Tilastokeskus
Statistikcentralen
Statistics Finland

Tutkimuksia
Forskningsrapporter
Research Reports
253

Economy-wide Material Flow Accounts with Hidden Flows for Finland: 1945–2008

Jukka Hoffrén (ed.)

Tilastokeskus
Statistikcentralen
Statistics Finland

Tutkimuksia
Forskningsrapporter
Research Reports
253

Economy-wide Material Flow Accounts with Hidden Flows for Finland: 1945–2008

Jukka Hoffrén (ed.)

Päätoimittaja – Chefredaktör – Principal editor:
Timo Alanko

Toimittajat – Redaktörer – Editors:
Jukka Hoffrén (ed.)

Taitto – Ombrytning – Layout:
Eeva-Liisa Repo

ISSN 1798–8578
= Research Reports
ISBN 978–952–244–233–8 (pdf)
ISBN 978–952–244–232–1 (print)

Helsinki – Helsingfors 2010

Foreword

Unsustainable population growth and trends in economic growth are the key challenges of EU environmental policy. These unsustainable trends are leading to overexploitation of environmental and natural resources and are thus also accelerating environmental hazards like climate change and greenhouse gas (GHG) emissions. The aim of EU environmental policy is at the moment to focus on reductions in the quantitative exploitation of nature to levels which will ensure viability. This would also reduce the undesirable environmental impacts that are determined by the magnitude of material flows. The particular subject of interest is extraneous material flows (hidden flows, HF) caused by the exploitation of natural resources. Although hidden flows are of no direct economic benefit, they undermine the viability of ecosystems.

This report represents the conclusion of the actions and procedures contained in the *Pilot study on economy-wide material flow accounts with hidden flows in Finland* project conducted from 2008 to 2009 at Statistics Finland. The aim of the project was to establish methodological and practical working methods for compiling reliable Finnish Material Flow Accounts (FIN-MFA) that include both direct material flows (DF) and hidden material flows in the Finnish economy. The physical flows of materials between the national economy, the global economy and the environment, as well as the accumulation of materials in the economy are represented by several aggregate MFA measures that were calculated for Finland during the project. The aggregate MFA measures take account of natural resources, products and their residuals, as well as their hidden flows. The reliability of MFA accounts has been improved and the multipliers used in the estimation of hidden flows were revised and updated during the project. Continued research in this area includes additional MFA account improvements and the ongoing updating of the multipliers used in the estimation of hidden flows.

This report was compiled by Head of Research Dr. Jukka Hoffrén (editor), Researcher Ms. Eeva-Lotta Apajalahti and Senior Statistician Ms. Hanna Rättö of Statistics Finland. The data on imported and exported material flows was also collected by Ms. Jenny Rinkinen, Ms. Anna Etelä-aho and Mr. Juha Kapulainen. Mr. Jukka Muukkonen provided many valuable comments during the project. The aim of the investigation is to introduce material flow accounting on a permanent basis into the production of Finnish statistics and to make proposals for further improvements. The project was financed by Eurostat, the Statistical Office of the European Communities, (Eurostat Grants for 2007/Theme 71/Module 71401 Environmental accounts/First priority area: Economy wide material flow accounts recommended for harmonised reporting EU wide).

Helsinki, January 2010

Jukka Hoffrén

Contents

Concepts

Direct Material Flow, DMF

This is an aggregate indicator that describes, in terms of total tonnage, the quantity of natural resources and recycled material entering the economy. The indicator can be used to assess improvements in the material intensiveness of a national economy, the introduction of more efficient production technologies and the achievement of the Factor objectives.

Direct Material Input, DMI

This is an aggregate indicator developed by Eurostat and its Task Force on Material Flow Accounting to describe, in terms of total tonnage, the quantity of natural resources contained in commodities produced by the economy.

Direct Material Consumption, DMC

This is an aggregate indicator to describe, in terms of total tonnage, the quantity of natural resources contained in commodities produced by the economy minus exports.

Eco-efficiency

A social action strategy which seeks to reduce the use of materials in the economy in order to reduce undesirable environmental impacts. Ever smaller quantities of materials have to produce a relatively higher degree of economic affluence which is more fairly distributed. The general objective of Eco-efficiency is to ”get more from less” (this is also known as qualitative growth).

Ecologically sustainable development

Ecologically sustainable development, also referred as *strong sustainability*, is the strictest definition of the goal of sustainable development policy, seeking to conserve the well-being of the natural environment under all circumstances. It is axiomatic here that the natural capital (or environment) cannot be replaced by any other commodity. This is the most common definition of sustainable development.

Ecological rucksack

The material and energy inputs required for a particular product over its entire life cycle that remain hidden from the consumer.

Environmental accounting

A system of accounting which gathers the relevant statistical data of natural resources, the quality of ecosystems and human environmental impacts in a systematic manner. Natural resource and material flow accounting provides a basis of environmental information for environmental accounting which seeks to express this information in financial terms and by using indicators. The system furnishes society with a comprehensive picture of the state of the natural environment and makes it possible to calculate gross national product adjusted for environmental factors, i.e. so-called "green GNP". The United Nations Statistical Office established the first SEEA environmental accounting system in 1993. A revised SEEA manual was published in 2003.

FIN-MFA

The Finnish Material Flow Accounting System with hidden flows (FIN-MFA) is a system of Finnish material flow accounts with hidden flow accounts from 1944 to 2007 developed in the *Pilot study on economy-wide material flow accounts with hidden flows in Finland* project in 2008-2009.

Gross Domestic Product, GDP

Gross Domestic Product (GDP) indicates the magnitude of total economic activity of a society in monetary terms by presenting the total value added produced by all institutional units resident in a country. GDP is the primary indicator of National Accounts (SNA).

Hidden Flows, HF

Extracting or harvesting primary natural resources often requires moving or processing large quantities of materials that can modify or damage the environment even though they have no economic value. These flows are classified as hidden flows. Hidden flows are not used for any specific area of production or consumption in the economy. There are two concepts associated with HF: *unused material extraction* and *indirect material flows*. The Wuppertal Institute recommends use of these more precise terms over HF.

Factor 4

This is an objective where the input of natural resources, raw materials and energy in each unit of production is to be reduced to one quarter of its current level in the medium term, i.e. over the next 20 to 30 years.

Factor 10

This is an objective where the input of natural resources, raw materials and energy in each unit of production is to be reduced to one tenth of its current level in the long term, i.e. over the next 30 to 50 years.

Material Flow Accounting, MFA

Material flow accounts entail accounting for materials from their extraction in the environment, via processing and use to outputs to the environment. MFA is a monitoring system for national economies based on methodologically organised accounts and denoting the total amounts for materials that flow in and out of an economy. Economy-wide MFA is a related concept which only involves flows that cross the system boundary of the economy in question. Material flow accounting enables the monitoring of total consumption of natural resources and the associated hidden flows, as well as the calculation of DMF and TMF indicators.

Material Flow Analysis, MFA

This is an evaluation method which assesses the efficiency of the use of materials with information from material flow accounting. Material flow analysis helps to identify the waste of natural resources and other materials in an economy, which would otherwise go unnoticed in conventional economic monitoring systems.

Material Input, MI

This is the sum of used and unused resources per unit e.g. the material required to produce one product. At the outset it gives the information necessary, for example, to compare various material alternatives.

MIPS (Material Input Per Service)

This is a unit of measurement developed by the German Wuppertal Institute, where the material intensiveness of various products and services can be monitored in relation to a single commodity unit produced.

Material Intensity, MIT

This is material input (MI) in relation to weight, energy or transport units. MIT includes all the material needed to produce the raw material or commodity as well as the weight of the material or product itself.

Sustainable Development, SD

The policy of sustainable development was introduced by the WCED in 1987 in response to the problems caused by economic growth. The aim of the policy of sustainable development is to *"satisfy current needs and conserve for future generations the opportunity to satisfy their own needs"*. This concept has several interpretations in practice, the most commonly known being strong and weak sustainable development.

System of National Accounting, SNA

This is an organised system of social monitoring based on methodical accounts describing the scope of activities in an economy in financial terms. Such systems are based on macroeconomic theory developed in the 1930s and 1940s. The primary indicator of the accounting system is Gross Domestic Product (GDP) which indicates the magnitude of economic activity in monetary terms.

Total Material Consumption, TMC

This is the total quantity of domestic and foreign resources needed for domestic production and consumption. It includes domestic and imported hidden flows, but excludes exports and their hidden flows. TMC is thus an indicator of the amount of material one economy uses.

Total Material Flow, TMF

An overall economic indicator which describes, in terms of total tonnage, not only the quantity of natural resources contained in the commodities produced by an economy, but also the hidden flows which are involved in such production. These material flows, which remain outside the economy, include wood materials which are not used in logging (branches, needles, leaves and roots), earth and stone which is excavated in mining and quarrying, along with usable ore and minerals, the earthworks necessary in the construction of infrastructure systems (roads and communities) and erosion resulting from human activities (including intensive agriculture).

Total Material Requirement, TMR

This is the sum of the total material input and the hidden material flow in an economy. It includes all the domestic and imported natural resources that the economy requires directly or indirectly. TMR is said to give the best overall estimate for the potential environmental impact associated with one economy's total natural resource extraction and use.

Unused Extraction, UE

Unused material extraction refers in most cases to domestic extraction residuals resulting from the extraction of natural resources. Unused material extractions are not treated or refined thus remain in the environment.

1 The Development of Material Flow Accounting

1.1 Sustainable development policy targets and material flows

National economies and the general public received a practical foretaste of the scarcity of natural resources with the first oil crisis in 1973-1975, which caused a deep recession in the world economy and subsequently prompted the industrialised countries to improve their energy efficiency. Despite these warnings, the solutions offered by conventional economic thinking for dealing with these problems were inadequate. Consequently, a total halt in economic growth in order to avoid the catastrophe threatening humanity has been proposed by many researchers. In the short term, the dependence of the industrialised countries on existing production structures and technologies, combined with people's desires, effectively outlined the possibilities available to governments. In the long run, the development was hampered by the reluctance and incompetence of scientists to provide answers to these problems. Solving these problems was almost totally to rely on technological development. (see e.g. Meadows et al 1992 and 1972).

In the political field – problems such as scarcity of resources, poverty in the developing countries, loss of biodiversity, pollution and waste, could not be ignored. Consequently, the General Assembly of the United Nations established the World Commission on Environment and Development (WCED) in 1983 to provide concrete recommendations for action on the interrelated issues of environment and development, as seen from the strategic long-term viewpoint. The WCED's final report, "Our Common Future", in 1987, introduced the "policy of sustainable development" to answer the problems caused by current economic growth. The WCED also proclaimed that the policy of sustainable development must *"satisfy current needs and conserve for future generations the opportunity to satisfy their own needs"*. This embraces two key concepts: the concept of needs, in particular the essential needs of the world's poor to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs. Thus, living standards that go beyond the basic minimum are sustainable only if consumption standards everywhere have regarded for long-term sustainability. (WCED 1987, 43–44)

Within the European Union, the first Eurostat (Statistical Office of the European Communities) conference to monitor the material balances of national economies was organised in March 1995. National economy material flow accounts, covering a large number of materials with widely varying environmental impacts, were produced in EU member countries' national statistical institutes in Austria, the Netherlands, Germany, and Sweden as well as in Norway (e.g. see Jonsson et. al 2000). The ConAccount (Co-ordination of Regional and National

Material Flow Accounting for Environmental Sustainability) co-ordinating project on material flow accounting and analysis was set up with European Union support (1996-1998) in order to co-ordinate the interest felt in this matter. The aim of the project was to promote research and co-operation between researchers pertaining to material flows and to establish links with decision-makers. (For further details see Bringezu et al. 1998 and Bringezu 1997). The project had a major influence on the development of national economy MFAs in Europe. Associated investigations were also conducted into the use of materials in certain industrialised societies, e.g. the USA, Japan, the Netherlands and Germany. In 2000 a follow-up study to the Wuppertal Institute's research work was conducted on the material outflows of the above-mentioned countries and Austria in order to learn more about the potential environmental burden of material flows (See Matthews 2000, 6).

Eurostat's *Economy-wide material flow accounts and derived indicators Guide*, which was first published in 2001, can be considered a start to compiling MFA in Europe (for the latest version see Weisz et al 2007). In addition, the OECD has carried out a *work programme on material flows and resource productivity* and has published (2008) a guide and accounting framework for compiling MFA in its member countries. Thus, basic frameworks and guidelines on compiling MFAs exist, but the establishment of a common integrated database on MFA is yet to see fulfilment.

1.2 Aim of the approach

The ecological impacts of human activities are induced by material flows that comprise, among other things, energy carriers, minerals, fuels, sand and gravel, soil, water, air and overburdening. In principle, all masses moved by human-made technical means have some environmental impacts and they should be taken into account. The first law of thermodynamics, i.e. the principle that the amount of material and energy remains constant in any flow or process in a system, claims that the input and output of a process must be equal. This is true for materials as well as for energy flows. To the extent that environmental impacts are the consequence of the magnitude of total material input into production in an economy, they can be lessened by reducing the use of materials e.g. by concentrating on what has been called qualitative growth. Materials accounting systems are a means by which the stocks and appropriate flows of natural resources can be combined in a single holistic system describing their interaction.

Estimations made by the United Nations suggested that the world population would increase from 2.5 billion to 6.1 billion between 1950 and 2000. Recent projections propose that the world population will go up to 8.9 billion by the year 2050. Thus, the rapid growth of the world population is set to continue. The UN has also predicted that, while the population of industrialised countries will in future remain at approximately the present level of 1.2 billion, that of the developing countries will rise from the present 4.8 billion to 7.7 billion. Experiences from the 1950-2000 period predicts that this population growth will inevitably increase material consumption, which is one of the main factors contributing to well-being, but also to environmental hazards.

It was in 1972 when environmental issues arrived on the agenda of global relations at the first international meeting focusing on the environment, the UN Conference on the Human Environment, which was held in Stockholm, Sweden. In the same year the United Nations Environmental Programme (UNEP) was established, with the objective of bringing together various United Nations agencies to work for environmental protection and formulate proposals on environmental issues. The Club of Rome report warned about the scarcity and the limits of natural resources that endanger the continuation of current kind of economic growth in industrialised countries.

The Eco-efficiency perspective is based on the idea of producing more from less i.e. qualitative growth. The main driving force behind increasing material flows (and ecological impacts) is growing material consumption which is driven by world population growth. As the world population is rapidly increasing, the average standard of living of the majority is improving, resulting also rapid increases in material flows. According to United Nations, rapid world population growth is set to continue. However, through Eco-efficiency improvements i.e. reducing the use of materials per unit of well-being, a greater population can be even sustained with less energy and by using fewer material resources. To estimate the use of materials in economic activities and to identify possible Eco-efficiency improvements, a systematic compilation of material flows is needed. Material Flow Accounting (MFA) aims to estimate the quantities of biosphere resources consumed by mankind in concrete physical figures. MFA and its main indicators are closely tied to the monitoring of sustainable development (e.g. see Moll et al 2005, Bringezu et al 2004 and 2003, Hinterberger et al 2003, OECD 2002 and 1998).

1.3 The Development of MFA accounting in EU member countries

During the 1990s, pioneering work was carried out by the German Wuppertal Institute on the adoption of Material Flow Accounting (MFA) techniques for monitoring the overall quantities of materials, mainly fossil energy sources, i.e. *material flows*, used in national economies. Nationwide statistical analyses of materials consumption were also compiled. Besides Germany, this approach was applied in the USA (World Resources Institute), the Netherlands (Ministry of Housing, Spatial Planning and Environment) and Japan (National Institute for Economic Studies) in 1997. During the period 1996–1998, the European Union also supported the Pan-European ConAccount (Concerted Action on Material Flow Accounting) research project headed by the Wuppertal Institute aiming to further develop MFA practices in Europe. Since the 1990s, MFA has constituted to one of the centrepieces of current ecological economics. It was only towards the end of the 1990s that material flow analyses gained a new, additional perspective called Eco-efficiency. The development work of the Wuppertal Institute, in many respects, meant a return to the 'original' materials balance monitoring of the late 1960s and early 1970s. One new feature, however, has been the attention drawn to hidden flows, i.e. those material flows which arise when natural resources are exploited but which do not enter the sphere of economic activity and thus do not benefit the economy. This point of view is based on the MIPS (Material Input Per Service) concept, developed by Friedrich Schmidt-Bleek (1994), which uses the amount of material invested in a given service over its entire life cycle as a gross indicator of its potential environmental impact. Even though MIPS concept was originally intended for evaluating individual products, processes and factories, it may also be applied to whole economies and to geographical areas. The principal concept of MIPS is the 'ecological rucksack' of a product or material, which includes the material flows involved in its manufacture and use but which do not form part of the product or material itself.

Today MFA accounts are specifically targeted at evaluating the use of natural resources and the natural resource productivity of the economies of the industrialised countries. The general objective of this approach is to help persuade society ”to produce more from less” (also known as qualitative growth), i.e. minimise the use of natural resources and at the same time maximise welfare. Thus a new aggregate measure for an industrial economy, called Total Material Requirement (TMR), was introduced. TMR measures the total use of natural resources that a national economic activity requires. The other important measure introduced was Direct Material Input (DMI), which is the aggregate measure of the natural resource commodities that enter an industrial economy for further processing. DMI includes all materials used for production: the natural resources needed for energy production, auxiliary material production, infrastructures, transportation, factories, etc., in a product line. Furthermore, besides the material flows included in DMI, TMR also includes the hidden or indirect material flows (or ecological rucksacks of direct flows). These hidden flows (HF) are material flows or relocations of materials which are the result of Direct Material Inputs but which never enter the economy (Voet et. al 2004, Hinterberger et al 1997, 10; Adriaanse et al. 1997, 7–8).

1.4 Previous research and data compilation in Finland

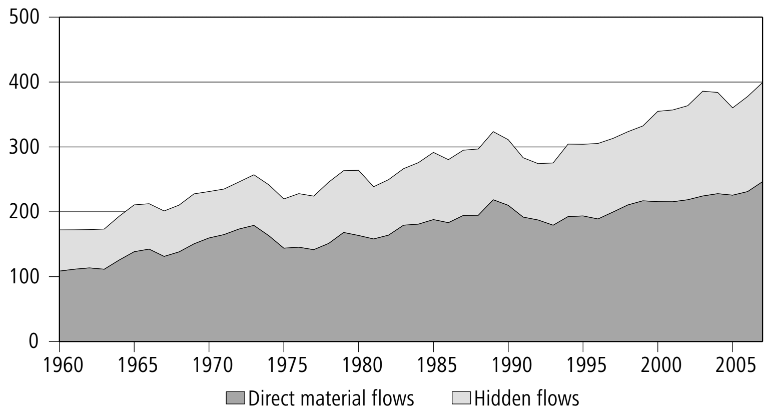
In Finland there have been several attempts to monitor the use of resources in the economy. The earliest were by Mr. Pekka Mäkelä in 1985 and by Mr. Urho Laine of the government's Economic Research Centre in 1994. Mäkelä compiled statistics on the use of natural resources for 1960–1980 and analysed the progress of material intensity (materials use per GDP-unit) in the Finnish economy. Based on Mäkelä's work, Laine compiled statistics on the use of materials for the period 1960–1991 and forecast the future use of materials. These early studies concentrated totally on direct material use and paid no attention to hidden flows (see Mäkelä 1984 and Laine 1994).

During the period 1996–1999 the Finnish material flow account time series from 1960 to 1998 were researched and compiled at Statistics Finland by Dr. Jukka Hoffrén (1997, 1998 and 1999b). Later, in the period 2000–2001, these figures were revised, updated and extended to the year 2000 (Hoffrén 2001) in order to be used in any Eco-efficiency analysis of Finnish economy. In these studies an excel-workbook called ”Malinda” was established to track yearly materials consumption in Finland. Furthermore, aggregate measures, such as the Direct Material Flow (DMF) and Total Material Flow (TMF) time series were established. The DMF indicator resembled the Direct Material Input (DMI) measure of the Wuppertal Institute, the most obvious difference being that it also took into account recycled materials. The TMF indicator was calculated on the basis of the DMF indicator by adding to it known hidden material flows and estimations of other hidden flows. The methods and multipliers used in tracking hidden flows were developed and recommended by the German Wuppertal Institute. However, the Malinda workbook was not acknowledged as official statistics and it was only used for R&D purposes.

At the end of the 20th century a more detailed study of hidden material flows in the Finnish economy was compiled in *Eco-efficient Finland* -project, conducted in collaboration with the Thule Institute (University of Oulu), the University of Oulu, the Forest Research Centre, the Agricultural Research Centre of Finland and the Finnish Environment Institute. The results were recorded in the so-called TMRFIN workbook of excel sheets. These time series of direct material Input (DMI) and total material requirement (TMR) in the Finnish economy at first covered the period 1970–1997. In measuring the use of natural resources, the concept of total material requirement (TMR) was favoured. The focus was on the linkages between the use of resources and the changing structures of the economy. The linkages were studied using input-output analysis. Later these time series were extended (see Mäenpää et al. 2001 and 2000). Today the TMR time series extend up till 2006. Finland has reported direct inputs, imports and exports figures that are based on this TMR data.

Volumes and trends with regard to direct material flows (DMI and DMF) are quite symmetrical in both studies (Malinda and FINTMR). However, there are great differences in the trends for TMF and TMR, which is partly explained by the different HF compilation methods used. Figure 1 shows the time series for DMF and HF compiled by utilising the Malinda Accounting System.

Figure 1.
Progress of Finnish Direct Material Flow and Hidden Flows 1960–2007
according to the Malinda Accounting System (Million Tonnes)



Source: Malinda.

In the 2000s the Malinda time series have been updated yearly and today they extend from 1960 to 2007. The use of the time series has been limited to Eco-efficiency analyses of the Finnish economy conducted by Statistics Finland. The advantage of Malinda is that it is a fairly easy statistical system to update on a yearly basis. The TMRFIN workbook, on the other hand is more extensive, but the in-depth research required can hardly be conducted on a yearly basis. Thus, Malinda provides a more promising starting point for this project. However, the quality of HF data and the reasons for any disparities differences will have to be examined more closely. The DMF data that Malinda produces can be regarded as very reliable, but the quality of hidden flows varies a lot. There is data available on hidden flows relating to domestic mining and quarrying that is very reliable. On the other hand, there are problems connected with the compilation of hidden flows of imports. Multipliers supplied by the Wuppertal Institute have been utilised to produce them.

In 2006 a statistical study on the impacts of increasing consumption on material flows in Finland from 1975 to 2005 was conducted. The investigation further analysed the division of direct material flows of Malinda into those satisfying consumer needs and indirect flows that remain in production but are needed in the manufacture of consumer goods. Firstly, the conclusions indicated that the Finnish economy is indeed very natural-resource intensive. However, when a large proportion of exports are eliminated, the domestic consumption figures turn out to be lower than expected. Secondly, per capita consumption has increased hand in hand with economic growth over time. Thirdly, there exist a shift from basic needs to more luxurious commodities. Fourthly, the observed dematerialization of Finnish household materials consumption during the 2000s supplied empirical evidence that the Environmental Kuznets Curve (EKC) assumptions can hold with respect to household materials consumption. (Hoffrén and Hellman 2007.)

In late 2007 Statistics Finland was granted an allowance from Eurostat to conduct a *Pilot study on economy-wide material flow accounts with hidden flows in Finland* during period 2008–2009. The study was carried out at R&D unit of Statistics Finland (project manager Dr. Jukka Hoffrén). The Environment and Energy Statistics unit responsible for actual statistical compilation of these statistics provided expertise to support the study. This pilot project for economy-wide material flow accounts covers the establishment of methodological and practical working methods to compile reliable yearly material flow accounts including direct material inputs as well as corresponding hidden and indirect flows for the Finnish economy. An improvement in the quality of hidden and indirect flows is expected. The general aim is to enable the compilation of yearly statistics of material flows in the Finnish economy. In this report the experiences gained from this pilot project are considered and a new statistical structure and data complement system called the FIN-MFA Accounting System is presented.

2 Outline of the Economy-wide FIN-MFA Accounting System

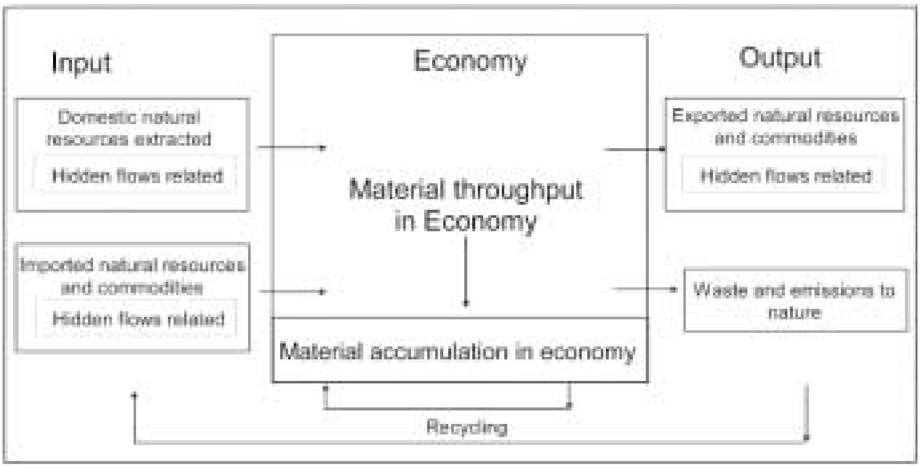
2.1 Theoretical background of MFA accounts

Economy-wide MFA provides a systematic and integrated overview of a national economy by tracking all physical interactions between the environment and the economy. Economy-wide MFA has been developed as a tool to systematically describe and monitor the industrial metabolism of national economies in a consistent manner. MFA also complements the System of National Accounts (SNA). The basic premise of an MFA-based analysis is that the magnitude of resource flow inputs into the economy determines the extent of all outputs to the environment, including waste and emissions. Thus, a reduction in resource inputs will automatically also reduce the outputs that include emissions and waste. This lowers pressure on the environment. In practice, economy-wide MFA accounts for all the human-induced physical input and output flows of an economy. The underlying principle is to account for all materials entering and leaving the economic system. MFA with hidden flows also aims to add the so-called hidden flows to the analysis.

In principle all economic activities can be reduced to activities that use energy carriers (fossil fuels, renewables, etc.) for transforming materials into the commodities that are useful to human beings. Besides useful commodities, these economic activities also create residuals (pollution and waste) that are usually harmful to human beings and to nature. Moreover, after the usefulness of commodities has expired, they are discarded to nature as waste and pollution. Generally, as time lapses, all manufactured commodities end up in nature as waste and pollution. Thus, it can be concluded that the ecological impacts of human activities can be expressed by material flows that comprise, among other things, energy carriers, minerals, fuels, sand and gravel, soil, water, air and overburdening. In principle, all masses moved using technical means cause environmental impact and they should be taken into account. The first law of thermodynamics, i.e. the principle that the amount of material and energy remains constant, states that the input and output of a process must be equal. This is true for materials as well as for energy flows. To the extent that environmental impacts are the consequence of the magnitude of total material input into production in an economy, they can be lessened by reducing the use of materials e.g. by concentrating on what has been called qualitative growth. Materials accounting system is a mean by which the stocks and appropriate flows of natural resources can be combined into a single accounting system.

Economy-wide MFA is based on a mass-balance approach. Thus the economy takes in raw materials – from the domestic environment and via imports from foreign countries – for further processing, manufacturing, production and consumption. Some materials, such as construction minerals, are stored in buildings and infrastructures for many years. At the end of their useful life, products

Figure 2.
Economy-wide material flows



(Source: Eurostat 2001, modified)

become waste and may be recycled or finally disposed of in landfills or incineration plants. Hence, the size of the resources input also determines the volume of subsequent waste and emissions.

The aim of material flow accounts is to track down all the materials that flow in and out of the economy. However, there are differences between material flows according to whether they emerge and can be seen as resource flows or direct flows e.g. wood resources or iron ore for production or as waste flows or residuals of production from the economy to nature. Also direct flows cause hidden flows i.e. flows that emerge when extracting virgin materials but which do not enter the economy.

The purpose of this project was to produce economy-wide material flow accounts with hidden flows. Thus, the FIN-MFA accounting system focuses on quantifying extracted domestic natural resources, imported natural resources and commodities, exported natural resources and commodities, and related hidden flows.

2.2 Structure of the FIN-MFA accounting system

The aim of this project was to introduce material flow accounting on a permanent basis into the production of Finnish statistics. The final outcome of *the Pilot study on economy-wide material flow accounts with hidden flows in Finland* project is the FIN-MFA accounting system, which is based on excel sheets. This workbook contains information on methodological and practical working methods as well as the multipliers for hidden flow calculations needed to compile reliable Material Flow Accounts (MFA), including direct material inputs as well

Table 1.
General structure of the FIN-MFA accounting system

Domestic Flows (Direct and hidden flows)
Metals and minerals
Forest and forest by-products
Agriculture
Earth Materials
Other non-renewables
Other renewables
Exported Flows (Direct and hidden flows)
Metals and minerals
Forest and forest by-products
Agriculture
Earth Materials
Other non-renewables
Other renewables
Imported Flows (Direct and hidden flows)
Metals and minerals
Forest and forest by-products
Agriculture
Earth Materials
Other non-renewables
Other renewables
Main Aggregates
Direct Material Input (DMI)
Direct Material Consumption (DMC)
Total Hidden Flows (THF)
Total Material Requirement (TMR)
Total Material Consumption (TMC)

as corresponding hidden material flows for the Finnish economy. FIN-MFA accounting system also results several aggregate MFA measures that are part of the workbook. The general structure of the FIN-MFA accounting system is given in Table 1.

The structure of the Finnish FIN-MFA workbook presented in Table 1 is more closely described in Appendix 1. The actual structure of direct domestic MFA accounts is described in detail in Appendix 2 and the relevant structure of domestic hidden flow accounts is described in Appendix 3. The sources of all MFA data, both domestic as well as imported and exported MFA accounts, is described in detail in Appendix 4. The structure of imported MFA accounts is described in detail in Appendix 5. All the appendices are written both in Finnish and English for the sake of clarity (to enable the continuation of MFA account compilation).

In FIN-MFA accounting, domestic flow accounts are divided by sector and they contain both direct and hidden flows. Domestic hidden flows are either compiled from existing statistics (e.g. mining,) or produced by using the relevant multipliers (earth materials, forest and forest by-products, agriculture).

By volume these domestic flows are by the far the most important component of FIN-MFA. The most work done, however, was in collecting material flows of external trade. As Finland is dependent on large-scale external trade, especially on exporting natural resource intensive commodities, these accounts represent an important component of the FIN-MFA workbook. Imported and exported hidden flows are solely produced by using the relevant multipliers.

The data on domestic flows and exports can be considered very reliable. Furthermore, the hidden flows related to domestic flows are quite reliable, as are the direct imported flows. However, there is a lot of uncertainty with respect to the reliability of how the imported hidden flows should be calculated, since they are produced on the basis of ecological rucksack coefficients that attempt to represent average ecological rucksacks related to a specific material item.

Finally, in FIN-MFA accounting, the economy-wide MFA main aggregates are calculated automatically by using the above-mentioned different material flows. The FIN-MFA accounting system approach enables the calculation of indicators such as DMI, DMC, TMR and TMC. These indicators describe different environmental impacts and they are needed in the subsequent MFA analysis and for policy-making.

2.3 Economy-wide MFA aggregate indicators

MFA aggregate indicators can be used as proxies of the environmental effects of economic activities or the human-induced environmental burden. However, material flow indicators do not directly tell about the actual environmental impact on the Earth. As the MFA approach does not classify the harmfulness of specific material flows, they cannot catch all possible environmental effects caused by material flows. Thus, small material flows that have big environmental effects can easily be neglected in these weight-based indicators. The focus on a reduction in the aggregate use of resources is thus a necessary, though not a sufficient, precondition for achieving environmental sustainability (Giljum et al. 2006).

The Eurostat methodological MFA guide states that it is not yet clear which of the aggregate indicators of material flows will be considered the most relevant and useful in the longer term. The guide appears to prefer the input indicators DMI and TMR as well as the consumption indicators DMC and TMC (Eurostat 2001, 35). Thus, several aggregate measures have been excluded from the FIN-MFA accounting system: Domestic Processed Output (DPO), which refers to the total weight of materials extracted from the domestic environment and imported from other countries to be used in domestic production which then flow to the domestic environment (i.e. emission and waste), Domestic Hidden Flows (DHF), which refer to the total weight of the materials moved or mobilised in the domestic environment for economic use which do not themselves enter the economy, and Total Domestic Output (TDO), which is the sum of DPO and DHF. Table 2 shows the commonly used aggregate indicators of material flows.

The FIN-MFA accounting system is designed to produce several economy-wide MFA indicators, such as DMI, DMC, TMR and TMC. As they indicate the overall metabolic performance of national economies they are summaries of different materials required by an economy in metric tonnes. These economy-wide

Table 2.
Aggregate indicators of material flows

Indicator	Total Material Requirement (TMR)	Direct Material Input (DMI)	Total Material Consumption (TMC)	Domestic Material Consumption (DMC)
Indicator class	Input	Input	Consumption	Consumption
Description	The sum of the total material input and the hidden/indirect material flow in a national economy. Includes all domestic extraction and imported material.	A flow of natural resource commodities that enter the economy to be further processed.	Total material use associated with the domestic consumption activities. Includes imports and their hidden flows, but excludes exports and associated hidden flows.	Total volume of materials directly used in an economy and consumed by domestic actors. Excludes exports and all indirect flows.
Relation to other MFA indicators (e.g.)	DMI + hidden flows (domestic and foreign) / TMC + exports and their hidden flows	TMR - hidden flows (domestic and foreign)	TMR - exports and their hidden flows	DMI – exports
Use	Estimate of the potential environmental impact associated with the extraction of natural resources and a nation's use of them.	Represents the economy's actual use and extraction of natural resource commodities.	Estimate of the environmental impact associated with a nation's use of materials.	Represents the economy's actual use of natural resource commodities.
	Measure of the physical basis of an economy in terms of primary materials.			

MFA indicators describe certain important trends in economic activities and the environment. These indicators can also be utilised in the analysis of the material basis of the economy as well as in Eco-efficiency analyses.

Direct Material Input (DMI) is the aggregate measure of the natural resource commodities that enter an industrial economy for further processing. The DMI includes all materials used for production: the natural resources needed for energy production, auxiliary material production, infrastructures, transportation, factories, etc., in a product line. From the point of view of environmental policy, DMI represents the proxy of potential environmental pressures caused to the welfare creation processes of a society.

Direct Material Consumption (DMC) accounts for all materials used by a country and it is the most comparable MFA indicator to GDP. DMC is calculated by subtracting exports from DMI. From the environmental perspective DMC can be regarded as a proxy of potential environmental pressures associated with the disposal of residual materials in the domestic environment.

Total Material Requirement (TMR) calculates all material inputs required by a national economy. Besides direct flows, TMR also includes hidden or indirect material flows (or the ecological rucksacks of direct flows). These hidden flows (HF) are material flows or relocations of materials which are caused by the utilisation of Direct Material Inputs but which never enter the economy (Hinterberger et al 1997, 10; Adriaanse et al. 1997, 7–8). Thus, TMR measures the total use of natural resources that a national economic activity requires. From the economic perspective, TMR is a measure of the physical basis of the economy, or the total primary resource requirements of all production activities of a national economy. TMR is a proxy for potential environmental pressures caused by the extraction of resources. Total Material Consumption (TMC) is a derivative of TMR. TMC equals TMR minus exports and their hidden flows. Thus, TMC is a proxy of all potential environmental pressures associated with the disposal of residual materials in the domestic environment.

There are several weaknesses in using these aggregate MFA indicators. DMI data is reliable and thus DMI is a good indicator to be used in national and international analyses and comparisons. But the crucial problem is that the DMI indicator may send a wrong signal if a country is decreasing its domestic resource extraction while increasing imports of materials. Also, DMI may be misleading for smaller-size open economies with a lot of export activities. The shortcomings associated with DMI and DMC, which are easy to produce, are that they do not account for the so-called hidden flows. Thus, in principle, TMR and TMC are the most comprehensive MFA indicators, but at the same time they are in many cases the weakest indicators as the availability of data is limited and the statistical methods used in their calculation are quite robust.

Measures that account for direct material flows, i.e. DMI and DMC, are more easily calculated than the measures that also take into account unused extraction i.e. hidden flows. The TMR measure tracks down all directly and indirectly used materials, and thus gives the most comprehensive picture of the total material requirement of an economy. The TMR indicator includes imports, direct and hidden, but excludes exports. Thus, TMR is not additive across countries; for example, for EU totals of TMR, intra-EU trade and hidden flows associated with intra-EU trade, must be netted out in the TMRs of Member States (see e.g. Eurostat 2001, 36). Since the TMC indicator includes exports, it does not share the double-counting problem in individual economies associated with TMR.

2.4 Ecological rucksacks and hidden flow multipliers

One new feature of MFA since the 1990s has been the attention drawn to hidden flows, i.e. those material flows which arise when natural resources are exploited but which do not enter the sphere of economic activity. This point of view is based on the MIPS (Material Input Per Service) concept, developed by Friedrich Schmidt-Bleek (1994), which uses the amount of material invested in a given service over its entire life cycle as a gross indicator of its potential environmental impact. Even though the MIPS was originally intended for evaluating individual products and services, it may also be applied to whole economies and to geographical areas. The principal concept of the MIPS is that of the "ecological rucksack" of a product or material, which also includes the material flows involved in its manufacture and use but which do not form part of the product or material itself.

The concept of ecological rucksack implies that every product which can be measured by weight carries also an additional burden in the form of unused natural resources and the natural resources used to maintain it till the end of the product cycle. The ecological rucksack is the total quantity of natural resources extracted from nature in order to manufacture one product and during the period of use of that product. The total quantity of hidden flows included in the concept can be determined by subtracting the weight of the product itself from the total quantity of natural resources utilised. The ecological rucksack serves as the basis of the component MI i.e. Material Input. The MI component can thus be calculated as the weight of the product or equipment needed for a specific service plus the ecological rucksack of the product (see Ritthoff, Rohn & Liedthe 2002). The ecological rucksack implies the stress humans are creating in nature in order to sustain their quality of life and to fulfil their needs.

In Europe, the Wuppertal Institute has been developing and compiling information on measures and indicators based on material flows. To be able to calculate the ecological rucksacks of different products and services we need databases of the use of materials in national economies. The Wuppertal Institute has been focusing in recent years on the compilation of EU-wide material flows, the hidden flow multipliers, and the material intensities of different raw materials. The identification of hidden flows, which form a major component of ecological rucksacks is crucial in order to determine the material needed to manufacture products and produce the services we use. The hidden flows are country-specific and depend greatly on primary production processes. National material flow accounting provides a basis for further material-based calculations.

To compile information on hidden material flows, the multipliers the hidden material flows are in many cases required. The multipliers give information on how much hidden material flows originate from production in tonnes (or kilograms) of direct flows e.g. how many tonnes are extracted from the earth's crust to produce one tonne of iron ore. Again, the domestic multipliers are in many parts easy to determine from official statistics but the multipliers for imported raw materials and commodities are not so transparent and therefore there is a need for international co-operation to determine them. One of the biggest challenges concerning multipliers is that there are differences between countries, as stated before, and so they must be country-specific e.g. in energy production the use of natural resources depends on the energy policy of the whole country. Depending on whether energy is produced from coal or nuclear power, there are very different effects and a different kind of demand for natural resources. But there are also differences between the production processes for primary materials e.g. in the mining sector the volume of hidden or indirect flows varies a lot, depending on whether the mine is an open-cast operation or subterranean, at least in terms of statistics.

In Europe, the Wuppertal Institute has been compiling country-specific data to determinate the coefficients of hidden flows. The work on determining these multipliers is very laborious and time-consuming, as they vary a lot, depend-

Table 3.
Examples of Material Intensities [t/t] of selected metals and minerals

material	specification	abiotic material	water	air	region
aluminium	primary	37.00	1047.7	10.870	Europe
	secondary	0.85	30.7	0.948	Europe
copper	primary	348.47	367.2	1.603	World
	secondary	2.38	85.5	1.16	World
Nickel	…	141.29	233.3	40.285	Germany
Ferrochromium	low carbon, 60% cr.	21.58	504.9	5.075	World
	high carbon, 75% cr.	13.54	221.4	2.300	World
zinc	electrolytic	22.18	343.7	2.825	Germany
	high-grade zinc; (secondary) IS	19.36	86.5	42.290	Germany
	mix	21.76	305.1	8.283	Germany
graphite	…	20.06	306.2	5.704	Canada

ing on their original location. Currently, the dynamics of the coefficients is not considered adequately and a major challenge is how to establish a database of dynamic multipliers which vary in time. To determine a coefficient, the concept of Material Input (MI) can be utilised. MIPS consider not only the weight of the product itself, but also the weight of ecological rucksack related actual weight of the commodity. The ratio of weight of actual commodity over the weight of ecological rucksack can be used to calculate hidden flow multipliers. (Ritthoff, Rohn & Liedthe 2002, 12). To determine some of the hidden flow multipliers of imported products we have used some of the material intensities determined by the Wuppertal Institute. Table 3 shows MITs for several metals and minerals (Wuppertal Institute, 2003).

3 Domestic Material Flows

3.1 Data compilation of domestic flows in Finland

Direct material flows are those that enter or exit the economy e.g. in the form of the raw materials of production in each sector and flows related to foreign trade. Domestic direct material flows are the natural resources extracted from the earth's crust within the system boundary i.e. country borders. In the Eurostat (2001) guide, direct (used) material inputs comprise all solid, liquid and gaseous materials (excluding air and water but including the water content of materials) that enter the economy for further use in production or consumption processes. The two main categories are domestically extracted raw materials and imports. Basically, direct flows are flows of primary production when the natural resources are extracted from nature. An exception to this is the recycled scrap metal collected within the economy and imported to Finland as a direct flow because it can be regarded on a par with iron ore due to its metal characteristics (its quality stays the same regardless of how many times it is used). The notable exception is hidden flows, because recycled metals do not cause hidden flows. Scrap metal is also a very important raw material for Finland, due to the country's significant metals industry.

The aim of this project has been to introduce material flow accounting on a permanent basis into the production of Finnish statistics. The structure of domestic MFA accounts is described in detail in Appendix 2 and the structure of domestic hidden flow accounts in Appendix 3. The sources of all MFA data both domestic as well as imported and exported MFA accounts, are described in detail in Appendix 4. The data for FIN-MFA workbook has been produced either (1) at the stage when it is taken from nature (logged, harvested, hunted, picked, quarried or mined etc.) or (2) at the stage when it is turned into commodities in the economic system (food items, equipment, cars etc.). For the convenience of statistics production, the first approach has been selected. However, this approach can only be used for domestic extraction and certain imported unprocessed materials, such as fossil fuels and wood. Imports, including food items and metal-based commodities, must be calculated on the basis of method (2).

The data on hidden material flows (HF) in Finland was compiled by interviewing experts in different sectors and from statistics updated by Finland's Ministry of Employment and the Economy, Ministry of the Environment and Ministry of Agriculture and Forestry, which are responsible for compiling data on the material flows for different sectors. Thus, the data on hidden flows as well as different hidden flows multipliers utilised to compile Finland's HF were collected from external sources. After calculations, we also compared the data collected to other studies carried out in Finland. Some of the hidden flows multipliers utilised we used were the Thule Institutes TMRFIN HF multipliers, if there was no more previous data available. MFA data on direct and hidden flows should always be interpreted by economic sector – as that aggregate material flows determined by weight unit of measure tend to dominate – in order to see the development of material usage and the changes in different economic sectors (Giljum, 2004; 2005). In the case of Finland, the material flows of the forest sector are very prominent in MFA accounts. The next chapters describe the methods used in compiling data and the results by each main economic sector.

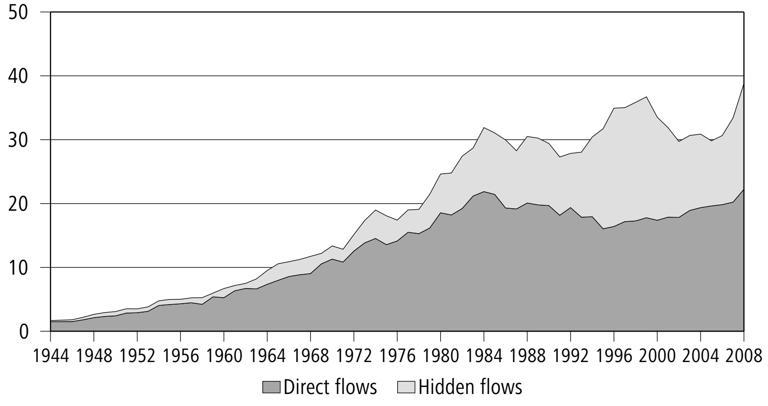
3.2 Domestic direct and hidden flows in Finland

3.2.1 Mining and quarrying

The data of hidden flows as well as direct flows is compiled by Finland's Ministry of Employment and the Economy. This is due to a long history of the Ministry's need to control the utilisation of metals, especially iron ores, in order to assess the magnitude of iron ore resources. Furthermore the metals sector has become one of the most important economic sectors in the country and it is also very important for Finland's exports. Every five years the Ministry publishes the statistics on mined metals and minerals as well as ´side rocks´, which are the hidden flows which directly enter the economy. MFA in the mining and minerals sector is illustrated in Figure 3 and is ready to be used in economy-wide MFA or by other countries importing raw materials produced in Finland.

Figure 3 helps emphasise the importance of determining hidden flows. By the end of 1970 the trend in hidden material flows had begun to significantly decouple from the direct material flows. This is due to decreases in the metal concentrations in iron ores. At the beginning of 1980 the mining sector was suffering ever decreasing metal concentrations and thus the magnitude of unused or hidden material flows began to rise in relation to direct flows. The differences in the development of direct and hidden flows can be seen best between the

Figure 3.
Direct and hidden flows for mining in Finland from 1944 to 2008 (Million tonnes)



Source: FIN-MFA.

1994 and 2001, during which period direct flows decreased and hidden flows peaked. Currently there are four new, large scale mining initiatives and start-ups in Finland which will, in according to estimations, increase the material flows in mining sector tenfold. The first new open-cast mine started operations at the beginning of 2008, two others will follow in the period 2009-2010 and one in 2013.

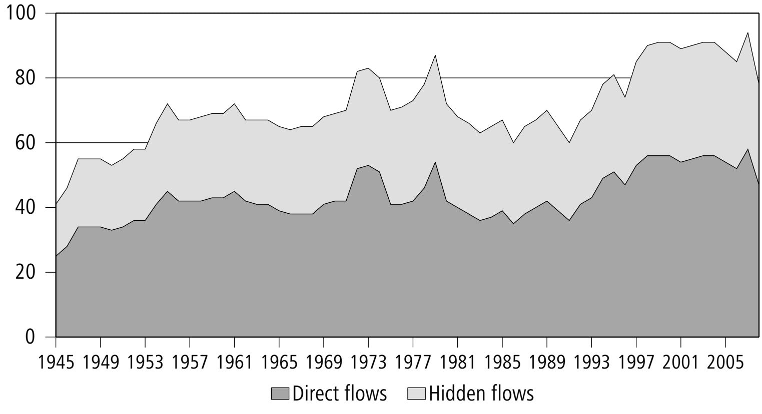
3.2.2 Forests and forest by-products

Forest materials are by volume one of the biggest material groups in Finnish MFA accounts. The data on wood material and other forest material (or forest by-products) used in human activities is mainly produced by the Finnish Forest Research Institute (Metla). The data on direct flows in Finland's forest sector have been compiled from the publications of the Finnish Forest Research Institute, which has a long history in this field. The hidden flow multiplier has been arrived at on the basis of interviews with experts from Metla. The forest sector's hidden flows include the estimates for residuals from felling and logging. No distinction was made between forest types and the main direct flow from which hidden flows were calculated is the quantity of round wood. Figure 4 shows trends in the direct and hidden flows for wood in Finland from 1945 to 2008.

The paper and pulp industry is the most important industrial sector and export sector in Finland. The size of the forest sector in terms of tonnes in MFA makes up almost one third of the economy and it is the second largest sector in MFA accounts. The relevant hidden flows are dependent on the magnitude of direct flows and they vary accordingly.

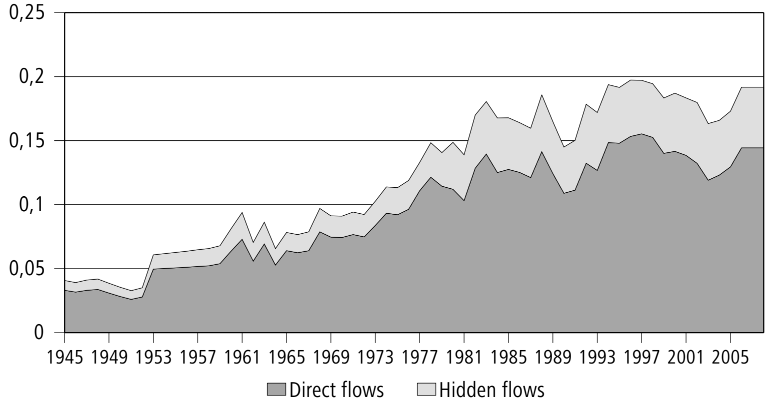
Forest by-products include fish, game and wild berries. The relevant data on direct material flows is available in the Metla's yearbooks as are the forest matter flows. The importance of forest products relates to the forest sector, as in some cases forest products complement logging activities. The source of hidden flow multipliers in the fishery data is the TMRFIN workbook. The rest of the multi-

Figure 4.
Direct and hidden flows for domestic wood in Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

Figure 5.
Direct and hidden flows for game, fish and wild berries in Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

pliers come from the *Kulutus Suomen kansantaloudessa 1900–1975 [Consumption in the Finnish Economy]* 1900–1975 (Laurila 1985) and from the Finnish Game and Fisheries Research Institute. Direct and hidden flows for game, fish and wild berries in Finland from 1945 to 2008 are shown in Figure 5.

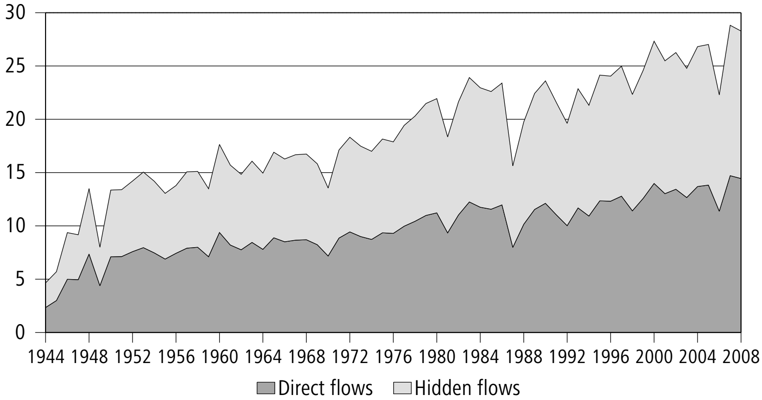
The structure of forest input data is described in Appendix 2 and the structure of relevant hidden flows (HF) are described in detail in Appendix 3. The sources of input data are described in Appendix 4.

3.2.3 Agricultural production

Agricultural materials are an important material group in Finnish MFA. The data on agricultural material use is produced by the Information Centre of the Ministry of Agriculture and Forestry in Finland. The data on direct material flows in the agricultural sector is also compiled from the comprehensive publications of the Information Centre of the Ministry of Agriculture and Forestry in Finland (Tike). The hidden flows for agriculture are based on interviews with experts at Agrifood Research Finland (MTT). The hidden flow multiplier used depends on the various agricultural strains considered. The major part of agricultural production in terms of tonnes in MFA are crops (e.g. biggest flows: barley, oats and silage), which cover almost 98 per cent of agricultural production in Finland. The magnitude of hidden flows is in proportion to direct flows. Figure 6 shows direct and hidden flows for agriculture in Finland from 1944 to 2008.

The agricultural data in figure 6 comprises horticultural production and crops. The structure of the agricultural input data is described in detail in Appendix 2. The structure of the relevant hidden flows (HF) is described in detail in Appendix 3. The sources of data are described in Appendix 4.

Figure 6.
Direct and hidden flows for agriculture in Finland from 1944 to 2008 (Million tonnes)



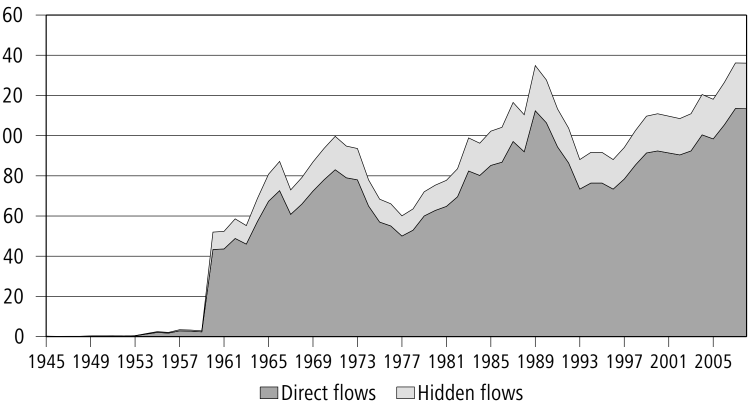
Source: FIN-MFA.

3.2.4 Extraction of earth materials

Earth materials are by volume the biggest material group in Finnish MFA. They account for almost half of all flows in Finland. Crushed rocks in the main account for most of the material flows of earth materials; other components are sand and gravel, crushed sand, clay and peat, which is one of the primary materials for energy production in many parts of Finland. The data on total earth material use is produced by Infra ry (the Association of Finnish Water and Earth Constructors) and the Finnish Environment Institute. The data on direct flows for earth materials is compiled from industrial statistics and energy statistics compiled by Statistics Finland, the Finnish Environment Institute (SYKE) supervised by the Ministry of the Environment, and the Geological Survey of Finland (GTK). The hidden flow multipliers used to assess hidden flows of sand, gravel, rocks and clay originate from the Wuppertal Institute studies and the hidden flow multiplier for peat is the same as that determined in the TMRFIN research. Direct and hidden flows for earth materials in Finland from 1945 to 2008 are shown in Figure 7.

As can be seen from Figure 7, there is a critical shortage of data between 1944 and 1960, which may have a major effect on the flows. The data on the use of earth materials can only be taken into account after 1960 and, as these flows are dominant in MFA accounts, this has an effect on the whole MFA process. The Geological Survey of Finland (GTK) is developing a common database on earth materials and planning to establish each year data compilation and integration with regard to earth materials and the mining sector. There was no information on the GTK´s work during the project period, but improvements to the data on earth materials are expected.

Figure 7.
Direct and hidden flows for earth materials in Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

The structure of domestic earth material accounts is described in Appendix 2 and the structure of relevant hidden flows (HF) is described in detail in Appendix 3. The sources of input data are described in Appendix 4.

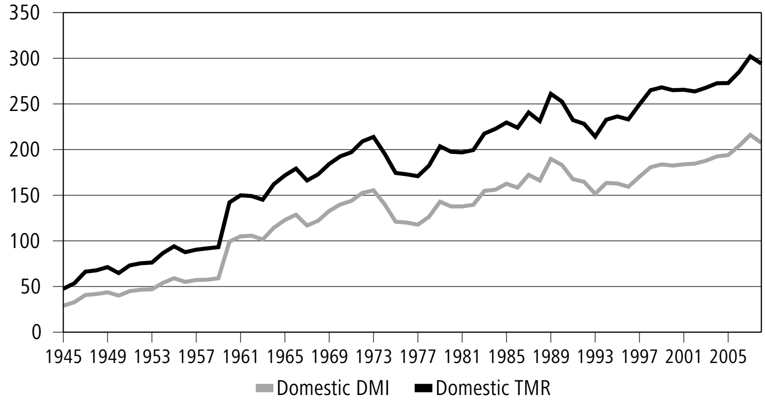
3.3 Aggregate measures of domestic flows

Indicators of material flows are designed to describe an economy's use of materials at different stages of the material flow chain. Being highly aggregate the indicators for material flows are subject to the usual challenges that aggregate indicators present. They can hide some important variations in their constituent variables or they can become dominated by one single large material group. A proper interpretation of MFA indicators therefore requires sufficient knowledge of their content (OECD 2008, 25–26). As MFA indicators are weight-based, there is a possibility that small material flows that actually have huge environmental effects due to their harmfulness are neglected. A focus on the reduction in the aggregate use of resources is therefore a necessary, though not sufficient, precondition for achieving environmental sustainability. (Giljum et al. 2006.)

There are three indicators for describing the quantity of material flows in the economy. These are Direct Material Input (DMI), Domestic Material Consumption (DMC) and Domestic Processed Output (DPO). DMI includes all natural resources used directly in an economy, DMC describes the amount of domestic and imported material used in the economy, and DPO is the sum of domestic extraction and imports. Direct and hidden domestic material flows in Finland from 1945 to 2008 are shown in Figure 8 and in Appendix 6.

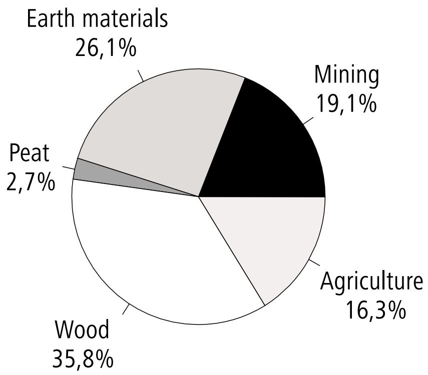
As can be seen from Figure 8, Finnish domestic DMI increased from 29.4 million tonnes in 1945 to 207.4 million tonnes in 2008. In the same period Finnish domestic TMR increased from 47.5 million tonnes to 294.2 million tonnes. Most increases in materials consumption occurred during the 1960s, 1980s and 2000s. The trends for both indicators have been up more or less since 1945, though there were notable reductions in the 1970s (due to the first oil crisis) and

Figure 8.
Direct and hidden domestic material flows in Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

Figure 9.
Breakdown of domestic hidden flows by sectors in Finland in 2008 (Per cent)

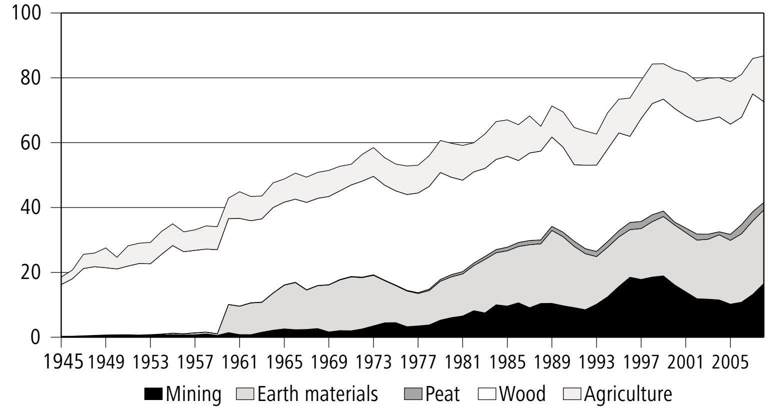


Source: FIN-MFA.

the 1990s (last economic recession). Generally, though, there is no evidence or indication of dematerialization or of any immaterialisation processes.

Total domestic hidden flows in 2008 amounted to 86.8 million tonnes i.e. 41.9 per cent of the volume of direct flows. The extent of hidden flows in earth materials, agriculture and forest sectors is directly related to that for direct flows, as in these sectors hidden flow multipliers have been used to calculate them. Thus, improvements in technology or in the quality of direct flows have no effects on the quantities of hidden flows. The mining sector is the only one where actual hidden flow statistics are compiled and so this is the only sector where the hidden flows are not tied to direct flows. In the forest and agriculture sectors, approximations and the use of multipliers are the only possible ways of assessing

Figure 10.
Trends in domestic hidden flows by sector in Finland from 1944 to 2008 (Million tonnes)



Source: FIN-MFA.

the scale of relevant hidden flows. Figure 9 gives a breakdown of domestic hidden flows by sector in Finland in 2008.

As can be seen from Figure 9, the biggest domestic flows are wood material (435.8 per cent), earth materials (26.1 per cent), mining-related (19.1 per cent) and agriculture-related (16.3 per cent) and. The hidden flows of peat represent quite a modest share of the total (2.7 per cent). Trends in all domestic hidden flows from 1945 to 2008 are shown in Figure 10 and in Appendix 6.

The data in Figure 10 is not completely comparable between years before the year 1960 due to data shortages in earth material flows, which is the largest flow of total hidden flows. The magnitude of hidden flows has increased 90 per cent since 1945. The hidden flows for the mining sector have increased most significantly: in 2007 they were nine times what they had been in 1960. During the same time period the hidden flows of earth materials increased 135 per cent and in the agricultural sector 72 per cent. The residuals from the forest sector have increased least, approximately 37 per cent in 47 years.

Figure 10 suggests that the hidden flow trends are set to continue in the 21st century. The increase in material flows depends on the economic situation and the magnitude of the depression we faced since at the beginning of 2008. The previous depression in Finland can be identified in MFA as well. At the start of 1990 Finland was in economic regression due to the financial crisis in the late 1980s. The economic situation began to improve by around the mid-90s. The first oil crisis in the mid-70s and subsequent economic recession can also be seen in the use of materials. Thus, in the near future the economic recession may have an effect on material flows to the extent that they might fall by approximately 10 million tonnes. The impact of the two economic recessions can best be seen in the use of earth materials, which suggests that the construction sector has suffered the most, or at least the longest, compared to other sectors.

4 Imported and Exported Material Flows

4.1 Compilation of material flows in external trade

By volume, the biggest imported materials are fossil fuels. The sources of FIN-MFA data are listed in Appendix 4 and the structure of fossil fuels input data is described in Appendix 5. The data used in FIN-MFA on fossil fuels is compiled and produced by Statistics Finland, Energy Statistics. Secondary substantial imported material flows represent ore, metals and minerals. The data on these is compiled and produced by the Federation of Finnish Technology Industries. Data on imports by volume is published on a yearly basis in their yearbook, also available on the internet.

The other imported material flows can be obtained from Finnish Customs, which compiles statistics on foreign trade. The statistics are comprehensive and they can be used by specific commodity statistics (SITC codes 1–4) or in terms of country-specific statistics (CN nomenclature 8-digit level). Detailed statistical information on the CN nomenclature 8-digit level can be obtained from Ultika, the statistical database on foreign trade. The structure of imported MFA accounts is described in detail in Appendix 3 and that of hidden flows of imports in Appendix 4.

The hidden flows connected with imported material flows are mostly produced using multipliers obtained from various sources. The multipliers give a rough estimate of to what extent hidden flows relate to a specific imported material flow quantity. One of the biggest challenges using multipliers is that there are differences between countries, as stated before, and therefore the multipliers must be country-specific e.g. in energy production the use of natural resources depends on the energy policy of the whole country: depending on whether energy is produced from coal or nuclear power, there are very different effects and a different sort of demand for natural resources. Thus, the multipliers for imported raw materials and commodities are not that transparent and there is a need for international co-operation to determine them.

In this study some country-specific multipliers produced mainly by the Wuppertal Institute have been utilised. At the current stage the evolvement or dynamics of the coefficients has not yet been considered and the major challenge in the future research is in establishing a database of dynamic multipliers which vary over time. To determine coefficients, the concept of Material Intensity (MIT) can be used to determine some of the multipliers. Material Intensity is the relation between the total for used and unused resources in weight units (Ritthoff, Rohn & Liedthe 2002, 12), e.g. MIT includes all the material needed to produce the material or product and also the weight of the material or product itself. MIT is normally used when calculating MIPS (Material Input Per Service) but can also be used to determine some of the multipliers for hidden material flows.

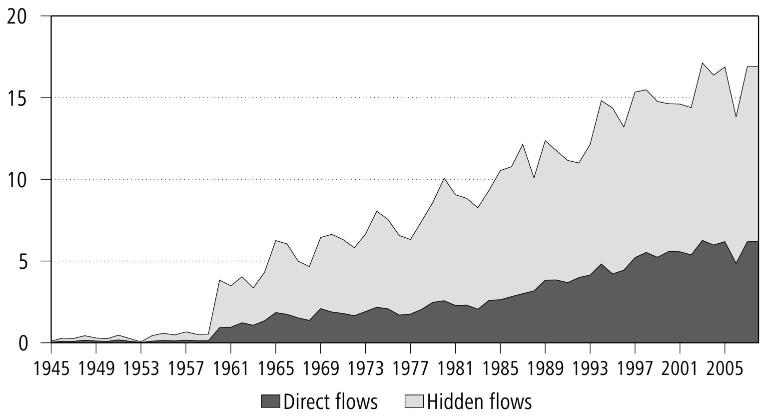
Material intensity determined by the Wuppertal Institute (2003) has been used to define some of the multipliers.

4.2 Compilation of imported direct and hidden flows

4.2.1 Mining and quarrying

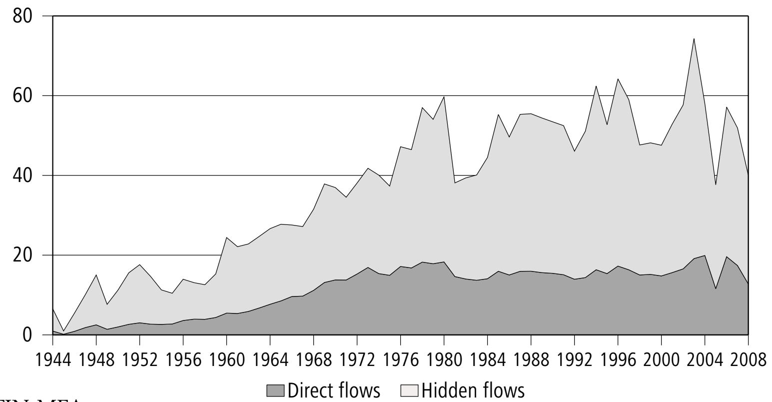
Import and export material flows for mining and quarrying are obtained from the Finland's Custom Service's Statistics. The statistics are very comprehensive and they provide yearly in-depth data on items of foreign trade in specific com-

Figure 11.
Direct and hidden flows for imported metals (Million tonnes)



Source: FIN-MFA.

Figure 12.
Imported direct and hidden flows for fossil fuels from 1944 to 2008 (Million tonnes)



Source: FIN-MFA.

modity statistics (SITC codes 1–4) or in country-specific statistics (CN nomenclature 8-digit level). Both monetary values and quantities (kg or metric tonne) for every trade item are published. The trend in the direct flows and hidden flows for imported metals is depicted in Figure 1.

As can be seen from Figure 11, the trend has been upwards since World War II. The structure of imported commodities originating from earth materials is described in detail in Appendix 5. The hidden material flows are calculated on the basis of these accounts. The data sources used include the Customs Services' External Trade Statistics from 1945 to 1959 and the Federation of Finnish Technology Industries Statistical yearbooks for the period 1960-2008.

The trend in direct flows and hidden flows for imported fossil fuels is depicted in Figure 12.

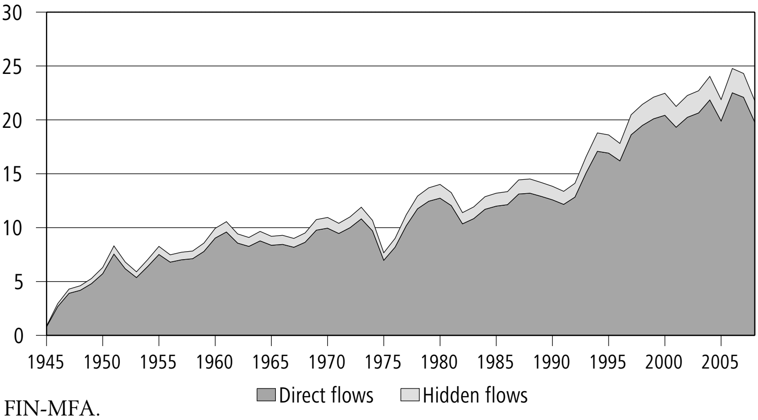
As can be seen from Figure 12, the trend in fossil fuels was up till the late 1970s and since then the use have stabilised. Furthermore, it is clear that the hidden flows connected with fossil fuel flows are quite considerable.

4.2.2 Forests and forest by-products

Although Finland is quite self-sufficient in forest resources, imports of wood have increased in the 2000s, to meet the growing export needs of the Finnish forest industry. The trend in imported direct flows and hidden flows for imported wood materials is depicted in Figure 13.

As Figure 13 shows, a lot of wood has been imported into Finland from Russia and the Baltic Countries. The vast majority goes in the manufacture of paper and paper products and for export to the EU and other industrialised countries. The structure of commodities originating from imported wood is described in detail in Appendix 5. The hidden material flows are calculated on the basis of these accounts. The data sources used include the Finnish Forest Research Institute's statistics, but also the Finnish Customs Services' statistics could be referred to.

Figure 13.
Direct and hidden flows for imported wood and wood products (Million tonnes)



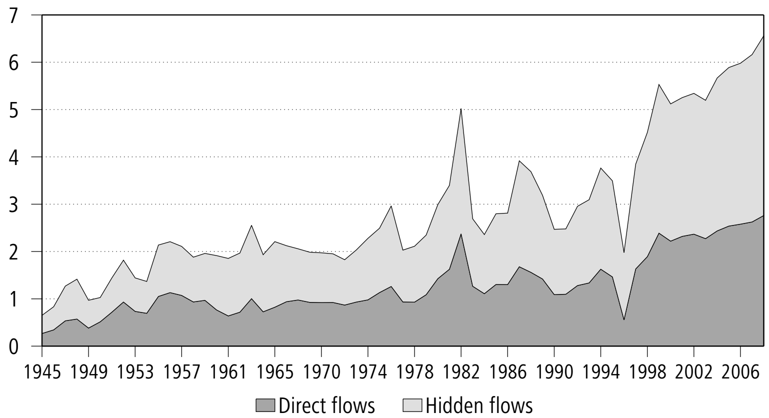
Source: FIN-MFA.

4.2.3 Agricultural products

Although Finland was previously quite self-sufficient in agricultural produce, imports of food have been significant, due to the northern location of the country: for example, most fruit must be imported. Since Finland joined the EU in 1995, imports have been somewhat increased. The trend in direct flows and hidden flows for imported food and agricultural products is depicted in Figure 14.

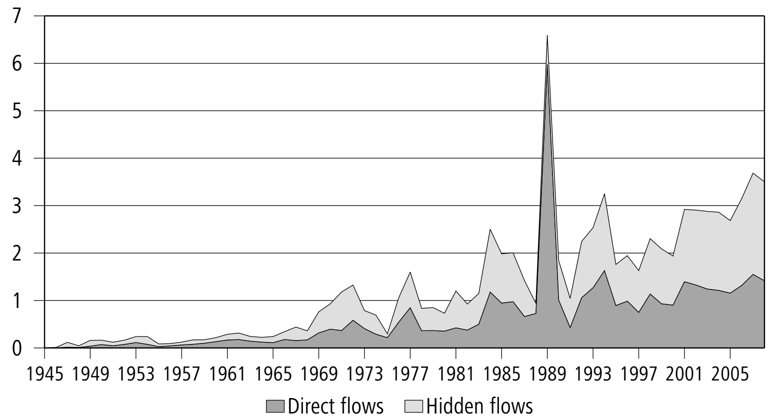
Since Finland joined the EU in 1995, exports of food have also been increasing to some extent. The structure of commodities from imported food is described in detail in Appendix 5. The hidden material flows are calculated on the basis of these accounts. The trend in direct flows and hidden flows for exported food and agricultural products is depicted in Figure 15.

Figure 14.
Direct and hidden flows for imported food and agricultural products (Million tonnes)



Source: FIN-MFA.

Figure 15.
Direct and hidden flows for exported food (Million tonnes)



Source: FIN-MFA.

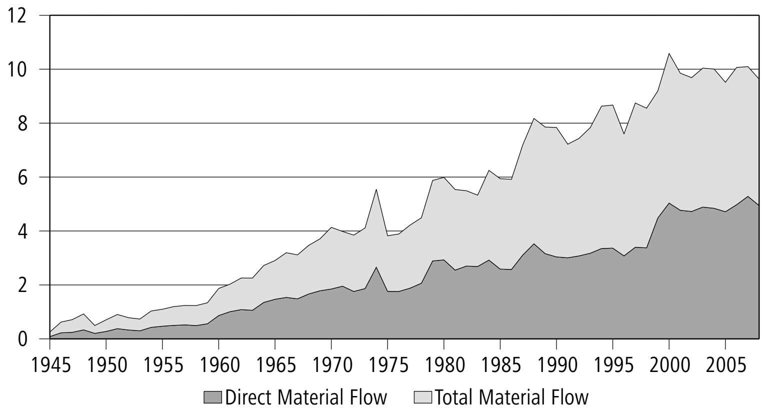
During the 2000s, hidden flows for food exports in particular have been growing. The structure of exported food commodities is described in detail in Appendix 5. The hidden material flows are calculated on the basis of these accounts.

4.2.4 Earth materials in external trade

The trend in direct flows and hidden flows for exported earth materials is depicted in Figure 16.

As can be seen from Figure 16, the increase in exported earth materials has been constant. Especially intense has been the increase in related hidden flows. The structure of exported earth materials is described in detail in Appendix 5. The hidden material flows are calculated on the basis of these accounts.

Figure 16.
Direct and hidden flows for exported earth materials (Million tonnes)



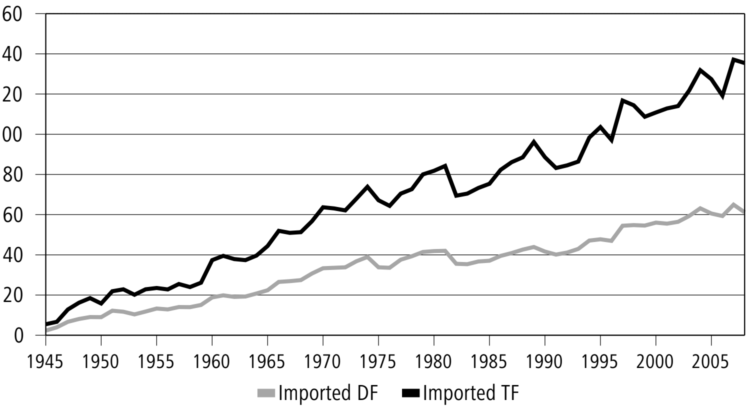
Source: FIN-MFA.

4.3 Aggregate measures of imported and exported flows

Direct and total imported material (including direct and hidden flows) flows to Finland from 1945 to 2008 are shown in Figure 17 and in Appendix 6.

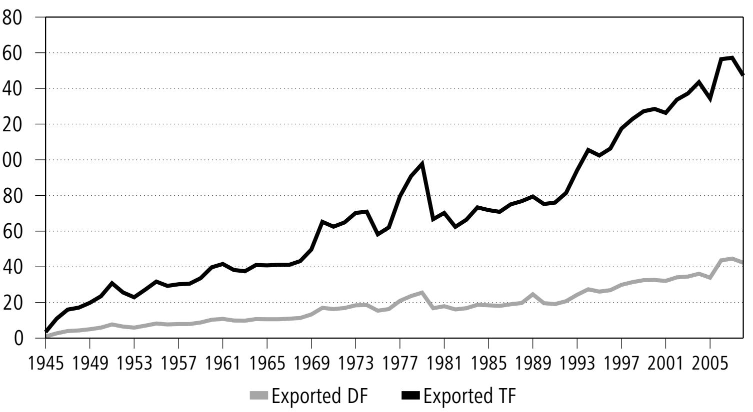
As can be seen from Figure 17, the direct material flow for imports increased from 4.4 million tonnes in 1980 to 61.2 million tonnes in 2008. In the same period the total material flow of imports increased from 18.7 million tonnes to 135.4 million tonnes. Most increases in these flows occurred during the 1980s, 1990s and 2000s. The trends of both indicators also continue upwards. Figure 18 and Appendix 6 show the corresponding flows for exports.

Figure 17.
Direct and hidden material flows for imports into Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

Figure 18.
Direct and hidden material flows for exports from Finland from 1945 to 2008 (Million tonnes)



Source: FIN-MFA.

As can be seen from Figure 18, the material flow for exports increased from 1980 to 2008. However, as the volume for direct flows doubled, the related hidden flows grew even faster. In this period they increased to almost two and a half times what they had been. Thus, the structure of Finnish exports has changed and now includes more hidden flows than ever before.

In FIN-MFA the calculation of hidden flows of imported and exported materials is totally based on multipliers provided by the Wuppertal Institute. The multipliers used are static ones and they do not take into consideration the actual changes in hidden flows. This is their major weakness. Moreover, they ignore the fact that materials imported from different countries into Finland represent different hidden flows. Thus, the hidden flows shown can be seen as approximations of imported materials. For now the imported hidden flow accounts in FIN-MFA are quite approximate and there is a need to consider them in more detail in the future.

The question of the dynamics of hidden flow multipliers is also a major challenge when compiling hidden flow accounts in other EU member countries. Since the ecological rucksacks tend to change over the years, the development of the HFs should be taken into consideration in MFA accounts. The HF multipliers for import and export flows should also be country-specific, since the ecological rucksacks for the same direct material flows vary a lot between different countries. As the global economy expands and given that material flows are almost constantly growing, all statistical offices are facing the same challenges and problems in determining hidden flows. The only way hidden flow statistics compilation can be produced is by establishing a common international database of dynamic and country-specific HF multipliers that would cover the time period from 1945 up till the present day. The database could be maintained by Eurostat and/or the OECD. The database would enable the national statistical offices to compile reliable statistics on imported material flow in the future. The establishment of harmonised and standardised annual Material Flow Accounting in the EU member countries is an extremely important task. Eurostat has a key role in ensuring the reliability and high quality of MFA compilation in EU member countries.

5 Utilisation of Hidden Flow Multipliers in the FIN-MFA Accounting System

5.1 Methodologies behind hidden flows

A hidden material flow (HF) is an inconsistent concept and needs more accurate defining. In the literature HFs are defined in many different ways. The Wuppertal Institute divides HF into unused material extraction and indirect material flows and recommends use of these more precise terms over HF (Wuppertal Institute 2008). According to Adriaanse et al (1997), HF occurs when commodities enter the economy e.g. they are accompanied by indirect flows. Different definitions by various authors can be seen in Table 4.

In this report we use hidden material flow as a common name for flows that do not enter the economy and divide it into *domestic indirect and unused flows* and *imported indirect material flows*. The latter is due to the extraction in the country of origin of the imported raw materials. Domestic hidden material flows may stay unused or another industrial sector might use these residuals as raw

Table 4.
Different definitions of hidden flows (HF)

Author	Definitions
OECD (2008b)	*Unused material extraction*: Materials are unused if they are extracted but remaining within the environment, e.g. overburden from coal mining disposed of at the mining site.
	Indirect material flows: The flows of materials that 1) are needed for the production of a product, 2) have occurred up-stream in the production process, and 3) are not physically embodied in the product itself.
Eurostat (2001)	Uses the unused extraction as a synonym for hidden flows and thus unused domestic extraction = domestic hidden flows.
	Unused domestic extraction: Materials extracted or otherwise moved on a nation's territory on purpose and by means of technology which are not intended or fit for use.
	Indirect flows are defined for economy-wide material flows only i.e. comprise imports and exports.
Adriaanse, A., S. Bringezu, A. Hammond, Y. Moriguchi. E. Rodenburg, D. Rogich and H. Schutz (1997)	*Ancillary material flow:* The material that has to be removed from the natural environment, along with the desired material, to obtain the desired material.
	Excavated and/or disturbed material flow: The material that has to be moved or disturbed to get access to a certain natural resource reserve or to create and maintain infrastructure.

materials in its own production when the flow becomes visible as a direct flow e.g. mining sector residuals are used, in many cases, in the construction sector.

Basically, the information on hidden flows of domestic primary production is quite easy to compile due to the good quality of statistical information in Finland but the hidden material flows of imported raw materials and commodities are not as transparent. The hidden material flows of imports are quite often country-specific and to determine these flows takes a lot of resources. The determination of hidden flows is of great concern in Material Flow Accounting as some of the materials needed in the economy have enormous hidden flows compared to their direct material input e.g. some metal ores. In addition, the significance of the hidden flows in industrialised countries grows when more goods are imported and fewer goods are produced on the domestic front as the production processes shift to developing countries, where the costs of production are lower. In the industrialised countries materials extraction related to imported goods should be acknowledged in MFA accounts as they help us to understand the adverse effects of our economic growth on global scale.

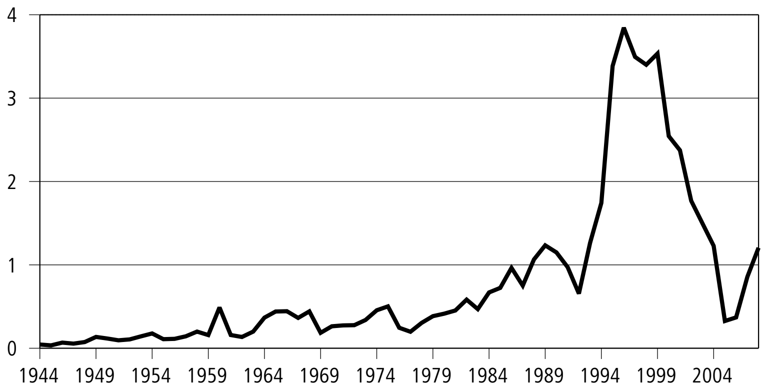
5.2 The dynamics of hidden flow multipliers

Hidden flows vary significantly between different material groups in time as well as between different economic sectors. As stated before, material flows should be analysed and interpreted by economic sectors if possible, and the same applies to hidden flows. The main problem with hidden flow multipliers in the context of statistics is that most of the multipliers are static percentage figures. Even though the multipliers are or could be updated from time to time, the problem with static figures remains the same if the new multipliers are adapted directly to all-time series of material flows. Due to the static characteristics of most hidden flow multipliers there cannot be assessments of the improvements in the efficiency of production or other improvements in excavation techniques, which have an effect on the magnitude of hidden flows. Furthermore, if the multipliers are dynamic there can be interpretations of changes in the structures of different economic sectors or in the whole economy. Hidden flows are vital in determining the effectiveness of different economic sectors to use materials extracted in relation to economy's total utilisation of materials. HFs effectively indicate whether material conservation has improved in the economy.

Finland's hidden flows multipliers used for forest, forest by-products, agricultural products and earth materials represent static multipliers, as certain percentage figures have been used to determine HF. The hidden flow multipliers derived from the metals and minerals sector, however, represent dynamic multipliers that vary in time. This is due to the long and comprehensive statistical history of specific information on metal and mineral quarrying and mining. The metals and minerals sector includes metallic ores, industrial minerals, carbonate rocks and industrial rocks. The dynamic hidden flow multipliers for each subgroup are shown in Figures 19 to 23.

The largest metallic ore deposits and mines in Finland at the present represent gold, chrome, nickel and copper ores. In the near future there will be three large new mining initiatives in gold and nickel ore sectors, and these will

Figure 19.
Dynamic hidden flow multipliers for metallic ores



Source: FIN-MFA.

significantly increase Finland's material flows in the metals and minerals sector, and according to some estimates, it will be a tenfold rise. This will be seen first in hidden flows when the biosphere on the earth's surface must be removed before the ore deposit is reached, and thus the hidden flows will increase significantly. An example of this in the statistics on the mining sector in 2007 is the new gold mine in northern Finland which produced in its first year only side-rocks and other hidden material flows, amounting to approximately 70 per cent of the total hidden flows for metallic ores. When the next new mines are opened a significant increase in the hidden flows for metallic ores can be expected. Figure 19 shows the trend in hidden flow multipliers for domestic metallic ores.

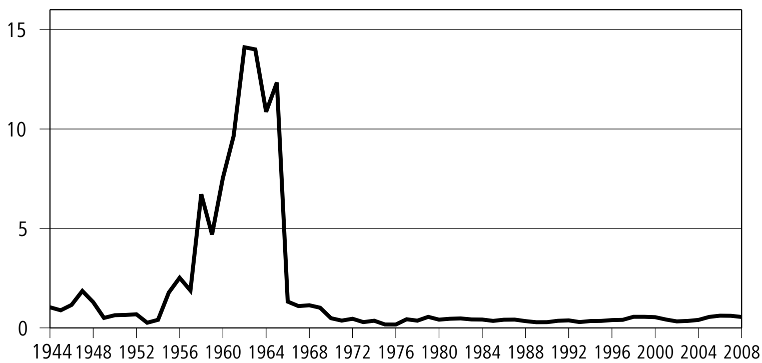
In Figure 19, the last rapid growth period for hidden flows of metallic ores began at the beginning of 1990 and peaked in 1996. From 1992 total material excavation started to rise and peaked in 1996 and at the same time the amount of useful iron ore declined dramatically. To be more accurate, total extraction of metallic ores rose around 50 per cent in the period 1992–1996 and the volume of side-rocks i.e. hidden flows, rose almost 200 per cent, so that share of hidden flows exceeded the useful iron ore fourfold. During that same period half of the metal ore mines in the country were closed (a reduction from 12 to 6) but that would not explain the growth in hidden flows. Finland's largest chrome mine increased its excavation operations significantly but there was no corresponding increase in useful metallic ores and it seems that the metal content of the deposit remained the same. The same trend seemed to continue until 2004 when the share of hidden flows in proportion to the amount of useful iron ore returned to the same level as it had been in 1992. From 1996, which was the peak year for total excavation of ore in the mine (12 million tonnes), the volume started to decline and was right down by the year 2004, when total excavation was only 4 million tonnes. The amount of useful iron ore has remained the same for almost the whole period 1996–2007. This can only be explained by the extension of the mine and implies that the opening of a new mine increases the volume of hidden flows significantly and has an impact for many years. In the year 2005 the chrome mine was transformed from an open-cast mine to a subterranean one as a result the volume of side-rocks and hidden flows was excluded from statistics. The number of mines in Finland doubled from 2002 to 2008 and this trend is set to continue as new mines are being opened.

The importance of dynamics in hidden flows is highlighted when it comes to statistical compilation and the construction of an MFA time series. Average multipliers e.g. from the 1970s, of hidden flows for metallic ores have an average of 1.18 and if that is compared to the time series for hidden flows in the Figure 19 above, it can clearly be seen that this figure does not give a truthful picture of total hidden flows related to metallic ores. If the latest hidden flow multiplier for the year 2008 is used, the multiplier is 1.21. That cannot be applied in the time series without compromising the relevance of hidden flows. Thus, whenever dynamic hidden flows are available they should be utilized when constructing time series. Figure 20 shows the trends in hidden flow multipliers for domestic industrial minerals from 1944 to 2008.

In Figure 20 the hidden flow multiplier peaked in the period 1954–1965. However, as the useful amount of produced minerals remained at a constant level, this rise is due to the increased volume of side-rocks. From 1954 to 1961, the total volume of all material flows relating to extracted industrial minerals increased eightfold. During that time period, no new industrial mineral mines were established, but economic growth was rapid, especially in the construction sector. Industrial minerals related only to the excavation of asbestos and talc. In 1965 and 1966 many new enterprises entered the business sector. From 1966 new mines were opened and the mining of feldspar was started.

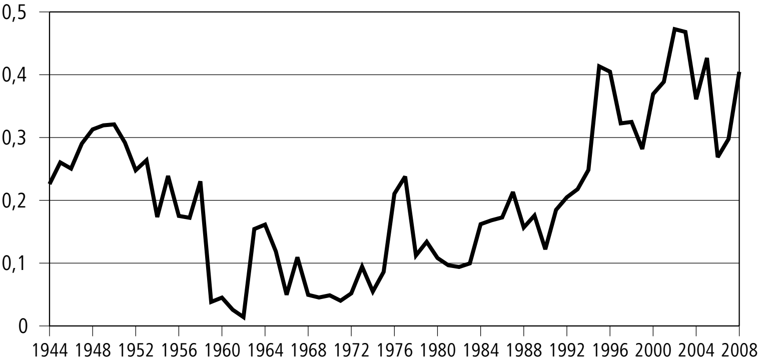
The volume of useful minerals did not differ much during the period, but the total volume of excavated materials increased by 1,100 per cent. In fact the volume of side rocks increased by 2,300 per cent during the period 1954–1965. Thus, in 1962 and 1963 unused materials accounted for 14 times the volume of useful minerals. The situation changed in 1966, when new feldspar mines were

Figure 20.
Dynamic hidden flow multipliers for industrial minerals



Source: FIN-MFA.

Figure 21.
Dynamic hidden flow multipliers for carbonate rocks (limestone)



Source: FIN-MFA.

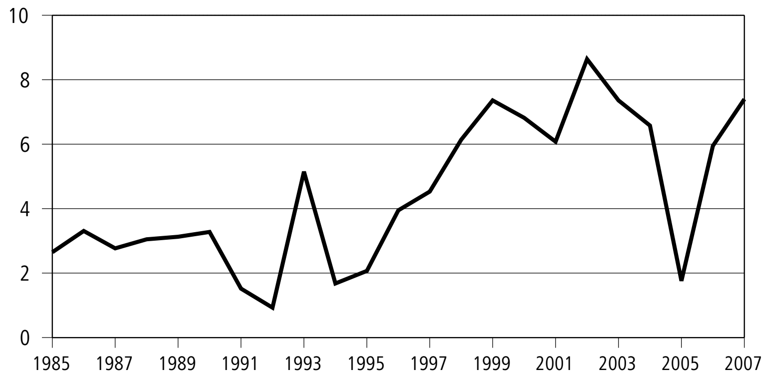
opened. The excavation of feldspar did not cause any hidden flows or side-rock flows, and when combined with the mining of asbestos and talc, hidden flows in relation to direct flows improved. Furthermore, the old asbestos and talc mines were more efficient as the relation between useful materials and hidden flows had improved slightly. Since 1966 new actors have emerged in the industrial minerals sector with new type of minerals entering the picture, and total excavation volumes have increased more than 40 times. This cannot be seen in the hidden flows because industrial minerals are used highly efficiently and the deposits of minerals are nearer the earth's surface than e.g. iron ores. Figure 21 shows the trend in hidden flow multipliers for domestic carbonate rocks from 1944 to 2008.

Figure 21 shows an overall upward trend in this specific hidden flow multiplier. However, there is a period of decline in 1950 and 1970. From the early 1970's to 2005 there was an obvious upward trend, indicating that new technologies had improved efficiency, which was then been gradually lost. Figure 22 shows the trend in hidden flow multipliers for domestic industrial rocks from 1944 to 2008.

In figure 22 the hidden flow multiplier for domestic industrial rocks is limited to the time period 1985–2008 because the classification only recognises industrial rocks after 1985. Earlier, industrial rocks were classified as industrial minerals. Furthermore, an upward general trend can be observed here. In Figure 23 industrial minerals and rocks flows have been summed up and a common hidden flow multiplier calculated.

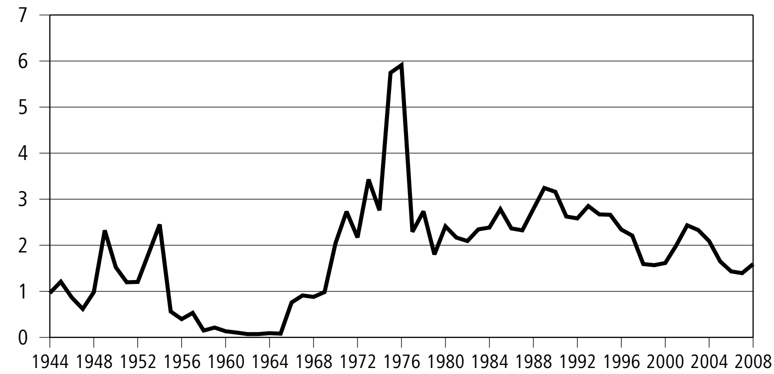
The picture that Figure 23 gives is confusing and hazy. It is hard to find any logical trend with regard to this multiplier. These empirical analyses on Finnish domestic hidden flow multipliers for mining and quarrying clearly show the challenge relating to the calculation of hidden flow time series using multipliers. As the multipliers are static they ignore the shifts in actual material volumes for

Figure 22.
Dynamic hidden flow multipliers for industrial rocks



Source: FIN-MFA.

Figure 23.
Dynamic hidden flow multipliers for industrial minerals and rocks



Source: FIN-MFA.

hidden flows. Thus, the hidden flow accounts produced by using multipliers are nothing else but good approximations. These time series hidden flow accounts have the advantage of suggesting approximations, but they lack reliability and the demands of quality that are generally required in statistics.

5.3 List of multipliers for hidden flow calculation

In the FIN-MFA accounting system multipliers have been used to produce hidden flow accounts for domestic forest, forest by-products, agricultural products and earth material, as well as for all imported and exported material flows. Table

Table 5.
Hidden flow multipliers for domestic material flows of FIN-MFA in 2007

1.	Metals and minerals	
1.1	**Metallic ores**	0.86
1.2	Carbonate rocks (limestone)	0.30
1.3	Other industrial minerals	0.61
1.4	Industrial rocks	7.40
2.	Earth Materials	
2.1	Sand and gravel	0.20
2.2	Crushed gravel	0.20
2.3	Crushed rock	0.20
2.4	Clay	0.20
3.	Peat production	
3.1	Peat	0.225
4.	Wood Material	
4.1	Residuals of roundwood	0.10
5.	Forest Products	
5.1	Commercial fishery	0.225
5.2	Recreational fishery	0.225
5.3	Moose	1.64
6.	Agricultural production	
6.1.01	Wheat	1.00
6.1.04	Rye	1.00
6.1.05	Barley, Feed & Malt Barley	1.00
6.1.08	Oats	1.00
6.1.09	Mixed crops	1.00
6.1.10	Other grain	1.00
6.1.11&12	Turnip rape & rape	2.03
6.1.14	Potatoes	0.43
6.1.15	Sugar beet	1.00
6.1.16	Peas	1.00
6.1.17	Hay	1.00
6.1.18	Silage	1.00
6.1.19	Green Fodder	1.00
	Other crop	0.82
6.2.1.03	White cabbage	0.90
6.2.1.12	Carrot	0.30
6.2.1.13	Beetroot	0.45
6.2.1.14	Swede	0.40
6.2.1.19	Onion	0.20
6.2.1.21	Gherkin	0.20
	Other vegetable	0.35

5 shows the actual hidden flow multipliers used to produce FIN-MFA hidden flow accounts.

The multipliers in Table 5 are actually calculated on the basis of the date for the year 2007. Some multipliers are aggregated, especially where it concerns iron ores. It is possible to compile more relevant hidden flows for Finland (or any other EU member country) using multipliers that are dynamic. If dynamic hidden flow multipliers are available they should be utilized when compiling MFA time series. However, there being no common database which covers as many countries as possible (within outside the EU e.g. the OECD countries), there are many shortcomings in compiling these country-specific MFAs. Of course, it is also possible to further develop the accuracy of multipliers, e.g. it is possible to distinguish different metals and their residuals by going to the mine-level. At present, most multipliers are based on interviews with specialists in different sectors and could be made more accurate through closer co-operation with relevant institutes and ministries.

6 Aggregate Measures of FIN-MFA Accounts

6.1 Characteristics of MFA aggregate measures

Aggregate indicators of material flows are designed to describe an economy's use of materials at different stages of the material flow chain. Being highly aggregate the indicators for material flows are subject to the usual challenges that aggregate indicators present. The FIN-MFA accounting system produces several economy-wide MFA aggregate indicators, e.g. DMI, DMC, TMR and TMC. These measures indicate the overall metabolic performance of national economies, as they represent the sum of all materials required by an economy in metric tonnes. MFA aggregate indicators act as proxies of the environmental effects of economic activities or the human-induced environmental burden. However, material flow indicators do not say anything direct about the actual environmental impact on the Earth. They are not able to account for the wide variety of environmental effects of different material flows. Thus, small material flows that have big environmental effects can easily be neglected in these weight-based indicators.

Direct material flow indicators measure all natural resources that enter the economy directly. Direct Material Input (DMI) aggregates all natural resource commodities that enter an industrial economy for further processing. DMI includes all materials used in production: the natural resources needed for energy production, auxiliary material production, infrastructures, transportation, factories, etc., in a product line. From the point of view of environmental policy, DMI represents the proxy of potential environmental pressures resulting from the creation of welfare in a society. Direct Material Consumption (DMC), on the other hand, accounts for all materials used by a country. Thus, when calculating DMC, exports are subtracted from the DMI indicator. DMC is the most comparable MFA indicator to GDP. From the environmental perspective, DMC can be regarded as a proxy of potential environmental pressures associated with the disposal of residual materials in the environment.

Total material flow indicators take into account all material inputs into the economy as well as their hidden flows (i.e. the ecological rucksacks of direct flows). Total Material Requirement (TMR) covers all material inputs required by a national economy. Besides direct flows, TMR also includes the hidden or indirect material flows (or ecological rucksacks of direct flows). These hidden flows (HF) are material flows or relocations of materials resulting from Direct Material Inputs but which never enter the economy. Thus TMR measures the total use of natural resources that a national economic activity requires. TMR is a proxy for potential environmental pressures caused by the extraction of natural resources. Total Material Consumption (TMC) is a derivative of TMR. TMC equals TMR minus exports and their hidden flows. Thus, TMC is a proxy of all potential environmental pressures associated with the disposal of residual materials in the domestic environment.

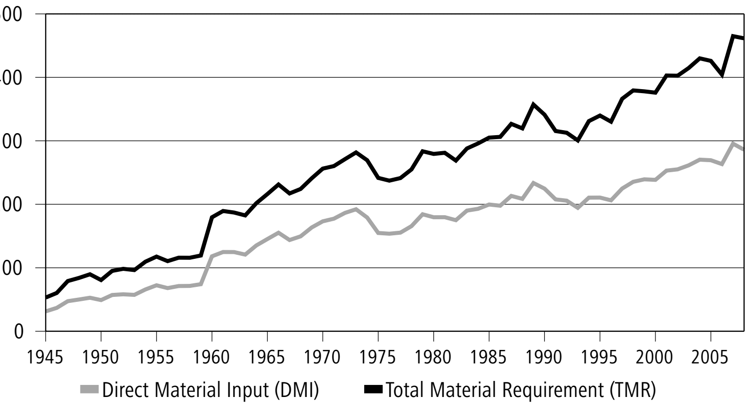
6.2 Trends in MFA aggregate indicators In Finland

Generally DMI and DMC are regarded as good indicators, as the data behind them is quite reliable. As the availability of hidden flow data is limited and the statistical methods used in their calculation are quite robust, the most comprehensive MFA indicators, TMR and TMC, are in many cases the weakest indicators. The trend in Finnish DMI and TMR from 1945 to 2008 is shown in Figure 24.

In 1945, Finnish DMI was some 29.4 million tonnes, whereas in 2008 it was 286 million tonnes. Likewise, the TMR grew from 51.2 million tonnes to 461.5 million tonnes during the same period. Trends in both indicators have been constantly upward, no indication of dematerialization or immaterialisation. Figure 25 shows the trend in Finnish DMI, DMC, TMR and TMC indicators between 1945 and 2008.

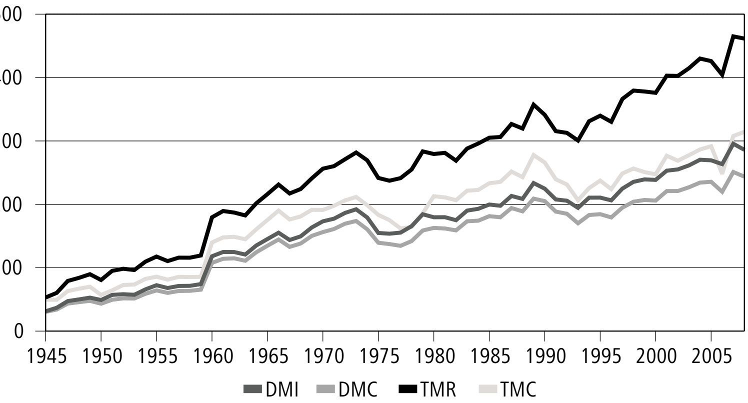
As can be seen from Figure 25, the trends in DMI and DMC are very similar, as are those for TMR and TMC measures. In practise, DMC has been 30 million tonnes below DMI and TMC over 60 million tonnes below TMR during the 2000's. Generally, DMI has been regarded as misleading in smaller-size open economies as a large volume of materials are exported abroad. Thus, DMC has been the preferred measure. The same applies to TMC and TMR measures.

Figure 24.
The trend in Finnish DMI and TMR measures in the period 1945 - 2008



Source: FIN-MFA.

Figure 25.
The trend in Finnish DMI, DMC, TMC and TMR measures in 1945 - 2008



Source: FIN-MFA.

6.3 Utilisation of aggregate measures in policy

Every policy area in the European Commission uses various indicators to support their policy-making. The future use of indicators is likely to focus on three different aspects: (1) more use of single indicators, (2) more use of indicator sets and (3) more use of composite indicators (European Commission 2007a.) A greater use of single indicators is required at individual policy level, where new specific policies are evaluated and monitored using new indicators. Statistical indicators describe quantitative variables measured or calculated individually or as part of a set and allow one to obtain as much valid empirical information as possible on a specific matter. The purpose of indicator-building is to represent a complex reality: the state of a society, its social, economic and ecological connections, and their development. (Radermacher 2005.)

From the point of view of policy, aggregate measures of material flows are useful in supporting economies, especially if measured regularly and consistently over time to identify trends in material intensity. The indicator should be combined with economic measures (e.g. TMR per unit GDP) to track changes in material intensity and, thereby, tendencies toward the dematerialization of an economy (or the reverse). TMR per unit GDP can also provide a tool to compare a country's material economy with those of other countries for a greater understanding of common as well as unique patterns. The measurement of levels and trends in, material requirements allow better identification both of priorities for policy intervention as well as points of leverage for that intervention.

Aggregate indicators combine large quantities of data in a single measure and are thus practical in, for example, comparing multi-dimensional phenomena in different countries. But due to their highly aggregate nature, not all dimensions of the measured phenomenon are visible in the aggregate measure. This means that, while highly aggregate measures can be illustrative and relatively easy to use in many cases, not all aspects of the complex phenomena they describe are necessarily fully reckoned with in the single measure. Despite that, aggregate measures can be useful tools in politics and in sharing information with the public, since they are relatively simple measures that can be easily communicated in many situations. The proper interpretation of aggregate measures, however, always requires sufficient knowledge of the contents of the indicator in question.

Indicators of material flows serve as proxies of the environmental impact and pressure of economic activities while measuring, for example, eco-efficiency. Indicators that also account for hidden flows can shed light on aspects of material extraction and use that are not taken into account in national economic accounts. All in all, material flow accounts help to answer crucial questions that lie at the heart of sustainable development: Is economic activity reducing its dependence on resources? Is it performing well in terms of eco-efficiency? Is it able to provide the same, or increased, level of well-being by using fewer resources? Is there evidence of the exportation of environmental damage to other world regions via international trade?

7 MFA Analysis of the Finnish Economy

7.1 Economic values relating to material flows

Direct material flows of natural resources into the economy can be evaluated with reference to their market price. Direct flows that are outputs of the economy include waste flows and exports. Waste can be priced by e.g. using the cost of dumping waste in landfills, which is obtained from national economic accounting systems. However, economic accounts do not capture the whole picture of an economy's use of natural resources, e.g. hidden material flows do not show up in these accounts. The market prices of natural resources do not reflect the externalities of the production chain or the sustainability of the use of the resources. The landfill fees most often do not reflect the landfill's whole impact on the environment. Market prices are thus only estimates of the total economic value of material flows. The evaluation of hidden flows is even more challenging. Hidden flows in one sector can be used as raw materials in another sector of the economy. In such a case, the evaluation of hidden flows can be carried out with reference to the opportunity cost of these materials or the price of transaction between sectors. The pricing of hidden material flows that are not used in any sector must be carried out indirectly. When hidden flows are negative externalities, their environmental impact can be economically evaluated, for example, by asking people how much they would be willing to pay to undo the environmental impact. Other methods of indirect pricing include evaluating the cleaning costs of the environment or the welfare losses to society. The inadequate functioning of the price mechanism, the underpricing of natural resources and the totally missing prices of numerous environmental services are the main reasons why other means have been developed to arrive at indicators of environmental impact. (Hoffrén 2001, 63.)

In addition to market price, the total economic value of environmental commodities consists of different utility values and other values. Utility values are benefits enjoyed by the current generation. They include the direct benefit from consumption (direct utility value), ecosystem services (indirect utility value) and the option value. The option value consists of the direct and indirect utility values of nature in the future. Other values that should be taken into consideration in the evaluation of environmental commodities are the value of the natural capital left behind for future generations (bequest value) and the right of the species to exist (existence value). The existence value means that the mere existence of the species is thought to have a certain value. (Hoffrén 1997.) The market price of a natural commodity most often only reflects its direct utility value and ignores other values. This can have severe consequences, as an incomplete economic evaluation of natural resources can lead to their extensive and fast depletion.

Neo-classical economics considers the undervaluation of natural commodities as a market failure. This market failure occurs because not all impacts associated with the use of natural commodities are evaluated in their price. Proposed settlements to the problems that arise from the non-priced impacts, or externalities, relate to correcting the incompleteness of the markets. The two main theories offering a solution to the problem of the undervaluation of natural commodities are 1) to compensate those suffering from the externality and 2) to define proprietary rights extensively. The practical applications of these theories are environmental taxes and emission trading programmes (Hoffrén 1997). Neo-classical economics thus assumes that when all impacts on e.g. the environment and people are accounted for in prices, the market failures associated with natural commodities can be corrected.

Expressing the environmental quality or the health of people in monetary terms is a challenge, although some valuation method exists. One of the most important reports on the evaluation of economic impacts on nature is the famous Stern Review (2006), where the economical impacts of climate change have been assessed. In Finland the Ministry of Transport and Communications has evaluated the economic impact of air pollutants from road transportation and uses these in evaluating and planning their projects (Finnish Road Administration 2005). Insurance companies also use evaluation systems when assessing the health and the life of people in their policies.

As stated earlier, the quality and type of different material flows have varying potential to cause environmental hazards. Also monetary evaluation methods vary a lot. Also the costs that affect value added are different in each sector in question, e.g. in the mining sector the costs of quarrying (and so the costs of HF) are very different from those in agriculture. In mining, building the infrastructure and removing the biomass and the extent of mineral deposits has an enormous effect on costs (which are ultimately reflected in the sector's value added). Monetary evaluations of hidden flows can thus be made by assessing costs. Further analysis of costs can be used in addition pricing wastes can be carried out by using the cost of dumping waste in landfills, which is derived from the national economic accounting systems or costs of land removals gives the information on the costs. However, economic accounts do not capture the whole picture of an economy's use of natural resources, e.g. hidden material flows do not show up in these accounts.

Hidden material flows are the consequence of economic activities the same way that direct material flows are. As stated earlier in Chapter 2.1, according to the laws of physics, the material throughput of an economy should be minimised in order to reduce the amount of waste and volumes of emissions that are discarded in nature. When economic activity and the use of natural resources are combined with the growing economic welfare in developing countries as well as with population growth, the only deduction to be made is that we are on an unsustainable path. Currently, the industrialised countries are using 80 per cent of the natural resources available and the developing countries are left with just 20 per cent, although the population of these countries represent 20 per cent and 80 per cent of the world population respectively. This is neither sustainable in the sense of environmental responsibility nor in the sense of social responsibility which are two out of the three sustainable development (SD) dimensions.

To maintain or steer the consumption of natural resources along a more sustainable path, the assessment of the current behaviour and consequences of our economic activity is most important. This has also been acknowledged in the political agenda, as the Total Material Requirement (TMR) indicator is at its highest priority level in the indicator set of Sustainable Development Indicators (SDI) of EU renewed Sustainable Development Strategy (EU SDS). Hidden material flows play an important role when calculating TMR: if the hidden flows are excluded from MFA accounting, we have only partly useful data on material flows and when this is the basis of material flow-related indicators which are used to assess sustainability, the figures underestimate the consequences as a whole.

Magnitude of direct material flows as well as hidden material flows can be characterised in different ways according to the potential environmental impacts these flows are producing. According to the OECD (2008), the first characterisation is made by material type usually by distinguishing between toxic flows and bulk flows. The second characterisation is made by the stage of the material flow cycle including extraction, processing, waste treatment and transportation stages. The third type of characterisation is to distinguish environmental pressures by location, which helps to monitor potential impacts due to changes in domestic material demand and consumption in relation to imported materials and different trade patterns. Furthermore, the OECD (2008) identifies two types of pressure which burdens the environment due to the use of material resources. First, there are pressures associated with the quantity and quality of the natural resource stocks from which the materials are extracted. Second, there are pressures associated with the environmental burden itself (pollution, waste, habitat disruption) while material resources are being used. The main concerns in both types with respect to environmental impact relate to the depletion rate and the reproduction capacity of natural resources, which causes changes in the environmental services provided by natural resources and had an adverse impact on environmental quality (e.g. air, climate, water, soil, biodiversity, landscape and human health).

The most harmful consequences of hidden flows relate to the magnitude of direct flows in most sectors. However, there are significant and relevant hidden flows e.g., in mining, that are independent from the magnitude of direct material flows. These factors depend on whether the mine is open-cast or subterranean, and the metal concentration of the iron ore as well as the extent of the deposit. There are always consequences of material extraction, mining and land use. Hidden flows are just one part of the process that has environmental consequences and should therefore be taken into consideration. An assessment of hidden flows also provides information on how efficient primary production systems are. By minimising and constantly reducing the magnitude of hidden flows, primary production becomes more efficient and the natural resources are used more effectively, and so the environmental consequences can be minimised as well. The material-based indicators are distorted if hidden flows are not taken into consideration. Thus, there is a clear need to know more about and focus more on the assessment of, hidden flows. There is a danger that if hidden flows are not taken into consideration, they will remain in the shadow and will be ignored in decision-making.

Characterisation of material flows demonstrates that the environmental impacts of aggregated material flows of different material types cannot be considered equal (Seppälä 2006 et. al). The Finnish Environment Centre (SYKE) is running the ENVIMAT Programme jointly with the Thule Institute to assess the different environmental impacts of the Finnish national economy in different production sectors. The ENVIMAT Programme connects life-cycle methodology to databases of the national material flow accounts and input-output analysis in order to assess the environmental impacts of final commodities. This is an ambitious goal and it is widely recognised that these kinds of extensive analyses suffer from the lack of proper methods for weighting the different emission flows. Using different weighting methods might mean that the results differ considerably. Furthermore, a common understanding of what are the most severe environmental consequences affects the results of environmental indices. For example, when the concern of global warming and carbon dioxide emissions are emphasized, this greatly affects to the weightings of other emissions.

The basic monetary evaluation of hidden material flows naturally faces the same problems as direct material flows as well as residual flows on the output side (i.e. waste, emissions, other residuals). The total economic value of environmental commodities consists of different utility values as well as other values that are not as obviously determined as the market-price-related values of natural resources. The market price of a natural commodity most often only reflects its direct utility value and ignores other values. This can have severe consequences, as an incomplete economic evaluation of natural resources can lead to their extensive and fast depletion when prices do not reflect the consequences as a whole. This also underlines the importance of hidden flows. The utility value that has a market price reflects only direct material flows and excludes hidden flows from the evaluation.

Different utility values are benefits that are enjoyed by the current generation and include direct a benefit from consumption (direct utility value), ecosystem services (indirect utility value) and the option value, which consists of direct and indirect utility values of nature in the future. In addition to these, there are also values that are difficult to determine in monetary terms but should be taken into consideration in the evaluation of environmental commodities. These are the value of the natural capital left behind for future generations (bequest value) and the right of species to exist (existence value). The existence value means that the mere existence of species is thought to have a certain value (Hoffrén 1997).

The monetary undervaluation of natural commodities is characterised as a market failure because not all impacts associated with the use of natural commodities are included in the price mechanism. It is difficult to include all different values that natural commodities have into prices. The current market-based solutions to undervaluations are related to the concept of externalities, which are the consequences of market failures. The proposed solutions try to bring the externalities into the sphere of markets by 1) determining the ownership of different materials more precisely so that compensation for the use of natural resources could be judged more appropriately (the polluter pays principle) and 2) the intervention of the public sector when more precise taxes are levied on different environmental goods when the compensation for the environmental costs is divided between society and the polluter or the agent that is exploiting the natural resources. The practical applications of these theories are reflected in environmental taxes and emission trading programmes. Although previously proposed solutions to market failures are in place and are being developed by different parties, they are currently inefficient or insufficient in scope to cover all the problems.

The market prices of natural resources do not reflect the externalities of the production chain or the sustainability of the use of resources. Market prices are thus only estimates of the total economic value of material flows. The economic evaluation of hidden flows is even more challenging. Hidden flows in one sector can be used as raw materials in another sector of economy. In such a case, the economic evaluation of hidden flows can be carried out with reference to the opportunity cost of these materials or the price of a transaction between sectors. The pricing of hidden material flows that are not used in any sector must be carried out indirectly. When hidden flows are negative externalities, their environmental impact can be evaluated, for example, by asking people how much they would be willing to pay to undo the environmental impact. Other methods of indirect pricing include evaluating the cleaning costs of the environment or the welfare losses to society.

7.2 Trends in the Eco-efficiency of the Finnish economy

The concept of Eco-efficiency was first proposed by Schaltegger and Sturm in 1990 and was later popularised by Schmidheiny and the Business Council for Sustainable Development (BCSD). The theoretical background to Eco-efficiency comes from ecological economics, and especially the idea of a throughput economy presented by Boulding, Daly, Ayres and Simonis. Eco-efficiency seeks to combine economic efficiency and the material efficiency of production with the objectives of sustainable development and the notion of social justice under a single heading. At a general level, combining these points of view means that the use of materials must be reduced in order to minimise adverse environmental impacts while at the same time with ever diminishing amounts of materials should be produced a relatively increasing degree of economic welfare which is also distributed in an increasingly equitable manner (Helminen 1998, 38).

A large number of indicators have been created to measure the achievement of Eco-efficiency, all seeking to describe the realisation of the objectives set. The principal indicators of Eco-efficiency reflect changes in the use of natural resources and energy in relation to production. It has not yet been possible to create any generally accepted indicators of Eco-efficiency for production, products and services. Besides international comparability, the calculation of Eco-efficiency calls for relatively easily available, reliable and up-to-date data (Working group on Eco-efficiency 1998, 17). The enterprises which have made a commitment to Eco-efficiency have tended to use the dimensions which are suitable for physical measurement. The formulation of price and welfare indicators is not a straightforward matter, even though financial evaluations form a central element of Eco-efficiency. On the other hand, some of the components of Eco-efficiency listed by the WBCSD can in practice be unsuitable for their purpose (Michaelis 1997, 9).

The summing up of different material tonnage figures into a single measure provides a very rough picture of the state of the environment. From a biological point of view, the use of a small amount of some highly toxic substance in the economy may have a greater impact than the use of a much larger amount of relatively harmless stone. Indeed, the hidden assumption behind the Eco-efficiency concept is that current environmental policy instruments adequately ensure that the ability of various material flows to cause varying kinds of environmental impacts can be neutralised by means of environmental and other social policy measures to a degree that enables the DMI and TMR measures to be compiled and used.

In Finland several economy-wide Eco-efficiency analyses have been conducted (e.g. see Vehmas et. al 2008, 2007, Hoffrén 2001, 1999) In this report, trends in Finnish Eco-efficiency has been analysed according to EU guidelines by using GDP data and the material flow aggregates of the FIN-MFA Accounting System. The trends in GDP/DMI and GDP/TMR are shown in Figure 26.

The Eco-efficiency trends in Figure 26 show very little improvement. However, if we restrict the analysis to time period from 1960 to 2008, the picture about the progress of Eco-efficiency development seems more positive. This is illustriated in Figure 27.

Figures 26 and 27 give a quite worrying picture of the development of Finnish Eco-efficiency. Earlier, eco-efficiency analysis based on the Malinda account-

Figure 26.
Trends in the Eco-efficiency of the Finnish economy from 1945 to 2008 (1960=100)

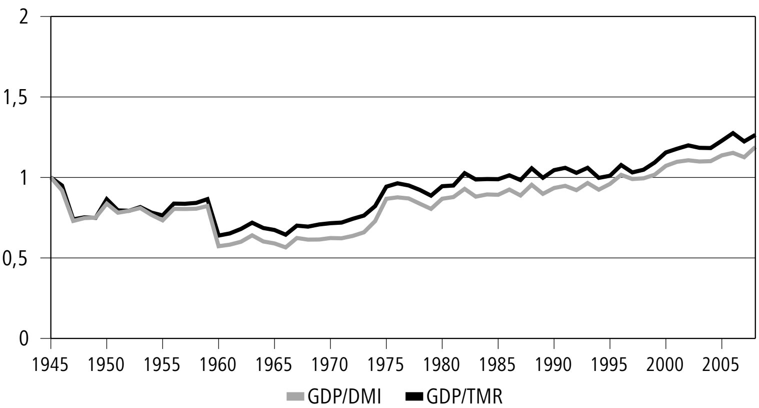
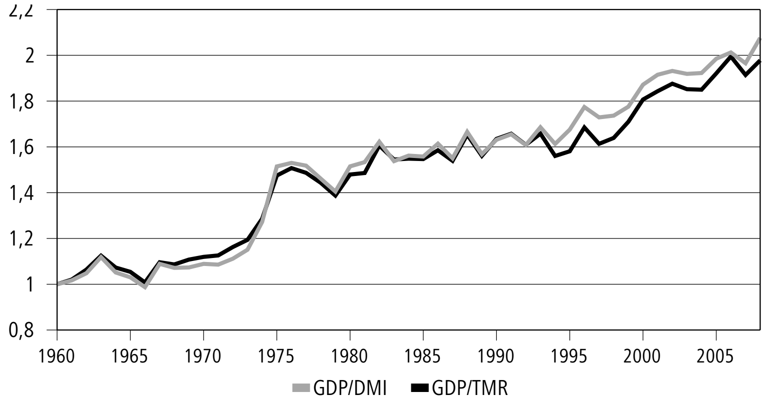


Figure 27.
Trends in the Eco-efficiency of the Finnish economy from 1960 to 2008 (1960=100)



ing system suggested an improvement by Factor 2.2 in Eco-efficiency measured by GDP/DMF (see Hoffrén 2001). The improved FIN-MFA accounts cause the increase in Eco-efficiency to remain much lower than levels measured previously. Earlier, Eco-efficiency analysis of the Finnish economy showed positive progress, but now it seems that Finnish Eco-efficiency has almost stabilised from 1975 and has since then only slightly improved. An economy-wide Eco-efficiency analysis presents many challenges. In fact, Eco-efficiency only describes the relative changes in input and output variables and ignores the absolute global limits imposed because of the requirements of sustainable development. However, in spite of these shortcomings, Eco-efficiency analysis provides many new insights into the functioning of an economy as a whole (e.g. see Hoffrén and Korhonen 2007, Hoffrén 2006).

7.3. A comparison of direct and hidden flows and waste flows

Statistics on waste are compiled by Statistics Finland. According to these statistics Finland accumulated 69.2 million tonnes of waste in dry weight in 2006. Of this, 2 million tonnes came from forestry, agriculture and fishing, 20.5 from mining and quarrying, 18 from manufacturing, 1.6 from energy supply, 23.1 from construction, 1.3 from services and 1.6 million from households. The waste flows are well identified and recorded in statistics, and directly usable for economy-wide material balances. However, since the time series are missing, no time series analysis can be done.

Finnish TMR was 432.8 million tonnes in 2006. Thus waste flow amount is only 16 per cent of the amount of TMR. In addition, total hidden flows for the

Finnish economy in 2006 were some 164.6 million tonnes, of which 81.1 million tonnes were domestic hidden flows and 73.1 million tonnes hidden flows related to imports. By volume they well exceed that of waste flows. Thus, waste flows provide a very restricted view of the magnitude of the residuals produced by the economy and discarded in nature. It is also important to realise, that statistics on waste record some waste materials that are also recorded as hidden flows in FIN-MFA, and this may lead to double accounting that falsifies the results of the analyses. To resolve these problems, more in-depth analysis of material flows and waste flows is needed in future research.

8 Continuation of Statistical Compilation and Proposals

8.1 Regular compilation of statistics

In Finland and in other EU member countries there is a clear need to start regular compilation of MFA accounts with hidden flows. The needs arise from the aims of sustainable development and environmental policy. Among the national statistical institutes there exist urgent and specific needs for standardisation, harmonisation and reliability with respect to MFA accounts, supervised and guided by Eurostat. *The Pilot study on economy-wide material flow accounts with hidden flows in Finland* project has recognised that monitoring of material flows, especially hidden flows, cannot be left to be carried out at national level but calls for international co-ordination. For reasons of reliability, the compilation of national MFA accounts with hidden flows is clearly the task of national statistical offices. In Finland too, the compilation of yearly MFA accounts should be the task of the national statistical office (Statistics Finland). The current situation, where statistics are compiled by researchers on an ad hoc basis, does not guarantee that all the issues required for official statistics are taken into consideration.

The methods and sources of data presented in this *Pilot study on economy-wide material flow accounts with hidden flows in Finland* report can be used in the future compilation of MFA accounts with hidden flows in Finland. During this pilot study reliable time series of complete Finnish MFA accounts covering the years from 1945 to 2007 have been compiled. Data sources, classifications, methods and procedures that ensure comparable accounts to be compiled on a regular yearly basis have been established. They can continue to be updated in the years to come, in order to improve the details and, thereby, data quality. The MFA accounts presented in this report aim to describe the annual physical flows of materials in the national economy, the economy of the rest of the world, and the environment, as well as material accumulation in the economy. It also tries to cover inputs relating to natural resources, products, residuals and ecosystems, and include indirect and hidden flows. The proposed FIN-MFA system will also produce both direct material flow data as well as reliable data about hidden flows (HF). Thus, it would fulfil most of the requirements of sustainable development measures.

If the approach described in this report for the yearly compilation of Finnish MFA accounts with hidden flows were adopted, it would take three months per year for one person to compile. Compilation at national level could be started quite quickly. Since the system proposed depends on organisations' timetables for producing the input data, the updating work required will be distributed and fragmented over the whole one-year period. The time lag for MFA accounts to be completed would be some 4–6 months for preliminary data and some 13 months for final data from the end of the year in question. If necessary, this time lag can be shortened by means of co-operation with organisations responsible for input data sources. Although much of the input data will come from outside sources, the compilation of MFA accounts is clearly a task of the national statistical office. Our recommendation is to start regular year-to-year MFA accounts compilation during 2010-2011. However, since the actual start of the compilation of MFA accounts with hidden flows in Finland will require additional resources, it remains a question to be solved at national level in co-operation with the Ministries of Finance and the Environment.

8.2 Reportings

The MFA data should be published yearly. Furthermore, in-depth analyses of the data are urgently needed to meet the sustainable development challenge and environmental policy needs. These analyses can only be reliably produced by the unit that produces the MFA data. The analysis should be published yearly at the same time as the actual data is published. In addition, the MFA data with hidden flows should be made freely available to all researchers in electronic format via the internet in order to encourage the use of this data.

8.3 Quality assurance

The compilation of direct material flow accounts relies on existing databases. Thus, the data quality is mainly based on the original data sources and their data compilation methods, unless the statistical office starts its own compilation of basic data. This seems an improbable, though desirable goal, in the future. Merging all the units compiling data to MFA accounts into single division would greatly improve the quality of MFA accounts as well as the quality of subsequent aggregate measures. They should be compiled by the national statistical office for reasons of reliability and they should be published in Official Statistics of Finland series (OSF i.e. Suomen Virallinen Tilasto, SVT). The MFA figures collected during this project can be judged as quite reliable. Yet there still is a need to improve the quality of basic data. A follow-up project to improve FIN-MFA basic data accuracy is needed. The calculation of hidden flows of exports and imports especially needs to be reviewed and improved.

The foremost challenge in the compilation of MFA accounts is hidden flows. Some hidden flow data is recorded by the same compilation institutes that attend to direct flows (e.g. mining), but for most of the flows we must rely on simplified and general multipliers as well as the view of experts in the various sectors. Thus, the magnitude and dynamics of indirect flows in these cases is determined by the magnitude of direct flows. From the perspective of official statistics, the use of multipliers is not at all desirable, but in some cases it is unavoidable. The quality perspective will call for more accurate and specific knowledge of ecological rucksacks relating to different substances of different origin if we want to include hidden flows in economy-wide-MFA accounts. Improving the reliability of MFA accounts and the multipliers used in estimating hidden flows is essential for future MFA compilation.

8.4 *International database for hidden flow multipliers*

The compilation of data on HF related to imported material flows requires special attention. Our proposal is that Eurostat and/or the OECD establishes a database of dynamic and country-specific HF multipliers that would cover the time period from 1945 up till the present day. This would be of great benefit to the reliability and comparability of HF accounts internationally and it is also crucial information when assessing the overall consequences for the natural environment of one economy's use of materials and services. It would enable analyses of different trends as well as country comparisons and would fortify the SD perspective in national economic and environmental policies. The FIN-MFA project can provide some relevant HF multipliers for data compilation, especially on the HFs of exported materials produced in Finland. However, there remain some critical questions for future developments. One of them concerns the dynamics of hidden flow multipliers. Since the ecological rucksacks tend to change over the years, HF trends should be taken into consideration in MFA accounts. The HF multipliers for import and export flows should also be country-specific, since the ecological rucksacks of same direct material flows varies a lot between different countries.

Many hidden material flows relating to some economic sectors are country-specific i.e. they depend on the utilisation of a country's stocks of natural resources as to which materials are exported, what concentrates exist, e.g. for metal ores, and what technology is being used. But the determination of country-specific coefficients takes up a lot of resources and is very time-consuming. Due to the nature of hidden material flows and the relevant multipliers, there is a clear need for a common international database for standardised, harmonised and good quality dynamic coefficients of hidden material accounts. Significant savings in time and resources could be made if the compilation of data for hidden material flows could be co-ordinated and a database established by Eurostat or the OECD with the co-operation between Eurostat, the national statistical offices in EU member countries, the OECD and the Wuppertal Institute. This could also be a solution to the variety of indirect or hidden flow multipliers and determining them in a standard way and without overlapping methods. This way, the dynamics of these multipliers could also be improved. At the EU level, the yearly-based data compilation of HF would thus rely on national statistical offices which supply the country-specific HF multipliers needed for a common international database of HF multipliers.

As the global economy expands and the challenges of tracking all material extraction due to globalisation increase, we also face globally the same challenges and problems in determining MFA. The more complicated the tracking of the use of natural resources becomes, the more urgent is the need to integrate the databases, especially in the case of country-specific hidden flows. The establishment of harmonised and standardised annual Material Flow Accounting at EU level is extremely important and it is the task of Eurostat to ensure that MFA compilation is reliable and harmonised across the EU.

9 Conclusions

The *Pilot study on economy-wide material flow accounts with hidden flows in Finland* project has reviewed and suggested several necessary actions and methods to compile MFA accounts on a regular yearly basis. To achieve good quality, the MFA accounting framework should be sufficiently comprehensive, i.e. the hidden flows of materials should be taken into consideration when compiling MFA. Although a considerable amount of research has been carried out on MFA, hidden flows are often excluded due to difficulties in determining them. In Europe, the Wuppertal Institute is one of the pioneering bodies in determining multipliers for country-specific hidden flows. Without hidden flows, MFA is only a partly suitable measure for assessing the environmental impacts of an economy and can thus be considered as a minimum estimation of the use of resources. If hidden flows are included, MFA can be considered sufficient to assess the use of natural resources and the achievement of sustainable development comprehensively and to derive the relevant aggregate indicators and analysis.

A reduction in the use of natural resources should be a common global target in reducing environmental impact. Before setting targets we need comprehensive data on how much of natural resources we are using currently. This also requires international co-operation. Comprehensive co-operation between Eurostat and institutions could be very beneficial to all. There is a need to establish close co-operation to standardise and harmonise the MFA framework, where key concepts, methods and procedures are defined exactly, so that no overlapping methods exist and so that the system boundaries are analogous. Furthermore, best practices will help to promote nationwide MFA in the EU.

The *Pilot study on economy-wide material flow accounts with hidden flows in Finland* project proposes an economy-wide MFA accounting system with hidden flows that would produce both direct material flow data as well as reliable data on hidden flows (HF). Thus, it would fulfil most of the requirements of sustainable development indicator. There is a clear need to start regular compilation of MFA accounts with hidden flows within EU member countries. The needs arise from the aims of sustainable development and environmental policy. There are urgent and specific needs for standardisation, harmonisation and reliability in MFA accounting that should be supervised and guided by Eurostat. HF monitoring, in particular, cannot be left to be carried out at national level but calls for international co-ordination. The compilation of national MFA accounts with hidden flows is clearly the task of national statistical offices. In Finland too, the compilation of yearly MFA accounts should be the task of Statistics Finland.

MFA data should be published yearly. Furthermore, in-depth analyses of the data are urgently needed to meet the sustainable development challenge and environmental policy needs. These analyses can only be produced reliably by the unit that produces the MFA data. The analysis should be published annually at the same time as the actual data is published. Moreover, the MFA data with hidden flows should be made available to all researchers by making it freely available in electronic format via the internet to encourage the use of this data.

This project could provide some relevant HF multipliers for hidden flow data compilation, especially for materials produced in Finland and exported. However, at EU level there remain challenges for future developments. One of them is the question of the dynamics of hidden flow multipliers. Since the ecological rucksacks tend to change over the years, HF trends should be taken into consideration in MFA accounts. The HF multipliers for import and export flows should also be country-specific, since the ecological rucksacks of the same direct material flows varies a lot between different countries. The compilation of data on HF related to imported material flows requires special attention. Our proposal is that Eurostat and/or the OECD establishes a database of dynamic and country-specific HF multipliers that would cover the time period from 1945 up till the present day. This would be a great benefit to the reliability and comparability of HF accounts internationally and it is also crucial information when assessing the overall consequences for the natural environment of one economy's use of materials and services. It would enable analyses of different trends as well as country comparisons and would fortify the SD perspective in national economic and environmental policies.

Many hidden material flows relating to some e economic sectors are country-specific i.e. they depend on the utilisation of a country's stocks of natural resources as to which materials are exported, what concentrates exist, e.g. for metal ores, and what technology is being used. But the determination of country-specific coefficients takes up a lot of resources and is very time-consuming. Due to the nature of hidden material flows and the relevant multipliers, there is a clear need for a common international database for standardised, harmonised and good quality dynamic coefficients of hidden material accounts. Significant savings in time and resources could also be made if the compilation of data for hidden material flows could be co-ordinated and a database established by Eurostat and/or the OECD. This could also be a solution to the variety of indirect or hidden flow multipliers and determining them in a standard way and without overlapping methods. This way, the dynamics of these multipliers could also be improved. At the EU level, the yearly-based data compilation of HF would thus rely on national statistical offices which supply the country-specific HF multipliers needed for a common international database of HF multipliers.

As the global economy expands and material extraction increases due to globalisation, so the challenges and problems in determining harmonised MFA methods also become greater. The more complicated the tracking of the use of natural resources becomes, the more urgent is the need to integrate the databases, especially in the case of country-specific hidden flows. The establishment of harmonised and standardised annual Material Flow Accounting at the EU level is extremely important and it is the task of Eurostat to ensure that MFA compilation is a practice across the EU.

Bibliography

Adriaanse A., S. Bringezu, A. Hammond, Y. Moriguchi. E. Rodenburg, D. Rogich and H. Schutz (1997), *Resource Flows: The Material Basis of Industrial Economies.* World Resources Institute (USA), Wuppertal Institute (Germany), Netherlands Ministry of Housing, Spatial Planning and Environment (The Netherlands) and National Institute for Economic Studies (Japan). Printed in USA.

Bringezu S., H. Schutz, S. Steger, and J. Baudisch (2004), International comparison of resource use and its relation to economic growth. The development of total material requirement, direct material inputs and hidden flows and the structure of TMR. *Ecological Economics* 51, 97–124.

Bringezu S., H. Schutz and S. Moll (2003), Rationale for and Interpretation of Economy-Wide Materials Flow Analysis and Derived Indicators. *Journal of Industrial Ecology* 7:2. 43–64.

Bringezu S., M. Fischer-Kowalski, R. Kleijn and V. Palm (eds.) (1998), *The ConAccount Agenda: The Conserted Action on Material Flow Analysis and its Research & Development Agenda*. Wuppertal Special 8. Wuppertal Institute for Climate, Environment and Energy. Wuppertal.

Bringezu S. (1997), From Quantity to Quality. Material Flow Analysis. In: Bringezu, S., M. Fischer-Kowalski, R. Kleijn, and V. Palm, V. (eds.) *Regional and National Material Flow Accounting: From Paradigm to Practice of Sustainability.* Proceedings of the ConAccount workshop, 21 – 23 January 1997, Leiden, The Netherlands. Wuppertal Institute for Climate, Environment and Energy. Wuppertal Special 4. 43–57.

Eurostat (2001), *Economy-wide material flow accounts and derived indicators – A methodological guide.* Luxembourg. Available at World Wide Web: <http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS–34–00–536/EN/KS–34–00–536–EN.PDF>

Finnish Road Administration (2005), *Tieliikenteen ajokustannusten yksikköarvot 2005* [online]. Suunnitteluvaiheen ohjaus. [viitattu 23.4.2008]. Tiehallinto. Helsinki. Available at: <http://alk.tiehallinto.fi/thohje/pdf/2100039-v-05tieliikent_ajokustann.pdf>.

Giljum S., F. Hinterberger, M. Wackernagel and J. Kitzes (2006), *Resource Use Indicators in the European Union. Policy Processes, Indicator Sets and Criteria for a Headline Indicator.* The Aachen Foundation. www.aachenfoundation.org

Giljum S. (2005). Material flow-Based indicators for Evaluation of Eco-Efficiency and Dematerialisation Policies. In Lawn, P. (Ed.) *Sustainability indicators in Ecological Economics.* Edward Elgar. Cheltenham. 376–398.

Giljum S. (2004). Trade, material flows and economic development in the South: the example of Chile. *Journal of Industrial Ecology* 8:1–2, 241–261.

Helminen R. (1998), *Eco-efficiency in the Finnish and Swedish Pulp and Paper Industry.* Acta Polytechnica Scandinavica. Mathematics, Computing and Management in Engineering Series No. 90. Espoo.

Hintenberger F., S. Giljum and. Hammer (2003), *Material Flow Accounting and Analysis (MFA). A Valuable Tool for Analyses of Society-Nature Interrelationships.* SERI Background Paper.

Hinterberger F., F. Luks, and F. Schmidt-Bleek (1997), Material flows vs. ”natural capital”. What makes an economy sustainable? *Ecological Economics*, 23, 1–14.

Hoffrén J. and Korhonen J. (2007), Editorial: Eco-efficiency is important when it is strategic. *Progress in Industrial Ecology* 4:1/2 – An International Journal, 1–18.

Hoffrén J. and Hellman J. (2007), Impacts of increasing consumption an material flows over time. Empirical results from Finland 1970–2005. *Progress in Industrial Ecology* 4:6 – An International Journal. Inderscience Enterprises Ltd. 463–481.

Hoffrén J. (2006), Reconsidering quantification of eco-efficiency: Application to a national economy. *Progress in Industrial Ecology* 3:6 – An International Journal. Inderscience Enterprises Ltd. 538-558.

Hoffrén J. (2001), *Measuring the Eco-efficiency of the Welfare Generation in a National Economy: The Case of Finland*. Statistics Finland. Research Reports 233. Hakapaino. Helsinki.

Hoffrén J. (1999), *Measuring the Eco-efficiency of the Finnish Economy.* Statistics Finland. Research Reports 229. Yliopistopaino. Helsinki.

Hoffrén J. (1998), *Material Flow Accounts as a Measure of the Total Consumption of Natural Resources.* The Finnish Environment 287. Ministry of the Environment. Edita. Helsinki.

Hoffrén J. (1997), *Finnish Forest Resource Accounting and Ecological Sustainability.* Research Reports 224. Statistics Finland. Helsinki.

Jonsson K., I. Linder and V. Palm, V. (2000), *En framtida nationell materialflödesstatistik. – användning av naturresursser, substanser och kemikalier i produktion och konsumption.* [Towards a national material flow statistics] Statistiska centralbyrån. Miljöräkenskaper. Rapport 2000:4. Örebro.

Laine U. (1994), *Use of Natural Resources in Finland.* [In Finnish]. Topic of Discussion 64. The Government Institute for Economic Research . Helsinki.

Laurila E. H. (1985). *Kulutus Suomen kansantaloudessa vuosina 1900–1975.* Elinkeinoelämän tutkimuslaitos B 42. Helsinki.

Matthews E. et al. (2000), *The Weight of Nations. Material Outflows from Industrial Economies.* World Resources Institute. Washington D.C.

Meadows D.H., D.L. Meadows, and J. Randers (1992), *Beyond The Limits. Confronting Global Collapse. Envisioning a Sustainable Future.* Chelsea Green. Post Mills.

Meadows D.H., D.L. Meadows, J. Randers, and C.W. Behrens (1972), *The Limits to Growth*. Universe Books. New York.

Michaelis L. (1998), *Increasing Resource Efficiency: Conceptual Framework and Policy Implications.* A paper presented in: Beyond Sustainability. Integrating behavioural, economic and environmental research. International NWO Conference. Amsterdam, 19–20 November. Conference proceedings. 54–59.

Michaelis L. (1997), *Eco-efficiency: Decoupling economic growth from environmental damage?* OECD. Environment Directorate. Environmental Policy Committee. Group on Pollution Prevention and Control. ENV/EPOC/PPC(97)8. OECD Headquarters, 5–6 November.

Moll S., Bringezu, S. and Schutz, H. (2005): *Resource Use in European Countries.* Wuppertal Reports No. 1. Wuppertal.

Mäenpää I. and A. Juutinen (2001), *Materials Flows in Finland: Resource Use in a Small Open Economy*. Journal of Industrial Ecology 5 (3) , 33–48.

Mäenpää, I., A. Juutinen, K. Puustinen, J. Rintala, H. Risku-Norja, S. Veijalainen and M. Viitanen (2000), *TMRFIN Suomen luonnonvarojen käytön tilastointijärjestelmä*. Oulun yliopisto/Thule-instituutti, CD-tallenne, 29.2.2000 Oulu.

Mäkelä P. (1985), *Use of Natural Resources and the GDP : Development of materials intensity 1960–2000*. Economic Planning Institute. Helsinki.

OECD (2008), *Measuring material flows and resource productivity*. Volume 1. The OECD Guide. OECD. Paris.

OECD (2002). *Indicators to measure decoupling of environmental pressure from economic growth*. Downloaded 24.6.2008. Available at World Wide Web: <http://www.oecd.org/dataoecd/0/52/1933638.pdf>

OECD (1998), *Eco-efficiency*. OECD. Paris.

Peltonen-Sainio P., S. Muurinen, A. Rajala and L. Jauhiainen (2008), Variation in harvest index of modern spring barley, oat and wheat cultivars adapted to northern growing conditions. *Journal of Agricultural Science* 146, 35–47. Cambridge University Press.

Radermacher, W. 2005. The Construction of Indicators. International Statistical Institute, 55th Session, 2005.

Ritthof M., H. Rohn and C. Liedtke in cooperation with Merten T.(2002), *Calculating MIPS. Resource productivity of products and services.* Wuppertal Spezial 27e. Wuppertal Institute for Climate, Environment and Energy at the Science Centre North Rhine-Westphalia. Visualisation Lab. Wuppertal Institute. Available at World Wide Web: <http://www.wupperinst.org/en/info/entnd/index.html?&beitrag_id=257&bid=169>

Seppälä J., and I. Mäenpää (2006), Suomen kansantalouden materiaalivirrat ja niiden ympäristövaikutukset, Suomen ympäristökeskuksen tuotannon esittely ja kulutuksen tutkimusohjelman esittely. *Ympäristö ja Terveys-lehti*. 6:2006, 37 vsk.

Schmidt-Bleek F. (1994), *MIPSbook or Fossil Makers – Factor 10 and more.* Draft translation. June 1996. Original in German: Wieviel Umwelt braucht der Mencsch – mips das Mass für Ökologisches Wirtschaften. Birkhäuser. Berlin.

Schutz H. and S. Bringezu (2008), *Final report: Resource consumption of Germany – indicators and definitions.* Translated version of the original final report in German "Ressourcenverbrauch von Deutschland – aktuelle Kennzahlen und Begriffsbestimmungen". German Federal Environment Agency (Umweltbundesamt). Available at World Wide Web: <http://www.umveltbundesamt.de>

Stern N (2007), *The Economics of Climate Change – The Stern Review.* Cambridge University Press.

IPCC. *Working Group III Report "Mitigation of Climate Change"*. Summary for Policymakers. http://www.ipcc.ch/SPM040507.pdf

Vehmas J., Luukkanen, J. and Kaivo-oja, J. (2007), Linking analyses and environmental Kuznets curves for aggregated material flows in the EU. *Journal of Cleaner Production 15*. 1662–1673

Vehmas J., J. Luukkanen.and J. Kaivo-oja (2008), Material flows and economic growth. Linking analyses and environmental Kuznets curves for the EU–15 member countries in 1980-2000. *TUTU Publications 8/2003*. Turku School of Economics and Business Administration. Finland futures research centre.

Voet van der E., L. van Oers, S. Moll, H. Schutz, S. Bringezu, S. de Bruyn, M.Sevenster and G. Warringa (2004), *Policy Review on Decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries.* Report 166, Department Industrial Ecology. Institute of Environmental Sciences Leiden University (CML), Leiden.

WCED (World Commission on Environment and Development) (1987), *Our Common Future.* [The Brundtland Report]. Oxford University Press. Oxford.

Weisz H., F. Krausmann N. Eisenmenger, H. Schutz, W. Haas and Schaffartzik (2007), *Economy-wide Material Flow Accounting "A compilation guide".* On behalf of Eurostat and the European Commission. 06 August 2007.

Weizsäcker von E., A.B. Lovins and L.H. Lovins (1997), *Factor Four. Doubling Wealth, Halving Resource Use.* The New Report to the Club of Rome. Earthscan. London.

Working group on eco-efficiency (1998), *Eco-efficiency and factors* [In Finnish]. Ministry of Trade and Industry. Working group and committee reports 1/1998. Helsinki.

Wuppertal institute (2003), *Material intensity of materials, fuels, transport services.* Version 2; 28.10.2003. Wuppertal Institute for Climate, Environment and Energy. Available at http://www.iwa.tuwien.ac.at/htmd2264/lehre/AWS-Vorlesungen/Ressourcenmanagement/2008_09/3%20MIPS%20Daten.pdf

Appendix 1. General Structure of the FIN-MFA Workbook

1.0 Summary (Main aggregates)
1.1 Domestic production of metal ores and minerals
1.2 Domestic flows of earth materials
1.3 Domestic peat production
1.4 Domestic wood production
1.5. Domestic forest by-products
1.6 Domestic agricultural production
1.7 Domestic flows (summary)
1.8. Exported flows

2.1 Imported metal ores and minerals
2.2 Imported flows of earth materials
2.3 Imported fossil fuels
2.4 Imported wood materials
2.5. Other imported non-renewables
2.6 Imported food products
2.7 Other imported renewables
2.8 Imported Flows (summary)

Appendix 2.
Domestic Direct Flows in FIN-MFA Accounts

1. Metallimalmit ja mineraalit – Metal ores and minerals

1.1 Metallimalmien ja mineraalien tuotanto – Production of metal ores and minerals

- 1.1.1 Malmi – *Metallic ores*
- 1.1.2 Muut teollisuusmineraalit – *Other industrial minerals*
- 1.1.3 Teollisuuskivet – *Industrial rocks*
- 1.1.4 Luonnonkivet – *Natural stones*

1.1 Yhteensä – *Total*

2. Maa-ainekset – Earth Materials

1.2 Suorat kotimaiset maa-ainesvirrat – Direct domestic flows of earth materials

- 1.2.1 Sora ja hiekka – *sand and gravel*
- 1.2.2 Soramurske – *crushed gravel*
- 1.2.3 Kalliomurske – *crushed rock*
- 1.2.4 Savi – *clay*
- 1.2.5 Luonnonkivet – *Natural stones*

1.2 Yhteensä – *Total*

3. Turvetuotanto – Peat production

1.3 Kotimainen turve – Domestic peat

- 1.3.1 Polttoturve – *Fuel peat*
- 1.3.2 Kasvu- ja kuiviketurve – *Other peat*

1.3 Yhteensä – *Total*

4. Puuntuotanto – Wood production

1.4 Puun ja puutuotteiden virrat – Wood flows

- 1.4.1 Runkopuu – *Roundwood*
- 1.4.2 Polttopuu – *Firewood*

1.4 Yhteensä – Total

5. Metsien ja luonnon muu tuotanto –
Forest and other natural by-products

1.5. Metsien sivutuotteiden virrat – Flows of forest by-products

- 1.5.01 Luonnonmarjat (kauppaantulomäärät) – *Wild berries (amount supplied to shops)*
- 1.5.02 Luonnonmarjat (kulutus kotitalouksissa) – *Wild berries (consumption in houdeholds)*
- 1.5.03 Sienet (kauppaantulomäärät) – *Mushrooms*
- 1.5.04 Jäkälä; kaupallinen poiminta – *Lichen (commericial gathering)*
- 1.5.05 Riistasaalis – Game catch
- 1.5.06 Poron liha – *Reindeer meat*
- 1.5.07 Ruokakalatuotanto (viljely) – *Production of eatable fish (fish farming)*
- 1.5.08 Ammatti/meri – *Professional fishing/sea*
- 1.5.09 Ammatti/sisä – *Professional fishing/inland lakes*
- 1.5.10 Vapaa-aika – *Leisure fishing*

1.5 Yhteensä – *Total*

6. Maatalouden tuotanto – Agricultural production

1.6 Maatalouden kotimainen tuotanto – Domestic Agricultural Production

1.6.01 Vehnä – *Wheat*
1.6.02 Syysvehnä – *Winter wheat*
1.6.03 Kevätvehnä – *Spring wheat*
1.6.04 Ruis – *Rye*
1.6.05 Ohra – *Barley*
1.6.06 Rehuohra – *Feed barley*
1.6.07 Mallasohra – *Malt Barley*
1.6.08 Kaura – *Oats*
1.6.09 Seosvilja – *Mixed crops*
1.6.10 Muut viljat – *Other grain*
1.6.11 Rypsi – *Turnip rape*
1.6.12 Rapsi – *Rape*
1.6.13 Ruistankio – *Camelina*
1.6.14 Peruna – *Potatoes*
1.6.15 Sokerijuurikas – *Sugar beet*
1.6.15 Herne – *Peas*
1.6.16 Kuivaheinä – *Hay*
1.6.17 Säilörehu – *Silage*
1.6.18 Tuorerehu – *Green fodder*
1.6.19 Tuorevilja – *Cereals harvested green*
1.6.20 Tuorerehu – *Green Fodder*
1.6.21 Muut rehujuurikasvit – *Other roots for fodder*

1.6 Viljelykasvien sato, yhteensä – *Yield of the main crop, total*

1.6.2 Puutarhatuotanto – *Horticultural production*
1.6.2.1 Vihannesviljely avomaalla – *Production of vegetables grown in the open*

1.6.2.1.01 Tarhaherne – *Garden pea*
1.6.2.1.02 Pensaspapu – *Bean*
1.6.2.1.03 Valkokaali – *White cabbage*
1.6.2.1.04 Punakaali – *Red cabbage*
1.6.2.1.05 Kukkakaali – *Cauliflower*
1.6.2.1.06 Savoijinkaali – *Savoy cabbage*
1.6.2.1.07 Ruusukaali – *Brussels sprout*
1.6.2.1.08 Parsakaali – *Sprouting broccoli*
1.6.2.1.09 Kyssäkaali – *Kohlrabi*
1.6.2.1.10 Lehtikaali – *Curly kale*
1.6.2.1.11 Porkkana – *Carrot*
1.6.2.1.12 Punajuurikas – *Beetroot*
1.6.2.1.13 Lanttu – *Swede*
1.6.2.1.14 Nauris – *Turnip*
1.6.2.1.15 Retiisi – *Radish*
1.6.2.1.16 Mukulaselleri – *Celeriac*
1.6.2.1.17 Palsternakka – *Parsnip*
1.6.2.1.18 Ruokasipuli – *Onion*
1.6.2.1.19 Purjo – *Leek*
1.6.2.1.20 Avomaankurkku – *Gherkin*
1.6.2.1.21 Kurpitsa – *Pumpkin*
1.6.2.1.22 Kesäkurpitsa – *Courgette*
1.6.2.1.23 Pehmeäkeräsalaatti – *Butter-head lettuce*
1.6.2.1.24 Rapeakeräsalaatti – *Crisphead lettuce*
1.6.2.1.25 Muut salaatit – *Other salad*

1.6.2.1.26 Kiinankaali – *Chinese cabbage*
1.6.2.1.27 Lehtiselleri – *Celery*
1.6.2.1.28 Pinaatti – *Spinach*
1.6.2.1.29 Raparperi – *Rhubarb*
1.6.2.1.30 Tilli – *Dill*
1.6.2.1.31 Persilja – *Parsley*
1.6.2.1.32 Valkosipuli – *Garlic*
1.6.2.1.33 Parsa – *Asparagus*
1.6.2.1.34 Sokerimaissi – *Sweet corn*
1.6.2.1.35 Muut vihannekset – *Other vegetables*

1.6.2.1 Yhteensä – *Total*

1.6.2.2 Vihannesten tuotanto kasvihuoneessa – *Production of vegetables in the greenhouse*

1.6.2.2.1 Tomaatti – Tomat – *Tomato*
1.6.2.2.2 Kasvihuonekurkku – Växthusgurka – *Cucumber*
1.6.2.2.3 Avomaankurkku – Frilandsgurka – *Gherkin*
1.6.2.2.4 Pehmeäkeräsalaatti – Huvudsallat – *Butter-head lettuce*
1.6.2.2.5 Rapeakeräsalaatti – Isbergssallat – *Crisphead lettuce*
1.6.2.2.6 Kiinankaali – Kinakål – *Chinese cabbage*
1.6.2.2.7 Paprika – Paprika – *Sweet pepper*
1.6.2.2.8 Tilli – Dill – *Dill*
1.6.2.2.9 Persilja – Persilja – *Parsley*
1.6.2.2.10 Muut yrttimausteet – Övriga örtkryddor – *Other herbs*
1.6.2.2.11 Porkkana – Morot – *Carrot*
1.6.2.2.12 Ruokasipuli – Lök – *Onion*
1.6.2.2.13 Valkokaali – Vitkål – *White cabbage*
1.6.2.2.14 Muut kaalit – Övriga kåler – *Other cabbages*
1.6.2.2.15 Kesäkurpitsa – Zuccini – *Courgette*
1.6.2.2.16 Muut yhteensä – Övriga totalt – *Other total*

1.6.2.2 Yhteensä – *Total*

1.6.2.3 Marjan- ja hedelmänviljely avomaalla – *Production of berries and fruit grown in the open*

1.6.2.3.01 Mustaherukka – Svarta vinbär – *Black currant*
1.6.2.3.02 Punaherukka – Röda vinbär – *Red currant*
1.6.2.3.03 Valkoherukka – Vita vinbär – *White currant*
1.6.2.3.04 Viherherukka – Gröna vinbär – *Green currant*
1.6.2.3.05 Vadelma ja mesivadelma – Hallon och åkerbärshallon – *Raspberry*
1.6.2.3.06 Karviainen – Krusbär – *Gooseberry*
1.6.2.3.07 Mansikka – Jordgubbe – *Strawberry*
1.6.2.3.08 Pensasmustikka – Buskblåbär – *Highbush blueberry*
1.6.2.3.09 Tyrni – Havtorn – *Sea buckthorn*
1.6.2.3.10 Marja-aronia – Bäraronia – *Chokeberry (Aronia spp.)*
1.6.2.3.11 Muut marjat – Övriga bär – *Other berries*
1.6.2.3.12 Omenat – Äpplen – *Apples*
1.6.2.3.13 Muut hedelmät – Övriga frukter – *Other fruit*

1.6.2.3 Yhteensä – *Total*

Viljellyt sienet – *Cultivated mushrooms*

2.1.2.4.01 Herkkusieni – Champinjon – *Champignon*
2.1.2.4.02 Muut sienet – Övriga svampar – *Other mushrooms*

1.6.2.4 Yhteensä – *Total*

1.6 Yhteensä – *Total*

Appendix 3.
Domestic Hidden Flows in FIN-MFA Accounts

1. Metallimalmit ja mineraalit – Metals and minerals

1.1 Metallimalmien ja mineraalien piilovirrat – Hidden flows of metal ore and minerals

1.1.1 Malmi – *Metallic ores*
1.1.2 Muut teollisuusmineraalit – *Other industrial minerals*
1.1.3 Teollisuuskivet – *Industrial rocks*
1.1.4 Luonnonkivet – *Natural stones*

1.1 Yhteensä – Total

2. Maa-ainekset – Earth Materials

1.2 Kotimaisten maa-ainesten piilovirrat – Hidden flows of domestic earth materials

1.2.1 Sora ja hiekka – *Sand and gravel*
1.2.2 Soramurske – *Crushed gravel*
1.2.3 Kalliomurske – *Crushed rock*
1.2.4 Savi – *Clay*
1.2.5 Luonnonkivet – *Natural stones*

1.2 Yhteensä – *Total*

3. Turvetuotanto – Peat production

1.3 Kotimaisen turvetuotannon piilovirrat – Hidden flows of domestic peat production

1.3.1 Polttoturve – *Fuel peat*
1.3.2 Kasvu- ja kuiviketurve – *Other peat*

1.3 Yhteensä – *Total*

4. Puuntuotanto – Wood production

1.4 Puun ja puutuotteiden piilovirrat – Hidden flows of wood flows

1.4.1 Runkopuu – *Roundwood*
1.4.2 Polttopuu – *Firewood*

1.4 Yhteensä – total

5. Metsien ja luonnon muu tuotanto – Forest and other natural by-products

1.5. Metsien sivutuotteiden piilovirrat – Hidden flows of forest by-products

1.5.01 Luonnonmarjat (kauppaantulomäärät) – *Wild berries (amount supplied to shops)*
1.5.02 Luonnonmarjat (kulutus kotitalouksissa) – *Wild berries (consumption in houdeholds)*
1.5.03 Sienet (kauppaantulomäärät) – *Mushrooms*
1.5.04 Jäkälä; kaupallinen poiminta –
1.5.05 Riistasaalis – *Game catch*
1.5.06 Poron liha – *Reindeer meat*
1.5.07 Ruokakalatuotanto (viljely) – *Production of eatable fish (fish farming)*
1.5.08 Ammatti/meri – *Professional fishing/sea*
1.5.09 Ammatti/sisä – *Professional fishing/inland lakes*
1.5.10 Vapaa-aika – *Leisure fishing*

1.5 Yhteensä – *Total*

6. Maatalouden tuotanto – Agricultural production

1.6 Maatalouden tuotannon piilovirrat – *Hidden flows of domestic agricultural production*

- 1.6.01 Vehnä – *Wheat*
- 1.6.02 Syysvehnä – *Winter wheat*
- 1.6.03 Kevätvehnä – *Spring wheat*
- 1.6.04 Ruis – *Rye*
- 1.6.05 Ohra – *Barley*
- 1.6.06 Rehuohra – *Feed barley*
- 1.6.07 Mallasohra – *Malt Barley*
- 1.6.08 Kaura – *Oats*
- 1.6.09 Seosvilja – *Mixed crops*
- 1.6.10 Muut viljat – *Other grain*
- 1.6.11 Rypsi – *Turnip rape*
- 1.6.12 Rapsi – *Rape*
- 1.6.13 Ruistankio – *Camelina*
- 1.6.14 Peruna – *Potatoes*
- 1.6.15 Sokerijuurikas – *Sugar beet*
- 1.6.15 Herne – *Peas*
- 1.6.16 Kuivaheinä – *Hay*
- 1.6.17 Säilörehu – *Silage*
- 1.6.18 Tuorerehu – *Green fodder*
- 1.6.19 Tuorevilja – *Cereals harvested green*
- 1.6.20 Tuorerehu – *Green Fodder*
- 1.6.21 Muut rehujuurikasvit – *Other roots for fodder*

1.6 Viljelykasvien sato, yhteensä – *Yield of the main crop, total*

1.6.2 Puutarhatuotanto – *Horticultural production*

1.6.2.1 Vihannesviljely avomaalla – *Production of vegetablesgrown in the open*

- 1.6.2.1.01 Tarhaherne – *Garden pea*
- 1.6.2.1.02 Pensaspapu – *Bean*
- 1.6.2.1.03 Valkokaali – *White cabbage*
- 1.6.2.1.04 Punakaali – *Red cabbage*
- 1.6.2.1.05 Kukkakaali – *Cauliflower*
- 1.6.2.1.06 Savoijinkaali – *Savoy cabbage*
- 1.6.2.1.07Ruusukaali – *Brussels sprout*
- 1.6.2.1.08 Parsakaali – *Sprouting broccoli*
- 1.6.2.1.09 Kyssäkaali – *Kohlrabi*
- 1.6.2.1.10 Lehtikaali – *Curly kale*
- 1.6.2.1.11 Porkkana – *Carrot*
- 1.6.2.1.12 Punajuurikas – *Beetroot*
- 1.6.2.1.13 Lanttu – *Swede*
- 1.6.2.1.14 Nauris – *Turnip*
- 1.6.2.1.15 Retiisi – *Radish*
- 1.6.2.1.16 Mukulaselleri – *Celeriac*
- 1.6.2.1.17 Palsternakka – *Parsnip*
- 1.6.2.1.18 Ruokasipuli – *Onion*
- 1.6.2.1.19 Purjo – *Leek*
- 1.6.2.1.20 Avomaankurkku – *Gherkin*
- 1.6.2.1.21 Kurpitsa – *Pumpkin*
- 1.6.2.1.22 Kesäkurpitsa – *Courgette*
- 1.6.2.1.23 Pehmeäkeräsalaatti – *Butter-head lettuce*
- 1.6.2.1.24 Rapeakeräsalaatti – *Crisphead lettuce*
- 1.6.2.1.25 Muut salaatit – *Other salad*
- 1.6.2.1.26 Kiinankaali – *Chinese cabbage*
- 1.6.2.1.27 Lehtiselleri – *Celery*

1.6.2.1.28 Pinaatti – *Spinach*
1.6.2.1.29 Raparperi – *Rhubarb*
1.6.2.1.30 Tilli – *Dill*
1.6.2.1.31 Persilja – *Parsley*
1.6.2.1.32 Valkosipuli – *Garlic*
1.6.2.1.33 Parsa – *Asparagus*
1.6.2.1.34 Sokerimaissi – *Sweet corn*
1.6.2.1.35 Muut vihannekset – *Other vegetables*

1.6.2.1 Yhteensä – *Total*

1.6.2.2 Vihannesten tuotanto kasvihuoneessa – *Production of vegetables in the greenhouse*

1.6.2.2.1 Tomaatti – Tomat – *Tomato*
1.6.2.2.2 Kasvihuonekurkku – Växthusgurka – *Cucumber*
1.6.2.2.3 Avomaankurkku – Frilandsgurka – *Gherkin*
1.6.2.2.4 Pehmeäkeräsalaatti – Huvudsallat – *Butter-head lettuce*
1.6.2.2.5 Rapeakeräsalaatti – Isbergssallat – *Crisphead lettuce*
1.6.2.2.6 Kiinankaali – Kinakål – *Chinese cabbage*
1.6.2.2.7 Paprika – Paprika – *Sweet pepper*
1.6.2.2.8 Tilli – Dill – *Dill*
1.6.2.2.9 Persilja – Persilja – *Parsley*
1.6.2.2.10 Muut yrttimausteet – Övriga örtkryddor – *Other herbs*
1.6.2.2.11 Porkkana – Morot – *Carrot*
1.6.2.2.12 Ruokasipuli – Lök – *Onion*
1.6.2.2.13 Valkokaali – Vitkål – *White cabbage*
1.6.2.2.14 Muut kaalit – Övriga kåler – *Other cabbages*
1.6.2.2.15 Kesäkurpitsa – Zuccini – *Courgette*
1.6.2.2.16 Muut yhteensä – Övriga totalt – *Other total*

1.6.2.2 Yhteensä – *Total*

1.6.2.3 Marjan – ja hedelmänviljely avomaalla –
Production of berries and fruit grown in the open

1.6.2.3.01 Mustaherukka – Svarta vinbär – *Black currant*
1.6.2.3.02 Punaherukka – Röda vinbär – *Red currant*
1.6.2.3.03 Valkoherukka – Vita vinbär – *White currant*
1.6.2.3.04 Viherherukka – Gröna vinbär – *Green currant*
1.6.2.3.05 Vadelma ja mesivadelma – Hallon och åkerbärshallon – *Raspberry*
1.6.2.3.06 Karviainen – Krusbär – *Gooseberry*
1.6.2.3.07 Mansikka – Jordgubbe – *Strawberry*
1.6.2.3.08 Pensasmustikka – Buskblåbär – *Highbush blueberry*
1.6.2.3.09 Tyrni – Havtorn – *Sea buckthorn*
1.6.2.3.10 Marja-aronia – Bäraronia – *Chokeberry (Aronia spp.)*
1.6.2.3.11 Muut marjat – Övriga bär – *Other berries*
1.6.2.3.12 Omenat – Äpplen – *Apples*
1.6.2.3.13 Muut hedelmät – Övriga frukter – *Other fruit*

1.6.2.3 Yhteensä – *Total*

Viljellyt sienet – Cultivated mushrooms

2.1.2.4.01 Herkkusieni – Champinjon – *Champignon*
2.1.2.4.02 Muut sienet – Övriga svampar – *Other mushrooms*

1.6.2.4 Yhteensä – *Total*

1.6 Yhteensä – *Total*

Appendix 4. Sources of direct material flow data

1. Kaivostuotanto (Domestic mining and imports of metals and minerals)

1.1 Kotimainen kaivostuotanto (Domestic mining)

Tiedot kotimaisesta metallimalmien, karbonaattikivien, muiden teollisuusmineraalien sekä muiden teollisuuskivien ja muiden vuosittaisesta tuotannosta ovat työ- ja elinkeinoministeriön mineraalipolitiikan yksikön keräämiä. Kyseiset vuoriteollisuuden louhintatilastot valmistuvat vuosittain toukokuussa.

Tiedot ovat ilmaiseksi saatavissa Työ- ja elinkeinoministeriön (TEM, Ministry of Employment and the Economy) sekä Geologian tutkimuskeskuksen (GTK, Geologival Survey of Finland) internetsivuilla:

Suomeksi:
http://www.tem.fi/index.phtml?s=2750
http://www.gsf.fi/luonnonvarat/tuotanto/
In English:
http://en.gtk.fi/ExplorationFinland/MineralProduction/

Lisätietoja: kaivosylitarkastaja Pekka Suomela, puhelin 010 606 3727, sähköposti: kaivosrekisteri@tem.fi

2.1 Metallien tuonti (Imports of metals and minerals)

Tiedot metallien viennistä ja tuonnista ovat saatavissa *Teknologiateollisuuden vuosikirja* -julkaisun liitteestä: Metallien tuotanto ja ulkomaankauppa, Metals production and trade (sivu 52).

Julkaisu on saatavana ilmaiseksi internetissä: http://www.teknologiateollisuus.fi

2. Maa-ainekset (Earth materials)

1.2 Kotimaisen maa-ainekset (Domestic earth materials)

Suomen suurimpien maa-ainesten hyödyntäjien (50 suurinta yritystä) kiviainesten tuotantotiedot kerää ja tuottaa vuosittain toukokuussa maa- ja vesirakennusalan yrittäjien ja yritysten etujärjestö Infra ry., Suomen ympäristökeskus (SYKE) ja Infra ry. arvioivat koko maan tuotantotiedot vuosittain loppusyksystä. Tilasto sisältää tiedot kalliomurskeen, soramurskeen ja hiekan ja soran otosta.
Lisätietoja: Infra ry, Johtaja Heikki Jämsä, puh. 010 821 0310, kännykkä: 050 587 2911, sähköposti: heikki.jamsa@infrary.fi

2.2 Maa-ainesten tuonti (Imports of earth materials)

Hyödykkeinä tapahtuva metallien tuonti löytyy kilogrammoina Tullin tuonti- ja vientitilastoista.

3. Turve ja fossiiliset polttoaineet – Peat and fossil fuels

1.3 Turvetuotanto – Peat production

Tiedot turvetuotannon määristä tuottaa Turveteollisuusliitto ry. Ne julkaistaan vuosittain joulukuussa Metsätutkimuslaitoksen (Metla) *Metsätilastollinen vuosikirja* -julkaisussa. Tiedot ovat saatavissa myös Metlan maksullisessa Metinfo -tietopalvelussa: http://www.metla.fi/metinfo/

2.3 Fossiiliset polttoaineet – Fossil fuels

Tilastot ovat saatavissa Tilastokeskuksen *Energiatilasto* -julkaisuista. Lopulliset tiedot julkaistaan vuosittain joulukuussa.

Suomen primäärienergialähteet (Primary energy sources in Finland) on esitetty *Energiatilasto* -julkaisun taulukossa 1.7. (sivut 38–39). Fossiilisten polttoaineiden kulutus on taulukossa esitetty tuhansina tonneina.

Hyödykkeinä tapahtuva fossiilisten polttoaineiden tuonti löytyy kilogrammoina Tullin tuonti- ja vientitilastoista.

4. Puuntuotanto – Wood production

1.4 Puun ja puutuotteiden virrat – Wood flows

Tiedot metsien puuaineksen kokonaispoistumasta julkaistaan vuosittain tammikuussa Metsätutkimuslaitoksen (Metla) *Metsätilastotiedotteita* -sarjassa ja joulukuussa *Metsätilastollinen vuosikirja* -julkaisussa. Tiedot ovat *Metsätilastollisen vuosikirjan* taulukossa 1.27. Tiedot ovat saatavissa myös Metlan maksullisessa Metinfo -tietopalvelussa: http://www.metla.fi/metinfo/

Tiedot puuaineksen tuonnista julkaistaan vuosittain tammikuussa Metsätutkimuslaitoksen (Metla) *Metsätilastotiedotteita* -sarjassa ja joulukuussa *Metsätilastollinen vuosikirja* -julkaisussa. Tiedot ovat *Metsätilastollisen vuosikirjan* taulukossa 10.2. Tiedot ovat saatavissa myös Metlan maksullisessa Metinfo -tietopalvelussa: http://www.metla.fi/metinfo/

5. Metsien ja luonnon muu tuotanto – Forest and other nature's by-products

1.5 Metsien sivutuotteet – Forest by-products

Tiedot metsien sivutuotteista julkaistaan vuosittain joulukuussa Metsätutkimuslaitoksen (Metla) *Metsätilastollinen vuosikirja* -julkaisussa. Tiedot ovat saatavissa myös Metlan maksullisessa Metinfo -tietopalvelussa: http://www.metla.fi/metinfo/

1.5.01 Luonnonmarjojen kauppaantulomäärät

Tiedot luonnonmarjojen (puolukka, mustikka, lakka ja muut) kaupallisesta poiminnasta vientiin kilogrammoina ovat Metsätilastollisen vuosikirjan taulukossa 6.7. Tiedot tuottaa Suomen Gallup Elintarviketieto (TNS Gallup Ltd. Food and Farm Facts).

1.5.02 Luonnonmarjojen kulutus kotitalouksissa

Arvioina käytetään samoja lukuja kuin Suomen kansantalouden tilinpidon laskennan pohjana.

1.5.03 Sienten kauppaantulomäärät

Tiedot villeinä kasvavien sienten kaupallisesta poiminnasta vientiin kilogrammoina ovat Metsätilastollisen vuosikirjan taulukossa 6.7. Tiedot tuottaa Suomen Gallup Elintarviketieto (TNS Gallup Ltd. Food and Farm Facts).

1.5.04 Jäkälän kaupallinen poiminta

Tiedot jäkälän kaupallisesta poiminnasta vientiin kilogrammoina ovat Metsätilastollisen vuosikirjan taulukossa 6.7.

1.5.05 Riistasaalis

Tiedot riistasaaliista kilogrammoina ovat Metsätilastollisen vuosikirjan taulukossa 6.1. Tiedot julkaistaan myös vuosittain elokuussa RKTL:n *Riistasaalis* -julkaisuissa, joka on saatavana myös internetissä osoitteessa:

http://www.rktl.fi/www/uploads/pdf/uudet%20julkaisut/tilastoja_5_07_korjattu090108.pdf

1.5.06 Porotalouden lihantuotos

Tiedot poron lihan tuotoksesta kilogrammoina ovat Metsätilastollisen vuosikirjan taulukossa 6.8.

1.5.07 Vesiviljelyn tuotanto

Tilastotietoja kalastuksen, kalan viljelyn sekä kalan tuonnin tonnimääristä kerää ja julkaisee riista- ja kalatalouden tutkimuslaitos (RKTL). Tiedot löytyvät seuraavista tilastoista (4.3.1–4.3.5).

Tiedot julkaistaan vuosittain kesäkuussa. Tiedot löytyvät RKTL:n *Vesiviljely* -julkaisuista sekä internetistä osoitteesta:

http://www.rktl.fi/tilastot/vesiviljelytilastot/vesiviljely/

1.5.08 Ammattikalastus merellä

Tiedot julkaistaan vuosittain kesäkuussa. Tiedot saalliiden määristä löytyvät *Ammattikalastus merellä* -julkaisuista sekä internetistä osoitteesta:

http://www.rktl.fi/tilastot/kalastustilastot/ammattikalastus_merella/

1.5.09 Ammattikalastus sisävesillä

Tiedot julkaistaan joka toinen vuosi joulukuussa.Tiedot löytyvät *Ammattikalastus sisävesillä* -julkaisuista sekä internetistä osoitteesta:

http://www.rktl.fi/tilastot/kalastustilastot/ammattikalastus_sisavesilla/

1.5.10 Vapaa-ajan kalastus

Tiedot julkaistaan joka toinen vuosi lokakuussa.Tiedot löytyvät *Vapaa-ajankalastus* – julkaisuista internetistä osoitteesta:

http://www.rktl.fi/tilastot/kalastustilastot/vapaa_ajankalastustilasto/

6. Maatalouden tuotanto – Agricultural production

Tilastot ovat saatavissa ilmaiseksi Tiken internet-sivuilta Matilda-tietopalvelusta osoitteessa: http://www.matilda.fi/servlet/page?_pageid=115,193&_dad=portal30&_schema=PORTAL30

Tiedot löytyvät seuraavista viidestä (2.1.1–2.2.4) tilastotaulusta. Tiedot julkaistaan vuosittain tammikuussa.

1.6 Viljelykasvien sato – Yield of the main crops
1.6.1 Peltoviljat – Crops
1.6.2 Puutarhatuotanto – Horticultural production

Maa – ja metsätalousministeriön tietopalvelukeskuksen puutarhayritysrekisteri (Horticultural enterprise register).

7. Muiden materiaalien tuonti ja vienti (Other imports and exports)

Hyödykkeinä tapahtuva metallien tuonti löytyy kilogrammoina Tullin tuonti – ja vientitilastoista.

Appendix 5. Structure of imported MFA accounts

1. Metallimalmit ja mineraalit – Metals and minerals

2.1 Metallimalmien ja mineraalien tuonti – Imports metal ores and minerals

Raudan ja muiden metallien tuonti
Rautamalmi-tuonti
Rautaromutuonti
Valssaustuotteet
Kupari
Nikkeli
Alumiini
Lyijy
Sinkki
Tina
Muut malmit
Kuona ja jätteet, tuhka

2.1 Yhteensä – Total

2. Maa-ainekset – Earth Materials

2.1 Suorat kotimaiset maa-ainesvirrat – Direct domestic flows of earth materials

SITC-koodi – *SITC Code*
2731 Rakennus- ja muistomerkkikivi, valmistamaton
2732 Kipsikivi, anhydriitti, kipsi; kalkkikivi
2733 Luonnonhiekka
2734 Sora, sepeli, piikivi, kivirouheet ja -jauheet
2741 Rikki (pl. sublimoitu, saostettu, kolloidinen)
2742 Pasuttamattomat rautapyriitit
2771 Teollisuustimantit
2772 Muut luonnon hioma-aineet
2782 Savi, kaoliini yms.
2783 Suola, natriumkloridi
2784 Asbesti
2785 Kvartsi, kiille, maasälpä yms.
2786 Kuona, hehkuhilse yms. jätteet
2789 Muut valmistamattomat kivennäisaineet

2.1 Yhteensä – *Total*

3. Turvetuotanto – Peat production

2.3 Fossiilisten polttoaineiden tuonti – Imports of fossil fuels

Moottoribensiini – *Motor gasoline*
Dieselöljy – *Diesel fuel*
Moottoripetrooli – *Motor kerosine*
Lentopetrooli – *Jet fuel*
Lentobensiini – *Aviation gasoline*
Kevytpö – *Light fuel oil*
Raskaspö – *Heavy fuel oil*
Nestekaasu – *LPG*
Valopetrooli – *Lamp kerosine*
Teollisuusbensiini – *Napahtha*

Kierrätysöljy – *Recycled oil*
Öljynjalostamon polttoaineet – *Refinery fuel*
Kivennäisöljyjä, raakoja
Kivennäisöljyn raakatisle
Bensiini
Raskasbensiini
Moottoripetrooli
Paloöljy
Total, liquid
Jalostamokaasut – *Refinery gases*
Kaasu (1000 m^3)
Maakaasu (1000 m^3)
Total, gas
Muut öljytuotteet – *Other petroleum products*
Muut öljytuotteet – *Other petroleum products*
Total, other oil products
Kivihiili – *Coal*
Koksi – Coke
Kivihiili ja koksi yhteensä – *Total for coal and coke*
Antrasiitti
Ruskohiili
Total, solid
3.1 Yhteensä – *Total*

4. Puuntuotanto – Wood production

2.4 Puun ja puutuotteiden virrat – Wood flows

Tuontipuu – *Imported wood*
SITC-koodi – *SITC Code*
24 Puutavara ja korkki
25 Paperimassa
63 Puu- ja korkkituotteet
64 Paperi ja pahvi sekä tuotteet niistä
2.4 Yhteensä – total

5. Muiden uusiutumattomien tuonti – Imports of other non-renewables

2.5. Muut uusiutumattomat luonnonvarat – Other imported non-renewables

SITC-koodi – SITC Code
26 Tekstiilikuidut sekä niiden jätteet
51 Orgaaniset kemialliset aineet
52 Epäorgaaniset kemialliset aineet
53 Väri- ja parkitusaineet
54 Lääkevalmisteet ja farmaseuttiset tuotteet
55 Haju-, kiillotus- ja puhdistusaineet
56 Lannoitteet, valmistetut
57 Muovit, valmistamattomat
58 Muovit, valmistetut
59 Erinäiset kemialliset tuotteet
61 Nahka,nahkatavarat ja muokatut turkisnahat
62 Kumituotteet
65 Tekstiilituotteet, pl. vaatteet
66 Kivennäisainetuotteet
69 Tuotteet epäjalosta metallista
71 Voimakoneet ja moottorit

72 Eri toimialojen erikoiskoneet
73 Metalliteollisuuskoneet
74 Yleiskäyttöiset teollisuuden koneet ja laitteet
75 Toimistokoneet ja atk-laitteet
76 Puhelin-,radio-,tv – yms. laitteet
77 Muut sähkökoneet ja – laitteet
78 Moottoriajoneuvot
79 Muut kuljetusvälineet
81 Tehdasvalmisteiset talot;lvi- ja valaisinkalusteet
82 Huonekalut ja niiden osat
83 Matkatarvikkeet, käsilaukut ja niiden kaltaiset säilytysesineet
84 Vaatteet ja vaatetustarvikkeet
85 Jalkineet
87 Kojeet, mittarit yms.
88 Valokuvauskojeet ja -tarvikkeet; optiset tuotteet yms.
89 Muut valmiit tavarat
91 Postipaketit, muualle luokittelemattomat
93 Erittelemätön

2.5 Yhteensä – total

6. Maataloustuotannon tuonti – Imports of agricultural produce

2.6 Maataloustuotteiden tuonti – Imported food products

SITC-koodi – SITC Code
0 Elävät eläimet (Aiempi. 001*)
1 Liha ja lihatuotteet
2 Maitotaloustuotteet ja munat
3 Kalat ja kalavalmisteet
4 Vilja ja viljatuotteet
5 Hedelmät ja kasvikset
6 Sokeri ja sokerivalmisteet, hunaja
7 Kahvi, tee, kaakao, mausteet; tuotteet niistä
8 Rehuaineet
9 Erinäiset elintarvikkeet
11 Juomat
12 Tupakka ja tupakkavalmisteet
21 Vuodat, nahat ja turkisnahat, raa'at
22 Öljysiemenet, öljypitoiset pähkinät ja ytimet

2.6 Yhteensä – total

7. Muiden uusiutuvien tuonti – Imports of other renewables

2.7. Muut uusiutuvat luonnonvarat – Other imported renewables

SITC-koodi – SITC Code
23 Luonnonkumi, synteettinen ja regeneroitu kumi
29 Muut eläin- ja kasviraaka-aineet
41 Eläinöljyt ja -rasvat
42 Kasviöljyt ja -rasvat
43 Valmistetut eläin- ja kasviöljyt yms.
44 Puu ja puusta valmistetut tavarat
45 Korkki
46 Oljesta yms valmistetut tavarat
47 Puumassa yms
48 Paperi, kartonki yms
49 Kirjat, sanomalhdet ja muut painotuotteet

2.7 Yhteensä – *Total*

Appendix 6. Trends in MFA Main Aggregates from 1945 to 2008

	Domestic DF	Domestic TF	Imported DF	Imported TF	DMI	TMR	DMC	TMC
1945	29	48	2	5	31	53	30	50
1946	33	54	4	7	37	60	34	49
1947	41	66	7	13	47	79	43	63
1948	42	68	8	16	50	84	46	67
1949	44	71	9	18	53	90	48	70
1950	40	65	9	16	49	81	43	57
1951	45	73	12	22	57	95	49	64
1952	46	76	12	23	58	98	52	73
1953	47	76	10	20	57	96	51	74
1954	54	87	12	23	66	110	59	82
1955	59	94	13	24	72	118	64	86
1956	55	88	13	23	68	110	60	81
1957	57	90	14	26	71	116	63	86
1958	57	92	14	24	71	116	64	85
1959	59	93	15	26	74	119	65	86
1960	99	142	19	37	118	180	108	140
1961	105	150	20	39	125	189	114	148
1962	106	149	19	38	125	187	115	149
1963	101	145	19	37	121	182	111	145
1964	114	162	21	40	135	202	125	161
1965	123	172	22	44	145	216	135	175
1966	129	179	27	52	155	231	145	190
1967	117	166	27	51	144	217	133	176
1968	122	173	27	51	149	224	138	181
1969	133	184	31	57	164	241	150	191
1970	140	193	33	64	173	256	156	191
1971	144	197	34	63	177	260	161	198
1972	153	209	34	62	186	271	170	206
1973	155	214	37	68	192	282	174	212
1974	140	196	39	74	179	269	161	199
1975	121	174	34	67	155	242	139	183
1976	120	173	34	64	154	237	137	175
1977	118	171	38	70	155	241	134	162
1978	126	182	39	73	166	255	142	164
1979	143	204	41	80	184	284	159	186
1980	138	198	42	82	180	279	163	213
1981	138	197	42	84	180	281	162	211
1982	139	200	36	69	175	269	159	207
1983	155	217	35	70	190	288	173	222
1984	156	223	37	73	193	296	174	223
1985	163	230	37	75	200	305	181	233
1986	158	224	39	82	198	306	180	235
1987	172	241	41	86	213	327	194	252
1988	166	231	43	89	209	320	189	243

	Domestic DF	Domestic TF	Imported DF	Imported TF	DMI	TMR	DMC	TMC
1989	190	261	44	96	234	357	209	278
1990	183	253	42	89	225	341	205	266
1991	168	232	40	83	208	315	189	240
1992	165	228	41	85	206	313	185	231
1993	152	214	43	86	194	301	170	207
1994	163	233	47	98	211	331	183	226
1995	163	236	48	104	211	340	184	237
1996	159	233	47	97	206	330	179	224
1997	170	250	54	117	225	366	195	249
1998	181	265	55	114	235	379	204	256
1999	185	269	55	109	239	378	207	251
2000	182	265	56	111	239	376	206	247
2001	184	265	56	113	253	403	221	277
2002	185	264	56	114	255	403	221	269
2003	188	268	59	122	261	415	227	278
2004	193	273	63	132	270	430	234	287
2005	194	273	61	127	269	426	236	292
2006	204	285	59	119	263	404	220	248
2007	216	302	65	137	296	465	251	308
2008	207	294	61	135	286	461	244	314

TUTKIMUKSIA-SARJA
RESEARCH REPORTS SERIES

Tilastokeskus on julkaissut Tutkimuksia v. 1966 alkaen, v. 1990 lähtien ovat ilmestyneet seuraavat:

164. **Henry Takala,** Kunnat ja kuntainliitot kansantalouden tilinpidossa. Tammikuu 1990. 60 s.
165. **Jarmo Hyrkkö,** Palkansaajien ansiotasoindeksi 1985=100. Tammikuu 1990. 66 s.
166. **Pekka Rytkönen,** Siivouspalvelu, ympäristöhuolto ja pesulapalvelu 1980-luvulla. Tammikuu 1990. 70 s.
167. **Jukka Muukkonen,** Luonnonvaratilinpito kestävän kehityksen kuvaajana. 1990. 119 s.
168. **Juha-Pekka Ollila,** Tieliikenteen tavarankuljetus 1980-luvulla. Helmikuu 1990. 45 s.
169. **Tuovi Allén – Seppo Laaksonen – Päivi Keinänen – Seija Ilmakunnas,** Palkkaa työstä ja sukupuolesta. Huhtikuu 1990. 90 s.
170. **Ari Tyrkkö,** Asuinolotiedot väestölaskennassa ja kotitaloustiedustelussa. Huhtikuu 1990. 63 s.
171. **Hannu Isoaho – Osmo Kivinen – Risto Rinne,** Nuorten koulutus ja kotitausta. Toukokuu 1990. 115 s.

171b. **Hannu Isoaho – Osmo Kivinen – Risto Rinne,** Education and the family background of the young in Finland. 1990. 115 pp.

172. **Tapani Valkonen – Tuija Martelin – Arja Rimpelä,** Eriarvoisuus kuoleman edessä. Sosioekonomiset kuolleisuuserot Suomessa 1971–85. Kesäkuu 1990. 145 s.
173. **Jukka Muukkonen,** Sustainable development and natural resource accounting. August 1990. 96 pp.
174. **Iiris Niemi – Hannu Pääkkönen,** Time use changes in Finland in the 1980s. August 1990. 118 pp.
175. **Väinö Kannisto,** Mortality of the elderly in late 19th and early 20th century Finland. August 1990. 50 pp.
176. **Tapani Valkonen – Tuija Martelin – Arja Rimpelä,** Socio-economic mortality differences in Finland 1971–85. December 1990. 108 pp.
177. **Jaana Lähteenmaa – Lasse Siurala,** Nuoret ja muutos. Tammikuu 1991. 211 s.
178. **Tuomo Martikainen – Risto Yrjönen,** Vaalit, puolueet ja yhteiskunnan muutos. Maaliskuu 1991. 120 s.
179. **Seppo Laaksonen,** Comparative Adjustments for Missingness in Short-term Panels. April 1991. 74 pp.
180. **Ágnes Babarczy – István Harcsa – Hannu Pääkkönen,** Time use trends in Finland and in Hungary. April 1991. 72 pp.
181. **Timo Matala,** Asumisen tuki 1988. Kesäkuu 1991. 64 s.
182. **Iiris Niemi – Parsla Eglite – Algimantas Mitrikas – V.D. Patrushev – Hannu Pääkkönen,** Time Use in Finland, Latvia, Lithuania and Russia. July 1991. 80 pp.
183. **Iiris Niemi – Hannu Pääkkönen,** Vuotuinen ajankäyttö. Joulukuu 1992. 83 s.

183b. **Iiris Niemi – Hannu Pääkkönen – Veli Rajaniemi – Seppo Laaksonen – Jarmo Lauri,** Vuotuinen ajankäyttö. Ajankäyttötutkimuksen 1987–88 taulukot. Elokuu 1991. 116 s.

184. **Ari Leppälahti – Mikael Åkerblom,** Industrial Innovation in Finland. August 1991. 82 pp.

185. **Maarit Säynevirta,** Indeksiteoria ja ansiotasoindeksi. Lokakuu 1991. 95 s.

186. **Ari Tyrkkö,** Ahtaasti asuvat. Syyskuu 1991. 134 s.

187. **Tuomo Martikainen – Risto Yrjönen,** Voting, parties and social change in Finland. October 1991. 108 pp.

188. **Timo Kolu,** Työelämän laatu 1977–1990. Työn ja hyvinvoinnin koettuja muutoksia. Tammikuu 1992. 194 s.

189. **Anna-Maija Lehto,** Työelämän laatu ja tasa-arvo. Tammikuu 1992. 196 s.

190. **Tuovi Allén – Päivi Keinänen – Seppo Laaksonen – Seija Ilmakunnas,** Wage from Work and Gender. A Study on Wage Differentials in Finland in 1985. 88 pp.

191. **Kirsti Ahlqvist,** Kodinomistajaksi velalla. Maaliskuu 1992. 98 s.

192. **Matti Simpanen – Irja Blomqvist,** Aikuiskoulutukseen osallistuminen. Aikuiskoulutustutkimus 1990. Toukokuu 1992. 135 s.

193. **Leena M. Kirjavainen – Bistra Anachkova – Seppo Laaksonen – Iiris Niemi – Hannu Pääkkönen** – Zahari Staikov, Housework Time in Bulgaria and Finland. June 1992. 131 pp.

194. **Pekka Haapala – Seppo Kouvonen,** Kuntasektorin työvoimakustannukset. Kesäkuu 1992. 70 s.

195. **Pirkko Aulin-Ahmavaara,** The Productivity of a Nation. November 1992. 72 pp.

196. **Tuula Melkas,** Valtion ja markkinoiden tuolla puolen. Kanssaihmisten apu Suomessa 1980-luvun lopulla. Joulukuu 1992. 150 s.

197. **Fjalar Finnäs,** Formation of unions and families in Finnish cohorts born 1938–67. April 1993. 58 pp.

198. **Antti Siikanen – Ari Tyrkkö,** Koti – Talous – Asuntomarkkinat. Kesäkuu 1993. 167 s.

199. **Timo Matala,** Asumisen tuki ja aravavuokralaiset. Kesäkuu 1993. 84 s.

200. **Arja Kinnunen,** Kuluttajahintaindeksi 1990=100. Menetelmät ja käytäntö. Elokuu 1993. 89 s.

201. **Matti Simpanen,** Aikuiskoulutus ja työelämä. Aikuiskoulutustutkimus 1990. Syyskuu 1993. 150 s.

202. **Martti Puohiniemi,** Suomalaisten arvot ja tulevaisuus. Lokakuu 1993. 100 s.

203. **Juha Kivinen – Ari Mäkinen,** Suomen elintarvike- ja metallituoteteollisuuden rakenteen, kannattavuuden ja suhdannevaihteluiden yhteys; ekonometrinen analyysi vuosilta 1974 – 1990. Marraskuu 1993. 92 s.

204. **Juha Nurmela,** Kotitalouksien energian kokonaiskulutus 1990. Marraskuu 1993. 108 s.

205a. **Georg Luther,** Suomen tilastotoimen historia vuoteen 1970. Joulukuu 1993. 382 s.

205b. **Georg Luther,** Statistikens historia i Finland till 1970. December 1993. 380 s.

206. **Riitta Harala – Eva Hänninen-Salmelin – Kaisa Kauppinen-Toropainen – Päivi Keinänen – Tuulikki Petäjäniemi – Sinikka Vanhala,** Naiset huipulla. Huhtikuu 1994. 64 s.

207. **Wangqiu Song,** Hedoninen regressioanalyysi kuluttajahintaindeksissä. Huhtikuu 1994. 100 s.

208. **Anne Koponen,** Työolot ja ammattillinen aikuiskoulutus 1990. Toukokuu 1994. 118 s.

209. **Fjalar Finnäs,** Language Shifts and Migration. May 1994. 37 pp.

210. **Erkki Pahkinen – Veijo Ritola,** Suhdannekäänne ja taloudelliset aikasarjat. Kesäkuu 1994. 200 s.

211. **Riitta Harala – Eva Hänninen-Salmelin – Kaisa Kauppinen-Toropainen – Päivi Keinänen – Tuulikki Petäjäniemi – Sinikka Vanhala,** Women at the Top. July 1994. 66 pp.

212. **Olavi Lehtoranta,** Teollisuuden tuottavuuskehityksen mittaminen toimialatasolla. Tammikuu 1995. 73 s.

213. **Kristiina Manderbacka,** Terveydentilan mittarit. Syyskuu 1995. 121 s.

214. **Andres Vikat,** Perheellistyminen Virossa ja Suomessa. Joulukuu 1995. 52 s.

215. **Mika Maliranta,** Suomen tehdasteollisuuden tuottavuus. Helmikuu 1996. 189 s.

216. **Juha Nurmela,** Kotitaloudet ja energia vuonna 2015. Huhtikuu 1996. 285 s.

217. **Rauno Sairinen,** Suomalaiset ja ympäristöpolitiikka. Elokuu 1996. 179 s.

218. **Johanna Moisander,** Attitudes and Ecologically Responsible Consumption. August 1996. 159 pp.

219. **Seppo Laaksonen** (ed.), International Perspectives on Nonresponse. Proceedings of the Sixth International Workshop on Household Survey Nonresponse. December 1996. 240 pp.

220. **Jukka Hoffrén,** Metsien ekologisen laadun mittaaminen. Elokuu 1996. 79 s.

221. **Jarmo Rusanen – Arvo Naukkarinen** – Alfred Colpaert – Toivo Muilu, Differences in the Spatial Structure of the Population Between Finland and Sweden in 1995 – a GIS viewpoint. March 1997. 46 pp.

222. **Anna-Maija Lehto,** Työolot tutkimuskohteena. Marraskuu 1996. 289 s.

223. **Seppo Laaksonen** (ed.), The Evolution of Firms and Industries. June 1997. 505 pp.

224. **Jukka Hoffrén,** Finnish Forest Resource Accounting and Ecological Sustainability. June 1997. 132 pp.

225. **Eero Tanskanen**, Suomalaiset ja ympäristö kansainvälisestä näkökulmasta. Elokuu 1997. 153 s.

226. **Jukka Hoffrén**, Talous hyvinvoinnin ja ympäristöhaittojen tuottajana –Suomen ekotehokkuuden mittaaminen. Toukokuu 1999. 154 s.

227. **Sirpa Kolehmainen,** Naisten ja miesten työt. Työmarkkinoiden segregoituminen Suomessa 1970–1990. Lokakuu 1999. 321 s.

228. **Seppo Paananen**, Suomalaisuuden armoilla. Ulkomaalaisten työnhakijoiden luokittelu. Lokakuu 1999. 152 s.

229. **Jukka Hoffrén,** Measuring the Eco-efficiency of the Finnish Economy. October 1999. 80 pp.

230. **Anna-Maija Lehto – Noora Järnefelt** (toim.), Jaksaen ja joustaen. Artikkeleita työolotutkimuksesta. Joulukuu 2000. 264 s.

231. **Kari Djerf,** Properties of some estimators under unit nonresponse. January 2001. 76 pp.

232. **Ismo Teikari,** Poisson mixture sampling in controlling the distribution of response burden in longitudinal and cross section business surveys. March 2001. 120 pp.

233. **Jukka Hoffrén,** Measuring the Eco-efficiency of Welfare Generation in a National Economy. The Case of Finland. November 2001. 199 pp.

234. **Pia Pulkkinen,** ”Vähän enemmän arvoinen” Tutkimus tasa-arvokokemuksista työpaikoilla. Tammikuu 2002. 154 s.

235. **Noora Järnefelt – Anna-Maija Lehto,** Työhulluja vai hulluja töitä? Tutkimus kiirekokemuksista työpaikoilla. Huhtikuu 2002. 130 s.

236. **Markku Heiskanen,** Väkivalta, pelko, turvattomuus. Surveytutkimusten näkökulmia suomalaisten turvallisuuteen. Huhtikuu 2002. 323 s.

237. **Tuula Melkas,** Sosiaalisesta muodosta toiseen. Suomalaisten yksityiselämän sosiaalisuuden tarkastelua vuosilta 1986 ja 1994. Huhtikuu 2003. 195 s.

238. **Rune Höglund – Markus Jäntti – Gunnar Rosenqvist (eds.),** Statistics, econometrics and society: Essays in honour of Leif Nordberg. April 2003. 260 pp.

239. **Johanna Laiho – Tarja Nieminen (toim.)**, Terveys 2000 -tutkimus. Aikuisväestön haastatteluaineiston tilastollinen laatu. Otanta-asetelma, tiedonkeruu, vastauskato ja estimointi- ja analyysiasetelma. Maaliskuu 2004. 95 s.

240. **Pauli Ollila,** A Theoretical Overview for Variance Estimation in Sampling Theory with Some New Techniques for Complex Estimators. September 2004. 151 pp.

241. **Minna Piispa.** Väkivalta ja parisuhde. Nuorten naisten kokeman parisuhdeväkivallan määrittely surveytutkimuksessa. Syyskuu 2004. 216 s.

242. **Eugen Koev.** Combining Classification and Hedonic Quality Adjustment in Constructing a House Price Index. (Tulossa).

243. **Henna Isoniemi – Irmeli Penttilä (toim.)**, Perheiden muuttuvat elinolot. Artikkeleita lapsiperheiden elämänmuutoksista. Syyskuu 2005. 168 s.

244. **Anna-Maija Lehto – Hanna Sutela – Arto Miettinen (toim.)**, Kaikilla mausteilla. Artikkeleita työolotutkimuksesta. Toukokuu 2006. 385 s.

245. **Jukka Jalava – Jari Eloranta – Jari Ojala (toim.)** Muutoksen merkit – Kvantitatiivisia perspektiivejä Suomen taloushistoriaan. Tammikuu 2007. 373 s.

246. **Jari Kauppila.** The Structure and Short-Term Development of Finnish Industries in the 1920s and 1930s. An Input-output Approach. Elokuu 2007. 274 s.

247. **Mikko Myrskylä.** Generalised Regression Estimation for Domain Class Frequencies. Elokuu 2007. 137 s.

248. **Jukka Jalava.** Essays on Finnish Economic Growth and Productivity, 1860–2005. Joulukuu 2007. 154 s.

249. **Yrjö Tala.** Kirkon vai valtion kirjat? Uskontokuntasidonnaisuuden ongelma Suomen väestökirjanpidossa 1839–1904.

250. **Hanna-Kaisa Rättö.** Hyvinvointi ja hyvinvoinnin mittaamisen kehittäminen. Huhtikuu 2009. 82 s.

251. **Pertti Koistinen (toim.),** Työn hiipuvat rajat. Tutkielmia palkkatyön, hoivan ja vapaaehtoistyön muuttuvista suhteista. Huhtikuu 2009. 159 s.

252. **Kirsti Ahlqvist.** Kulutus, tieto, hallinta. Kulutuksen tilastoinnin muutokset 1900-luvun Suomessa. Maaliskuu 2010. 314 s.

253. **Jukka Hoffrén (ed.) – Eeva-Lotta Apajalahti – Hanna Rättö.** Economy-wide Material Flow Accounts with Hidden Flows for Finland: 1945–2008. March 2010. 89 pp.

Tutkimuksia-sarja kuvaa suomalaista yhteiskuntaa ja sen kansainvälistä asemaa tutkittujen tietojen pohjalta. Sarjassa julkaistaan Tilastokeskuksessa laadittuja tai Tilastokeskuksen aineistoihin perustuvia tieteellisiä tutkimuksia

This study represents the conclusions of the Pilot study on economy-wide material flow accounts with hidden flows in Finland project conducted at Statistics Finland. The aim of the project was to establish methodological and practical working methods and procedures for compiling Finnish Material Flow Accounts (FIN-MFA) that include both direct material flows (DF) and hidden material flows (HF) in the Finnish economy. The material flows between the national economy, the global economy and the environment, as well as the accumulation of materials in the economy are represented by several aggregate MFA measures that take into account natural resources, products and their residuals, as well as their hidden flows.

Tilastokeskus, myyntipalvelu
PL 4 C
00022 TILASTOKESKUS
puh. (09) 1734 2011
faksi (09) 1734 2500
myynti@tilastokeskus.fi
www.tilastokeskus.fi

Statistikcentralen, försäljning
PB 4 C
FI-00022 STATISTIKCENTRALEN
tfn +358 9 173 420 11
fax +358 9 173 425 00
sales@stat.fi
www.stat.fi

Statistics Finland, Sales Services
PO Box 4 C
FI-00022 Statistics Finland
Tel. +358 9 1734 2011
Fax +358 9 1734 2500
sales@stat.fi
www.stat.fi

ISSN 1798–8578
= Research Reports
ISBN 978–952–244–233–8 (pdf)
ISBN 978–952–244–232–1 (print)