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"ENVIRON": ENVIRONMENTAL IMPACTS FROM ADVANCED COMMUNICATIONS-EVIDENCE FROM AN INPUT-OUTPUT THEORY

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ABSTRACT

The ENVIRON model estimates environmental impacts (positive, negative) from the introduction and use of Advanced Communications (AC); Information Society Technologies (IST) in industrial, commercial and business sectors in Greece. The model estimates effects on output, employment, income, environment and energy requirements. It is based on the: (i) Leontief Input-Output theory-analysis, (ii) Introduction of AC/IST and in particular of the Telematics as a new sector into the economic system of a country, and (iii) Incorporation of pollution emission factors into the system.

The types of AC represented are grouped into six categories: access to information systems, electronic transactions, robotics and tele-action, tele-working, mobile communications and video facilities. Industry sectors considered are transport, business and services, public and domestic.

The application of ENVIRON indicates that the introduction of AC into the production process will result into a 15.8% decrease of energy consumption, a reduction of 14.32-10.14% in SO_2, and it will have strong positive effects on the economic system of Greece especially on profits related to environmental protection. The model demonstrates the use of the Leontief Input-Output analysis in environmental impacts analysis matters and policy.

KEYWORDS: Advanced Communications, Environment, Information society, Input-Output Analysis, Leontief, Impacts.

INTRODUCTION

Objective

The ENVIRON Model developed (Bonazountas *et al.*, 1996) quantifies the benefits from the introduction of AC on competitiveness and environmental parameters based on an Input-Output (I-O) model that captures the industrial, commercial and business sectors. The model is based on: (i) the Leontief's analysis; (ii) the introduction of telematics as a new sector into the system; and

(iii) the incorporation of pollution emission factors. To mathematically handle the analysis, the various types of AC are grouped into six categories: access to information systems, electronic transaction, robotics & teleaction, teleworking, mobile communications, and finally video facilities.

The need of an analysis

The traditional trade-off between society's needs for a clean environment and increasing production cost with a lower competitiveness, has a long history with several countries refusing to participate in international agreements for environmental regulations in order to protect certain industrial sectors. To a large extent, regulatory regimes for environment are applied in different countries in ways providing advantages to national productive investments related to induced economic development (Jorgenson and Wilcoxen, 1990). According to Porter and Van der Linde (1995) the issue has been analysed incorrectly from "a static view of environmental regulation in which technology, products, processes and consumer needs are all fixed".

ENVIRON aimed at the estimation of benefits and impacts from AC. It proves that the introduction of AC in a social accounting framework permits the touching of Pareto efficiency, and results in situations in which both parties can improve their position. The introduction of AC may contribute considerably to the inducement of a generalised innovation process (Porter *et al.*, 1995), contradicting, therefore, conventional views on the economic environment. This in turn can positively affect in firm's competitiveness and at the same time promote efficient allocation of resources.

THE LITERATURE

Lave *et al.* (1995) pointed out that life cycle assessment (LCA) models could best quantify environmental implications through the use of old interdependence that characterises the economic system, i.e. between the different sectors of the economy and between producers and consumers. In reference to an environmental policy analysis, they adopted existing criticisms of the method of LCA used by the Society of Environmental Toxicology and Chemistry (SETAC). To demonstrate full interdependence and the interactive nature of modern production structures, they adopted an environmental input-output life-cycle analysis (EIO-LCA) to estimate direct and indirect effects (environmental discharges of a particular kind) of increased demand. As the application of the EIO-LCA method seems to be appropriate for environmental policy analysis, the correlation between AC and environment can be also based upon an EIO-LCA, assuming the introduction of AC into such a model. The information revolution of the recent twenty years attracts the increasing interest of governments and industrialists in areas where the use of telematics can provide practical answers to environmentally cautious societies. Moreover, industrialists face environmental questions from the viewpoint of increasing business activities while at the same time telematics can reduce production cost and increase competitiveness. This is made possible because *today's structure of cost includes, at an increasing rate, expensive information, whose handling by electronic files tends to reduce costs and/or increase quality standards*. Input-Output analysis has been given a limited attention in environmental policy and decision-making and only after 1993 has this technique appeared in the literature in environmental pollution and decision-making. Examples are the work of Lave *et al.* (1995), Kuroda *et al.* (1993) and Panethinitakis (1993), Arrous (2000) and Bonazountas *et al.* (1995).

THE "ENVIRON" MODEL

AC and the Environment

Aiming at modelling relationships between the use of AC and the environment, the following steps have been applied, in the context also of the Greek economy:

- Estimation of effects on output, employment, income, environment and energy requirements with conventional technologies
- Estimation of effects on output, employment, income, environment and energy requirements with use of AC-Telematics
- Comparison of the above

It is obvious that the results depend on the determination of Telematics or the new clean technology within the economic systems. Three alternatives are considered in correlating the information sector in the input-output framework:

i. As an abstract from the main Leontief table, i.e. a sector without reference to primary input,
ii. As a separate, well defined sector with inputs, output distributed, final demand and primary inputs based on information available by the Hellenic National Statistical Service (ESYE),
iii. By breaking down each one of the N industries

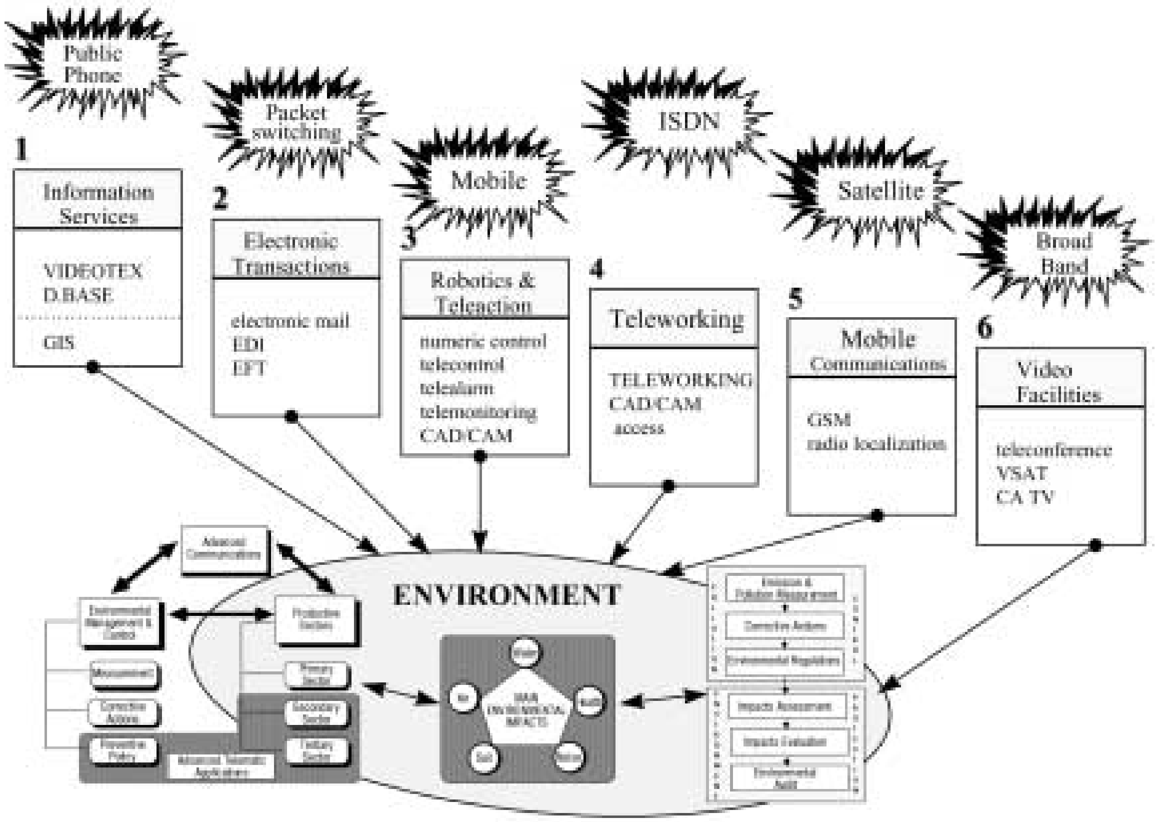
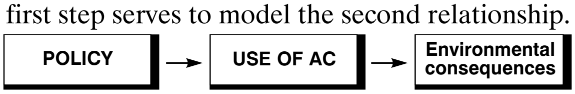


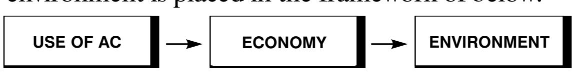
Figure 1. Classification of Advanced Communications (Bonazountas *et al.*, 1996)

into separate parts: the "information" and the "non-information"; A method introduced by Staeglin (1989).

From the above alternatives, the third one has been adapted towards demonstrating the results as a pilot plan by also using findings of Staeglin on the interrelationship between the information sector, thus defined, and the rest of the sectors. The key chain of causality is shown below. The first step serves to model the second relationship.



Two main perspectives are involved: (i) the short & medium-term, and (ii) the long-term. AC is assumed to influence the environment through the economy; thus, a model of the economy between AC and the environment is placed in the framework of below.



AC is expected to affect the economy in two main ways: (i) changes in production technology typically arising from substitution of transport by telecommunication, and (ii) patterns of consumption typically arising from substitution.

Classification of AC

There exist two ways in categorising the AC-telematics applications: (i) via application domains as[1]: Teleworking, electronic inter working for SMEs, distance learning, university linkages, traffic management, health care, electronic highways for digital cities, elderly and disabled, electronic government, and other, (ii) via AC communication sectors. The developed model follows the second classification aimed to better capture the telematics applications supported by the European Commission Framework Telematics Programme (IST 2002). This classification of AC is shown in Figure 1. The different types of AC are divided in six main groups with four sectors (Table 1).

[1] Reported into the European Commission, IST, Telematics Framework programmes. The definition Information Society Technologies (IST) or *Telematics* originates from the use of telecommunications and informatics, and implies in Europe the use of information technologies in sectors of applications, as health, transport, education, elderly and handicapped, environment, language engineering, digital cities and other.

Table 1. Classification of Advanced Communications

SECTORS ▶ MAIN GROUP ▼	Services	Use	Environmental relations	Sectors affected
Access to information systems				
Services-general	• Videotex • Data Bases	• Environmental information (pollution index, weather, earthquake, etc.) • To make transactions without displacements (teleshopping, home banking, etc.)	• Availability of data about the evolution and the present situation of the environment (developed applications, applied technologies, on-going projects, grants, etc.) • Facilitate the election of the most adequate itineraries for each moment in function of the traffic situation. • Optimisation of the transported load. • To reduce the transport movements, so it decreases the pollution.	• Agriculture • Tourism • Communications • Transport • Banking • Health
Services-GIS	• All types of GIS applications	• Study of the environment knowledge and the situation of natural spaces • Simulations on the effects of new constructions	• Allows the simulation of environmental impacts of different alternatives for the construction of buildings, roads, different industries, etc. • Optimisation of design and avoidance of obstacles • Detection of levels of communication • Control of fluvial routes • Observation of forests • Maintenance and amplification of roads and other infrastructures • Exploration of mineral sites and oil fields, identification of crops, data for meteorological phenomena	• Agriculture • Automobile • Tourism • Transport and communications • Energy • Building • Mining
Electronic Transactions				
	• Electronic mail • Electronic Data Interchange • Electronic Funds Transfer	• Electronic transmission of reports and commercial documents • Paying with credit cards and financial operations through the use of remote terminals.	• Eliminates the necessity of a great part of paper support • Reduces the utilisation of traditional services of couriers-mail • Optimises the stock in warehouses which at the same time represents a better utilisation of transportation which generates less pollution • Decreases the risk of contamination specially in determined types of toxic products • Decreases considerably the use of paper, money and coins.	• Chemical • Automobile • Food industry • Financial • Commerce • Tourism • Offices
Robotics & Teleaction				
	• Numeric control • CAD/CAM • Telecontrol • Telealarm • Telemonitoring • Teledetection	• Permits the control of productive processes through computer systems • Allows distance activation and control of machinery, equipment, construction sites, natural resources, without forgetting the application for the investigation of natural resources and control of the environment.	• Control of productive processes, security and quality • Prediction of natural disasters • Avoids the excess of contamination due to the incorrect utilisation of equipment • Favours the control and reduces the risk of robbery and deterioration of dangerous materials	• Fishing and agriculture • Equipment manufacturing • Automobile • Energy • Chemical • Mining

SECTORS ▶ MAIN GROUP ▼	Services	Use	Environmental relations	Sectors affected
Robotics & Teleaction				
			• Control of atmospheric and acoustic contamination, of the supply and sanitation of water, and the elimination of wastes • Distance control of vehicles contamination • It is possible to make explorations of mineral sites and oil fields, as well as detection of anomalies due to escapes in oil fields, without forgetting the possibilities of analysis of temperatures, indexes of vegetation, control of erosion processes, and levels of humidity in fields and the detection and quantification of burnt surfaces • The application of teleaction services to the domestic area generates important energetic savings.	• Commerce and with applications to domestic sector
Teleworking				
	• Access to CAD/CAM centres • Teleworking	• Favours work at home or from different locations where the work centre is situated • Allows the performance of designing manufacturing functions through simulations in computers and also to send long distance work commands.	• Reduces the number of displacements of workers • Favours energetic saving and the contaminating effect • Allows a better utilisation of cloth fragments in the textile sector, through the use of computers and diminishes the generation of wastes.	• Textile and confection • Automobile • Leather and all kind of services
Mobile communications				
	• Mobile telephone • radio-localisation	• Allows for permanent communication and localisation without the need of wires • Permanent contact 24 hours a day, constitutes the antecedent of personal telephony	• Reduction of environmental risks by speeding up and facilitating the application of steps in cases of particular negative phenomena like fires • Improvement in public transport • Increase of security in transporting dangerous or contaminating loads because of the permanent localisation • Possible impacts on health for cellular infrastructure	• Fishing • Building • Tourism • Health • Transport • Communications
Video facilities				
	• Video-conferencing • distribution of TV by cable • VSAT applications.	• Transmission of images • Teletraining • Business communications	• Reduction in the number of meetings and displacements, less consumption of fuel • Facilitates telemedicine with the sending of X-rays and other images and the access of distant medical services, development of distance education.	• Information • Health • Educational and Research sector.

Environmental factors and sectors

The environmental interactions between the actions derived from the utilisation of AC technologies and environmental factors are not the same in all economic activity systems because these are mainly indirect effects. Therefore, matrices of specific effects must be constructed for each one study-case. Considering the contribution to global contamination, as well as the potential receptivity toward the utilisation of AC, the cases studied were selected among the sectors that capture almost 90% of pollution and emissions in Greece, namely, manufacturing, transport, business-services, public sector, and domestic sector.

The manufacturing and energy industries in the European Union are responsible for 86% of the SO_2 and of 40% of the NO_x emissions.

The transport sector is a principal contributor to atmospheric contamination via NO_x and HC at levels of 54% and 53% respectively of the total emissions. The transport sector consumes 31% of the energy, corresponding to ground transportation alone 85% of the total consumed in this sector.

The direct environmental impacts of the business & services sector include: (i) Important energy consumption for heating, air conditioning, lighting and operation of computer and communication equipment (Consumes along with the domestic sector, in all of the EU, 35% of the final consumption), (ii) The emission of atmospheric contaminants (SO_2, NO_x, CO, etc.) in their destination, because of the combustion installations for heaters, or in their origin and the contamination in the production of electric energy in power plants (It is responsible along with the domestic and institutional sector for the direct emission of 8% of the total emission of SO_2, and of 5% of NO_x), (iii) A considerable consumption of paper, cardboard and, in a lesser fraction, plastics, glass and metals. This aspect consequently produces a secondary effect, which is the generation of a large amount of waste that in most cases is not reused nor recycled, contributing to the existing problem of wastes, (iv) Several of the subsections that are included in this group are also indirectly responsible of environmental impacts because of the generation of an important demand of transportation to satisfy the necessity of supply (commercial sector), and the generation of an important demand of transportation for workers and clients (commerce, banks). More than 50% of all the trips produced in cities have a non-labour motive.

The public sector is of a double interest: (i) One aspect shares many of the characteristics of the services sector in relation to the consumption of final energy, high production of wastes and attraction of motorised travel. The possibility to reduce environmental impacts through the utilisation of AC is very high, (ii) Another aspect included into this sector is the responsibility of public management of the environment, of the surveillance and control of environmental quality parameters and the prevention of the occurrence of natural catastrophic risks, services in which the utilisation of the application of telemetry and telecontrol are being used more often.

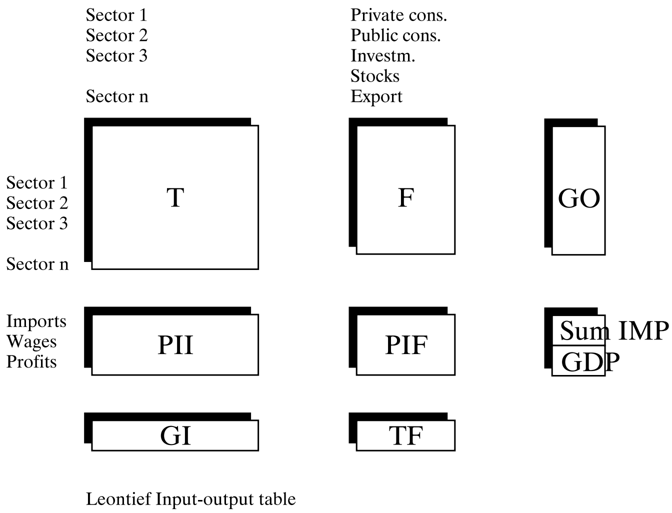
Among the interesting services from the perspective of AC, the following five are important: (i) Nets (set of actions) for the control of atmospheric contamination (local nets, regional nets), (ii) Nets for the control of acoustic contamination in the urban environment, (iii) Nets for the control of the quality of superficial waters, (iv) Nets for the control of floods in rivers, and (v) Geographic Information Systems (GIS) for the management of natural resources (i.e., the management of terrestrial and marine ecosystems).

Finally, the domestic sector includes homes that share common characteristics with the business and services sector in its interrelation with the environment; important participation in the consumption of final energy, atmospheric contamination due to the combustion of fossil fuels, high production of wastes, etc.

Mathematical modelling

The mathematical modelling is accomplished in three phases: “with” and “without” the implication of AC: (i) Development of the Leontief matrix system, (ii) Introduction of telematics into the system, and (iii) Incorporation of pollution emission factors into the system.

Model development is accomplished in two steps. (i) A 9x9 system of I-O Tables was employed, (ii) The model was expanded to account for a 35x35 Matrix. The structure of the Leontief Matrix System is shown on Figure 2. The basic model notations are given in Table 2.



T	intersectoral transaction matrix
F	matrix of final demand
PII	primary outputs to intermediate consumption
PIF	primary input to final demand
TF	total final demand
GO, GI	Gross output, gross input

Figure 2. The Leontief matrix system

The Structure of the Leontief Matrix-System

The model considers the fundamental matrix balance equation of Leontief:

$$\{X\} = [A]\{X\} + \{F\} \quad \text{or} \quad \{X\} - [A]\{X\} = \{F\}$$

– solved as $[I - A]\{X\} = \{F\}$

and $\{X\} = [I - A]^{1}\{F\}$

– where the elements of [A] are $a_{ij} = \dfrac{x_{ij}}{x_j}$

– where x_{ij} = intermediate input delivered from i^{th} to the j^{th} sector).

Derived Estimations-Effects

Based on the above Leontief system *output multipliers* are estimated as: $[I - A]^{-1}\{I\}$

Factor income multipliers can be also estimated as: $[V]\{X\} = [V][I - A]^{-1}\{I\}$

Changes from the demand side are calculated as: $[\mathrm{I} - \mathrm{A}]^{-1}\{\Delta F\} = \{\Delta X\}$

The direct labour coefficients represent the ratio of labour employed to national currency (a million drachmas, mGDR) gross output at sectoral level. In other words it is a measure of productivity: $(\lambda^{-1}) = (L)[\hat{X}]^{-1}$

Global labour coefficients (direct and indirect) are estimated as: $(\lambda^{2}) = [\hat{\lambda}^{-1}][I - A]^{-1} = (I)[\Lambda]$

Table 2. Basic model notations of the Leontief Matrix System

[A]	Square matrix of I-O coefficients (Leontief Matrices)
[ΣAM]	Social accounting matrix
$[\Pi^A]$, $[\Pi^B]$, $[\Pi^\Gamma]$	Average propensities to spend for endogenous Π^A and exogenous Π^B accounts and *leaks* Π^Γ, for SAM
$[R^A]$, $[R^B]$, $[R^\Gamma]$	Social accounts in form of Matrices
[V]	kxn matrix of (k) primary input requirements per unit of output
[Λ], [Λ*]	Calculated matrices of labour coefficients
[B]	$A^2 + A^3 + \ldots$
{F}	Column vector of final demand
{X}	Column vector of gross output
(P1)	Row vector of primary inputs
(L)	Row vector of (Sectoral) employment
(P)	Vector of emission of pollutant
(E)	Vector of energy consumption
E_x	Gross elasticity of demand between transport and telecom

The functionally interrelated sectors that produce gross output (in national currency, million drachmas, mGDR) use directly the labour described previously. The gross output value vector also uses as input, intermediate output produced by other sectors according to the I-O coefficients.
Therefore, the increased output in one sector directly and indirectly affects the level of output of all other sectors. To this extend it affects the level of employment of all sectors. However, the noticeable difference between direct and global labour coefficients is that in the first case it is the output produced by the employed labour. In the latter case it is labour needed to produce one unit of final demand.
Employment change (the demand effect) is calculated as: $[\Lambda]\{\Delta F\} = \{\Delta L\}$
It expresses the change in demand that imposes changes in employment as technology remains constant (between two periods). If we accept that the use of AC increases productivity, total employment effects when changing the employment in one sector, can be calculated by: $(\lambda^3) = (1)[\Lambda]\left[\hat{\lambda}\right]^{-1}$

The estimation of time series for energy use/output ratio (E/X) and particularly the estimation of output elasticity of energy use (dE/E)/(dX/X) i.e. the energy coefficient, could lead to be identification of some characteristics of the evolutionary process involved.
As the comparison between countries may pose problems (because of the involvement of energy/currency units), estimation of both two energy intensities might be required: thus, the direct productive energy requirements to produce one value unit of goods: $E_i = e_i / X_i$ or {E}
The "global" direct, i.e. plus indirect energy requirements to produce one value unit of goods by each sector delivered to final demand is estimated from:

$\left[\overset{*}{E}\right] = \left[\hat{E}\right][I - A]^{-1}$, and for the matter

$$\left[\Delta \overset{*}{E} F\right] = \left[\hat{E}\right][I - A]^{-1}\{\Delta F\}$$

where $\left[\overset{*}{E}\right]$ is the energy-economy matrix, which leads to the estimation of energy multipliers.

The consequences for pollution can be derived from the model via changes in the production in any sector, as for emission type "a" (e.g. SO_2):
$[\hat{P}][I - A]^{-1}\{F\} = \{\Delta EM\}$

Where:

$[\hat{P}]$ Diagonal matrix of coefficients expressing the relationship between emission of pollutant "a" and gross output, and
$\{\Delta EM\}$ Vector of change in emission of pollutant type "a".

Data showing the relationship of both energy consumption and pollution (by type of pollutant: NO_x, SO_2, CO_2, particles solid waste, noise etc.), gross output by sector and final consumption, is available for Greece, some European countries and the USA.

The relationship between policy, use of AC and the economy

Policy implies active intervention into the market mechanism in order to reach goals, which the market in itself will not achieve, or in the case of market breakdown (because of the existence of positive or negative externalities, for example). Policy options can be classified as positive or negative.
In terms of AC, "positive" policy options involve the promotion of use of AC, usually by use of positive incentives (support for training, investment support, subsidised infrastructure provision, information provision, etc.). "Negative" policy options include environmental taxes and regulations, where complete control corresponds to an infinite tax. The model considers a sector-by-sector analysis of cross elasticity between transport and telecommunications inputs, in order to evaluate the effects of price changes in one input on consumption of the other. This is undertaken sectorally, as there are technological constraints upon the price mechanism, i.e.,

$$E_x = \frac{\%\Delta Q_{DA}}{\%\Delta P_E}$$

where:
E_x cross elasticity of demand
$\%\Delta Q_{DA}$ percentage change in quantity demanded of product A
$\%\Delta P_E$ percentage change in price of product B.

In this way, different policy options, both negative and positive can be related to consumption of telecommunications and other inputs, both to intermediate production and to final demand, in turn the effects on the following environments:

Socio-economic	Physical/biotic
– income	– energy consumption
– employment	– pollution by type of pollutant
– balance of trade	

Introduction of AC-Telematics into the system

The introduction of Telematics into the system is carried out for operational purposes in *three plus one ways*. ENVIRON applied the method (C-method) aimed to expand the Greek Input-Output Tables using a *new sector called Telematics* for the years 1975 and 1980 (prior to the introduction of the telematics era in Greece). For the construction of this sector information provided by Staeglin (1986) regarding the composition of inputs and distribution on output has been incorporated.

However, only the *direct* effects of the telematics are accounted, because of recent data availability shortcomings, substitution possibilities have been excluded. In more detail, the introduction of telematics in the I-O model followed the steps:

- The sales of telematics to the remaining 35 sectors of the economy were estimated by applying the informatics input to gross output ratio (Staeglin, 1986). Therefore, the output of each of the 35 industries was increased by the relevant telematics output estimation.
- The intra-sectoral flows for telematics were estimated by applying the share of the informatics intra-sectoral flows in the total intermediate demand as used in the Staeglin study.
- The sales of telematics to final demand were estimated by applying the share of the informatics final demand sales in total gross production as used in the Staeglin study.
- The input purchases of the telematics sector from the rest 35 sector were set to zero, because of lack of information.
- The primary inputs for telematics and the final demand of the other 35 sectors were calculated as a residual, in order to *balance the Table*.
- The energy consumption coefficient for telematics was set to zero.

The above adjustments are followed by the estimation of output, income, employment and energy-use levels, as well as the energy-use elasticity for each of the 36 industries for the years 1975 and 1980, respectively.

MODEL APPLICATION

Input for Greece

- Input-Output for Greece, was considered for the years 1975 and 1980, prior to the introduction of the true information era in the country, given also the lack of more recent data for verification purposes
- Vectors of sectoral employment for the years 1975 and 1980
- Data for telematics as input
- Vectors of emission of pollutants
- Vectors for energy consumption (derived)
- Estimated a sector-by-sector cross elasticity of demand between transport and telecom has been obtained.

Output Multipliers

Table 3 presents the output multipliers for both the 35 and the 36-sectors of the I-O Tables for 1975. Output multipliers express the total output effects of one-unit increase in final demand for the output of a particular sector. In some detail, a multiplier of 1.22 for "sector-i", indicates that if final demand for the output of sector-i increases by one unit, the total economy-wide increase in output would be increased by 1.22, because in order to produce more output, sector-i would have to increase its purchases from input-providing sectors, triggering therefore, a whole series of repercussions as the economy adjusts to the new level of economic activity.

For the 1975 35-sector Table, the size of multipliers is generally average, ranging from 1 to 2.75. Output multipliers associated with the telematics-augmented 36-sector Table are also of average size, ranging from 1.02 to 2.75. *The introduction of telematics in the economy not only increases the level of gross production, but also enhances the share of inter-industry transactions in total gross output, and reduces economic leakage from the study area.* As a consequence, an increase in output would accrue higher "benefits" to the economy under investigation. With the exception of sector 13 (Leather Products), the introduction of telematics results in positive output effects, ranging from 0.0002 to 0.08. For 1980, the introduction of telematics also results in positive output effects, ranging from

Table 3. Output Multipliers, Greece, 1975

Sector	Leontief (35x35)	(1)	Augmented* Leontief (36x36) (2)	Difference (2) - (1)
1	Agriculture	1.4153	1.4973	0.0821
2	Mining	1.2634	1.2972	0.0338
3	Food Industry	2.2457	2.2895	0.0438
4	Beverages	1.8777	1.9189	0.0412
5	Tobacco	1.5156	1.5635	0.0479
6	Textiles	1.7166	1.7611	0.0445
7	Shoe	2.4313	2.4314	0.0002
8	Clothing	2.3095	2.3387	0.0292
9	Wood	1.4234	1.4714	0.0480
10	Furniture	1.5918	1.6359	0.0441
11	Paper	2.1577	2.1738	0.0161
12	Publishing	1.8782	1.9052	0.0270
13	Leather	2.7533	2.7516	-0.0017
14	Rubber	2.0012	2.0336	0.0324
15	Plastic	1.5894	1.6229	0.0335
16	Chemicals	1.7877	1.8198	0.0322
17	Oil-Products	1.5445	1.5768	0.0323
18	Cement	1.4713	1.5034	0.0322
19	Glass	1.5957	1.6267	0.0310
20	Non-Metal Industry	1.6502	1.6806	0.0304
21	Metal Industry	1.7595	1.7952	0.0356
22	Metal Products	2.2048	2.2297	0.0249
23	Machinery	1.5041	1.5476	0.0434
24	Electrical Machinery	2.2199	2.2367	0.0168
25	Transport Means	1.9606	1.9866	0.0259
26	Other Industries	1.4129	1.4571	0.0442
27	Construction	1.6116	1.6462	0.0345
28	Electricity	1.3941	1.4269	0.0327
29	Transport	1.7760	1.8213	0.0453
30	Telecommunications	1.0899	1.1675	0.0776
31	Commerce	1.2919	1.3612	0.0693
32	Banks	1.6603	1.7149	0.0546
33	Other Services	1.1163	1.1867	0.0704
34	Domiciles	1.0676	1.0871	0.0195
35	Public Services	1.0000	1.0191	0.0191

* Telematics augmented Leontief Table

0.002 to 0.07. The lowest positive output effects appear in Electric Machinery (+0.0011), Paper (+0.0017) and Printing (+0.0027). Sectors with comparatively high positive output effects include Telecommunications (+0.74), Agriculture (+0.74) and Banking (+0.725).

Global labour coefficients

The estimated global labour coefficients indicate the *effect of a one-unit increase in final demand for the output of a particular sector on total employment*. For example, a global labour coefficient of size 3 for sector-i, indicates that if final demand for the output of sector-i increases by 1 million drachmas, then 3 new jobs will be generated in the economy. In the case of 35-sector table, the size of the global labour coefficients is generally average, ranging from 0.07 to 3.91. Global labour coefficients associated with the telematics-augmented 36-sector Table are also average, ranging from 0.07 to 3.55. The lowest coefficients appear in Domiciles (0.07), Telematics (0.45), Oil by-products (0.56) and Metal Industries (0.86). Sectors with high labour coefficients include Agriculture (3.56), Furniture (2.90) and Food (2.77). Due to the increase in gross production, the introduction of telematics results with the exception of sector 34 (Domiciles) in the decrease of global labour coefficients, ranging from -0.02 to -0.36.

Labour coefficients associated with the telematics-augmented for the 1980 table, range from 0.16 to 3.17. The lowest coefficients appear in Domiciles and Telematics (both 0.16), Cement (0.54) and Oil by-products (0.66). Sectors with high labour coefficients include Agriculture (3.17), Furniture (3.02) and Food (2.58).

The adopted mechanical exercise proved that the introduction of telematics into the system can alter the performance of the system in favour of productivity by reducing the demand for labour i.e. increasing output per unit of labour input. This observation also affects the performance of the system as a whole, which is expressed by the global labour coefficients. However, due to the increase in gross production, the introduction of telematics results in the decrease of global labour coefficients, ranging from -0.01 to 0.39.

Energy Use

Energy requirements coefficients *indicate the energy consumption by sector i, caused by a one-unit increase in final demand for the output of sector I*. In the case of the 35-sector table, energy-use/output coefficients range from 0 to 2.9E-05. The lowest energy-use/output coefficients appear in Domiciles and Public Services (both zero), and Construction (5.94E-09). Sectors with comparatively higher direct energy coefficients include Cement (2.9E-05), Electricity (1.6E-05) & Glass (1.52E-05).

Coefficients associated with the telematics-augmented 36-sector Table-range from 0 to 2.8E-05. The lowest energy-use/output coefficients appear in Domiciles, Public Services, and Telematics (all zero), while sectors with comparatively high direct energy coefficients include Cement (2.8E-05), Electricity (1.59E-05), and Glass (1.47E-05). The introduction of telematics resulted in the decrease of total energy consumption, ranging from -2.6E-08 to -9.3E-07. The decline is minimal for industries such as Telecommunications, Public Services and Banking, but comparatively higher in the case of Oil by-products, Glass, Cement and Mining.

Relative Changes 1975-80 (Employment-Energy Use)

Total employment effects, which indicate job gains or losses, are presented in accordance to relative changes occurred in the structure of the economy, between 1975 and 1980. In the case of 35-sector model, most sectors (24) are associated with a negative employment effect, with coefficients ranging from -2.6 to -1.23, an inevitable result of the progressing productivity. When telematics are introduced into the system, negative employment effects generally become even stronger indicating the further progress of productivity-competitiveness.

Regarding the energy-use elasticity, almost all coefficients are positive and range from 0.47 to 15.8. The introduction of telematics results in a marginal change of these coefficients. These changes are negative for 16 sectors, positive for 11, while there is no change in the coefficients of the rest 8 sectors.

Level of Profit

Information collected and the adopted technique of introducing telematics into the system has resulted in a situation in which there is no-change in the level of sectoral employment (with the exception of the telematics industry). This is a strong assumption that *directly leads to a decreasing labour/output ratio*.

Under these assumptions the *telematics-technical-change* may be well influenced by other social factors (cash flow rate, capacity utilisation and the level of fixed capital). In any case telematics will tend to increase profits per unit of output if we consider this as a first round effect. In the long run the level of profits cannot be expected to be related to technical matters only. Moreover, political decisions could have a new starting point knowing that *there is no single economic theory of technical progress* (Seyfried, 1988).

Direct income coefficients for both the 35 and 36-sector I-O Tables for 1975 indicate the *increase in*

Table 4. Atmospheric Pollutant Emissions by Industrial Sector*

Fuel/energy source	Pollutant (kg/unit)					
	Unit	TSP	SO_2	NO_x	H_xC_y	CO
Natural gas	t	0,34	20	3,6	0,058	0,32
Anthracite	t	5,00	18	1,5	1,25	45
Lignite	t	3,5	15	3	0,5	1
Bitumen, coal	t	6,5	19	7,5	0,5	1
Oil gases	m^3	0,21	0,01	1,43	0,036	0,19
Oil	t	1,04	19,9	13,2	0,13	0,66
Oil products	t	2,13	20,1	7,5	0,41	0,59
Electricity**	MWh	0,19662	2,50234	1,23632	2,11225	0,34891

* WHO, 1982, OMS, Publication Offset No 62, Rapid Evaluation of Sources of Pollution of Air, Water and Soil.
** Values for UCPTE 88 (Interconnected European Network) from BUWAL, 1991, Schriftenreihe Umwelt Nr 132, Oekobilanz von Packstoffen Stand 1990.

sectoral income generated by a unit increase in the output of a particular sector.

Emission Coefficients SO_2 and TSP

Atmospheric pollutant and emissions are obtained from international statistics (WHO 1990, EPA 1990). This research is focused only on SO_2 and TSP. Consequently we estimated SO_2 and TSP per sector and estimated nation-wide emissions for the entire production of each sector (Table 4).

Model output Tables refer to one particular year and contains the results for one particular pollutant, and each table includes also the *conventional* estimations i.e. *without* telematics and the *augmented* estimations, i.e. after the introduction of telematics. In the third column the difference demonstrates the impact of telematics-technical-change on the economy.

Although linearity is a very strong assumption, the introduction of telematics appears to considerably reduce SO_2 emissions, and not only in the traditionally polluting industrial sectors like chemicals, oil by-products, cement and electricity. The novelty is the estimation of SO_2 emissions directly and indirectly impacting a sector. For example: Agriculture shows a considerable reduction of SO_2 when telematics are introduced (14.32%). This trend is also true for other sectors, where the decrease in SO_2 is in the range of 10.14%.

CONCLUSIONS

The analysis shows that the introduction of AC/IST in the economy induces both economic and environmental benefits. Under this perspective, it is believed that there is room for considerable scepticism concerning the traditional view of an existing trade-off between the social desire for a clean environment and increased industrial competitiveness.

Regarding the economic effects, the analysis demonstrates that the introduction of AC/IST in the economy increases the level of gross production and at the same time reduces economic leakage. Moreover, there is an increase of output per unit of labour, resulting therefore in the increase of sectoral productivity, competitiveness and consequently the share of profits in gross output.

The adoption of AC/IST decreases energy consumption, promoting therefore sustainable economic development, and more important, induces a considerable economy-wide reduction of pollutant emission-output ratios.

In quantitative terms based on ENVIRON, the introduction of AC/IST may have the following effects:

- *Sectoral gross production*: Output multipliers can increased from 5.8% in the agricultural sector to 7.11% in the telecommunications sector.
- *Sector global labour requirements*: Labour coefficients have decreased in all cases, i.e., the introduction of telematics resulted in the reduction of demand for labour per unit of output. The average reduction is about 8-10%.
- *Productivity*: The decrease in labour demand per unit of output is synonymous to the

increased labour productivity under the *ceteris paribus* conditions. In the pilot application case the demonstrated improvement can be regarded as impressive.

- *Energy per unit of output*: The model demonstrates under the assumptions made, a considerable reduction in energy consumption. The use of AC seems to reduce energy use in most sectors directly and indirectly and benefit the national economy, i.e., balance of payment, exchange rates and the environment.
- *Cost, competitiveness, profit*: The pilot project recommends that the introduction of AC may well reduce the labour-output ratio. Under ceteris paribus conditions, the telematics-technical-change seems to improve competitiveness in micro and macro level directly and indirectly. In this respect, some one can expect increased profit and at the same time improved real wages. Standard of leaving is expected to be improved because of: (i) improved production per employee, and (ii) improved competitive position of the country, and (iii) prospects for increasing growth rates of output and increased employment opportunities.
- *New business opportunities*: As in most cases, the historical moment of realisation of innovations made by new production processes always have been related with new business opportunities (profit), new offers to labour and growth prospects (i.e., chemicals, plastics, trains). However, environmental issues have been consistently neglected. This is probably the first time where business opportunities, growth prospects and improvement of the standard of living can be combined with a *Clean Environment*.
- *Emission coefficients-pollution*: Under the assumption of linearity, the introduction of telematics seems to decrease SO_2 and TSP in all cases directly and indirectly. Thus, telematics can reduce the cost of production, increase competitiveness and at the same time reduce pollution at levels of 10-15%.
- *Pollution per se*: Based on industrial international statistics of emission, simulations indicated for example, that: SO_2 emissions can directly and indirectly impact a sector, and in the example of Agriculture a considerable reduction of SO_2 is achieved when telematics are introduced (14.32%). This trend is also true for other sectors, where the decrease in SO_2 is in the range of 10.14%. However, SO_2 and TSP are also reduced in 1975-1980.

In terms of overall results, the introduction of telematics into the macro-system had the following results in the pilot case of Greece: (i) Increases output in almost every sector, (ii) Decreases global employment per unit of output i.e. the system seems to become more efficient and therefore more competitive as labour produces direct and indirect by more output, (iii) Demonstrates a downward trend in energy requirements per unit output and consequently linearity reduces emission coefficients, (iv) Reduces pollutant emissions into the environment, and (v) Can achieve balanced industrial growth with environmental protection.

Although environment and industrial production have an antagonistic relationship and their trade-off cannot meet Pareto efficiency criteria, the analysis demonstrates that the introduction of AC can considerably contribute to more efficient allocation of resources and into the improvement of the environment.

Finally, it must be stressed that, although ENVIRON delivers appropriate results, these results should *not be regarded* as appropriate for decision or policy-making. These results are *indicative* of what can be delivered to decision makers for policy, assuming additional effort is spent to calibrate and verify model results with true and updated data. Nevertheless, the methodology proposed indicates the use of a new approach in mathematical environmental modelling for policy, and not policy *per se* at this stage.

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