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DESIGN AND IMPLEMENTATION OF A DATABASE FOR THE ESTIMATION OF ENVIRONMENTAL INDICATORS IN AN INPUT – OUTPUT FRAMEWORK WITH THE USE OF NAMEA TABLES

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Abstract

The aim of the present paper is to design and implement a database for the estimation of environmental indicators by sector of economic activity at the macroeconomic level by means of input – output analysis with the use of NAMEA environmental tables. The database is programmed in VBA with the use of SQL queries and is implemented in a Microsoft Access environment through a friendly interface for inserting the data requested by the model (number of sectors, number of pollutants, etc). The computational results of the dataset of the relevant pollution coefficients (direct, indirect and total) by sector of economic activity are inserted in the database for further elaboration. Through the creation of the data base we can pinpoint the sectors and the pollutants that cause the largest environmental load and compare the results with the corresponding databases of other countries.

Keywords: Database, VBA, SQL, environmental Input – Output, NAMEA

1 Introduction

The increasing interest in regulating and controlling air pollution on a European and international level reveals the need for developing the means for the qualitative and quantitative estimation of the various air pollutants. An all increasing volume of available data makes their collection and categorization through a practical to access, update and modify tool, imperative.

In this paper one of the most popular methods towards that end, the environmental input-output analysis with the use of NAMEA tables, is being combined with an electronic database management system to calculate the air pollutant production intensities by industry (direct, indirect and total) for the whole economy as well as for each category of final demand. The database system approach, as realized here, enables the user to define the number of sectors and pollutants for the investigated period, providing a convenient and adjustable tool for the presentation and interpretation of the model output.

Moreover, we calculate the emissions produced in the whole economy after the increase of a unitary expansion of the final demand for a given industry together with the total emissions of pollutant in the whole economy owing to one unit increase of a given industry production. Also, an application of the model provides the estimation of various environmental indicators that address global environmental problems.

The content of this paper is organized as follows: Section 2 describes briefly the methodological framework, section 3 illustrates the database outlay and design, section 4 incorporates a usage example of the database with input - output reports and section 5 concludes the paper.

2 Methodology

Input-output analysis is used to calculate emissions multipliers for different industries and various pollutants [1, 2, 3, 4, 5, 6]. The analytical model is as follows:

Z: matrix of intermediate deliveries
x: the vector of the total resources of the sector
and

$$A = Z \cdot (diag(x))^{-1} \tag{1}$$

The balance equation is:

$$x = Ax + y \tag{2}$$

where:
A: the matrix of technical coefficients
y: the vector of final use of the products
Solving for x the balance equation (eqn (2)) yields:

$$x = (I - A)^{-1} y \tag{3}$$

where:
$(I-A)^{-1}$: the Leontief inverse matrix

The direct coefficients (a_{kj}) of the pollutant air intensity as emissions expenditures per gross output for each industry (j) are defined as:

$$a_{kj} = E_{kj} / x_j \ , \ j=1...n \tag{4}$$

where:
E: is the matrix of emissions
k: type of emission

The total environmental dependencies are calculated as follows:

$$\varepsilon_{kj} = \partial a_{kj} (I - A)^{-1} \tag{5}$$

where:
ε: the matrix of the total induced emission including the indirect effects.

The row sum of ε, eqn. (5), is the total emission intensity including direct and indirect emissions for the jth industry. The column sum of ε, eqn. (5), provides the total emissions of pollutant in the whole economy due to a unit increase of a given industry production. The direct and indirect emission intensity per unit of final demand categories is computed by:

$$\varepsilon^d = \partial \varepsilon_{kj} F \tag{6}$$

where:
F: the vector containing the final demand for each category
ε^d**:** the matrix coefficients of extent of each emission factor intensity on each of the final demand category.

The final demand categories are the private and government consumption (C), the investments (I) and the exports (E).

Based on the aforementioned analysis the NAMEA tables contains the following environmental indicators that address environmental problems ([8,9]):

Greenhouse effect:

$$CO_2 + N_2O \cdot 309{,}315 + CH_4 \cdot 20{,}996 \tag{7}$$

Acidification theme:

$$NO_x \cdot 0{,}217 + SO_2 \cdot 0{,}313 + NH_3 \cdot 0{,}588 \tag{8}$$

Tropospheric ozone precursor theme:

$$NO_x \cdot 1{,}22 + NMVOC + CO \cdot 0{,}11 + CH_4 \cdot 0{,}014 \qquad (9)$$

3 Database outlay and design

Based on the aforementioned methodology, the necessary input matrices/vectors for the database are:

- Intermediate deliveries, Z
- Gross outputs, X
- Final use, Y
- Emissions, E
- Final demand consumption, Fc
- Final demand investment, Fi
- Final demand exports, Fe

and the following matrices are derived for each year in the examined time period:

- Leontief inverse matrix, $Q=(I-A)^{-1}$
- Direct coefficients, $a=E/X$
- Total induced emissions, $\varepsilon=\hat{a}(I-A)^{-1}$
- Total emission intensity including direct and indirect emissions for a given industry
- Total emissions of pollutants in the whole economy due to a unit increase of a given industry production.
- Direct and indirect emission intensity per unit of final demand, $\varepsilon_c^d = \hat{\varepsilon}\,Fc$, $\varepsilon_i^d = \hat{\varepsilon}\,Fi$, $\varepsilon_e^d = \hat{\varepsilon}\,Fe$
- Environmental theme indicators: greenhouse effect, acidification theme, tropospheric ozone precursors theme

The database provides the possibility of inserting A directly, thus eliminating the need for Z. Apart from that insertion of Fc, Fi, Fe is optional.

The whole database system was designed according to the following specifications:

1. Data input and output in a straightforward and user friendly manner
2. Independent grouping of the sectors of economy according to user demand
3. The number of sectors of the economy, pollutants or time period concerned, is also user defined without any constraints
4. Presentation of results in a tabular form
5. Automating saving of the whole database for every group of data employed with a user defined file name

6. Result retrieval for each economy sector and each pollutant in various time periods

using a proxy of the zero normal form. MS Access RDBMS (**R**elationship **D**ata **B**ase **M**anagement **S**ystem) was employed taking under consideration the ease of use and the large number of existing installations worldwide. Custom subroutines, functions or algorithms were written in MS VBA language ([12, 13, 14]). Input matrices are in MS Excel format which is usually employed in public available economical data. The use of SQL queries ([15]) enables the user to focus on specific sectors of economy and/or pollutants and/or periods, thus providing tailor made reports.

4 Usage Example

An example based on data for Greece for the year 1988 for 7 sectors of the economy and 7 pollutants (Mylonas *et al* [1]) was constructed in order to briefly demonstrate the capabilities of the database.

Figure 1 presents all user input parameters, where figure 2 displays the options the user has in order to generate various reports. The user can select the years of interest, the calculated matrices and individual sectors for the presentation of results.

The two following sample reports both display direct coefficients for the year 1988, the first for all sectors of the economy (figure 3), whereas the latter (figure 4) only for two sectors selected by the user.

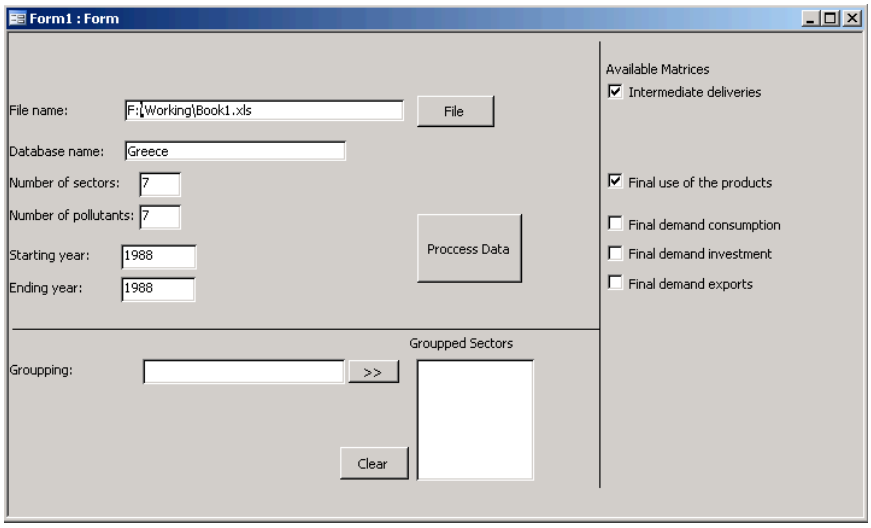

Figure 1. Form for user input parameters.

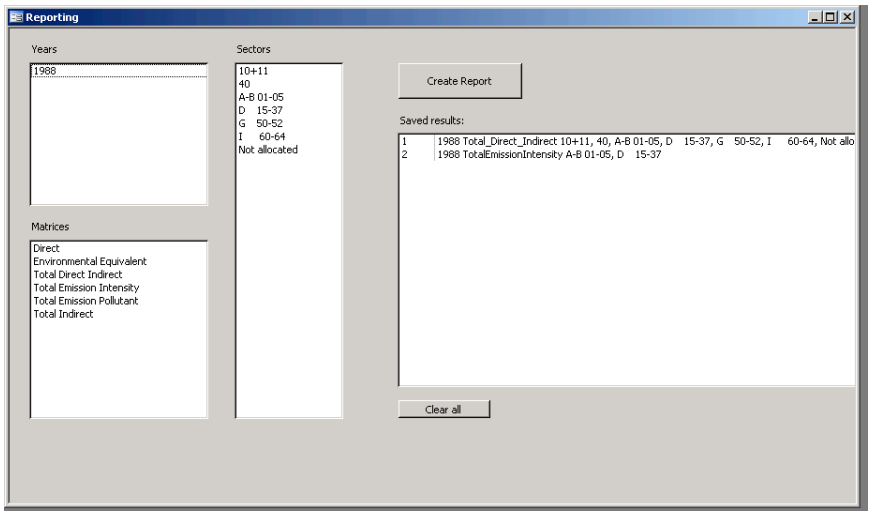

Figure 2. Reporting form of the database.

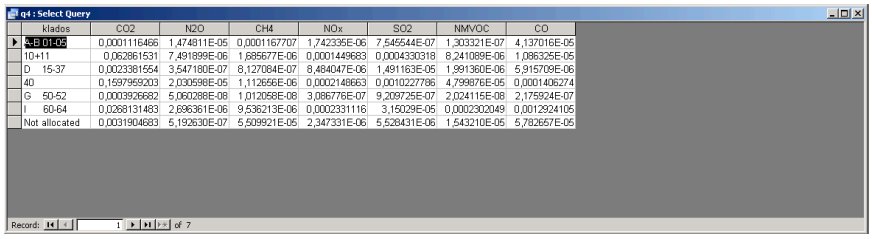

Figure 3. Direct emissions coefficients for the year 1988 for all sectors of economy. User created report.

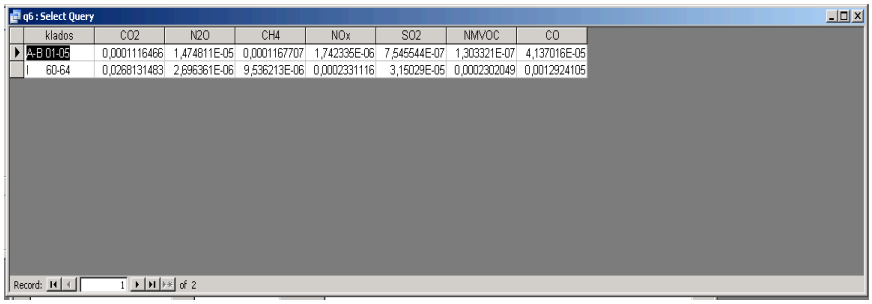

Figure 4. Direct emissions coefficient for the year 1988 for selected sectors of economy. User created report.

5 Conclusions

In the present paper we applied the input – output analysis to a collection of data in order to provide several important measures of economical and environmental concerns. Creating a database allows for the systematic and consistent entry of data and their consequent analysis. The researcher, therefore, has a practical and valuable tool in hand to determine the pollutants that pose significant environmental stress, understand interactions between the economy and the environment and easily identify the interrelationships across selected sectors through convenient and adjustable reporting of the results.

The implementation of the above database allows to estimate – for a given time period - the air pollutant production intensities (direct, indirect and total) by sector of economic activity for the total economy and for each category of final demand. Also, we are able to calculate emission multipliers that account for direct and total emissions of the pollutants per unit of demand in each economic sector and for the final demand categories. Finally, we are capable of computing several environmental themes and store all of the above matrices in the database for further examination and evaluation.

The new objective is to develop a practical tool for environmental and economic research, with the ability to encompass cross countries analysis. Such a project cannot be undertaken unless the knowledge management infrastructure, like the DBMS described above, is not in place and clearly defined.

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