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ANALYSIS

Economic and environmental efficiency using a social accounting matrix

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ABSTRACT

This paper aims to show the utility of the so-called Social Accounting Matrix and Environmental Accounts (SAMEA) for economic and environmental efficiency analysis. The article uses the SAMEA for Spain in 2000, applied to water resources and greenhouse gas emissions. This matrix is used as a central core of a multisectorial model of economic and environmental performance, and it calculates the denominated "*domestics SAMEA multipliers*" and their decomposition into characteristic, direct, indirect and induced effects. These multipliers show some evaluation of economic and environmental efficiency. Also, we present an application of these multipliers that demonstrates that there is no causal interrelation between those sectors with higher economic backward linkages and those with higher environmental deterioration backward linkages.

1. Introduction

Environmental problems caused by humans activities has led the establishment of rules that seek to prevent environmental degradation and to make economic and social development compatible with the viability of natural systems, in what has been termed sustainable economic development. Of special importance are two problems that are altering climatic processes and causing serious imbalance in ecosystem health: the shortage and dilution of resource quality and emissions polluting the atmosphere, causing the greenhouse effect.

The importance of these issues makes it necessary to develop an analytical instrument to analyse them and to design the most appropriate economic and environmental strategies. This work contributes to this objective, using a methodology to analyse the efficiency of all productive sectors.

To this means, we use the domestic Spanish Social Accounting Matrix and Environmental Accounts (SAMEA) for 2000, sourced from official data of the Spanish Statistical Office in Morilla (2004). This SAMEA integrates physical water circular flow and emissions to the atmosphere of greenhouse

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effect gasses (GE), together with the economic flow sourced from the National Accounting of Spain.

Using this database, we obtain the domestic production multipliers, emissions of greenhouse effect gasses and consumption of water. We decompose the SAMEA in direct, indirect, induced, and a new multiplier, characteristic effects and, finally, the backward linkages. These decompositions allow us to analyze the efficiency – or not – of each activity sector along the whole economic circuit and to draw conclusions on the economic and environmental systems of Spain.

2. Theoretical fundamentals of the hybrid systems and the SAMEA

The idea of confronting environmental and economic accounts has had conceptual precedents in the works developed by: Daly (1968), Isard (1969), Ayres and Kneese (1969), Leontief (1970) and Victor (1972). These works introduced the analysis of the "physical economy" in the input–output model. Also, from an analytical perspective, there has been significant contribution following the symmetrical environmental input–output table (SEIOT) based on the Leontief methodology, namely, those that are concerned with atmospheric emissions and water. We will highlight the following: Leontief and Ford (1971), Stone (1972), Forsund (1985), Proops (1988), Proops et al. (1993), Lofting and McGauhey (1963) and Hawdon and Pearson (1995).

From an official statistics perspective, it was not until the approval of the "National Accounts System of United Nations, 1993 (NAS93)," where it appeared, for the first time, that the national system of accounts was extended to environmental accounting. However, NAS93 only introduced the debate on how to introduce environment metrics in the national accounting system, without choosing a methodology to use. Accordingly, it was constituted in 1994, in the Statistical Commission of the UN, the so called Group of London on Environmental Accounting that has energized international discussion in this area. Finally, from 2003 we have the last version of SEEA03 (System Environmental and Economic Accounting). This manual collects, in a systematic and coherent way, the precisions and conceptual delimitations of the cost of physical flows linked to the environmental sphere and its connection with monetary flows associated with production activity and consumption. Sections 4 and 6 refer to the combined articulation of a Social Accounting Matrix (SAM) and physical flows associated to this, giving a hybrid SAM, which means, a SAMEA in accordance with the regular terminology.

It has been the European Community that has carried out the most important progress in this domain. In this sense, the document produced by the European Commission in 1994, titled "Directions of the European Union in relation to the environmental indicators and the Green National Account: the integration of the systems of information economic and environmental" is an important starting point in this area.

In Spain, at an official level, there is a precedent of a regional agency, part of a regional government – Andalusia – which elaborated the Environmental Input–Output Table for 1990 (TIOMA-90) based in Pajuelo (1980), although this work was not subsequently continued. Based on this table, it is necessary to highlight the following applications: Castro et al. (1996), Saenz de Miera (2000), Velázquez (2003) and André et al. (2005). Similar table was made in Valencia (Almenar et al., 1998).

Also, we want to note the contribution of Manresa and Sancho (2004) that used a Social Accounting Matrix for Catalonia-1987, to integrate data from energy consumption and atmospheric emissions and to evaluate the environmental repercussions using SAM multipliers. We also note the study developed by Sánchez Chóliz et al. (1994), in which the "water values" for Aragón, a northern region of Spain, were calculated.

At the national level, these hybrid systems of information have not developed much. In fact, there is no official Environmental Social Accounting Matrix. However, the National Statistical Office has advanced the development of statistical environmental information concerning water, residuals, flows of materials and environmental protection, following Eurostat. These statistics, in our opinion, need greater connection to extend the economic accounts toward social and environmental accounting as a whole. The unique reference nowadays for an Environmental Social Accounting Matrix, we find in Morilla (2004), on which this work is based.

The Social Accounting Matrix and Environmental Accounts (SAMEA) follows the structure proposed in the SEEA03, the NAS93 and the EAS95, and contains the following elements (refer to Table 1 and Table A.1, in the Appendix):

- From an economic point of view, the SAMEA contains a Social Accounting Matrix (SAM), where the flows are expressed in monetary units, associated to the economic flow, that means, these are related to production activity

Table 1 – Structure of an environmental SAM

SAMEA	National economy	Rest of the world economy	National environment	Rest of the world environment
National economy	SAM: flows of product, distribution of income,		Residuals by resident	Residuals by resident
Rest of the world economy	final consumption and capital formation		Residuals by non-resident	to ROW
National environment	Natural resources inputs	Natural resources exports		
Rest of the world environment	Natural resources from ROW			
National residuals	Residuals reabsorbed			Cross boundary residual outflows
Rest of the world residuals	Residuals reabsorbed		Cross boundary residual inflows	

Source: Morilla (2004).

Table 2 – Exogenous and endogenous accounts in SAMEA

SAMEA		SAM			EA
		Endogenous accounts (m)	Exogenous accounts (k)	Totals	Endogenous accounts (v)
SAM	Endogenous accounts (m)	Y_{mm}	X_{mk}	Y_m	E_{mv}
	Exogenous accounts (k)	X_{km}	X_{kk}	X_k	–
	Totals	Y_m	X_k	–	E_v
EA	Environmental endogenous accounts (r)	R_{rm}	–	R_r	–

Source: Morilla and Llanes (2004).

and consumption, as well as those that refer to a subsequent distribution and redistribution of these flows.

- From an environment point of view, the SAMEA contains two matrices expressed in physical units: firstly, for rows, where the flows of natural resources show what the productive system uses as inputs (in this case, refer to receptions of water resources) or the reabsorbed residuals that are picked up and processed; and secondly, for columns, where recycled water is picked up by nature once it has been used by the production process, household consumption and the emission of greenhouse effect gasses.

The information that has been used was contained in the domestic SAMEA of Spain-2000, detailing emissions of greenhouse effect gasses and consumption of water with homogeneous activity sectors developed by Morilla and Llanes (2004).

3. The model

The domestic SAMEA has been used to build an environmental multisectorial model under linear, fix price, equilibrium, obtaining various multipliers. To do this, information has been divided, in the function of variables that are considered to be determined in an endogenous and exogenous way in the model. Table 2 shows this partition in a theoretical domestic SAMEA:

- *From the economic point of view*, reading SAM by rows, we have the total of revenues of each sector that can be considered to be distinguished between endogenous or exogenous accounts.
- *From the environmental point of view*, reading by rows, the SAMEA includes the environmental inputs consumed as resources and, by columns, emissions and discharged pollutants to nature.

From an economic point of view, the formulation is obtained using the SAM component of the SAMEA that expresses the endogenous economic variables considered as a linear function of the exogenous variables. In this way, the total of an endogenous account can be expressed as the sum of the transactions among endogenous accounts (y_{mj}) and with the sum of the exogenous ones (x_{mj}), in matrix form:

$$Y_m = Y_{mm} \cdot i_m + X_{mk} \cdot i_k. \tag{1}$$

where i represents a column vector of unitary elements.

If we divide the monetary transactions of the SAM by the total outputs, we obtain the average propensity to spend in the interior, A, that we have denominated *Domestic SAM Coefficient*, whose characteristic element a_{ij} represents the proportion of the total expenditure of the account j that is dedicated to the account i:

$$A_{mm} = Y_{mm} \cdot \hat{Y}_m^{-1} \tag{2}$$

where this symbol "^" makes reference to a diagonalized matrix.

Following Eq. (1), the endogenous variable m, can be expressed as:

$$Y_m = A_{mm} Y_m + X_{mk} \cdot i_k \tag{3}$$

Solving for Y_m:

$$Y_m = [I - A_{mm}]^{-1} \cdot X_{mk} \cdot i_k = M_{mm} \cdot X_{mk} \cdot i_k = M_{mm} \cdot Z_m. \tag{4}$$

In Eq. (4), Z_m represents the vector whose elements $Z_m = \sum_{j=1}^{k} x_{mj}$ and this shows domestic exogenous flows. M_{mm} is the *SAM multiplier* and each element m_{ij} represents the multiplier's effect in the total of the endogenous variable, y_i, against unitary changes in expenditure, caused by impulses in the exogenous national demand of goods and services j account. For example, in the case of the production account, the elements of this account would be interpreted as the multiplier effect in the production of goods and services of sector i, when the exogenous demand of sector j is increased by one unit.

On the other hand, to analyse both the economy and the environment, the links in the economy, measured in monetary terms, together with the physical levels of environmental variables, must be defined. Considering the hypothesis that these variables have a directly proportional relationship with the production of the activity sectors and, in those cases, with households' income, we can estimate the technical coefficients (physical–monetary):

- *Vector of technical coefficients of resources reception of the environment* (α_m): the elements of this vector are defined as the relationship among the captured resources of nature (in physical units) for the activity or institutional sector m (in this case, households) and the output or total employments of this activity or sector m (in monetary units). In matrix terms, $\alpha_m = \hat{R}_m \cdot \hat{Y}_{mm}^{-1} \cdot i_m$, where R_m is the vector of the captured resources of nature and i_m is a unitary vector of order ($m \times 1$).

- *Vector of technical coefficients of emissions to the environment* (β_m): the elements of this vector are defined as the relationship among emissions to the environment (in physical units) for the activity or institutional sector m (households, in its case) and the output or total employment of this sector. In matrix terms, $\beta_m = \hat{E}_m \cdot \hat{Y}_{mm}^{-1} \cdot i_m$, where V_m is the vector of emissions to the environment.

Based on these considerations, variations in production levels and environmental repercussions in terms of reception of resources and emissions to the nature can be expressed respectively, before variations in the accounts that are considered as exogenous:

$$Y_m = [I{-}A_{mm}]^{-1} \cdot Z_m = M_{mm} \cdot Z_m \quad (5)$$

$$R_m = \hat{\alpha}_m \cdot (I{-}A_{mm})^{-1} \cdot Z_m = M_{mm}^{R} \cdot Z_m \quad (6)$$

$$E_m = \hat{\beta}_m \cdot (I{-}A_{mm})^{-1} \cdot Z_m = M_{mm}^{E} \cdot Z_m \quad (7)$$

where we can obtain the following relationships of domestic multipliers associated to a domestic SAMEA:

- $(I-A_{mm})^{-1}$ is the denominated domestic multipliers SAM "M_{mm}."
- Regarding emissions, $\hat{\beta}_m \cdot (I-A_{mm})^{-1}$, will pick up emission multipliers whose element "m_{ij}^{E}", shows the increase that will take place in emissions by the activity sector or, in this case also for households "i," before unitary variations in the exogenous variables "z" of the account "j".
- Concerning the reception of resources: the SAM multipliers for reception of resources, $\mathbf{M}_{ij}^{R}$, one for each type of resource "r," shows the increase that will occur in environmental inputs for the sector "j" before unitary variations in the exogenous variables "z" of the account "i".

We have decided to follow the most utilized hypothesis in this type of model, for example, such as those formulated by Robinson and Roland-Holst (1988) and Polo et al. (1991a,b), where they consider as exogenous accounts, those related with the public sector or outside the control of the national economic system, namely, the foreign sector. Investment is considered endogenous in this pattern.[1]

4. SAMEA multipliers decomposition and inefficiency analysis

First of all, we would like to make an observation. Due to their entropy character, production activity and consumption always cause undesired effects to the environment (Georgescu-Roegen, 1971). Therefore, this problem represents a conflict between the economy and the environment and could be defined from the perspective of the most efficient allocation of resources, that is, the capacity to generate economic value in connection with minimal impact on the environment. From this perspective, the effects that the production of diverse goods and services has on the economy and the environment can be classified as:

- *Characteristic effects* caused by the manufacturing processes of each good or service.
- *Direct effects* caused by the expansion of production of other activity sectors that need intermediate inputs of the manufacturing process, an activity branch. For example, agricultural production requires inputs of other activities and this requirement causes effects on production and the environment;
- *Indirect effects* that occur in the productive structure, derived from the productive cycle by the relationships between consumption and intermediate demand among activity sectors. To satisfy the input requirements of the agricultural sector, remaining activities require other inputs and this generates new environmental effects; and
- *Induced effects* from the generation of income that assumes a circular flow of income. The production of each activity generates a feedback process from the income of the production factors toward to the expenditure of the institutional sector and to each activity's own productive process and the environment.

Therefore, from an economic and environmental efficiency perspective it remains necessary to not only analyse the characteristic effects that cause the manufacturing processes of each good or service, but to also analyse the direct, indirect and induced effects, and to assess the economic and environmental impact of the different economic activities.

The SAMEA obtained and the model contain a multi-sectorial database that allows one to analyse these effects and to plan sustainable development policy. According to the model proposed in Eqs. (5), (6) and (7), the SAM domestic multipliers – SAMEA – pick up the total effects (characteristic, direct, indirect and induced) of each activity. One can proceed to carry out their decomposition in the following way:

- Let **I** represent the impacts matrix, truncated in "*n*" activity branches that measure the economic changes that we want to simulate in each productive activity, and assume one million Euros for each one.
- Let **A** represent the coefficients domestic matrix of the SAM, truncated in "*n*" activity branches that measure the intermediate consumption of each productive activity for each product unit.
- Let $\mathbf{M}_T$ represent the interior multipliers matrix of a symmetric input–output table, according to Leontief model which measures the characteristic, direct and indirect effect of each activity production.
- Let $\mathbf{M}_S$ represent the domestic multipliers matrix of the SAMEA truncated in "*n*" activity sectors that measure the total effect of each activity in the production.

So, we have:

$$M_S = \textit{Characteristic Effect} + \textit{Direct Effect} + \textit{Indirect Effect} + \textit{Induced Effect}$$

$$M_S = I + A + (M_T{-}I{-}A) + (M_S{-}M_T) \quad (8)$$

[1] This is the usual thing in this type of models.

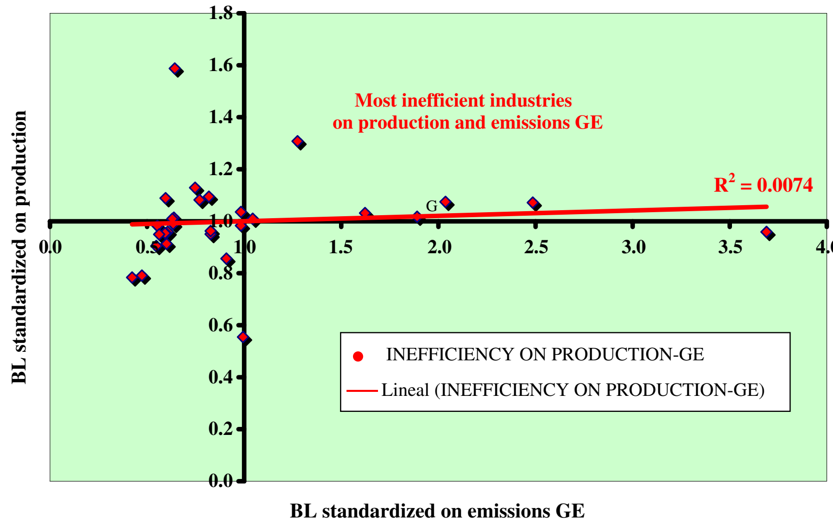

Fig. 1 – Inefficiency on greenhouse emissions (GE) of different industries.

From Eqs. (5), (6), (7) and (8), the domestic multipliers matrix SAMEA of consumptions of water and polluting emissions to the atmosphere GE can be disaggregated in:

$$M_S^R = \hat{\alpha}_m \cdot I + \hat{\alpha}_m \cdot A + \hat{\alpha}_m \cdot (M_T – I – A) + \hat{\alpha}_m \cdot (M_S – M_T) \quad (9)$$

$$M_S^E = \hat{\beta}_m \cdot I + \hat{\beta}_m \cdot A + \hat{\beta}_m \cdot (M_T – I – A) + \hat{\beta}_m \cdot (M_S – M_T). \quad (10)$$

5. Results

The analysis of multiplier decomposition and calculation of the productive backward linkages (BL), allow this to be observed as if they vary the effects of each activity along the economic system following the direct, indirect and induced effects. In Tables 3 and 4 of the Appendix the BL that is associated to these effects is shown. Now follows the multiplier decomposition and their effects:

- Firstly, what one can observe through the analysis of the BL is that, even when the productive processes do not generate emission pollution,[2] or do so in a reduced or limited way, these production processes generate a direct, indirect and induced contamination. So, for example, agriculture has a low characteristic effect in atmospheric contamination (73,000 t for each million Euros), but the direct effects rise to 580,000 t. Moreover, the emissions that the productive system generates to satisfy the derivative demand of the agricultural industry causes another 370,000 t GE, and by the circular flow of the income-induced effect — an additional 622,000 t. Consequently, one of the seemingly less polluting activities of the productive system, with emissions four times lower than average, becomes the most polluting activity when you analyse the whole economy. Something similar occurs with the requirement of water for this branch.
- Secondly, it is necessary to highlight the importance of the characteristic and induced effects, on average 75% of the total. It is worth noting the induced effects (around 40% on average) and the characteristic effects of each activity (around 35% on average).
- It is important to also observe the differences for the branches in the linkage effects. Increments present a significant variability: the most articulate activity branches in the interior are those that have the biggest direct and indirect effects (mainly the primary and industrial sectors), and those related with services that have a greater impact on increasing the value of the induced effects. The importance that induced effects have as a motor of economic growth and the relevance that these effects acquire, mainly service accounts, justifies the relevance of using a SAMEA instead of the traditional Leontief model.

The analysis of multiplier decomposition allows the study of economic or environmental efficiency along the whole economic flow for each productive activity. However, in linking these items, economic and environmental efficiency, it is necessary to relate the environmental effects that each activity causes with the economic effects that each activity generates. To do this, we relate the economic and environmental multipliers calculated in Eqs. (8), (9) and (10). Table 4 in the Appendix incorporates the indicators that have been obtained by dividing the respective environmental effects with regard to the economic effects of each productive sector. The most inefficient activities can be observed, in boldface and shaded — in the sense of combining a greater backward linkage effect in an economic sense and a smaller environmental backward linkage effect. From this perspective, the following conclusions can be drawn:

- In Figs. 1 and 2 there is no relation between those activities with a greater economic and environmental backward

[2] Of course one talks about to that it does not generate emissions directly.

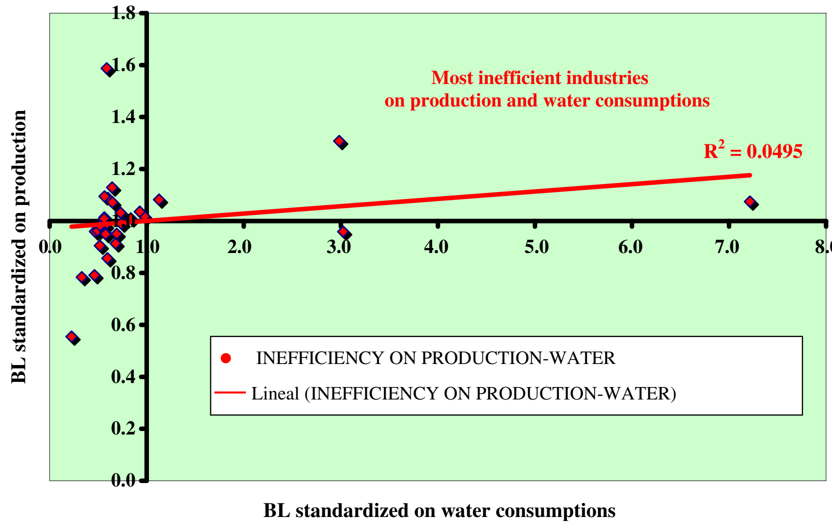

Fig. 2 – Inefficiency on water consumption of different industries.

linkage effect. Therefore, one could conclude that a strategy of economic development that tries to develop economic growth sectors with a high capacity to generate value is compatible with another strategy that initiates structural changes that improve the environmental efficiency of the economy. Alternatively, it would be possible to apply environmental policies that try to minimize environmental impact without causing any significant economic effect if environmental policy is adjusted in a compatible way with key economic activity sectors and in this way contribute to improve the efficiency of the sustainable economic development model.

- Following the GE emissions, the eight factors that surpass the level of total inefficiency, from the combined perspective of having the lowest capacity to generate production in the economy as compared to the repercussions they cause to the environment are, in this order: Electricity, Non metallic mineral products, Agriculture, Fishing, Extractives and Refining, Chemical products, other services and Metallic products.
- As concerning water, the following are the four most inefficient activities from a combined economic and environment perspective, in order: Agriculture products, Electricity, Agroalimentary products and Hotels
- Finally, it is worth analysing the decomposition of the total efficiency indicator in the characteristic, direct, indirect and induced effects (see Table 4 in the Appendix). It has been shown that the explanatory factors of the inefficiency of each sector, considering the whole economic production circuit for each good or service are in the first stage. The characteristic and direct factors of the production function of each good or service are the factors that cause the main impact on total efficiency. In general, the indirect and induced effects cause less impact in the

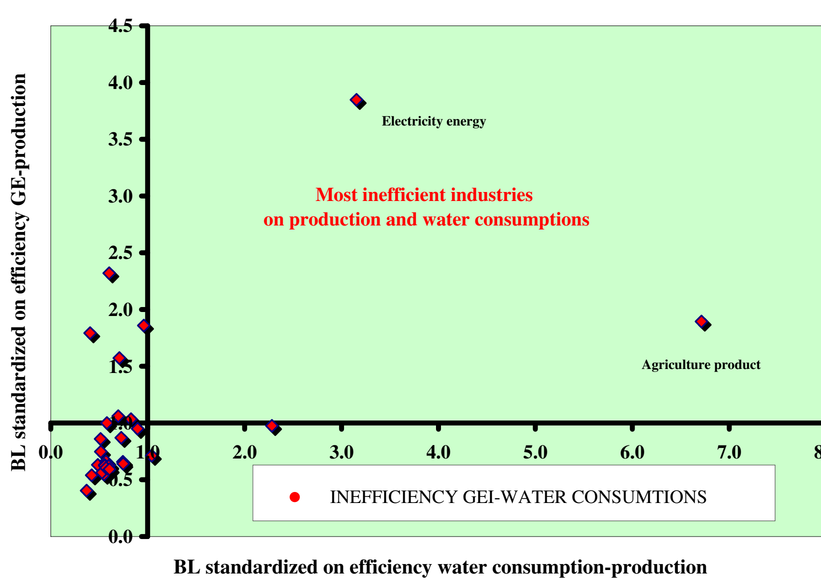

Fig. 3 – Economic and environmental inefficiency on greenhouse emissions and water consumption.

various activity sectors. The conclusion is obvious: the structural reformation process can concentrate on improving the production function of the most inefficient activities from a combined economic and environmental perspective. In this sense, Fig. 3 shows the relationship among the production GE and production–water consumption efficiency indicators. Observe that two activities stand out namely, Primary activities and Electric power production.

6. Conclusions

In this article we analysed the efficiency of the different economic activity sectors of the Spanish economy, using a SAMEA from 2000, with a grade detail to thirty homogeneous activity sectors and four institutional sectors, relative to the resources utilised and atmospheric pollution emission gases that they contribute to the greenhouse effect. Based on this matrix, we have calculated domestic "multipliers SAMEA." Starting with these multipliers, we have obtained synthetic indicators of efficiency, and we evaluated the different productive processes of the activity sectors of the Spanish economy. Therefore, we have developed decomposition multipliers in their characteristic, direct, indirect and induced effects and also the backward linkages of production activities. These operative indicators of the total efficiency trajectory for each activity have been obtained by the economic circuit and also the repercussions from an integrated economic and environmental perspective.

One of the main conclusions obtained is that, in the Spanish economy, there is no causal relation between sectors with greater capacity to generate chains of value added (measured through production) and those that cause greater environmental deterioration (measured by GE or water consumption). Therefore, it is possible to design an environmental policy that attempts to address the major deterioration that some activities cause, in a way that is compatible with minimal impact on developing the economic growth capacity of key sectors and to improving the efficiency of a sustainable economic development model. From this perspective, there are two activities that require greater intensity of focus in the processes of structural reformation, because of their limited economic–environmental efficiency in as compared to other activities: namely primary activities and electric power production.

Finally, we consider that the estimated chronological series of SAMEAs opens up a new research line that will allow improved study of the temporal evolution of efficiency of the various activity sectors and will integrate the input–ouput and econometric models to reach a Dynamic Economic and Environmental Multisectorial Model.

Appendix A

Table A.1 – SAMEA Structure. Spain 2000. Applied to Water Resource

SAMEA-ESP-2000				National economy				
						Institutional sectors		
				Productions (industries)	Generation of income account	Household	Corporations	Non-profit Institution Serving Households
				1	2	3	4	5
National economy		Productions (industries)	1	Intermediate consumptions on domestics products	0	Household consumptions on domestics products	0	NPISH consumptions on domestics products
National economy		Generation of income account	2	Value added and net indirect taxes	0	Indirect taxes on consumption	0	0
National economy	Institutional sectors	Household	3	0	Compensation of employees and Gross operating surplus	Property income and current transfers	Property income and current transfers (1)	Property income and current transfers
National economy	Institutional sectors	Corporations	4	0	Gross operating surplus not distributed	Property income and current transfers	Property income and current transfers	Property income and current transfers
National economy	Institutional sectors	Non-profit Institution Serving Households	5	0	Gross operating surplus	Property income and current transfers	Property income and current transfers	Property income and current transfers
National economy	Institutional sectors	General Government	6	0	Net taxes on productions an capital consumption	Property income and current transfers	Property income and current transfers	Property income and current transfers
National economy		Saving	7	0	0	Household savings	Corporations saving	NPISH saving
Rest of the world		Current	8	Intermediates imports	Compensation of employees to ROW and Indirect taxes	Import of goods and services+property income current transfers to ROW	Property income and current transfers to ROW	Property income and current transfers to ROW
Totals			9	Total output	Total payments to factors	Total use of households	Total use corporations	Total use NISH
Environment		Abstraction of surface and grandwaters	10	Abstraction of water	0	0	0	0
Environment		Recycling, re-use and treatment of wastewater	11	Recycling, re-use and treatment of wastewater	0	0	0	0
Environment		Consumptions of water : abstractions and distributions	12	Consumptions of water	0	Consumptions of water by resident household	0	0

Economy: the monetary data that comes from the Marco Input–Output is in normal font; in bold font is that of the Matrix of Closing the circuit and, on a dark background and in clear font, the balances.
Environment: the bold font and shaded background shows the environmental accounts in physical units and the dark background and clear font, the balances.
(1) Include the adjustments by the variation in the net participation of household in the reserves of the pensions fund.
Source: Morilla (2004).

(continued on next page)

Table A.1 (*continued*)

		Rest of the World	Totals	National environment			
	Capital						
General Government	Investment	Current		Wasterwaters by Environmental protection services	Water return	Net flow from environment to national economy (-)	Greenhouse emissions
6	7	8	9	10	11	12	13
Government consumptions on domestics products	Gross capital formations on domestics products	Exports of product	Total demand	Discharge of wastewaters	Discharge of wasterwaters	Apparent water consumption	Greenhouse emissions
Indirect taxes on consumption	Indirect taxes on Gross capital formation	Compensation of employees and Net taxes on productions from ROW	Total factors income	0	0	0	0
Property income and current transfers	0	Property income and current transfers from ROW	Total households income	Discharge of wasterwaters	0	Apparent water consumption	Greenhouse emissions
Property income and current transfers	0	Property income and current transfers from ROW	Total corporations income	0	0	0	0
Property income and current transfers	0	Property income and current transfers by ROW	Total NISH income	0	0	0	0
Property income and current transfers	0	Property income and current transfers from ROW	Public revenue	0	0	0	0
Government saving	0	Current balance	Total saving	0	0	0	0
Import of goods an services+property income+ current transfers to ROW	Import of investment goods and services	0	Payments to RW	0	0	Apparent water consumption	0
Total use public sector	Total investment	Revenues from RW		Discharge to public sewage system	Direct return	Apparent water consumption incorporated to economy (-)	Total emissions
0	0	0	Abstraction of water			Total abstraction water (-)	
0	0	0	Wastewater treatment			Return to nature (+)	
0	0	0	Total water consumption				

Table A.2 – Economic and environment Infficiency on productions and greenhouse emissions (GE). Spain 2000

Industry		Effect on production (millions of € per million produced)					Effect in Greenhouse emissions (thousands of tons of CO2 per million €)				
		Totals effect	Characteristic effect	Direct effect	Indirect effect	Induced effect	Totals effect	Characteristic effect	Direct effect	Indirect effect	Induced effect
AA	Agriculture, hunting and forestry	3.25	1	0.38	0.32	#REF!	2628	1605	244	204	575
BB	Fishing	3.12	1	0.37	0.22	1.53	2094	1264	148	106	575
CA	Mining of energy product	3.08	1	0.29	0.17	1.62	2440	1470	272	83	615
CB	Other mining	3.14	1	0.47	0.25	1.42	1269	200	410	125	535
DF	Manufacture of coke, refined petroleum products and nuclear fuel	1.68	1	0.12	0.05	0.51	1283	962	105	26	189
EE	Electricity, gas and water	2.90	1	0.31	0.17	1.43	4761	3721	411	98	531
DA	Manufacturing of food product, beverages and tobacco	3.96	1	0.72	0.58	1.66	1645		580	370	622
DB	Manufacturing of textile product	2.76	1	0.40	0.25	1.12	775	96	152	102	426
DC	Manufacturing of leather product	3.30	1	0.62	0.54	1.14	768	59	99	178	431
DD	Manufacture of wood and cork	3.00	1	0.47	0.30	1.23	819	69	163	122	464
DE	Manufacturing of paper, publishing and printing	2.88	1	0.44	0.29	1.15	1068	291	209	134	434
DG	Manufacturing of chemical products	2.59	1	0.40	0.22	0.97	1172	497	203	105	368
DH	Manufacturing of rubber and plastics product	2.39	1	0.28	0.14	0.97	611	52	126	66	367
DI	Manufacturing of other non-metallic	3.24	1	0.52	0.31	1.42	3208	2100	406	166	536
	mineral product						1269	404	263	149	452
DJ	Manufacturing of basic metals and	2.98	1	0.48	0.31	1.20					
	fabricated metal products	2.90	1	0.41	0.28	1.21	782	52	142	128	460
DK	Manufacturing of machinery and equipment						964	28	225	180	531
DL	Manufacturing of electrical equipment	3.42	1	0.61	0.41	1.40					
DM	Manufacturing of transport equipment	2.37	1	0.34	0.21	0.82	546	24	113	97	311
DN	Other manufacturing including recycling	3.07	1	0.49	0.32	1.25	823	97	121	130	475
FF	Construction	3.31	1	0.52	0.39	1.41	1056	34	289	201	533
GG	Trade and repair of motor vehicles	3.05	1	0.31	0.17	1.58	813	48	107	67	591
HH	Hotels and restaurant	3.28	1	0.37	0.35	1.55	994	16	171	228	579
II	Transport, storage and communications	2.91	1	0.29	0.16	1.47	1068	355	99	62	553
JJ	Financial intermediations	4.81	1	0.81	1.64	1.35	829	6	66	222	535
KK	Real estate, renting and business activities	2.97	1	0.24	0.17	1.56	714	4	54	71	585
LL	Public administration	2.89	1	0.20	0.11	1.57	772	18	103	52	599
MM	Education	2.89	1	0.11	0.06	1.71	765	17	58	31	659
NN	Health and social work	2.74	1	0.17	0.10	1.47	706	30	67	47	562
OO	Other community, social and personal service activities	3.06	1	0.33	0.18	1.55	1347	538	144	78	586
PP	Activities of private households as employers	2.87	1	–	–	1.87	726	_	–	–	726
Economy average		3.03	1	0.38	0.29	1.36	1291	471	185	121	513

Bold font and shaded background shows those effects that are greater than average.
The total effect measures the global impact of an economic activity in the set of the economy and the environment.
The environmental typical effect is the same as the technical coefficients physical–monetary.
The direct effect is caused by the production structure for each product by million €.
The indirect effect measures the impact in the chain that the manufacture of a product produces on another industry.
The induced effect measures the feedback that produces the circular flow of the rent.
Source: Own elaboration.

Table A.3 – Economic and environment Inefficiency on productions and water consumptions. Spain 2000

Industry		Effects on production (millions of € per million produced)						Effect in the waters consumptions (thousand of m3 per million € produced)						Efficiencies (B)/(A) (thousand of m3 of water per million €)				
		Peso % en la production	Total effect	Characteristic effect	Direct effect	Indirect effect	Induced effect	Peso % en la emissiones	Totals effect	Characteristic effect	Direct effect	Indirect effect	Induced effect	Eficiencia total	Eficiencia propia	Eficiencia directa	Eficiencia indirecta	Eficiencia inducida
AA	Agriculture, hunting and forestry	**3.0**	**3.25**	1	0.38	**0.32**	**1.55**	**1.66**	**873**	**712**	**60**	**49**	**52**	**268**	**712**	**157**	**154**	34
BB	Fishing	**0.2**	**3.12**	1	0.37	0.22	**1.53**	**0.7**	88	11	7	**17**	**53**	28	11	20	**78**	35
CA	Mining of energy product	**0.1**	**3.08**	1	0.29	0.17	**1.62**	**0.8**	118	39	16	5	**57**	38	39	56	31	**35**
CB	Other Mining	**0.3**	**3.14**	1	**0.47**	0.25	**1.42**	0.2	112	33	**22**	7	50	36	33	**48**	29	35
DF	Manufacture of coke, refined petroleum products and nuclear fuel	1.6	1.68	1	0.12	0.05	0.51	5.5	27	3	6	1	17	16	3	49	28	**34**
EE	Electricity, gas and water	2.2	2.90	1	0.31	0.17	**1.43**	**28.6**	**366**	**286**	**25**	6	**49**	**126**	**286**	**81**	36	**34**
DA	Manufacturing of food product, beverages and tobacco	**5.9**	**3.96**	1	**0.72**	**0.58**	**1.66**	**1.5**	**361**	7	**204**	**93**	**58**	**91**	7	**284**	**159**	**35**
DB	Manufacturing of textile product	1.5	2.76	1	**0.40**	0.25	1.12	0.5	82	8	**23**	12	40	30	8	**57**	49	36
DC	Manufacturing of leather product	**0.6**	**3.30**	1	**0.62**	**0.54**	1.14	0.1	72	1	7	**24**	40	22	1	11	**44**	36
DD	Manufacture of wood and cork	0.7	3.00	1	**0.47**	**0.30**	1.23	0.2	90	3	**28**	**15**	43	30	3	**60**	**49**	35
DE	Manufacturing of paper, publishing and printing	2.1	2.88	1	**0.44**	0.29	1.15	2.1	84	11	**20**	12	40	29	11	**46**	42	35
DG	Manufacturing of chemical products	2.7	2.59	1	**0.40**	0.22	0.97	4.8	72	20	10	8	34	28	20	25	38	35
DH	Manufacturing of rubber and plastics product	1.2	2.39	1	0.28	0.14	0.97	0.2	56	5	11	5	34	23	5	40	36	35
DI	Manufacturing of other non-metallic mineral product	**1.8**	**3.24**	1	**0.52**	**0.31**	**1.42**	**13.3**	78	2	17	9	**50**	24	2	33	31	**35**
DJ	Manufacturing of basic metals and fabricated metal product	4.1	2.98	1	**0.48**	**0.31**	1.20	5.7	69	6	12	8	42	23	6	26	27	35
DK	Manufacturing of machinery and equipment	1.8	2.90	1	**0.41**	0.28	1.21	0.3	56	1	5	7	43	19	1	11	25	36
DL	Manufacturing of electrical equipment	**2.0**	**3.42**	1	**0.61**	**0.41**	**1.40**	0.2	78	2	14	12	**50**	23	2	23	30	36
DM	Manufacturing of transport equipment	4.6	2.37	1	0.34	0.21	0.82	0.4	40	1	5	6	29	17	1	13	27	**36**
DN	Other manufacturing including recycling	**1.2**	**3.07**	1	**0.49**	**0.32**	1.25	0.4	68	6	6	12	44	22	6	13	36	**36**
FF	Construction	**10.1**	**3.31**	1	**0.52**	**0.39**	**1.41**	1.2	68	3	5	10	**50**	21	3	10	26	35
GG	Trade and repair of motor vehicles	**9.1**	**3.05**	1	0.31	0.17	**1.58**	1.5	68	3	6	4	**55**	22	3	19	25	**35**
HH	Hotels and restaurant	**6.7**	**3.28**	1	0.37	**0.35**	**1.55**	0.4	**136**	7	16	**59**	**53**	**42**	7	44	**168**	34
II	Transport, storage and communications	7.2	2.91	1	0.29	0.16	**1.47**	8.9	60	0	3	5	**51**	21	0	11	31	**35**
JJ	Financial intermediations	**3.9**	**4.81**	1	**0.81**	**1.64**	1.35	0.1	71	0	4	**15**	**52**	15	0	5	**9**	39
KK	Real estate, renting and business activities	11.5	2.97	1	0.24	0.17	**1.56**	0.2	63	2	3	4	**54**	21	2	14	24	34
LL	Public administration	4.0	2.89	1	0.20	0.11	**1.57**	0.2	70	2	7	4	**57**	24	2	35	36	36
MM	Education	3.1	2.89	1	0.11	0.06	**1.71**	0.2	69	0	4	3	**63**	24	0	33	40	**37**
NN	Health and social work	3.8	2.74	1	0.17	0.10	**1.47**	0.4	63	0	4	5	**53**	23	0	24	53	**36**
OO	Other community, social and personal service activities	**2.5**	**3.06**	1	0.33	0.18	**1.55**	**4.8**	101	32	9	5	**55**	33	32	–	30	35
PP	Activities of private households as employers	0.6	2.87	1	–	–	**1.87**	0.0	70	0	–	–	**70**	24	0	#VALUE!	–	**37**
Media economic		100.0	3.03	1	0.38	0.29	1.36	100.0	121	40	19	14	48	40	40	49	49	35

Bold and shaded shows the effects that are greater than average.
The total effects measure the global impact of an economic activity in the set of the economy and the environment.
The environmental typical effects are the same to technical coefficients physical–monetary.
The direct effects are caused by the structure of the production of each product by million €.
The indirect effects measure the impact in chain that produces the manufacture of a product on the other industry.
The induced effects measure the feedback that produces the circular flow of the rent.
Source: Own elaboration.

Table A.4 – Economic and environmental inefficiency on productions in Spain, 2000

Industry		Efficiency greenhouse emission/production (thousand of tn CO2 per million €)					Efficiency water consumpton/production (thousand of m3 of water per million €)				
		Total inefficiency	Characteristic inefficiency	Direct inefficiency	Indirect inefficiency	Induced inefficiency	Total inefficiency	Characteristic inefficiency	Direct inefficiency	Indirect inefficiency	Induced inefficiency
AA	Agriculture, hunting and forestry	808	1605	644	636	370	268	712	157	154	33.8
BB	Fishing	671	1264	398	489	375	28	11	20	78	34.7
CA	Mining of energy product	792	1470	937	501	379	38	39	56	31	35.4
CB	Other Mining	405	200	879	509	376	36	33	48	29	34.8
DF	Manufacture of coke, refined petroleum products and nuclear fuel	764	962	890	500	372	16	3	49	28	34.1
EE	Electricity, gas and water	1640	3721	1328	584	373	126	286	81	36	34.2
DA	Manufacturing of food product, beverages and tobacco	416	73	809	635	375	91	7	284	159	34.7
DB	Manufacturing of textile product	280	96	381	416	380	30	8	57	49	35.6
DC	Manufacturing of leather product	233	59	161	328	379	22	1	11	44	35.5
DD	Manufacture of wood and cork	273	69	347	409	378	30	3	60	49	35.3
DE	Manufacturing of paper, publishing and printing	371	291	470	469	378	29	11	46	42	35.2
DG	Manufacturing of chemical products	452	497	510	472	378	28	20	25	38	35.2
DH	Manufacturing of rubber and plastics product	255	52	447	457	379	23	5	40	36	35.5
DI	Manufacturing of other non-metallic mineral product	989	2100	786	541	377	24	2	33	31	35.1
DJ	Manufacturing of basic metals and fabricate metal products	426	404	555	488	378	23	6	26	27	35.4
DK	Manufacturing of machinery and equipment	269	52	344	454	380	19	1	11	25	35.6
DL	Manufacturing of electrical equipment	282	28	371	440	379	23	2	23	30	35.5
DM	Manufacturing of transport equipment	230	24	329	465	379	17	1	13	27	35.5
DN	Other manufacturing including recycling	268	97	245	403	379	22	6	13	36	35.5
FF	Construction	319	34	558	517	379	21	3	10	26	35.4
GG	Trade and repair of motor vehicles	266	48	350	386	375	22	3	19	25	34.7
HH	Hotels and restaurant	303	16	456	647	374	42	7	44	168	34.4
II	Transport, storage and communications	367	355	343	391	376	21	0	11	31	34.9
JJ	Financial intermediations	173	6	81	136	395	15	0	5	9	38.7
KK	Real estate, renting and business activities	240	4	222	431	374	21	2	14	24	34.5
LL	Public administration	267	18	503	459	382	24	2	35	36	36.0
MM	Education	265	17	519	487	385	24	0	33	40	36.6
NN	Health and social work	258	30	398	477	382	23	0	24	53	36.0
OO	Other community, social and personal service activities	441	538	–	426	379	33	32	–	30	35.4
PP	Activities of private households as employers	253	–	–	–	387	24	0	–	–	37.1
Average		426	471	484	419	379	40	40	49	49	35.4

Bold and red denotes those effects that are greater than average.
The total effect measures the global impact of an economic activity in the the economy and the environment.
The environmental typical effect is the same as the technical coefficients physical–monetary.
The direct effect is caused by the production structure of each product by million €.
The indirect effect measures the impact in the chain that the manufacture of a product produces on another industry.
The induced effect measures the feedback that produces the circular flow of the rent.
Source: Own elaboration.

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