CHANGES IN ENERGY COSTS AND ENERGY INTENSITIES IN THE SPANISH ECONOMY

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ABSTRACT

Changes in energy costs and energy intensities in the Spanish economy are explained in terms of direct energy requirement effect, energy inputs substitution effect and indirect non-energy input effect, through decomposition of the change in the inverse of the input-output matrix. Data is based on a 24-sector aggregation (4 energy sources and 20 non-energy sectors) from available Spanish input-output tables since 1980. From a technical point of view, the focus is on two issues of the decomposition analysis. First, by means of a perfect decomposition scheme, in which changes in energy intensity are evaluated using the arithmetic mean for two adjacent periods, interaction terms do not exist. Second, the use of the hybrid units approach, in which the monetary units of the energy rows of the structural matrix are replaced by their physical unit equivalent (toe), is compared with the direct monetary-based energy rows one. The results with both approaches are different, mainly in the 1980s. The direct effects of decreasing energy-input intensity and decreasing energy cost shares are stronger, although some sectors exhibit significant indirect effects, which cannot be ignored when explaining changes in energy use over time.

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1. INTRODUCTION

Spain presents a relatively diversified overall energy structure, including primary nuclear energy. Energy policy is important because Spain is highly dependent on energy imports. In addition to nuclear energy, there is some domestic coal production. Spain has reduced its oil imports, but import dependence has increased with the introduction of natural gas from northern Africa. Improvements in sectoral efficiency are compensated for by changes in the consumption structure due to the modernization of the Spanish economy.

Energy per GDP has been a widely used measure for considering trends in energy use. It is not, however, a good measure of the level of energy efficiency on a sectoral basis. Energy efficiency is related to how much energy is needed to satisfy demand for a given energy service. Different branches of the economy grow and evolve at different rates, causing the structure of the economy to change over time. Since each branch or activity has a different energy use per output, these changes influence the overall ratio of energy use to GDP.

The determinants of the relation between energy and output can be studied using production theory in a partial or general equilibrium framework. Distinguishing between the factors driving up energy demand from those factors making it more efficient is the key to relating past changes in energy use to future ones. Growth in energy use, however, can also be reduced by changes in economic structure, such as shifts in the manufacturing base towards producing goods that require less energy. These reductions should not be mistaken as the results of improved energy efficiency. To identify the elements that make energy use more efficient, changes in past energy use resulting from changes in the structure of economic activity need to be separated from those related to improved energy efficiency.

Nevertheless, a multiple sector framework is more convenient for collecting the complete rank of interconnections among sectors. The development of a complete

applied general equilibrium model presents large empirical problems if a high degree of disaggregation is desired. A simpler alternative is the use of input output tables, and the analysis of the changes in the perspective of general equilibrium through the inverse matrix. This option implies a loss of predictive capacity, but it is a reasonable and informative description of the changes in energy requirements.

The fundamental idea of a multi-sector framework is that at the time of considering the energy necessary to produce specific goods, (such as chemicals) it is not enough to consider the total energy required by each specific sector (chemicals). This latter demand for energy is called direct energy requirements. However, energy is also needed to produce energy inputs as well as non-energy inputs in the production of chemicals. Thus, the measurement of total energy use requires counting both direct energy use and the indirect energy required for the production of all the intermediate consumptions. This type of analysis is well known through Leontief's inverse matrix.

A comment on units is interesting. Zarnikau (1999) investigated the aggregation of fuels in technical units or in economic terms. Although results are generally similar, the economic terms are preferred because substitution effects due to changing relative prices within the energy aggregate are taken into account. In addition, measuring input and output at constant prices, the intensities can be interpreted as technical coefficients, and the results compared with those obtained using input-output approaches. In this paper, a hybrid input-output system with energy in physical data and the usual input-output table with energy in monetary values are used and compared.

The second section introduces the theoretical model. Subsequently, the empirical analysis carried out is presented and the most relevant results are commented on in section three. The most important conclusions are collected in the final section of the paper.

2. THEORETICAL MODEL

Rose and Casler (1996) define Structural Decomposition Analysis (SDA) as "the analysis of economic change by means of a set of comparative static changes in key

parameters in an input-output table". The basic idea in SDA is to express an identity in various components, which should fulfil the properties of being (1) completely exhaustive, which is guaranteed by the decomposition of the identity, and (2) mutually exclusive, which requires a certain degree of care in the mathematical derivation in order to avoid an interaction effect of difficult interpretation. Applications of the structural decomposition analysis are numerous, many of them in relation to energy studies.

Casler and Afrasiabi (1993) applied a mixed methodology to determine direct and indirect changes in the energy-output ratio. The methodology is used in Alcántara and Roca (1995) to analyse the CO2 emissions in the period 1980-90 in Spain. In the critical review by Rose and Casler (1996), the relations of SDA to other methodologies, such as decomposition indexes, are commented on, and details are given of its application to the case of the energy, such as the hybrid units method, in which energy rows are substituted by their physical equivalent in the structural matrix. Ang and Zhang (2000) carry out a complete review of index decomposition analysis applications in energy and environmental studies, in which they include 15 references to the SDA methodology, quoted as 'a more sophisticated and elaborated version' of the decomposition analysis based on Laspeyres indexes.

In the structural decomposition analysis, as in other analyses of energy intensity, there inevitably appears a 'index number' problem, caused by the decomposition of an increase in value in an element of 'price' (intensity) and another element of 'quantity' (share). Rose and Casler (1996) expressed the problem clearly, and indicate the existence of two procedures in Betts (1989), which allowed the property of exhaustive decomposition to be fulfilled, although they consider that having to choose arbitrarily between two procedures is not really satisfactory. Nevertheless, it seems to be preferable to choose a theoretically acceptable decomposition, in accordance with the theory of index numbers. Fujikawa et al. (1995**)** applied the Bennet decomposition to input-output in a direct comparison between costs structures. Diewert (1998) studied the properties of Bennet's indexes in detail.

The most characteristic feature of SDA is that it does not consider the inverse matrix to be just one entity, but rather an aggregation in different sectors related to the

decomposition presented. Specifically in this work, the changes of the inverse matrix caused by direct uses of energy (related directly with the energetic sectors) and by the indirect uses (associated with the consumption of energy in the not energetic sectors) are considered differentially.

Therefore, in the decomposition analysis of energy intensities a common analysis of Leontief's inverse matrix is performed, with the extension of separating the structural matrix into two groups of elements (energy and non-energy). A mixed structure is frequently presented, in which energy consumption is considered in physical units and non-energy consumption in value. In this current study, both approaches, that is hybrid units (energy in physical units and non-energy in value) and monetary-based energy rows, are applied.

Definitions:

Consider an economy with **n** sectors of which **m** are energetic.

A: mixed structural matrix (nxn) of economic sectors. In the hybrid units approach, the rows pertaining to the energy sectors are expressed in physical units (tons of oil equivalent).

ε: matrix (mxn) that measures sectoral energy requirements; εij measures the total energy of type i required by the economic sector j.

e: matrix (mxn) that selects the m rows of energy sectors of the inverse matrix; e is composed of zeros and ones.

Thus

$$\boldsymbol{\varepsilon = e\,(I-A)^{-1}} \qquad (1)$$

In two periods, 0 and 1

$$\boldsymbol{(\varepsilon_1 - \varepsilon_1 A_1) - (\varepsilon_0 - \varepsilon_0 A_0) = 0} \qquad (2)$$

Defining $\boldsymbol{\varepsilon^* = (\varepsilon_0 + \varepsilon_1)/2}$, $\boldsymbol{\Delta\varepsilon = \varepsilon_1 - \varepsilon_0}$, $\boldsymbol{A^* = (A_1 - A_0)/2}$, $\boldsymbol{\Delta A = A_1 - A_0}$, expression (2) can be rearranged

$$\boldsymbol{\Delta\varepsilon = \varepsilon^*\ \Delta A\ (I - A^*)^{-1}} \qquad (3)$$

(3) is an adaptation of the expression derived by Casler and Afrasiabi (1993), with two advantages, from both empirical and theoretical perspectives. It is a perfect decomposition scheme in which there is no interaction term. Secondly, period 0 is not taken arbitrarily as the base (Laspeyres), but rather the average of period 0 and period 1. Consequently, it is an exact result rather than an approximation eliminating small terms of interaction.

The **A** matrix and, consequently, $\Delta\mathbf{A}$, can be broken down into n matrixes $\mathbf{A}^{i}$ each one containing zeros except in column i, in which the structural coefficients appear.

$$\Delta\mathbf{A} = \Delta\mathbf{A}^{1} + \Delta\mathbf{A}^{2} + ... + \Delta\mathbf{A}^{n} \qquad (4)$$

Another possible decomposition is $\mathbf{A} = \mathbf{A}_E + \mathbf{A}_N$, where matrix $\mathbf{A}_E$ is made up of the energy rows of the structural matrix and the remaining rows with zeros, and $\mathbf{A}_N$ with zeros in the rows of the energy sectors and with the values of the structural matrix in the non-energy sectors.

$$\Delta\mathbf{A} = \Delta\mathbf{A}_E + \Delta\mathbf{A}_N \qquad (5)$$

Both decompositions (4) and (5) of $\Delta\mathbf{A}$, can be applied simultaneously. An example helps to interpret the components of changes in the inverse matrix and to see the interdependences of energy use among sectors. Let us consider an industry i (chemicals). The changes in the direct energy requirements of this sector i are accounted for in the matrix $\Delta\mathbf{A}_E^{i}$ that only have non-zero entrances in the energy rows of the column i (chemicals). The changes in direct and indirect requirements are measured substituting (4) and (5) in the expression (3). The remaining formula is:

$$\begin{aligned}\Delta\boldsymbol{\varepsilon} = {} & \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_E^{1}\ (\mathbf{I}-\mathbf{A}^{*})^{-1} + \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_E^{2}\ (\mathbf{I}-\mathbf{A}^{*})^{-1} + \ldots + \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_E^{n}\ (\mathbf{I}-\mathbf{A}^{*})^{-1} + \\ & + \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_N^{1}\ (\mathbf{I}-\mathbf{A}^{*})^{-1} + \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_N^{2}\ (\mathbf{I}-\mathbf{A}^{*})^{-1} + \ldots + \boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_N^{n}\ (\mathbf{I}-\mathbf{A}^{*})^{-1}\end{aligned} \qquad (6)$$

The matrix $\Delta\mathbf{A}_N^{i}$ measures the change due to the energy requirements of non-energy sectors that sell to sector i (chemicals), which does not affect the direct use of energy

with regard to output (intensity) in this sector. However, since energy is required to produce all non-energy inputs, changes in the non-energy requirements of sector i affect the total energy requirements of all the sectors of the economy. The particular form of the equation lets us measure both the direct effects $\boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_{\mathbf{E}}^{\mathbf{i}}\ \mathbf{(I-\ A^{*})^{-1}}$ and the indirect effects $\boldsymbol{\varepsilon}^{*}\ \Delta\mathbf{A}_{\mathbf{N}}^{\mathbf{i}}\ \mathbf{(I-\ A^{*})^{-1}}$ in an exhaustively and exclusively.

3. EMPIRICAL ANALYSIS.

The data used in this study came from the following sources: (1) 1980 and 1985 Input-Output Tables for Energy; (2) 1980, 1985, 1990 and 1994 Input-Output Tables; (3) 1980, 1985 and 1990 Industrial **S**tructure Survey of Spain; (4) National Accounts. All the data used is published by the Spanish National Statistics Institute (INE). The input-output tables for Spain (1980, 1985, 1990, 1994) used in this study are industry by industry (symmetric) tables with different aggregations. They are linked, with the corresponding adjustments, into homogeneous tables with 51 sectors. Input-output Tables for Energy are only available for 1980 and 1985. The construction of Inpu**t**-Output Tables in physical terms is based on estimated quantities given prices and information in (3) and the Input-Output Tables in (2).

In order to simplify the analysis and the interpretation of the results, 24 sectors are considered**,** as described in Tables 1 and 2, with 4 energy-producing sectors and 20 non-energy sectors.

---------- INSERT TABLE 1 AND TABLE 2 HERE---------- --------

The energy rows of the structural matrix are measured in energy units (TPE) in the hybrid units approach. The National Statistics Institute (INE) has only published energetic input-output tables for 1980 and 1985, where units are Terajoules. For 1990 and 1994, the following rules have been applied in the conversion to energy units. The relation between energy value and consumption in tons of petroleum equivalent (TPE), was calculated separately for the different sectors using energy statistics. In order to standardise to constant 1990 prices, the energy rows of the structural matrix for 1994 was adjusted taking the sectoral output deflator for each column, so that direct energy intensities are measured for unit of output at 1990 prices.

The effects of the changes in the economic structure between periods on the energy intensities were analysed by means of the hybrid structural decomposition analysis. Direct and indirect tables of effects are obtained as the result of multiplying the matrixes of energy intensity change by the vector of final demand, expressed as a percentage of the final total demand, with the partition developed in equation (6).

As mentioned above in the theoretical section, the structural matrix and the energy intensity matrix were evaluated in the arithmetic mean for two adjacent periods. When calculating the change in a particular structure of final demand the arithmetic mean of the two periods was also applied.

The decomposition of the change of the energy intensity, by type of energy and sector detail, is presented in two tables. Table 3 shows the direct and indirect effects when the hybrid units approach is applied, calculated for each of the 4 types of energy and the 24 sectors included in the analysis. Table 4 presents the direct and indirect effects, corresponding to the monetary values of energy rows in the structural matrix.

---------- INSERT TABLES 3 and 4---------- ----------

Between 1980 and 1985 all direct changes (for the 24 sectors and 4 energy sources) in energy intensities are positive, but total direct changes in energy costs are negative for (2) coke and (3) crude oil, natural gas and oil products. Total direct changes are negative in the 1985-90 period and the same applies for 1990-94, except for oil. The most important changes are the direct own effects for each energy source, in particular electrical energy and oil. These two energy sources exhibit higher quantitative effects.

In general, direct changes are stronger than indirect changes, and both work in the same direction, although this difference decreases in the 1985-90 and 1990-94 periods. Indirect changes in energy costs are more important than direct changes for the sector of coking products in the 1980-85 and 1985-90 periods. In the first period, the direction is the opposite, counteracting direct effects; in the second period indirect effects reinforce direct changes. When considering energy intensities**,** the situation is completely different, indirect changes in energy intensities for coking products are higher than

direct changes for this second period, counteracting the direct effects. The same applies to electrical energy in period 1980-85.

Indirect changes in energy intensities are mostly positive in the 1980-85 period, negative in 1985-90, and negative, except in sectors 5,6,10,11,12,17,18 in the 1990-94 period. Indirect changes in energy costs are similar, except for electrical energy in the 1980-85 period, which is negative.

Table 5 presents correlation coefficients between sectoral changes in energy costs and energy intensities. Indirect effects are highly correlated showing that both approaches yield similar results. Only in the first period, 1980-85, is the correlation slightly lower, particularly in the case of 'Oil, natural gas and oil products'.

---------- INSERT TABLES 5---------- ----------

However, the picture is different when looking at the direct effects. We can see negative correlations for some energy sources, in the 1980-85 and 1985-90 periods. In the first period, this coefficient is only positive for electrical energy (and moderate, 0.407). It is interesting to highlight the negative value for oil, -0.814, indicating an important difference when interpreting this change from a cost or a physical point of view. Declining oil prices during the eighties explain this. In the second period, we can see a high and negative correlation coefficient for coking products. Electrical energy also exhibits a negative correlation coefficient, although in this case it is moderate in value. In both cases there are relevant changes in costs but very small effects on intensities.

4. CONCLUSIONS

In conclusion, the direct effects of energy input only explain part of the relations between energy use and output production, since the indirect effects also contribute to changes in total energy use. In some cases, it was shown that indirect effects are more important and counteract direct changes. The structural decomposition analysis allows the identification of those sectors in which input requirements are more responsible, directly or indirectly, for changes in the relation between energy and output. The major

changes are directly caused in the utilisation of energetic factors. Nevertheless, the indirect effects of non-energy factors that extend or reduce the direct effects are significant.

In the study of energy use in Spain between 1980 and 1994 it was observed that, in general, both direct and indirect effects work in the same direction. Consequently, the improvement in energy intensity that has been observed in sectoral studies is reinforced when considering the indirect effects.

The comparison between the mixed units approach and the monetary approach led to the conclusion that some positive effects obtained when energy intensity is measured become negative effects when monetary values are used. Thus the use of mixed units can mask 'cost saving' efficiency improvements. This finding is in line with the arguments in Zarnikau (1999) favouring the use of economic values instead of physical quantities in the (partial) analysis of energy intensity.

5. REFERENCES

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TABLE 1

ECONOMIC SECTORS

	SECTOR
1	COAL AND RADIACTIVE MINERALS
2	COKING PRODUCTS
3	CRUDE OIL, NATURAL GAS AND OIL PRODUCTS
4	ELECTRICAL ENERGY
5	WATER, STEAM, HOT WATER AND MANUFACTURED GAS
6	AGRICULTURAL, FORESTRY AND FISHERY PRODUCTS
7	METAL EXTRACTION
8	NON-METAL EXTRACTION
9	CHEMICAL PRODUCTS
10	METALLIC PRODUCTS
11	AGRICULTURAL AND INDUSTRIAL MACHINERY
12	OFFICE AND DATA PROCESSING MACHINERY
13	ELECTRICAL EQUIPMENT
14	TRANSPORTATION EQUIPMENT
15	FOOD, BEVERAGE AND TOBACCO
16	TEXTILE, LEATHER, FUR SKINS AND FOOTWEAR INDUSTRIES
17	OTHER INDUSTRIES
18	PAPER AND CARDBOARD
19	RUBBER AND PLASTIC
20	BUILDING CONSTRUCTION
21	COMMERCE, EATING AND DRINKING PLACES, LODGING PLACES
22	TRANSPORT SERVICES
23	OTHER ON-SALE SERVICES
24	NON-SALE SERVICES

TABLE 2
INPUT-OUTPUT TABLES OF SPANISH ECONOMY 1980,1985,1990 AND 1994.
ENERGY ROWS IN A 24 SECTORS DISAGGREGATION.
CURRENT 10^6 pta

TIO 1980

ENERGY SECTOR / ECONOMIC SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1 COAL AND RADIOACTIVE MINERALS	23797	36251	0	63138	99	0	3553	1397	919	276	53	0	33
2 COKING PRODUCTS	0	64	0	0	176	0	39873	1287	826	1092	41	0	44
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	1199	1192	878048	107419	61094	64713	20271	62750	42081	4780	1637	42	1093
4 ELECTRICAL ENERGY	3648	329	4999	35360	4564	8463	53551	25469	28515	11201	2889	236	4565

TIO 1985

ENERGY SECTOR / ECONOMIC SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1 COAL AND RADIOACTIVE MINERALS	397	60354	23	220607	3	3	26061	20674	5906	884	165	1	102
2 COKING PRODUCTS	0	0	0	0	333	0	71619	554	3265	1421	35	0	55
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	3942	4885	1630890	83396	1677	129778	50330	61538	67292	10728	3199	135	4979
4 ELECTRICAL ENERGY	9921	489	11674	129325	10733	26833	102135	56250	99584	25512	6294	719	11971

TIO 1990

ENERGY SECTOR / ECONOMIC SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1 COAL AND RADIOACTIVE MINERALS	16682	33279	0	268101	10	3	30118	23285	7694	966	55	1	96
2 COKING PRODUCTS	0	0	0	0	415	0	50028	717	4265	1825	49	0	72
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	2947	118	55856	67284	5944	197612	23292	37403	131751	7802	3285	140	4433
4 ELECTRICAL ENERGY	15175	1112	12354	166818	20238	43808	107210	88332	100334	35813	9256	1055	17267

TIO 1994

ENERGY SECTOR / ECONOMIC SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1 COAL AND RADIOACTIVE MINERALS	43	5	85	198	12	0	826	2500	1670	3088	1830	255	1932
2 COKING PRODUCTS	26742	237	2044	7051	3353	8032	8080	11219	7303	6124	2983	1455	3992
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	2209	89	7702	7558	132	46502	202202	20551	9917	29815	3609	970	11794
4 ELECTRICAL ENERGY	3458	330	4206	22445	3282	119122	35735	50711	53772	79265	40986	16883	47020

TABLE 2
INPUT-OUTPUT TABLES OF SPANISH ECONOMY 1980,1985,1990 AND 1994.
ENERGY ROWS IN A 24 SECTORS DISAGGREGATION.
CURRENT 10^6 pta

TIO 1980												
ENERGY SECTOR / ECONOMIC SECTOR	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Int. demand**
1 COAL AND RADIOACTIVE MINERALS	265	90	274	54	17	36	11	1703	151	633	572	133322
2 COKING PRODUCTS	11	488	8	11	64	5	0	0	0	0	0	43990
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	3675	23586	5947	3359	9645	2200	47762	17414	168190	24661	20565	1573323
4 ELECTRICAL ENERGY	8183	20142	12218	7161	11536	6413	16175	97911	5894	22778	14989	407189
											total	2157824
TIO 1985												
ENERGY SECTOR / ECONOMIC SECTOR	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1 COAL AND RADIOACTIVE MINERALS	321	1296	604	175	602	211	1977	1514	262	2060	1584	345786
2 COKING PRODUCTS	16	770	9	9	0	0	0	0	0	0	0	78086
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	9517	51766	17944	4878	22654	6465	94575	125906	386301	74578	60508	2907861
4 ELECTRICAL ENERGY	22093	40392	29933	12260	27539	17003	11935	194826	17108	72281	70189	1006999
											total	4338732
TIO 1990												
ENERGY SECTOR / ECONOMIC SECTOR	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1 COAL AND RADIOACTIVE MINERALS	314	895	1008	194	388	12	2808	2094	408	2719	787	391917
2 COKING PRODUCTS	24	878	10	13	0	0	0	0	0	0	12	58308
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	6842	37532	13558	5823	13607	4014	117804	135118	348738	79335	92881	1393119
4 ELECTRICAL ENERGY	39984	60897	39882	20924	38437	28368	23562	316707	22803	122530	129589	1462455
											total	3305799
TIO 1994												
ENERGY SECTOR / ECONOMIC SECTOR	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1 COAL AND RADIOACTIVE MINERALS	1790	5914	7398	68450	2033	1158	3293	4845	2470	23530	34356	167681
2 COKING PRODUCTS	10251	15871	8270	6974	4117	3084	0	350410	43806	905811	145729	1582938
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	3633	84890	17982	21256	77504	1087	5289	90528	142537	86222	46330	920308
4 ELECTRICAL ENERGY	31901	221616	64366	37488	53637	39404	238265	649499	122854	189944	75930	2202119
											total	4873046

TABLE 3

DIRECT AND INDIRECT CHANGES IN ENERGY INTENSITIES (toe/10^9pta)

1 COAL AND RADIOACTIVE MINERALS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	301.8806	0.3417	-0.1015	0.0032	0.0005	-0.0001
2	4.5396	-0.2849	0.1689	-0.0001	0.0000	-0.0000
3	0.1764	-0.0057	-0.0002	0.0033	-0.0042	-0.0015
4	100.7487	-36.0630	-4.4426	0.0010	-0.0070	-0.0005
5	0.1521	-0.0019	-0.0022	0.0309	-0.0079	0.0032
6	1.4524	0.0171	0.0033	0.1334	-0.0504	0.0816
7	22.5579	5.2386	-12.0673	2.0253	-3.6528	-0.4858
8	14.3023	-5.1640	-3.6634	-0.4852	0.1977	0.1259
9	4.8475	0.7763	-0.5580	0.1810	-0.2776	-0.2677
10	4.4981	-0.0401	-0.0163	0.7437	-0.7798	0.3895
11	1.5559	-0.0772	0.0080	-0.0289	-0.2751	0.2553
12	0.1922	-0.0001	-0.0002	0.0114	-0.0800	0.0211
13	1.8482	-0.0239	0.0046	0.2640	-0.5819	-0.0356
14	4.4491	-0.0864	0.0476	0.6180	-1.4878	-0.1038
15	3.0976	-0.3863	0.0419	0.1164	-0.2878	-0.0310
16	1.4703	0.0797	-0.1160	0.0348	-0.1321	-0.0306
17	0.8882	-0.0402	0.0066	0.0832	-0.0906	0.0286
18	1.0774	-0.3723	-0.0314	0.0019	-0.0324	0.0488
19	0.7872	-0.1861	-0.0050	0.0233	-0.1419	-0.0008
20	11.1304	-0.5157	-0.0142	-1.2276	-2.3882	-0.3618
21	5.1284	-0.1040	-0.1022	-0.2017	-0.3776	-0.1736
22	1.0422	0.0435	-0.0358	0.0437	-0.0934	-0.0264
23	6.0655	-0.1805	-0.1369	-0.2401	-0.4882	-0.4581
24	2.5204	-0.9460	-0.2892	-0.1600	-0.0718	0.0207
total	496.4085	-37.9815	-21.3016	1.9749	-11.1104	-1.0025

2 COKING PRODUCTS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	0.0088	0.0000	-0.0000	0.0035	0.0006	-0.0001
2	53.2355	-0.0000	0.0000	-0.0003	0.0001	-0.0001
3	0.0995	-0.0004	0.0002	-0.0060	-0.0032	-0.0022
4	0.0699	-0.0008	-0.0001	-0.0036	-0.0052	-0.0019
5	0.4214	-0.1249	0.0000	-0.0177	-0.0047	0.0023
6	0.9548	0.0001	-0.0000	0.1485	-0.0217	0.0867
7	49.6816	7.9428	-2.1615	5.0069	-5.7157	-1.0995
8	1.5690	0.1234	0.0557	0.0636	-0.0173	-0.0012
9	1.8880	1.2304	-1.6559	0.2805	-0.1044	-0.1380
10	8.3135	0.1310	-0.9577	1.7925	-1.1653	0.8357
11	2.7379	0.0082	0.0067	0.0527	-0.3915	0.5213
12	0.2836	0.0000	-0.0000	0.0501	-0.0949	0.0242
13	3.0462	0.0100	-0.0009	0.5306	-0.7730	-0.0742
14	6.7307	0.0032	0.0014	1.2653	-2.0133	-0.2775
15	1.8467	0.1949	-0.0374	0.1680	-0.0892	-0.0179
16	0.3957	0.0019	-0.0006	0.0453	-0.0612	-0.0029
17	0.8171	0.0029	0.0013	0.1304	-0.0869	0.0644
18	0.3622	-0.0000	-0.0000	0.1103	-0.0090	0.0534
19	0.4494	-0.0000	0.0000	0.0769	-0.1188	0.0242
20	5.4575	-0.0000	-0.0000	0.3643	-0.9403	-0.3905
21	1.1910	0.0001	-0.0000	-0.1773	-0.1348	-0.1024
22	0.6406	0.0000	-0.0000	-0.0141	-0.0522	-0.0322
23	2.6637	0.0000	-0.0000	-0.0244	-0.2396	-0.1794
24	1.0606	0.0061	-0.0068	-0.0865	-0.1186	-0.0601
total	143.9249	9.5289	-4.7558	9.7592	-12.1600	-0.7677

TABLE 3

DIRECT AND INDIRECT CHANGES IN ENERGY INTENSITIES (toe/10^9pta)

3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	0.1970	0.0152	-0.0179	0.0278	-0.0020	-0.0010
2	0.3386	-0.1207	0.0251	0.0002	-0.0007	-0.0005
3	20683.7051	-166.1490	80.4956	0.0862	-0.0405	-0.0346
4	35.8523	-2.7048	1.0548	0.1107	-0.0999	-0.0278
5	1.3589	1.0161	-1.6996	-0.0037	-0.0318	-0.0034
6	64.4320	38.7637	-24.7029	4.2876	-2.5033	0.0857
7	46.3257	-11.0564	0.5991	6.0517	-3.8479	-0.4717
8	57.0116	-12.4016	2.6619	-1.8449	0.0709	0.3283
9	50.9332	8.5117	-7.1242	0.1940	-1.5159	-1.7490
10	14.9063	-1.1337	1.2499	1.6433	-1.2032	0.4471
11	6.8036	-0.0126	1.3386	-0.5118	-0.7107	0.6099
12	1.0814	-0.0069	0.0266	0.0190	-0.2833	0.1183
13	8.0871	-0.6642	0.2768	0.3994	-1.2125	-0.0226
14	19.2952	-0.8060	3.3490	1.5615	-3.3348	0.3273
15	76.6727	-5.8824	-1.3372	-1.9402	-8.8041	-5.7884
16	19.0584	-2.0392	-0.7959	-0.2133	-2.0075	-0.6377
17	9.3272	0.3306	0.5572	0.9110	-0.8874	-0.2668
18	17.1015	-4.4707	0.0534	-1.1255	-0.7229	0.1817
19	8.1942	-1.1261	0.3114	-0.3694	-1.0923	-0.2610
20	96.3317	-7.4437	-1.6357	-0.6324	-6.8712	-1.7085
21	77.5293	-4.5004	-2.1669	-0.6045	-6.0109	-3.6303
22	122.7624	16.2651	-9.2601	1.9485	-1.0081	-0.6288
23	76.0131	0.7112	-2.4228	-0.6639	-3.1169	-5.3324
24	33.0691	8.7027	-2.0324	-2.4243	0.2363	-0.3049
total	21526.3874	-146.2018	38.8038	6.9070	-45.0008	-18.7713

4 ELECTRICAL ENERGY						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	0.1643	0.0190	-0.0108	0.0050	0.0005	-0.0003
2	0.0106	0.0051	0.0015	-0.0015	0.0008	-0.0006
3	1.3086	0.1117	-0.0993	-0.0054	0.0085	-0.0036
4	4043.1567	-2.0282	-0.4192	-0.0198	-0.0144	-0.0051
5	2.0812	-0.0029	-0.0615	-0.2204	-0.0067	0.0013
6	8.0299	1.5177	0.4897	0.6659	-0.2529	0.2976
7	25.5049	-0.6022	0.3334	2.5449	-2.3826	-0.4248
8	10.7468	0.3697	-0.9243	-0.3771	0.0803	0.1687
9	15.3589	-3.4784	-1.6213	-0.0641	-0.2973	-0.3596
10	7.1768	0.2585	0.0412	0.9947	-0.5781	0.3943
11	2.8594	0.0697	0.2214	-0.1506	-0.2564	0.3410
12	0.4331	0.0052	-0.0115	0.0574	-0.1192	0.0533
13	3.9711	-0.3080	0.0457	0.2997	-0.5391	-0.0171
14	8.7996	-0.1114	0.3211	0.8037	-1.4439	0.0327
15	13.4635	0.8001	0.1077	-0.2219	-0.9465	-0.4518
16	6.4695	0.5355	-0.2152	0.0062	-0.4618	-0.1280
17	3.3812	0.4418	0.2189	0.1911	-0.2140	0.0132
18	7.9766	-1.2578	-0.2597	-0.4536	-0.2011	0.0092
19	3.6581	0.2773	0.1009	-0.0089	-0.2653	-0.0240
20	14.1354	-0.0241	0.0102	-0.5956	-1.7717	-0.3746
21	24.8267	9.4714	-3.0442	-0.8013	-1.1337	-0.7389
22	4.6151	-0.2813	-0.0176	0.1782	-0.2130	-0.0626
23	15.5002	3.7541	-0.8209	0.6088	-0.6878	-1.4280
24	9.0533	1.7163	0.2683	-0.2140	-0.0872	0.0482
total	4232.6814	11.2587	-5.3454	3.2215	-11.7825	-2.6596

TABLE 4

DIRECT AND INDIRECT CHANGES IN ENERGY COSTS (10^3pta/10^9pta)

1 COAL AND RADIOACTIVE MINERALS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	-726.6529	213.6436	-44.1743	3.5438	0.9221	-0.1838
2	-60.7219	-74.2928	52.8732	-0.7481	0.3584	-0.1890
3	-3.0529	-3.8507	0.2715	-0.0015	0.1836	-0.2480
4	1038.2512	-330.8560	-349.6425	-2.3467	-2.5667	-0.4401
5	48.4103	-8.7643	-1.1236	-5.4211	-0.3798	0.1100
6	35.8520	7.0320	7.7134	18.5031	-6.9475	7.5731
7	236.0240	-5.3199	-255.4753	180.9267	-199.3976	-29.2156
8	384.9499	-122.4264	-86.3625	-16.0400	5.1184	5.2968
9	142.0963	-87.8235	-57.1022	7.3397	-13.2133	-12.8905
10	26.0119	-24.3130	-10.5440	66.9557	-43.4899	23.8537
11	1.6304	-8.9018	4.0271	-3.7833	-16.5593	16.8433
12	-0.6766	-0.5370	-0.1950	2.5183	-5.5107	1.5835
13	9.1171	-16.0648	0.8590	20.9308	-33.8439	-1.8379
14	10.3375	-24.9672	6.3940	50.2572	-87.2281	-4.6054
15	8.8061	-21.3503	2.1650	-4.5475	-27.6292	-8.4528
16	19.2932	-14.4327	-5.8855	1.0388	-13.7719	-2.7923
17	1.6296	-5.2245	3.8338	7.7981	-7.7405	1.5097
18	25.7596	-29.3231	-4.9776	-5.4838	-4.7071	1.7224
19	6.7270	-14.3581	1.6038	1.6165	-10.1493	-0.1511
20	-16.1592	-20.8725	-0.1433	-29.3179	-97.2429	-17.8491
21	-122.0699	-170.9504	-53.1306	-25.5340	-35.4832	-17.0527
22	13.4722	-11.0452	-1.2089	6.6180	-7.7665	-1.9585
23	77.1667	-53.3700	-16.5919	19.8529	-29.0075	-35.3812
24	99.2155	-50.7255	-1.2605	-6.8406	-5.7226	0.5393
total	1255.4170	-879.0941	-808.0769	287.8352	-641.7749	-74.2161

2 COKING PRODUCTS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	-0.2926	0.1226	-0.0225	1.4373	0.4760	-0.0513
2	-1.2033	-0.0402	0.0234	-0.1131	0.0484	-0.0270
3	-0.4049	-0.5146	0.2116	-0.2982	-0.1487	-0.0883
4	0.3351	-0.3373	-0.1672	-0.2814	-0.6155	-0.1316
5	6.4932	-1.6043	-0.0035	-0.0777	-0.1199	0.0436
6	0.0712	0.0829	-0.0203	3.9807	-0.5646	1.6217
7	-2.1760	-142.4213	-40.5970	135.9148	-137.6151	-20.6193
8	-24.6619	-1.2796	0.9944	1.5996	-0.4146	-0.0164
9	17.5679	4.3442	-30.9681	7.4953	-2.5195	-2.5890
10	-3.4824	-1.8417	-17.9768	48.7278	-28.0983	15.7023
11	-0.6356	-0.0781	0.1323	1.4006	-9.5696	9.8613
12	-0.0015	-0.0010	-0.0002	1.3663	-2.3258	0.4526
13	-0.3740	-0.2210	-0.0155	14.6019	-18.8163	-1.3959
14	-0.0546	-0.0975	0.0374	34.1528	-48.4103	-5.1686
15	-2.5455	-0.9557	-0.6953	4.5352	-2.1696	-0.3495
16	-0.0336	-0.0447	-0.0169	1.2963	-1.5044	-0.0580
17	-0.1346	-0.0076	0.0292	3.5619	-2.1114	1.2033
18	-1.7975	-0.0551	-0.0059	2.9645	-0.2257	0.9998
19	-0.1384	-0.0249	0.0026	2.0733	-2.8687	0.4507
20	-0.0941	-0.0349	-0.0020	9.3519	-22.7364	-7.3096
21	-0.1301	-0.3251	-0.0702	-3.8788	-3.4329	-1.9332
22	0.0068	-0.0254	-0.0124	-0.2243	-1.3161	-0.6068
23	0.1546	-0.0966	-0.0223	-0.5330	-6.0198	-3.4087
24	0.2085	0.0555	-0.1262	-2.4196	-2.9668	-1.1173
total	-13.3234	-145.4015	-89.2914	266.6341	-294.0458	-14.5351

TABLE 4

DIRECT AND INDIRECT CHANGES IN ENERGY COSTS (10^3pta/10^9pta)

3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	-10.5661	8.2555	-14.8676	19.8785	-2.6041	-0.7656
2	20.4761	-35.0278	15.1041	-13.5686	-0.4332	-0.3469
3	-6270.6463	-9072.0012	6136.3651	-19.1772	-3.1072	-2.6788
4	-3747.3931	-181.5354	126.8528	-49.6481	-17.8977	-3.7765
5	-1563.3148	40.0068	-61.6661	-142.1236	-1.2420	-0.1066
6	-51.6777	1247.0751	-876.7577	285.5215	-93.2755	5.0217
7	50.8689	-124.7840	19.0018	228.7259	-140.5024	-20.0668
8	-971.4876	-353.6138	88.6833	-109.9982	2.5767	12.6829
9	-486.5398	886.7220	-264.9982	9.2284	-57.1741	-64.2476
10	48.3694	-41.9444	44.5719	67.0431	-44.6604	18.8963
11	-8.9372	-6.4440	49.6980	-29.9754	-27.3761	24.3889
12	-1.5945	-0.1522	0.8805	1.5312	-10.8190	4.5591
13	47.1640	-22.3993	10.2289	10.8490	-44.7046	-0.9616
14	22.1022	-68.6517	121.1713	56.8949	-124.8399	11.5923
15	-86.3147	-117.3330	-46.9883	-113.6650	-330.2361	-203.8811
16	85.2358	-35.0760	-29.6363	-23.4307	-74.0417	-23.1139
17	-27.5612	7.9371	21.1997	44.9789	-33.7059	-9.1649
18	37.9850	-123.1757	0.3697	-73.5941	-28.2776	6.4983
19	11.7531	-39.7495	11.7131	-21.4280	-38.1360	-9.3171
20	10.0408	-152.2339	-58.3912	2.5773	-265.4743	-63.4226
21	1079.0046	-171.3827	-95.2742	-351.9718	-230.1995	-131.9526
22	-348.3193	-65.1194	-332.7584	59.7474	-40.0912	-22.9183
23	230.7691	-62.3113	-91.8298	-37.2846	-121.1599	-198.2082
24	154.9699	245.8988	-70.8225	-117.7207	5.7393	-10.8768
total	-11775.6133	-8237.0401	4701.8497	-316.6095	-1721.6423	-682.1665

4 ELECTRICAL ENERGY						
	DIRECT EFFECTS			INDIRECT EFFECTS		
SECTOR	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1	-21.4238	41.6199	-29.3153	12.1032	2.3395	-0.8164
2	-4.9662	6.9554	5.3641	-4.5032	2.2294	-1.2644
3	-20.2377	-19.8047	-0.4350	1.0785	2.9162	-0.9859
4	703.7565	-767.3677	-208.1344	-14.9391	-10.9023	-2.3998
5	332.9163	-53.3352	-7.9972	-40.9292	-1.0747	0.1628
6	259.5836	47.2590	57.1289	94.3089	-38.8176	37.1625
7	-42.4029	-145.8265	29.4990	334.3781	-324.8858	-54.7012
8	371.7167	-288.8469	-117.8123	-63.9033	11.9047	21.1838
9	569.5073	-673.5332	-205.1641	-8.4113	-44.8358	-45.4537
10	154.0486	-138.8839	4.4011	132.3962	-80.8511	50.6292
11	7.6246	-46.2286	28.1413	-31.3529	-37.8879	43.8313
12	-4.9900	-3.6325	-1.4260	9.6378	-17.8454	6.7044
13	63.3458	-103.7642	5.7802	40.2033	-78.2965	-2.2506
14	98.5018	-152.3678	40.4465	105.2753	-206.4557	3.7492
15	-48.4420	-86.8594	13.1840	-72.5745	-143.9936	-57.0267
16	127.8721	-117.8511	-26.9569	-4.0353	-71.2383	-16.0366
17	0.9504	-31.5484	27.3824	26.9920	-32.6850	1.6970
18	124.2369	-166.0414	-32.4085	-56.8957	-27.5493	1.2760
19	35.3034	-76.4728	12.6195	-2.1730	-39.1972	-3.0087
20	-380.2282	-77.7954	1.0104	-110.3492	-269.3444	-47.6698
21	-647.8457	-1142.7968	-379.5292	-134.5504	-180.9023	-92.8334
22	101.7337	-80.9971	-3.6479	44.6200	-35.7225	-7.9964
23	470.9241	-329.4637	-103.2706	173.4041	-111.2883	-180.2654
24	686.0982	-230.4367	32.7579	-17.3843	-17.6796	5.9148
total	2937.5835	-4638.0197	-858.3821	412.3962	-1752.0634	-340.3980

TABLE 5
CORRELATION BETWEEN CHANGES IN ENERGY COSTS AND CHANGES IN ENERGY INTENSITIES

	DIRECT EFFECTS			INDIRECT EFFECTS		
ENERGYSECTOR / PERIOD	1980/85	1985/90	1990/94	1980/85	1985/90	1990/94
1 COAL AND RADIOACTIVE MINERALS	-0.3171	0.7191	0.8004	0.9169	0.9860	0.9753
2 COKING PRODUCTS	-0.0624	-0.9822	1.0000	0.9999	1.0000	1.0000
3 CRUDE OIL, NATURAL GAS AND OIL PRODUCTS	-0.8137	0.9863	0.9866	0.7956	0.9992	0.9995
4 ELECTRICAL ENERGY	0.4066	-0.4137	0.9479	0.9719	0.9970	0.9999