Resources, Conservation and Recycling 116 (2017) 61–69

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Total residual output flows of the economy: Methodology and application in the case of the Czech Republic

Jan Kovanda

Charles University Environment Center, J. Martiho 2/407, 162 00 Prague 6, Czech Republic

ARTICLE INFO

Article history:
Received 21 June 2016
Received in revised form 6 September 2016
Accepted 12 September 2016
Available online 22 September 2016

Keywords:
Economy-wide material flow accounting and analysis (EW-MFA)
Output material flows
Emissions and waste
Unused domestic extraction
Czech Republic

ABSTRACT

The article goes beyond standard emission and waste statistics and elaborates upon total residual output flows of economies based on economy-wide material flow accounting and analysis (EW-MFA). This concept allows for evaluation of total environmental pressures related to material output flows and assessing the potential trade-offs if environmental policies are more successful in some fields than in others. We provide basic information on EW-MFA and its output accounts and indicators and describe in detail the methodology of their compilation. The methodology is then applied to the Czech Republic for the period 1990–2014. All major components of residual output flows, i.e. emission and waste flow, dissipative use flow and unused domestic extraction accounts, as well as domestic processed output (DPO) and total domestic output (TDO) indicators, went down in the monitored period. We identified a few major driving forces behind this decrease, including changes in the structure of the economy, changes in the structure of TPES, technological change, advances in waste management, and changes in the agricultural system of the Czech Republic. The results further indicate that another decrease in DPO and TDO indicators is at stake, as Czech economic policies are aimed at maintaining the current relatively high proportion of manufacturing industries in the economy.

1. Introduction

Standard emission and waste statistics usually report separately on the selection of the residual output flows of the economy such as emissions released to the atmosphere and production and treatment of solid waste. This fact not only hampers evaluation of total environmental pressures and impacts related to residual output flows of economies, but also does not allow the assessment of potential trade-offs if environmental policies are more successful in some fields than in others. This can lead to an uneven decrease in particular emission and waste streams and the uneven distribution of environmental pressures across particular environmental media, such as air, soil and water. Both shortcomings are addressed by economy-wide material flow accounting and analysis (EW-MFA), which covers all residual output flows from the economy (Bringezu and Bleischwitz, 2009; Fischer-Kowalski et al., 2011; OECD, 2008).

EW-MFA is considered a convenient tool for monitoring the vast range of issues related to the consumption of materials and emission and waste management, such as monitoring material and resource productivity, assessing the implications of trade and globalisation, and quantifying the overall rate of the cyclical use of materials (OECD, 2008). EW-MFA is rooted in a system of accounts which quantify the physical exchange between a national economy, the environment, and foreign economies on the basis of the total material mass flowing across the boundaries of the national economy. The ultimate step of compiling these accounts is to achieve a material balance – that is, a state when material inputs into the economy equal material outputs summed with additions to the physical stock of the economy (e.g. traffic infrastructure, buildings and durable goods).

EW-MFA defines an array of input and output material flows which in turn compose various material flow indicators (Eurostat, 2001). The input flows include domestic extraction account (DE), i.e. raw materials extracted from domestic territory and harvested biomass, and the import account (IM), for instance. The output flows include, among others, the export account (EX) and residual flows to the national environment, i.e. emission and waste flow (EW), dissipative flow (DF) and domestic unused extraction (UDE) accounts. While there is a lot of studies out there focusing on input material flows and indicators (Behrens et al., 2007; Dittrich and Bringezu, 2010; Krausmann et al., 2009; Steinberger et al., 2010; Weisz et al., 2006; West et al., 2014) and particular types of output flows and material stocks (Fishman et al., 2014; Hashimoto et al., 2009; Muller et al., 2011; Pauliuk et al., 2013), the residual out-

E-mail address: jan.kovanda@czp.cuni.cz

http://dx.doi.org/10.1016/j.resconrec.2016.09.018
0921-3449/

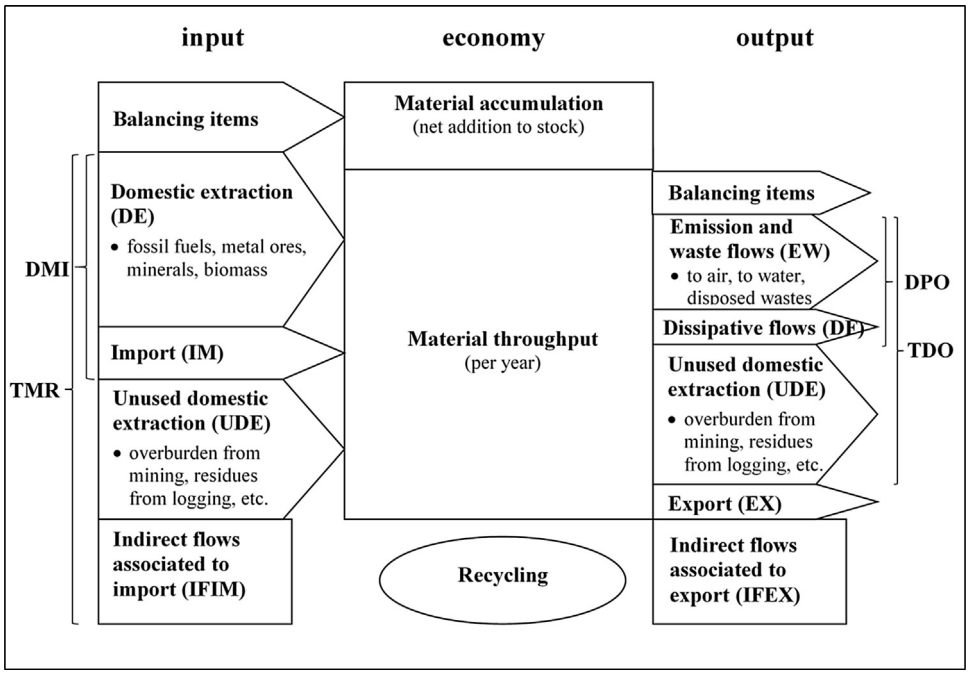

Fig. 1. Scheme of economy-wide material flow balance depicting selected indicators (Eurostat, 2001, amended).

put flows are in their entirety rarely analysed (Matthews, 2000) which might be caused by poor statistics on some output flows such as domestic unused extraction, and not very well developed methodological standards for their compilation. The overall aim of this case study is to overcome this gap by describing the methodology of total residual flow compilation, providing information on used data sources, analysing the total residual output flows compiled for the Czech Republic for 1990–2014 and to discuss what useful information these total residual output flows can provide to policy-makers.

The rest of the article is structured as follows: Chapter 2 provides some basic information on economy-wide material flow accounting and analysis, the variety of input and output flows it covers and its indicators, as well as describing in detail the approaches and data sources used for the compilation of total residual output flows for the Czech Republic. Chapter 3 shows the development of residual output flows in the Czech Republic broken down by types of flows and the environmental media they enter. Chapter 4 relates the results to the development of other social, economic and environmental variables, and discusses trends in residual output flows, while Chapter 5 concludes on the future development of residual output flows in the Czech Republic.

2. Methods and data

2.1. Economy-wide material flow accounting and analysis (EW-MFA)

As a follow-up to pilot studies such as work by Steurer (1992), Schütz and Bringezu (1992), the Ministry of the Environment of Japan (1992), Adriaanse et al. (1997), and Matthews (2000), a first attempt to standardize EW-MFA was undertaken by the statistical office of the European Union, which published a methodological guide for economy-wide material flow accounts and derived indicators (Eurostat, 2001). The standardization process was continued with the Organization for Economic Co-operation and Development (OECD) work program on material flows (OECD, 2008) and a series of compilation guides developed by Eurostat for its survey on material flow indicators (e.g. Eurostat, 2013). In parallel, there was a group of activities which aimed at developing material flow indicators comprising import and export in the form of raw material equivalents (RME), i.e. all raw materials needed for their production (e.g. Schoer et al., 2013).

Material flows mobilized by the economy can be divided into three categories: water, gases (from the atmosphere) and materials (from the earth's crust). Water and atmospheric gas flows are one order of magnitude higher than the total flows of other materials (Schandl et al., 1999). The EW-MFA methodology therefore concentrates on materials (mainly solid materials, but also oil, natural gas, liquid and gaseous industrial chemicals, etc.), and includes only that part of the water and atmospheric gas flows necessary for an overall balance (water contained in materials, imports and exports, emissions to water and to air, etc.). As stressed in the introduction, setting up a material balance is the ultimate step of economy-wide material flow accounting. Fig. 1 shows the scheme of such a balance depicting material accounts which are formed by various input and output flows into and from the economy.

Domestic material inputs consist primarily of extracted raw materials and produced biomass that has entered the economic system (domestic extraction account/DE/). Domestic material outputs consist primarily of emissions to air and water and disposed wastes (emission and waste flows account/EW/), and use of, for instance, fertilizers, pesticides and solvents (dissipative flows account/DF/account). The EW-MFA methodology further includes a concept of unused extraction. The unused domestic extraction (UDE) account consists of material flows that have taken place as a result of resource extraction, but which did not directly enter the economic system. Examples include biomass left in forests after logging, overburden from extraction of raw materials, movement of earth resulting from the building of infrastructure, etc. Foreign trade (import and export accounts/IM, EX/) also plays an important role in the analysis because it represents an important material flow across the boundaries of the economic system. Used and unused extraction is associated with foreign trade in the same way as domestic economic activities and is identified as raw material equivalents of import and export accounts (used extraction needed for production of import and export, including their weight/RMEIM, RMEEX/) and indirect flows of import and export accounts (used