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NATIONAL ACCOUNTING MATRIX WITH ENVIRONMENTAL ACCOUNTS (NAMEA) – AN OVERVIEW OF ENVIRONMETALLY EXTENDED INPUT–OUTPUT ANALYSIS

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Abstract. Increasing human pressure on the environment results in the need for tools to precise identification of the environmental damage source. Environmentally-extended input–output analysis (EEIO) is an answer for that demand. National accounting matrix with environmental accounts (NAMEA) is one of the attempts to create complete EEIO tables. The aim of the paper is to present NAMEA tables as an useful source of data and tool which allows to conduct environmentally-extended input-output analysis in relation to environmental policy. NAMEA tables show emission data per sector. The aim of it is to integrate environmental data with data on economic activity as recorded in the National Accounts framework. NAMEA tables are a useful data source and tool for both environmental policy and another economic studies and researches.

Key words: national accounting matrix with environmental accounts, NAMEA, input–output analysis, environmentally-extended input–output tables

INTRODUCTION

Since 1970s it become a common knowledge and realization, that input–output analysis can be used in environmental policy. Wasily Leontief created an expanded input–output tables, however quality of data referred to environment was very limited. Environmentally-extended input–output analysis (EEIO) was under constant interest of both scientists and politics and was being developing. It is very important to understand the nature and the scale of impact made by different sectors of the economy on the natural environment. It is a clue point in order to achieve and maintain sustainable development.

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However, the usage of environmentally-extended input–output analysis has been very limited since its development due to many reasons. Two decades later European Union Statistical Office – Eurostat started working on developing a new tool, which can possibly be another milestone step in this topic – national accounting matrix with environmental accounts – NAMEA. Over the years it became a complex tool, though it is still in the process of developing. Data collected within NAMEA are available openly and for almost all European countries. Therefore, it can be used to fulfil the gap, that was being a restrain in developing complete EEIO analysis.

The aim of the paper is to present NAMEA tables as an useful source of data and tool which allows to conduct environmentally-extended input–output analysis in relation to environmental policy.

INPUT–OUTPUT ANALYSIS (IO)

One of the basic instruments to assess the state of the economy input–output analysis. Typically, this tool is used at the macroeconomic level, to assess the relationship between different sectors of the economy or to assess the impact of international trade on economy. In practice input–output analysis can be used in microeconomics as well. In this case instead of the whole economy one estimates the flow of goods and energy connected with a certain product.

The legitimacy of the inter–sector analysis was first noticed by François Quesnay, who analyzed three sectors: agriculture (production class), the non-agricultural sector, for instance services and trade (sterile class) and land owners (proprietary class). His results were presented in the form of an economic table [Sulmicki 1959, Czyżewski 2011]. In this simplified graphical form Quesnay tried to explain general economic interdependencies [Ruiz and Pellet 2011].

The development of inter-sector approach to the economy have been presented in the works of Léon Walras, who sought to maximize the role of mathematics in economics in order to make it similar to the natural sciences. He developed the theory of general equilibrium, which to this day is the basis for the evaluation of input–output. His system of interdependent equations accurately showed that the economic balance of the households and the balance of final goods is consistent with the balance of enterprises and of production factors [Landreth and Colander 2005]. General equilibrium, clear and stable mechanisms for calculating flows between the various branches of economy were the way to achieve the increasing importance of economics as a science.

The development and systematization of the method of calculating input–output tables has been made by Leontief [1936], who divided the economy into several groups and described the relationship between them with inputs and outputs. The results are presented in the form of matrix. Usually the results are divided into four groups. Indirect demand associated with the different phases of production belong to the first one. The second group consist of data connected with final demand. The third section presents the macroeconomic effects created in particular sectors and analyzed from the perspective of income. The fourth part concerns the distribution of generated income. It happens (for instance in the case of statistics carried out by the Polish Central Statistical Office), that the fourth part is not analyzed and published.

Publications of above mentioned three scientists (Quesnay, Walras and Leontief) are the basis for the construction of modern input–output models. The modern solutions are based on the same basis [Miller and Blair 2009], differing only in details such as the selection of the data (and their sources), the assessment of the particular branches (the amount of products calculated in the branch) or the method of valuation of the branch. General principles and logic of the construction of the matrix usually remain unchanged. The differences often arise from the purpose of the survey. The exception is the issue of input coefficients. In most cases, according to Leontief, it is assumed that the proportions between the production factors are fixed. In some cases, for instance using translog production function (Dale W. Jorgenson), this assumption can be changed [Samuelson and Nordhaus 1999].

As already mentioned, input–output flows are an effective tool to assess the state of the economy. Understanding the interdependencies in the economy allows the state to make more informed decisions and development policies. Analysis of input–output also enables the evaluation of the structure of expenditures. In this regard, one can explore both indirect and direct costs as well as current and capital expenditure. Relevant factors allow to assess the effectiveness of the sector. However, one must remember that quantitative indicators may not be sufficient to give a clear answer concerning the importance of the sector. In extreme cases the sector with little economic significance may be extremely important for another much more profitable branch of economy or may have a strategic importance for security.

ENVIRONMENTALLY-EXTENDED INPUT-OUTPUT TABLES (EEIO)

Input–output analysis may also be used in environmental policy. Leontief [1970] already proved it by creating an expanded input–output tables. Increasing human pressure on the environment results in the need for tools to precise identification of the environmental damage source. It is necessary to maintain environmental balance and quality of life. Traditional input–output analysis give insight into the product flow between different economic sectors. Monetary analysis allow to estimate the value of economic transactions between different sectors in economy, including output for exports, capital formation and final consumption. Such information can be extended with environmentally related data usually treated as externalities, for instance resource use and emissions [Batten 1981, Dobos and Tallos 2011]. Such analyses are called environmentally-extended input–output tables (EEIO) – this is a long-established technique that continues to grow in popularity as a method for evaluating the relationship between economic activities and downstream environmental impacts. It can be used in various aspects, for instance as a method of assessing the overall human pressure on the environment, analysis of the sources of emissions (like greenhouse gases, nitrogen), and also as a method of identifying sectors of the economy essential from the point of view of the resource consumption (like water, the land, the living resources leading to the degradation of biodiversity) [Kitzes 2013]. There are even attempts to use EEIO as an instrument to measure global flows of resources [Tucker 2011].

Environmental input–output tables can be used to achieve three basic objectives [Tukker et al. 2006]:

- environmental problem analysis (the nature and causes of environmental problems);

- prospective effect analysis of policies (ex ante prediction of effects of policy measures);
- monitoring and ex post effect analysis of policies (analysis of impact and effectiveness of policy measures, including time series analysis).

The EEIO has an important advantage. It is the combination of monetary and environmental data. Due to this it is possible to identify the consequences of the impact of the economy on the environment and an indication of the relationship between production and consumption of resources and emission of harmful substances into the environment. These data can be analyzed in different ways, for instance on the macroeconomic scale (sectoral perspective) or microeconomic scale (product perspective). The starting point is the use of input–output tables created in physical terms (physical input output table – PIOT), which allows to specify material consumption and the harmfulness of a given economic sector. These data, if possible, can be supplemented by the monetary valuation. However, it is worth remembering that it is not always possible to clearly calculate the value of external effects (both environmental and social one). Furthermore, various studies may use separate methods of such calculation. This means that various EEIO analyses should be treated with caution, especially in the case of the results comparison.

International input–output analysis can be environmentally extended too. The tables built this way can give significant information about international environmental pressure. It is especially important in the case of wealth countries and regions, which rely on import of many goods. In many situations the imported goods require a lot of resources or energy. In addition, their production is connected with heavy pollution. The restrictions of typical environmental policy force companies to outsource such unpleasant production. Input–output tables can show such trade and describe the amount of pollution and resource consumption attached to foreign trade. In this way one can find out about real environmental pressure connected with consumption of particular goods (usually without the environmental cost of international transport). However, in many EEIO the international flows lack the data about technological aspects of production, like energy efficiency or resource consumption [Mayer and Flachmann 2011].

The EEIO is a powerful tool, which help to implement the sustainable development. It can be used on the macroeconomic scale to asses the situation of a whole economy or to serve as a tool in particular sector. For instance, it is used in forestry [Mattila et al. 2011]. An implementation of sustainability means that social aspects of flow between sectors should be included into analysis. It is even more difficult than implementation of environmental one, especially at the international level, because social attitude can vary depending on the cultural system.

The EEIO can be useful in many situations. Usually it helps to valuate the flow of goods and emissions. Such valuation can be used not only as an information about intersectoral environmental pressure, but also as an ecological guide for investments. The investor can estimate how many harm to the environment can be made due to the capital expenditure, and choose between possible options [Shmelev 2010].

The results of the published environmental input–output tables [Mrówczyńska-Kamińska 2014] indicate that this tool is an effective way to take into account externalities in the national economy and its various sectors.

NATIONAL ACCOUNTING MATRIX WITH ENVIRONMENTAL ACCOUNTS (NAMEA)

This technique shows emission data per sector. That means, that its consist only emissions and does not include IO tables themselves or EEIO tables themselves. The aim of NAMEA is to integrate environmental data with data on economic activity as recorded in the National Accounts framework [Eurostat 2002]. It is a hybrid flow account, which denotes a combination of national accounts data, mainly in matrix format, for instance supply and use tables, and environmental accounts, for instance waste accounts (Fig. 1) [Eurostat 2009]. NAMEA is a conceptual tool that links conventional national accounts and environmental accounts. It jointly presents environmental and economic data broken down by industry and household categories [Luksch et al. 2006]. It helps to identify the sources of emissions. It is also a conceptual tool that organizes and holds information on the economy and the environmental pressure expressed in monetary and physical units [Eurostat 2006]. The final goal is to construct comprehensive environmentally extended input–output tables, however it was not achieved yet. There is no obligation for EU countries to construct NAMEA tables.

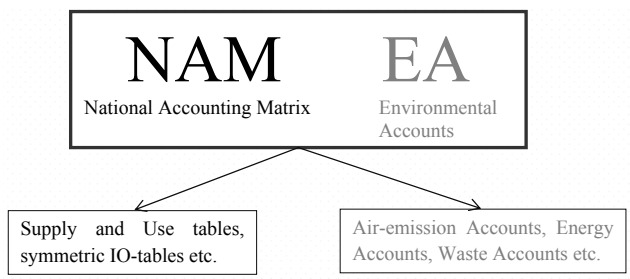

Fig. 1. Schematic of hybrid flow accounts identifying the two main components, a national accounting matrix (NAM) and environmental accounts (EA)

Source: Eurostat [2009].

Tables of NAMEA started being produced by the Dutch Central Bureau of Statistics in the 1990s [Eurostat 2002] or, in accordance to another source [Ostergren 2008], in late 1980s. It quickly becomes clear that there would be an added value in such tables, therefore Eurostat started to work at NAMEA tables at European level. The first Eurostat workshop on NAMEA was held in 1995. Since then, there has been extensive development of NAMEAs in EU countries. Four years later 11 pilot studies on NAMEA for air emissions were available. In 2000, a set of NAMEA for air emissions standard tables was prepared by Eurostat focusing on air emissions but also cover some economic data. These tables were later revised in 2002 in order to improve the comparability of data between countries as well as with other air emission statistics. The new set of tables was finally sent out as a starting point for a collection of NAMEA data on a regular basis [Eurostat 2004].

Currently NAMEA-Air – NAMEA tables for air emissions, are quite sufficiently developed. There are no complete NAMEA tables on emissions to other compartments and

on resources extracted from nature. The availability for NAMEA tables with regard to other environmental media, for instance emissions to water and soil and the use of natural resources is very limited. Only several countries developed national NAMEA tables for emissions other than to the air, for instance the Netherlands, Sweden, Denmark and Germany are quite advanced in NAMEA-Water tables [Tukker et al. 2006]. Several countries have compiled NAMEA tables on energy and resource use, water use, wastewater and solid waste [Eurostat 2001a]. Dutch NAMEA tables cover following themes: the greenhouse effect, ozone layer depletion, acidification, eutrophication, solid waste, wastewater and the exploration of crude oil and natural gas [Schanau et al. 2010].

In accordance to NAMEA-Air Figure 2 illustrates how national accounting supply and use tables as well as environmental accounts – emissions – can be expanded to complete NAMEA. The left side of the figure is the NAM, which consists of the supply and use tables of the ordinary national accounts. The right side of the figure (EA) shows that production activities result in emission as well as in goods and services (the last ones are covered by traditional accounts). It is important to mention, that whilst NAM part is presented in monetary terms, the EA part is presented as physical data.

Although NAMEA-Air is the best elaborated type of NAMEA tables in most EU countries [Tukker et al. 2006], it is very important do notice, that even if it is the best elaborated among all NAMEA tables it is still "merely an overview of environmental interventions per sector, including some private household activities" [Tukker et al. 2006]. Furthermore, according to Eurostat report [Eurostat 2005a], "the full use of the NAMEA--Air framework is highly dependent on the different countries delivering the actual data. This they do not do even today. The response rate is quite low and missing data has had to be estimated". However, situation is getting better each year.

NAMEA-Air compilation guide lists around 20 substances for inventory in three priorities [Eurostat 2004]. Priority 1 includes greenhouse gases: carbon dioxide, carbon dioxide from biomass, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Priority 2 includes some other substances: nitrogen oxides,

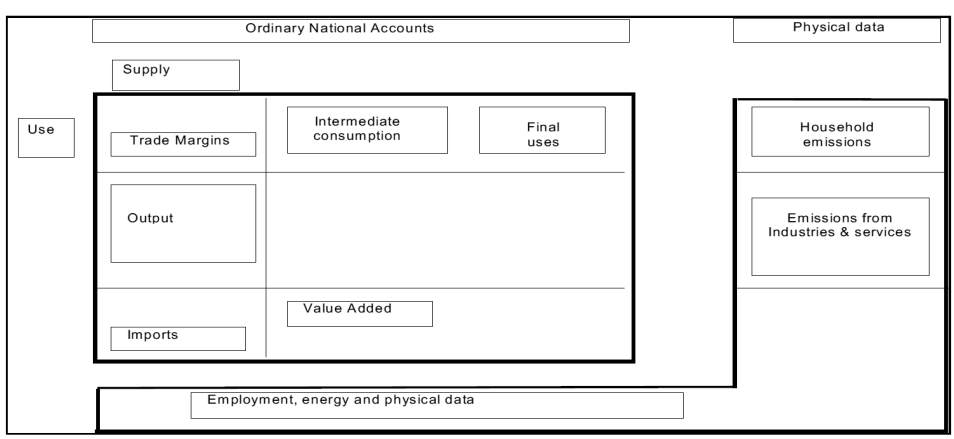

Fig. 2. Schematic description of NAMEA-Air

Source: Eurostat [2001b].

sulphur oxides, ammonia, non-methane volatile organic compounds, carbon monoxide, particulate matter, chlorofluorocarbons, hydrochlorofluorocarbons, mercury, lead, cadmium. Priority 3 includes some heavy metals: arsenic, zinc, chromium, selenium, copper, nickel. Furthermore energy accounts are included. Because there is no legal obligation to provide those data by EU countries, the priorities are made only to show where to start with gathering data if resources are limited.

The current NAMEA-Air tables have also another limitation in usage. Not each EU country cover all the priorities and they do not provide date about the same emissions. For instance, the Italian NAMEA-Air includes 10 pollutants: carbon dioxide, sulphur oxides, nitrogen oxides, nitrous oxide, ammonia, methane, carbon monoxide, non-methane volatile organic compounds, lead and particulate matter [Tudini and Vetrella 2004]. Data bases available at Eurostat network cover emissions of: nitrogen oxides, methane, nitrous oxide, carbon dioxide and sulphur oxides. Some further emissions are described in different reports and studies. Even if all countries provide Eurostat with all substances' emissions there are still only around 20 substances and it covers just a small number of total emissions to the air.

Table. NAMEA-Air data availability for EU-15 countries[a]

Period	BE	DK	DE	GR	ES	FR	IE	IT	LU	NL	PT	FI	SE	UK	AT
1990		X		X		X		X		X				X	X
1991		X	X	X		X		X		X				X	X
1992		X	X	X		X		X		X				X	X
1993		X	X	X		X		X		X			X	X	X
1994	X	X	X	X		X	X	X		X			X	X	X
1995–present	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[a] Some data from BE, GR, ES, FR, LU, PT, FI and SE in the time frame from 1995 till present are estimated.
Source: Eurostat [2005a], own study based on ec.europa.eu/eurostat.

Based on information from the Table it can be said, that EU-15 countries have been providing Eurostat with required data since 1995, though some of the data have been estimated. At the beginning of analyzed period only a few countries provide Eurostat with data as it was a beginning of gathering information about emissions. Since 1995 it has become a wider initiative. Among new EU countries (accessed in or after 2004) only Cyprus, Poland and Lithuania provided Eurostat with adequate data in 2005 [Tukker et al. 2006]. Fortunately, since than situation has improved.

Another problem is that currently there are only national NAMEA-Air tables. There is no easy way to create an European NAMEA-Air table. Each national NAMEA-Air table includes emissions by sectors as well as imports and exports. The last ones are not linked to foreign sectors or countries, therefore connecting all national NAMEA-Air tables into one European one is not a simple task [Tukker et al. 2006].

Besides some limitations national NAMEA tables (if exist) can be still use to undertake some analysis and studies. For instance, Weidema and cowriters [2005] did an extensive study into the environmental impacts of products for Denmark. Danish NAMEA tables were used as a basis. Dutch NAMEA tables were used several times in different

studies and reports analysis [Schanau et al. 2010]. The NAMEA was also listed as a source of data required to assess the indicators for sustainable consumption and production (like energy and material) as well as an useful statistical tool for monitoring sustainable development in European Union [Eurostat 2006, 2007].

In order to provide any comprehensive support to any of the policy fields requested for European Union NAMEA tables have to be more complex and connected with IO tables as well as material flows tables.

Tukker and cowriters [2006] described the possibility to construct NAMEA++ tables, which would be a comprehensive environmentally extended input–output tables. It will use European data, both for the monetary part and for the environmental one. It will, however, require much more specific and detailed data than the ones available at present days. Eurostat in official statistical requirements listed some objectives to achieve, which includes publication of first regular publication of NAMEA-Air results and first EU-25 estimation additionally [Eurostat 2005b] as well as develop NAMEA-Water and NAMEA-Waste [Eurostat 2008]. Eurostat is also working on developing energy accounts, which are sometimes referred to as NAMEA-Energy [Eurostat 2013]. The objective is to establish energy accounts (with a priority on physical flow accounts) in the European Statistical System (ESS). Data collection will start in 2011. For the first 4–5 years this data collection will be however on a voluntary base.

CONCLUSIONS

Presented overview of NAMEA tables confirms, that it is a useful data source and tool for both environmental policy and another economic studies and researches. Gathering data necessary to conduct a complete environmentally-extended input–output analysis NAMEA tables provide scientists and politicians with possibilities that were not available earlier. It would open a way to understand the real impact made by different sectors of the economy on the natural environment and to achieve sustainable development.

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NATIONAL ACCOUNTING MATRIX WITH ENVIRONMENTAL ACCOUNTS (NAMEA) – STUDIUM PRZEPŁYWÓW MIĘDZYNARODOWYCH Z ROZSZERZENIEM ŚRODOWISKOWYM

Streszczenie. Rosnąca presja człowieka na środowisko naturalne rodzi zapotrzebowanie na narzędzia do precyzyjnego zidentyfikowania źródeł zanieczyszczeń środowiska. Odpowiedzią na to zapotrzebowanie jest analiza przepływów międzynarodowych z rozszerzeniem środowiskowym (EEIO). National accounting matrix with environmental accounts (NAMEA) jest jedną z prób opracowania tabel EEIO. Celem artykułu jest przedstawienie tablic NAMEA jako użytecznego źródła danych oraz narzędzia do przeprowadzania analiz przepływów międzygałęziowych z rozszerzeniem środowiskowym w odniesieniu do polityki środowiska. Tabele NAMEA zawierają dane dotyczące emisji z poszczególnych sektorów. Celem NAMEA jest integracja danych środowiskowych z danymi dotyczącymi działalności gospodarczej, zarejestrowanych w ramach rachunków narodowych. Tabele NAMEA są użytecznym źródłem danych oraz narzędziem zarówno dla potrzeb polityki środowiska, jak i innych studiów oraz opracowań ekonomicznych.

Słowa kluczowe: national accounting matrix with environmental accounts, NAMEA, analiza przepływów międzygałęziowych, tabele przepływów międzynarodowych z rozszerzeniem środowiskowym

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