor 1,5). In addition to that, the manufacture of "dirty products" (metals, paper, petroleum products) is very limited within the Feldbach economic system.

A comparison between the Feldbach and the Austrian SPI area at industry level reveals a significantly changed composition of the total area consumption. While households represent still a main area consuming factor, Agriculture and forestry take the first place among area consuming industries. Other industries that are of low importance at the national level (Other mining and quarrying, Manufacture of leather products, Manufacture of food products and beverages, Construction work, Sewage and refuse disposal) figure most prominently at the Feldbach district level. On the other hand, industries with a high share in national SPI area, such as Manufacture of basic metals, Manufacture of pulp, paper and paper products, Land transport, Manufacture of chemicals are not among the ten industries exerting most pressure on the environment. (Fig.7.14)

The change in industrial composition does not leave the shares of SPI area per environmental compartment unchanged. While Austria's SPI area is composed of 72 % emissions to air, 24 % emissions to water and 4 % emission to soil, the respective Feldbach values are 61 % emissions to air, 32 % emissions to water and 7 % emissions to soil. (Fig.7.15) Most of the increased area consumption by water emissions is due to the relatively larger Agriculture and forestry industry which accounts for 72 % of overall water emissions' SPI area.

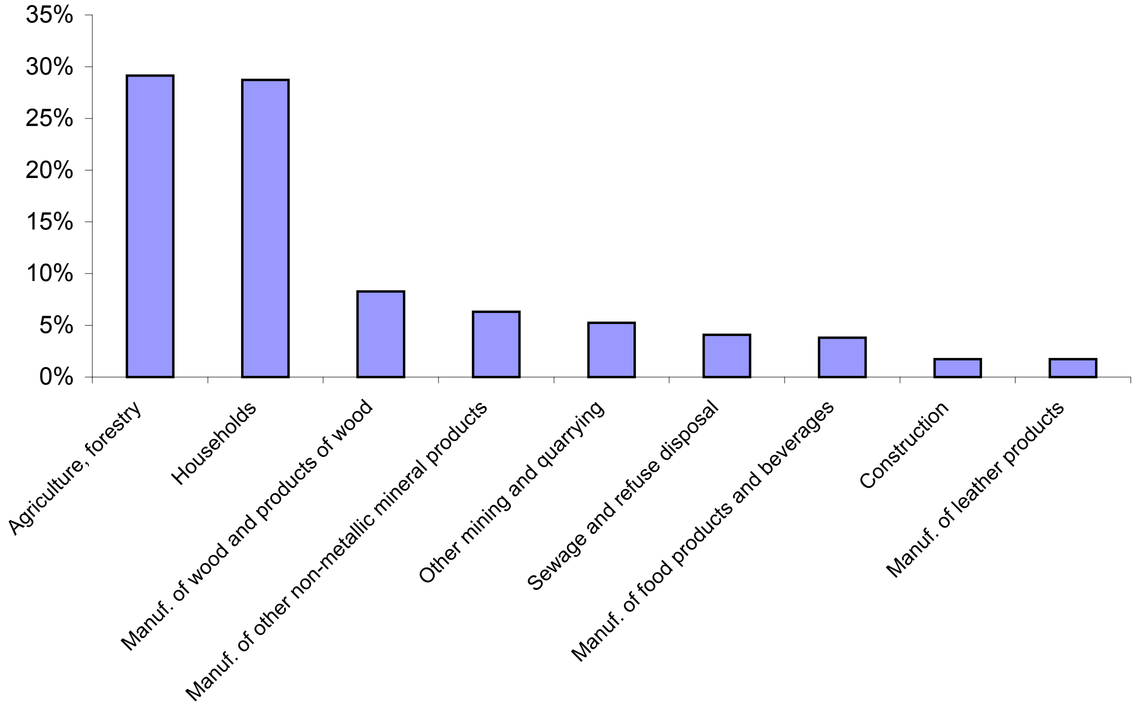


Figure 7.14: Feldbach SPI area consumption per industry and households

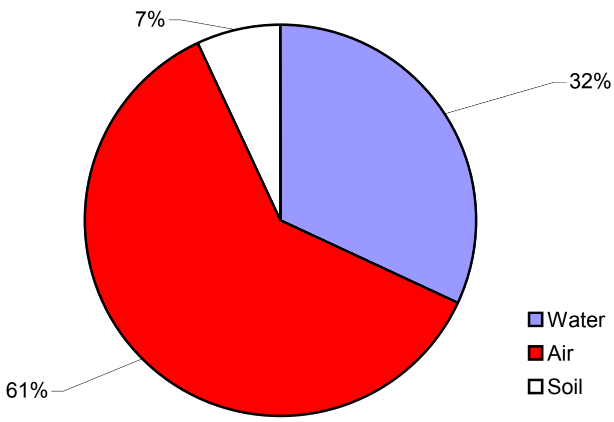


Figure 7.15: Feldbach SPI area consumption per environmental compartment

7.3.3 The Consumption Surplus Index for Feldbach

For political districts, there are no data analogous to data on final consumption expenditure on the national level available. Therefore, consumption surplus will be calculated indirectly by means of regional gross median income. It is assumed that regional consumption surplus available is proportional to the latter. Thus, the results for the Consumption Surplus Index for Feldbach are the Austrian results weighted by RF_{fce}.

$CSI_{FB} = (U_{D\ FCE} + U_{D\ Dwellings} + U_{D\ Valuables}) * RF_{fce}$

CSI_{FB} = 8362 mill. ATS

Calculations of the Consumption Surplus are shown in Table A19.

From the increasing amount of Austrian consumption surplus (1990 to 1995) and a steady increase in regional gross median income for the Feldbach district it follows that the sustainability criterion of non-decreasing C_S is fulfilled. More detailed analysis of regional societal value needs more data on regional consumption expenditure. The collection of such data goes beyond the scope of this work. The same is true for the regional Survivability Consumption Index which relies on regional final uses data as well.

7.3.4 The Economic Exchange Index for Feldbach

Data on trade flows are not recorded at the district level. No standard statistics exist for imports and exports to and from political districts. In the absence of the possibility to consult data on economic exchange directly, it is helpful in our case to calculate trade flows indirectly with the help of the Feldbach supply and use tables. These do not display import and export flows explicitly, but the difference between total use and total supply of a product yields a net import or export of the product for the region.

$V_{E\,j} = S_{R\,j} - U_{R\,j}$

with $V_{E\,j}$ Value of net exports of product j

$V_{I\,j} = U_{R\,j} - S_{R\,j}$

with $V_{I\,j}$ Value of net imports of product j

$V_E = \Sigma_j V_{E\,j}$

$V_I = \Sigma_j V_{I\,j}$

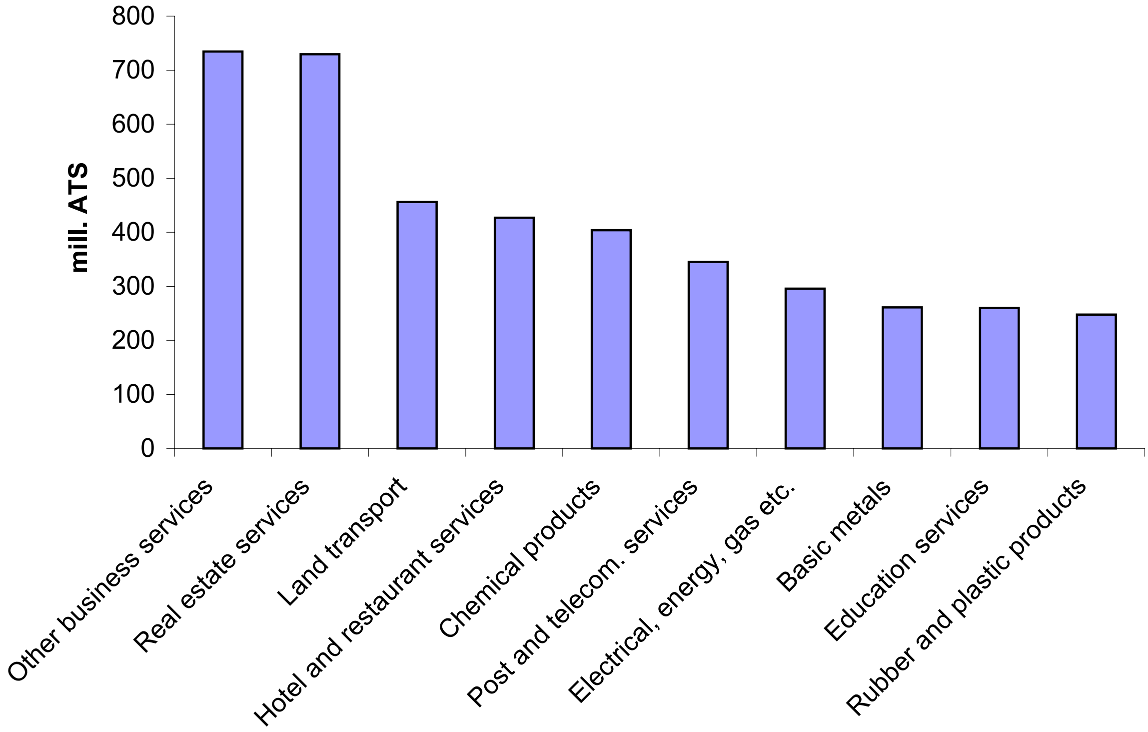
V_E = 5084 mill. ATS

V_I = 6697 mill. ATS

EExI = V_E - V_I = **-1613 mill. ATS**

Calculations at the product level are shown in Table A25.

The Feldbach region has a foreign exchange deficit in goods and services of 1613 mill. ATS. The main imports and exports are shown in Figures 7.16 and 7.17. Among the main imports are goods as well as services. Nearly 50 % percent of total net imports are services (48 %). On the other hand, exports consist of goods mainly. Only 13 % of total net exports are services.



Figures 7.16: Value of main net imports to the Feldbach region

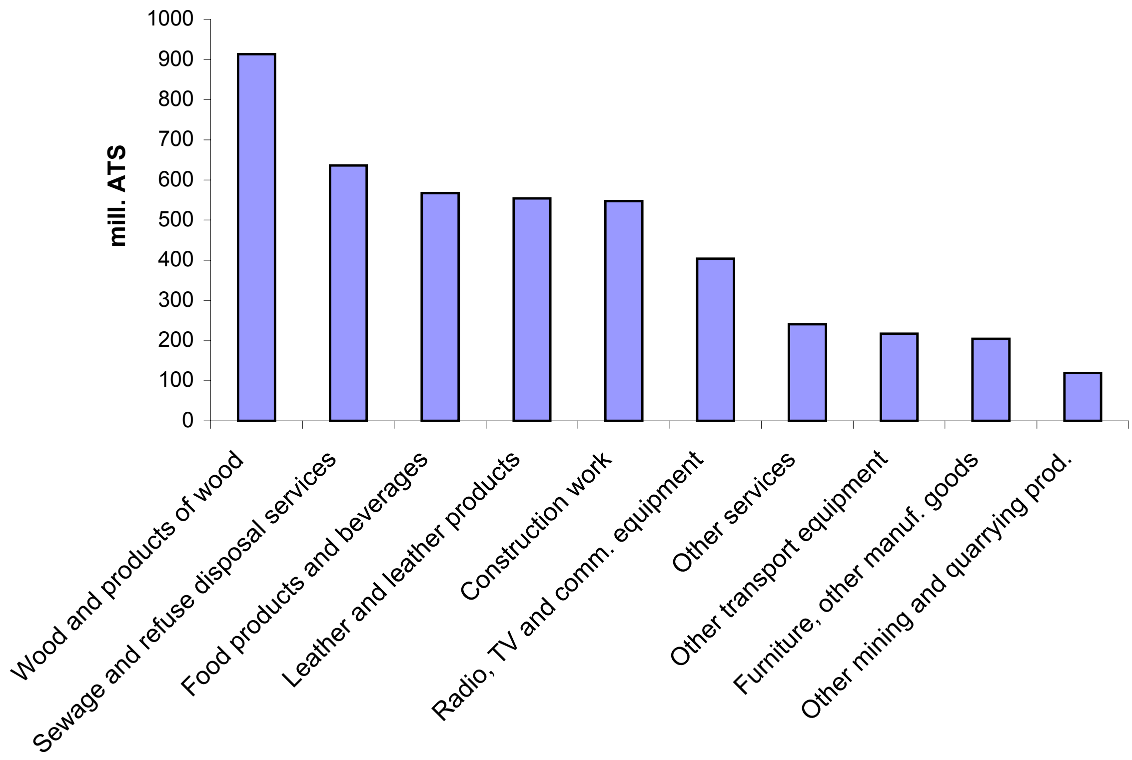


Figure 7.17: Value of main net exports from the Feldbach region

The Feldbach foreign exchange deficit is of disproportional size compared to the Austrian one. While Austria shows a deficit of 2,9 % of total domestic value added, Feldbach's deficit amounts to 12,4 % of total regional value added. Feldbach's economy seems particularly weak in service activities and strong in the manufacture of goods. While the balance of services deficit is up to about 20 % of regional value added, the balance of goods shows a surplus of 7,6 % of regional value added.

The foreign exchange deficit of the Feldbach region does not represent a major threat to the solvency of the region as the number of people working in surrounding regions transfer their wages to the Feldbach region. But the results characterise an economic system that is highly dependent on the ROW.

7.3.5 The Survivability Consumption Index for Feldbach

The Feldbach region's Survivability Consumption Index is calculated by multiplying Austrian final uses for C_{SURV} by the reduction factors for GFCF and FCE (see Table A20 for calculations).

SCI_{1995} = 4303 mill. ATS

The composition of products for C_{SURV} is virtually unchanged in relation to the Austrian composition (which of course is a result of the reduction factors applied). All other results as well are analogous to Austrian results.

7.3.6 The Economic Efficiency Index for Feldbach

Starting point for the calculations of the regional Economic Efficiency Index is the value of net exports and net imports from and to the region. Together with the share of products for intra-economic use taken from the national calculations ($P_{i\ imp\ econ}$, $P_{i\ exp\ econ}$) direct imports to the Feldbach economic system and direct exports to ROW economic systems are determined. Indirect imports and exports (products needed for the provision of direct imports and exports) are calculated on the basis of the regional use tables. Domestic as well as imported flows are considered. Calculations follow the way outlined in Section 7.2.5. The value of net imports and exports multiplied by $A_{iP\ spec}$ yields the SPI area imported to the Feldbach economic system and exported from the Feldbach economic system to ROW economic systems. Value products provided by the Feldbach economy (U_{RV}) are calculated analogously to calculations for Austria. Reduction factors for industries (RF_i) are applied.

The results for the Feldbach economy are:

$A_{R\ econ}$ = 55585 km^2

$A_{P\ imp\ econ}$ = 32131 km^2

$A_{P\ exp\ econ}$ = 20526 km^2

$A_{tot\ econ}$ = 67189 km^2

$C_{S\ dom}$ = 6921 mill. ATS

EEI_{FB} = 0,10 mill. ATS / km^2

Calculations of $C_{S\ dom}$ are shown in Table A21, of $A_{tot\ econ}$ in Table A22.

The difference between the Feldbach economic efficiency and the Austrian economic efficiency (0,14 mill. ATS / km^2) has mainly two reasons. First, the composition of total products for final uses differs slightly between the two economic systems. While 30 % of the products provided by the Austrian economy are products for consumption surplus, only 29 % of the Feldbach economy's products fall into that category. Second, the composition of the consumption surplus products (in terms of SPI area incorporated in the product in relation to the basic price of the product) is different. While up to this point only industries and their value added – SPI area efficiency have been considered, we use incorporated value added (basic prices) and incorporated SPI area in products for this analysis (aggregation along the process chain). It can be seen that the share of products with a high price per incorporated SPI area ratio is higher for Austria than for Feldbach. In other words, Feldbach produces more consumption surplus products with lower prices and higher area consumption along the process chain than Austria. Education services (1,18 mill. ATS/km^2) account for 5,7 % of Austrian consumption surplus products and 4,6 % of Feldbach consumption surplus products. Real estate services (1,26 mill. ATS/km^2) represent 15,2 % of Austrian consumption surplus products and 9,3 % of Feldbach consumption surplus products, Retail trade services (0,99 mill. ATS/km^2) 12,7 % of Austrian consumption surplus products, 14,8 % of Feldbach consumption surplus products, Post and telecommunication services (1,3 mill. ATS /km^2) 2,1 % for Austria and 0,2 % for Feldbach.

7.3.7 The Import and Export Efficiency Indices for Feldbach

The Import and Export Efficiency Indices for the Feldbach region are calculated on the basis of total net imports and total net exports to and from the region. As with the Austrian calculations, exports are assumed to have incorporated only the regions area consumption and value added, while imports have incorporated total SPI area and value added (imported plus domestic) according to the Austrian use table. Incorporated area and value added are calculated with area consumption per unit of product and value added per unit of product.

The results for Feldbach are:

$A_{P\ imp}$ = 38749 km^2

$A_{P\ exp}$ = 20989 km^2

$VA_{P\ imp}$ = 5649 mill. ATS

$VA_{P\ exp}$ = 3136 mill. ATS

IEfI = 0,146 mill. ATS / km^2

EEfI = 0,149 mill. ATS / km^2

Detailed calculations are shown in Table A23.

The first striking point of the results for regional import an export efficiency is the considerable difference to the Austrian values (IEfI = 0,104 mill. ATS / km^2, EEfI = 0,112 mill. ATS / km^2). Apparently, the share of high value – low area products in trade is much higher on the regional than on the national level. The main reason for this is that the lion's share of interregional trade takes place within one nation and that especially high efficiency products are traded within nations regardless of regional borders but not between nations. A look at trade flows at the single product level makes the difference visible. (Table 7.6) Here again, the analysis shows products that are directly or indirectly (incorporated in other products) traded.

Tab. 7.6: Share in total trade flows of high efficiency products for Feldbach and Austria

Product	Efficiency [mill. ATS / km^2]	Share in Austrian trade flows [%]	Share in Feldbach trade flows [%]
Other business services	3,93	7,3	7,9
Real estate services	11,45	2,2	7,1
Post and telecom. services	2,06	2,1	4
Education services	1,30	0,2	2,7
Renting services of machinery and equipment	23,57	1,7	1,4
Health and social work services	1,31	0,1	1,4
Computer and related services	14,34	0,9	1,3

It can be seen that regional trade in Real estate services, Post and telecommunication services and Education services is particularly high in relation to international exchange of these products.

But regional trade in high efficiency products and its absence on the international level can be used to explain only one of the two regional efficiency ratios. As the Feldbach region is a net importer of all products listed in Table 7.6, the reason for its high export efficiency has to be found elsewhere. A look at export data shows that, on the one hand, Feldbach is weak in high efficiency exports. Intuitively, one could conclude that the regions export efficiency is lower than its import efficiency. But a closer look reveals that the Feldbach region does not export products of very low efficiency either. Feldbach is a net importer of low efficiency products. The region’s main exports are of medium efficiency. Table 7.7 shows the efficiency of main imports and export of value added. Table 7.8 shows the efficiency of main imports and exports of SPI area.

Table 7.7: Efficiency of main imports and exports in terms of value added

Import		Export	
Product	Efficiency [mill. ATS / km^2]	Product	Efficiency [mill. ATS / km^2]
Other business services	3,93	Sewage and refuse disposal services	0,18
Real estate services	11,45	Wood and products of wood	0,10
Land transport services	0,14	Construction work	0,79
Post and telecom. services	2,06	Food products and beverages	0,17
Hotel and restaurant services	0,44	Leather and leather products	0,24
Electrical energy etc.	1,87	Radio, TV and comm. equipment	0,72
Chemicals	0,07	Other services	22,16
Products of agriculture, forestry	0,03	Products of agriculture, forestry	0,03
Education services	1,30	Other mining and quarrying products	0,03
Recreational, cultural and sporting services	0,56	Other transport equipment	0,60

Table 7.8: Efficiency of main imports and exports in terms of SPI area

Import		Export	
Product	Efficiency [mill. ATS / km^2]	Product	Efficiency [mill. ATS / km^2]
Basic metals	0,02	Wood, products of wood	0,10
Coke, refined petroleum products	0,02	Products of agriculture, forestry	0,03
Products of agriculture, forestry	0,03	Other mining and quarrying products	0,03
Chemicals	0,07	Leather and leather products	0,24
Land transport services	0,14	Other non-metallic mineral products	0,05
Pulp, paper and paper products	0,04	Food products and beverages	0,17
Coal and lignite	0,01	Sewage and refuse disposal services	0,44
Crude petroleum, natural gas, metal ores	0,06	Radio, TV and comm. equipment	0,72
Fabricated metal products	0,25	Construction work	0,79
Rubber and plastic products	0,16	Other transport equipment	0,60

It can be seen that while the main imports to the Feldbach region in terms of value added have very high efficiency, the main imports in terms of SPI area are of very low efficiency. 40 % of overall SPI area imported is incorporated in Basic metals and Coke and refined petroleum products the efficiency of which is among the lowest. In contrast, main exports in terms of value added and main exports in terms of SPI area can be attributed to mostly the same products (an indication for average efficiency). It can be seen that the main SPI area exports are due to products of still low efficiency but of considerably higher efficiency than that of Basic metals and Coke and refined petroleum products. The comparatively small differences in efficiency of main imports and exports in terms of SPI area outweigh the higher differences of main imports and exports in terms of value added because trade in SPI area is highly concentrated on few products (10 main products: 97 % of SPI area exported, 86 % of SPI area imported) while trade in value added can be attributed to a greater number of products. (Figures 7.18 to 7.21)

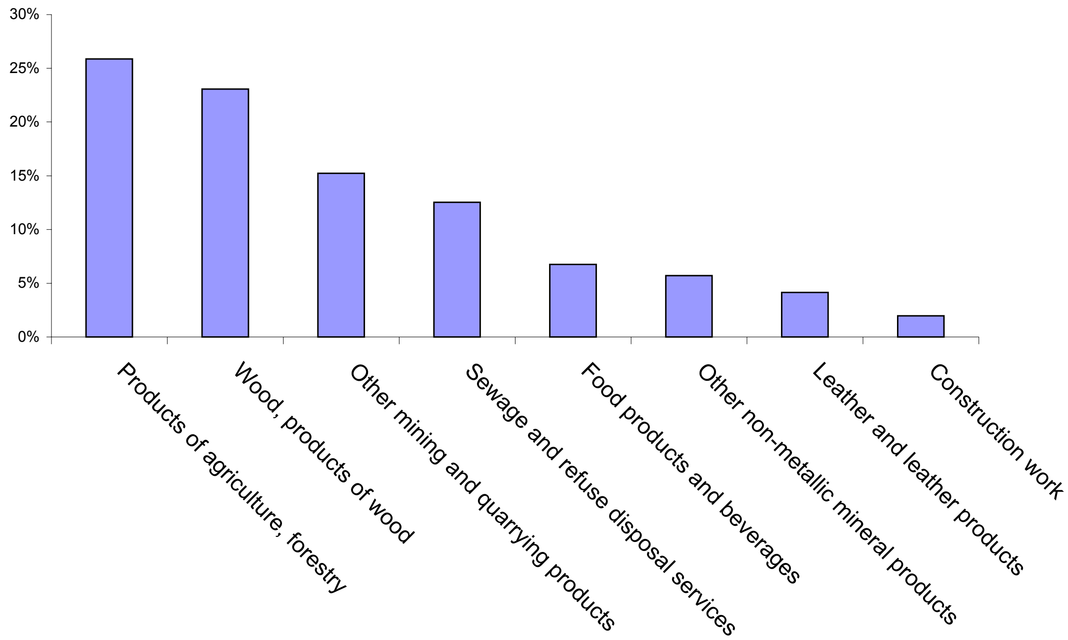


Figure 7.18: Main SPI area exports from Feldbach in percent of total SPI area export

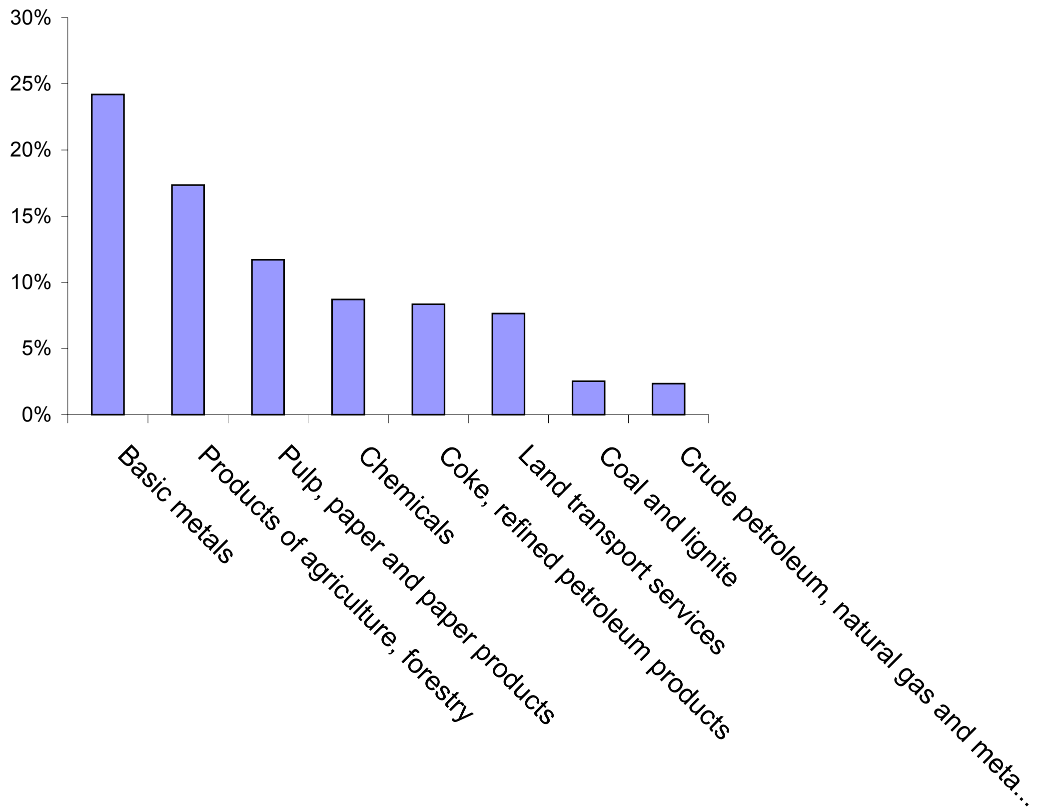


Figure 7.19: Main SPI area imports to Feldbach in percent of total SPI area import

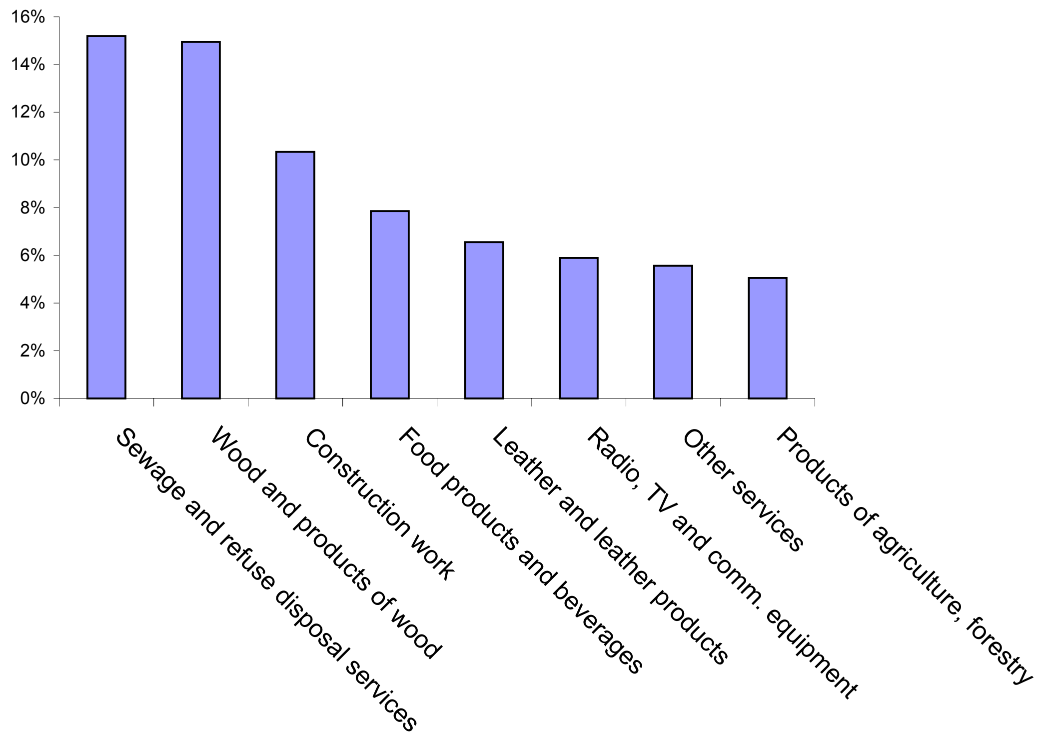


Figure 7.20: Main exports of value added from Feldbach in percent of total value added exported

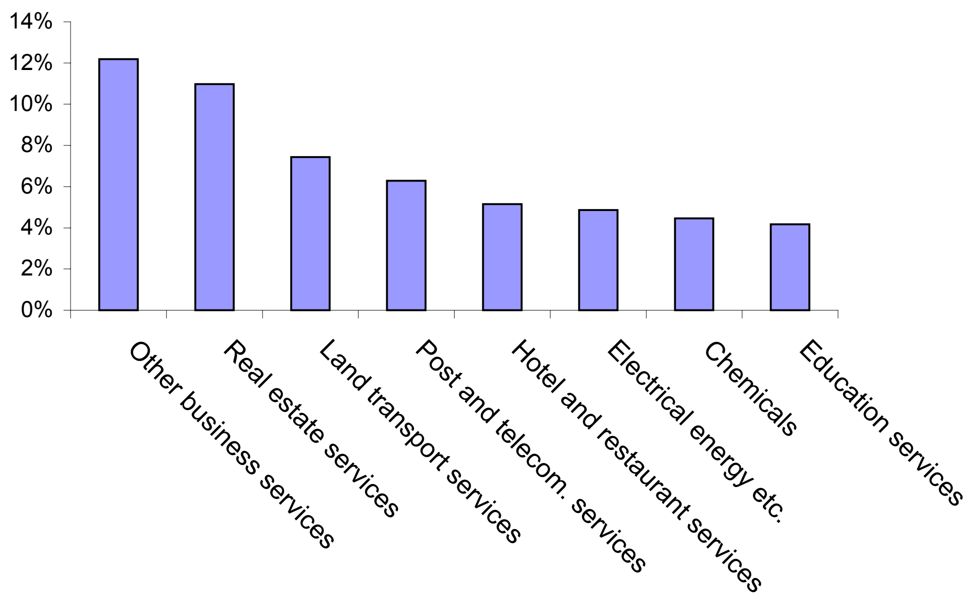


Figure 7.21: Main imports of value added to Feldbach in percent of total value added imported

7.3.8 The Functional Composition Index for Feldbach

As for Austria, the functional composition of the Feldbach economic system is calculated on the basis of regional flows only. Intermediate regional flows are derived from regional supply and use tables. As no classes of final uses are available for Feldbach, the repartition of flows to the Consumption surplus function and the Production function is assumed to be identical with the Austrian final uses. Thus, the share of the domestic supply of a product used for Production and Consumption surplus is the same for Austria and Feldbach. Survivability products can be ascribed to 100 % to the Survivability function.

The results for Feldbach are:

$FCI_{VA\,S}$ = 30,7 %

$FCI_{VA\,P}$ = 23,7 %

$FCI_{VA\,C}$ = 45,6 %

$FCI_{A\,S}$ = 45,4 %

$FCI_{A\,P}$ = 20,7 %

$FCI_{A\,C}$ = 33,9 %

Calculations at the product level are shown in Table A24.

Table 7.9 shows a comparison in functional composition between Austria and the Feldbach region. It becomes visible, that the Feldbach Survivability consumption function takes up a greater share of total economic activity than the Austrian one (in terms of area consumption as well as value added). On the other hand, the Austrian Consumption surplus function is of considerably bigger relative size than the Feldbach region's Consumption surplus function. The Austrian Production is smaller and terms of value added but bigger in terms of area consumption than its Feldbach counterpart.

Table 7.9: Functional composition in percent of total SPI area and total value added of the Austrian and the Feldbach economy

	Austria		**Feldbach**	
	Value added	SPI	Value added	SPI
Survivability	25,3	28,0	30,7	45,4
Production	25,8	40,9	23,7	20,7
Cons. surplus	48,9	31,1	45,6	33,9

Striking differences in efficiency between the regional and the national economic functions can be detected. While Austria has highly efficient Survivability and Consumption surplus functions, its Production function is of low efficiency in relation to the Feldbach Production function. (Table 7.10)

Table 7.10: Efficiency of economic functions [mill. ATS / km2] for Austria and the Feldbach region

	Austria	Feldbach
Survivability	0,22	0,16
Production	0,15	0,27
Cons. surplus	0,38	0,32

Analysis at the product level (Tables 7.11 – 7.14) shows that main value adding products are to a significant extent ascribed to the Consumption surplus and the Survivability function. Many high efficiency products have high value shares (e.g. Real estate services, Retail trade services, Post and telecommunication services), a fact that partly explains the high overall efficiency of the Consumption surplus function relative to the other functions for Feldbach as well as Austria. The relatively high efficiency of the Austrian Survivability function is mainly due to Public administration services, Health and social work services, Education services and Electrical energy, gas. The Feldbach Survivability function is composed of higher shares of Food products and beverages and Products of agriculture the low efficiency of which explains the lower overall efficiency compared to Austria. The Production function consists of medium efficiency products when main value adding products are considered (Construction work, Wholesale trade services, Land transport services, Machinery and equipment, Wood and products of wood, Radio, TV and communication equipment). With a rather high share of Other business services Austria's Production function has a somewhat higher efficiency than Feldbach's Production function when the focus is on main value adding products. A look at the functional allocation of main area consuming products shows that while low efficiency products are rather evenly distributed among the three functions for Feldbach, the main share of low efficiency products is allocated to Production in Austria. Basic metals are at the origin of more than 16 % of total SPI area consumption are to 86 % allocated to Production. Other products of very low efficiency show similar allocation (Pulp, paper and paper products, Chemicals and chemical products).

Table 7.11: Functional allocation of main value adding products for Feldbach

	Survivability [%]	**Production [%]**	**Cons. Sur. [%]**	**Efficiency [mill. ATS / km^2]**	**% of total VA**
Construction work	5	46	49	0,79	10
Public administration services	100	0	0	1,16	9
Wholesale trade services	9	43	48	1,22	7
Retail trade services	3	4	93	1,14	6
Health and social work services	100	0	0	1,31	6
Food products and beverages	88	0	12	0,17	5
Real estate services	5	9	86	11,45	5
Education services	50	0	50	1,30	5
Products of agriculture and forestry	83	2	15	0,03	5
Wood, products of wood	1	41	58	0,10	4
Sewage disposal services	14	8	78	0,18	4
Radio, TV and com. equipment	1	83	16	0,72	3
Hotel and restaurant services	2	7	91	0,44	3
Leather and leather products	1	24	75	0,24	2

Table 7.12: Functional allocation of main area consuming products for Feldbach

	Survivability [%]	**Production [%]**	**Cons. Sur. [%]**	**Efficiency [mill. ATS / km^2]**	**% of total SPI area**
Products of agriculture and forestry	83	2	15	0,03	40
Other non-metallic mineral products	3	55	42	0,05	9
Wood, products of wood	1	41	58	0,10	11
Other mining and quarrying products	36	28	36	0,03	7
Leather and leather products	1	24	75	0,24	2
Food products and beverages	88	0	12	0,17	5
Public administration services	100	0	0	1,16	2
Construction work	5	46	49	0,79	2

Table 7.13: Functional allocation of main value adding products for Austria

	Survivability [%]	Production [%]	Cons. Sur. [%]	Efficiency [mill. ATS / km^2]	% of total VA
Construction work	5	46	49	0,79	8,2
Real estate services	4	7	89	11,45	8,0
Public administration services	100	0	0	1,16	7,1
Wholesale trade services	8	46	46	1,22	6,7
Health and social work services	100	0	0	1,31	6,1
Education services	50	0	50	1,30	5,7
Retail trade services	2	3	94	1,14	4,9
Other business services	11	44	46	3,93	4,4
Hotel and restaurant services	2	4	94	0,44	4,2
Land transport services	8	33	60	0,14	3,7
Products of agriculture and forestry	71	7	22	0,03	2,9
Food products and beverages	84	1	15	0,17	2,8
Electrical energy, gas etc.	52	14	34	1,87	2,8
Post and telecom. services	11	20	69	2,06	2,7
Machinery and equipment	2	86	12	0,66	2,2
Trade and repair services of motor vehicles	3	22	75	1,22	2,2

Table 7.14: Functional allocation of main area consuming products for Austria

	Survivability [%]	Production [%]	Cons. Sur. [%]	Efficiency [mill. ATS / km^2]	% of total SPI area
Basic metals	2	86	12	0,02	16,63
Products of agriculture and forestry	71	7	22	0,03	23,36
Other non-metallic mineral products	4	53	43	0,05	6,49
Land transport services	8	33	60	0,14	6,22
Pulp, paper and paper products	7	70	23	0,02	10,57
Coke, refined petroleum products	47	27	26	0,02	3,71
Chemicals, chemical products	4	67	29	0,07	3,31
Public administration services	100	0	0	1,16	3,60
Food products and beverages	84	1	15	0,17	3,11

7.4 Concluding Remarks on the Sustainability Assessment

In Section 6.4, it has been held that sustainability assessment cannot be limited to a simple comparison between an actual and a targeted (reference) state. Sustainability criteria (reference states) can only serve as guidelines for the assessment of the development of economic systems over time. Then, sustainability assessment should be done interpreting trends towards or away from states of sustainability rather than focusing on single points in time.

Such long term analyses lie beyond the scope of this thesis. In consequence, our case studies do not provide the assessment of trends towards or away from sustainability. Their view is restricted to the analysis of one point in time. Moreover, comparable studies on other economic systems would be needed to allow for more profound interpretation of indices such as the Economic Efficiency Index or the Function Composition Index. However, some conclusions can be drawn from the case studies:

- For both economic systems, the area consumed for the supply of resources and the dissipation of residuals exceeds by far the geographical area available. With Ecological Sustainability Indices of 42 (Austria) and 31 (Feldbach) both economic systems are far from a state of sustainability. The Feldbach district “finances” its ecologically somewhat better position by importing “dirty” products such as petroleum products, paper and basic metals.

- Both economic systems are sustainable from a consumption surplus point of view over a period of 5 years (1990-1995). There is a lack of data for the Feldbach districts final uses (and therefore the Consumption Surplus), though.
- Economic exchange is more or less balanced for Austria. A deficit of about 3 % of GDP does not represent a significant threat to the solvency of the national economy. For the Feldbach district the situation is different. As it is not only a net importer of low value – high area products but also of many high value services, its exchange deficit amounts to over 12 % of total regional value added. Solvency problems and significantly lower real wages compared to the Austrian economy are counteracted by a large number of commuters to adjoining districts that transfer their wages to the Feldbach district.
- The Feldbach district’s weakness in services is not only the cause for the exchange deficit but also reduces the district’s overall economic efficiency (Consumption surplus per area used). Its Economic Efficiency Index is at only 70 % of the Austrian one.
- Both economic systems show export efficiencies that are only insignificantly than the import efficiencies. For the Feldbach district – that is weak in high value services – this is due to the production of a considerable amount of medium efficiency products. Low efficiency products and high efficiency services are imported, medium efficiency products are exported. Many of the high efficiency services that Austria exports to the Feldbach region are not traded at the international level. 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. Feldbach has a low efficiency Survivability function and medium to high efficiency Production and Consumption surplus functions.

The main weaknesses lie for both economies in the consumption of natural sources and, above all, sinks. The overuse of natural capital represents the main threat for the sustainability of the Austrian and the Feldbach economies. A second very critical point is the Feldbach exchange deficit.

8 Conclusions

The theoretical foundations for statistical analysis of economic sustainability are laid. Systems Theory, Economic Statistics, Ecology and other disciplines have developed theoretical bodies of sufficient explanatory strength to allow for comprehensive analysis of economic sustainability as it is understood by this thesis.

Empirical studies at the regional as well as the national level are few. Standardised data collection, mainly of physical flows, is about to start. These data will be available for national economic systems only and one would most probably expect to much from our statisticians by calling for comprehensive data survey at the regional level as well. Therefore, regional sustainability assessment will always have to rely upon national data converted by auxiliary methods. As economic sustainability analysis has to focus on trends, structures and design patterns of economic systems rather than specific singular ecological or economic problems, the accuracy of the data base – though it is of course not irrelevant – does not represent a major obstacle for regional sustainability assessment as we see it.

What seems more important is that the guiding principles of economic sustainability – nature, consumption surplus and solvency – are considered at the national as well as the regional level. In concrete terms this calls for an extension of what today is presented as a System of Environmental Economic Accounts. While 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 in this respect.

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 co-operation and symbiosis that may create win-win situations from the viewpoint of economic sustainability. Further work is needed to make clear possible patterns of co-operation between continents, nations and regions and to explain how economically unsustainable parts can give a sustainable whole.

Moreover, further research on possible paths towards sustainability is necessary. Strategies for the investment of today’s natural sources and sinks for future sustainability are indispensable as wide-ranging technological changes seem to be one out of a number of inevitable measures on the way to a more sustainable future.

The implementation of a system of indices of economic sustainability is feasible at the national level as well as the regional. Statistical instruments are readily available at national statistical offices. Aid to convert national data to regional data can be provided in form of software programs and the like. Thus, it seems possible to carry out economic sustainability analysis from the national down to the (Austrian) district level. What is needed and what calls for further research is first the development of a clear-cut notion of economic sustainability on the basis of criteria such as those presented in this thesis. Then, possible sustainable development paths can be elaborated on the basis of this notion. These development of the paths requires beside scientific statistical and modelling knowledge the contribution of relevant economic, political and social actors.

9 References

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