INTERNATIONAL INPUT-OUTPUT CONFERENCE IN BALATONFÜRED

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The International Input-Output Association (IIOA) and the Hungarian Society for Economic Modelling (HSEM) in co-operation with the Hungarian Statistical Association and the Hungarian Central Statistical Office organized a conference on "Inter-industrial Relations in Economic Modelling" in Balatonfüred between 23–26 February 2000.

Back in 1998, the New York conference of the IIOA made clear that researchers are looking for new implementation areas of input-output. Many questioned the future of input-output for researchers, whether it can provide anything new or is 'only' a very important, widely spread and used practical method. The organizers of the Balatonfüred conference hoped to find an answer to these questions.

The aim of the conference was to overview the main up-to-date economic modelling methods and to discuss the forthcoming trends. The programme committee (Mária Augusztinovics, András Bródy and Tamás Révész) did not limit the programme to conventional input-output topics. Other modelling experiments, results were also presented which included input-output a broader framework.

The conference was medium-sized, altogether there were 36 registered participants of 10 countries. The relatively small number of participants gave the conference a workshop-character. Out of 18 announced papers only one was cancelled. The chairmen of the sessions managed to keep the presentations in the desired time limit while they did not discourage anyone's interest in discussing, arguing. Participants regularly attended the meeting. It can be said that the conference had a familiar and at the same time a constructive, creative atmosphere.

Concerning the details: Mr. *Sándor Pálfy*, mayor of Balatonfüred held the welcoming address appreciating the significance of the conference and wishing good work and pleasant stay in the town and in Hungary. A short presentation by Professor *Ferenc Forgó* (Budapest University of Economics), the first president of the co-host Hungarian Society for Economic Modelling was part of the opening ceremony. He spoke about the ten-year function of the HSEM, emphasising the society's work in sustaining modelling activity and in maintaining its earlier appreciated level. He explained why the input-output method preserved its up-to-dateness for 70 years. He listed the following main reasons:

1. The problem that it addresses has been known for a long time and no economist questions the relevance of the analysis of the sectoral

interrelationships in a modern economy.

2. The basic model and most of its variants are relatively simple, elegant, and mathematically treatable.
3. Statistical verification, though imposes a lot of problems, interesting enough in themselves, is not out of reach as is the case with so many elegant, theoretical models.
4. Part of the model can be, and in a lot of countries has been incorporated in the statistical system thereby producing long time series to study.
5. It provides food for thought for a healthy mix of people: economists, statisticians, mathematicians, computer scientists. It is a prototype of a project where cooperation, teamwork and synergy are all part of daily life and indispensable ingredients of success.

1st session

Chaired by JAN OOSTERHAVEN (Groningen University, Netherlands)

- EZRA DAVAR (Ben-Gurion University, Israel): *Input-Output in the 21st Century*. He pointed out that although the majority of statistical offices compile input-output tables, input-output analysis is usually not used for the solution of meaningful economic problems. One of the reasons –in his opinion– was the dissonance between theoretical input-output analysis and real life economic activities. That is why input-output analysis should develop and some directions for its perfection and extension should be suggested. Vivid debate followed this presentation, which the chairman postponed to the closing round table discussion. (The programme committee chose this paper to be presented first on purpose, for they expected the atmosphere to be warmed up.)
- ERNŐ ZALAI (Budapest University of Economics, Hungary): *Economics a'la Leontief versus von Neumann*. The paper focused on the similarities and the difference between the Leontief and Neumann model of growth, then showed a general framework of dynamic economic models from which both models could be derived and that made the conceptual difference explicit.
- PÉTER BUDAVÁRI (Ministry of Finance, Hungary): *Adjustment of I/O: general RAS method*
- ERIK DIETZENBACHER, (Groningen University, Netherlands, co-author: BART LOS): *Structural Decomposition Analyses with Dependent Determinants*. Using the decomposition of value added growth as a prototype example they examined the phenomenon of several determinants being not independent. The paper indicated that dependencies may cause a

bias in the results of decomposition analysis. An alternative to overcome this problem was proposed, illustrated by macroeconomic data of the Netherlands from 1972 to 1986.

- NIKOLAOS ADAMOU, (Aristotelian University of Thessaloniki, Greece, co-author: GÜLAY GÜNLÜK-SENESEN): *Labour Productivity Decomposition: its Origin, Generation and Benifit Spillover. The Case of Turkey 1973-1990*. It was one of the most interesting papers. Starting with the origin of industrial productivity (labour reduction and output expansion) he examined the industrial generation and the benefit spillover of productivity applying the similarity of production and allocation activities in multi-sectoral linear systems. The model was first applied to the Turkish —not to the Greek— economy, since Turk statistical data are of far better quality.

2nd session

Chaired by ERNŐ ZALAI (Budapest University of Economics, Hungary)

- KORNÉLIA MURA-MÉSZÁROS (Hungarian Central Statistical Office, co-authors: MÁRIA FORGON, ZOLTÁN NÁDUDVARI, LÁSZLÓ TELEGDI): *Compilation of the Hungarian IOT with Estimated Industrial Output*. The paper presented the input-output developing tasks in Hungary and the efforts made in order to fulfil the ESA'95 recommendations. In 1998 there were several changes in the Hungarian statistical data collection system benefiting the introduction of commodity flow. The procedure of confronting the data, cross-checking and revision necessitates a continuous co-operation between macroeconomic and branch statistics.

- TAMÁS TARJÁN (Research Institute of Economics, Hungary): The Role of Human Capital of Hungarian in its Integration to Europe (Jánossy's trendline theory: could it be applied to transitional country?) He compared Jánossy's trendline theory with some growth models and on the basis of purchasing power parity data he tried to predict the macroeconomic prospects of Hungary and Central Europe.

- HELMUT MAIER (Berlin School of Economics, Germany): *Using IOT to Reflect Inter-industrial Relations of Investment Decisions* (two recent applications). A practically oriented paper presented two applications of Leontief's theory undertaken in 1999 at Berlin School and an other one which made use of the R59 input-output table of Germany of 1993.

- UTZ-PETER REICH (Mainz University of Applied Sciences, Germany): *Purchasing Power Parity as a Measure of Equality in World Trade*. The paper analysed the inequality of world trade using purchasing power parities calculated by means of a Geary-Khamis index. It proved that this method works in terms of an input-output framework.

- Tamás Révész (Ministry of Economic Affairs, Hungary): *Accounting for Demand-effects in Input-output Price-models.* This model introduced so-called reference prices. After the theoretical part the paper presented the results of a plausible scenario for Hungary.

3rd session

Chaired by Utz-Peter Reich (Mainz University of Applied Sciences, Germany)

- Jirina Lapisakova (Slovak Statistical Office, co-author: Viera Hajnovicová): *The Impact of Internal and External Disparities on Structural Changes in the Slovak Economy.* The paper showed the development of main macroeconomic indicators in Slovakia during the years of transition (1991-1998). The analysis was based on two supply and use tables for 1994 and 1996.

- Marius Plich (University of Lodz, Poland): *Economic-Ecologic Model for Poland.* The paper described the compilation of environmental data with input-output tables for Poland. A special attention was given to air pollutants.

- Silvana Kühtz (Potenza University, Italy, co-author: Carmen Izzo): *Economy-Energy-Enviroment Analysis of Tourism-related Activities Using Input-Output Process Aproach.* The input-output process model (IOPM) was applied to the local supply chain of tourism related activities based in a recently established Italian Natural Park.

- Erzsébet Kovács (Budapest University of Economics, Hungary): *Industrial Development and Insurance Industry.* Using several statistical methods she presented that the insurance industry is still underdeveloped in the Central European region.

- Jan Oosterhaven (Groningen University, Netherlands, co-authors: Gerard J. Eding, Dirk Stelder): *Cluster, Forward and Backward Linkages, and Bi-Regional Spillovers: Policy Implications for Two Dutch Mainport regions and Rural North.* The paper described a consistent framework to detect clusters of interrelated economic activity and to evaluate both the regional and the national economic significance of individual sectors and of the average sector per region, using bi-regional input-output tables. The authors applied the methodology to three Dutch regions that are especially important from a policy perspective.

4th session

Chaired by Helmut Maier (Berlin School of Economics, Germany)

- ALEJANDRO CARDENETE (Huelva University, Spain, co-author: FERRAN SANCHO): *Impact Assesment Using Accounting Matrix.* An empirical study on the role of the petro-chemical sectors in Andalusia using a regional social accounting matrix (SAM). The paper showed the decomposition of the extended multipliers in three categories of effects and the empirical analysis, which measured the impact on sectoral total gross output due to the presence of the petrochemical industries under different scenarios of final demand.
- ILONA CSERHÁTI (ECOSTAT, Hungary): *Fiscal Policy Analysis with Macro Models.* The ECO-LINE quarterly macroeconometric model of the Hungarian economy is designed for short and medium term forecasting and policy analysis. The presentation was illustrated by showing some fiscal policy simulations.

Round table discussion

The round table discussion was the last momentum of the conference chaired by ANDRÁS BRÓDY. He praised Leontief's initiative compared the approaches of Leontief and Neumann, and encouraged the participants to refer to the practical modelling, economic policy and educational aspects of the topic. The following discussion dealt with many significant aspects of input-output. Those intervening recalled the relevant thoughts of Slucki and Lange.

Some claimed that input-output cannot give room to new theoretical ideas any more, and generally the interest in macro-models has decreased. It is hard to attract students to this area, universities do not do enough to improve the situation. (E.g., at the Budapest University of Economic Sciences there is no compulsory course in economic statistics.) A question under discussion was the long procession period (2-3 years) of statistical input-output tables, how much it impedes the credibility of modelling, i.e., the adaptability of input-output to problems of economic policy. It is doubtful to what extent politicians and decision makers rely on existing models.

The majority of the participants (including N. Adamou, H. Maier, A. Bródy, M. Augusztinovics) were more optimistic in the judgement of the present and future of input-output. It is obvious that input-output itself does not provide much new ground for theoretical research, but an increasing number of new application areas emerged. Its system of interdependence is included in almost every complex economic model. An interesting new phenomenon is that more and more researchers of analogous areas attend input-output conferences, since the organic way of thinking, which is induced by input-output, encourages the analysis of logically similar problems not described by input-output.

The chairman closed the conference with an affirmation of the survival of Leontief's conception on interdependence and circularity.

INPUT-OUTPUT MODELS FOR ECONOMY-ENERGY-ENVIRONMENT ANALYSIS OF TOURISM-RELATED BUSINESSES IN A NATURAL PARK

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The analysis of relationships among socio-economic activities and the environment is fundamental to plan a sustainable development. In the present work an Input-Output (I-O) analysis based upon production processes is used to estimate energy and material flows (including pollutants/waste) in the supply chain of tourism-related activities based in a recently established Italian natural park (Pollino natural park). Tourism is a sector of utmost importance for present and future development policies of the park, therefore monitoring energy use and pollution levels in this sector can be useful for the sustainable development of the area. In particular, flows of energy necessary to lodging activities (hotel supply chain) are investigated and consequent production of pollutants evaluated. An increased need of energy due to the growth of tourism demand may cause an increment of pollution. The I-O model formulated herein enables to examine the local supply chains of the main lodging companies already existing in the park, and allows to balance positive and negative impacts caused by future tourism development and economy-energy-environment interactions.

1 Introduction

The economic impact of tourism-related businesses is remarkable. The World Travel and Tourism Council (The Economist, 1998) estimates that the total 1996 economic value of goods and services attributable to tourism was 10.6% of the gross global product. In 2000 Europe holds still the 50% of the whole market (Il Sole 24 Ore, 2000). In Italy the economy linked to tourism represents the 5.7% of the added value, the 11% of total consumption and counts above 1 million and 600 thousand employees (Beato, 1999). The importance of tourism as an area of academic investigation (see for example, Gonzales and Moral 1996; Borooah, 1999) stems in fact from the large contribution that it makes to the national income of several countries and the potential that it offers for generating output and employment growth. Generally, these studies deal with two main aspects: demand growth and infrastructure growth. In fact, the development of tourism-related activities may push local development and in particular that of rural areas with employment rates

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much lower than the national averages, i.e. almost all the Mediterranean area. But unplanned development of tourism may spoil the nature, so the question about environmental aspects (e.g., increased pollution and waste materials) arises.

Sustainability has gained considerable momentum as the main basic ground for development programs (Kyoto Protocol, 1997) and recently within this framework new forms of tourism-related activities have started to grow, i.e. sustainable tourism.

The problem deepens when these activities are based in natural parks where it is necessary to protect the environment, to favour local socio-economic development and to keep traditions alive. It is then strategic to plan the development of tourism-related businesses in a natural park in the more general and cogent framework of a sustainable development that complies with certain constraints (Migliorini et al., 1999). Besides, parks themselves should be considered as models and laboratories of a global sustainable development. They prove that it is possible to develop profitable activities (also based upon naturalistic values) and at the same time to protect the environment (Giuntarelli, 1998). To put sustainable development into practice it is necessary to explore how economic and social activities interact with the environment and influence each other. In particular, relationships among economy, energy and environment (Uno, 1998) and the policies for local development should be analysed although their investigation may be very complex. In the face of such complexity, models based upon input-output approach may provide tools that allow to deepen the understanding of flows relationships both in micro-scale and macro-scale regions (Ayres, 1978).

In this paper, the I-O approach as proposed by Albino et al. (2000), is applied to the supply chain of tourism-related activities to analyse the impact on the environment of material and energy flows entailed by tourism-related processes located in a natural park and to plan in advance which tourism-related activities and which type and intensity of such activities may be allowed.

2 Input-output models for supply chains

Input-output technique has been typically used to analyse the economic structure of regions in terms of economic flows between sectors (Leontief, 1951). Herfindhal and Kneese (1965) approached the resource/environment interface from an economic perspective. Later Cumberland (1966) suggested the extension of conventional I-O models to incorporate environmental factors in analysing regional development strategies. Leontief (1970) published a formulation of the extended I-O model to include both residuals generation and abatement activities.

Input-output can also be used for enterprises (termed Enterprise Input-Output (EIO)). In Italy, for example, a project was developed to forecast at a sectoral level the macroeconomic effects of the Italian conglomerate IRI, on the Italian economy and especially on southern Italy regions. Through I-O techniques IRI's internal structure and its influence on the outside was studied (La Noce et al., 1993).

Recently, Lin and Polenske (1998) used an input-output approach for enterprises based on production processes, where the production system of a company is composed of interrelated production processes that combine factor inputs to produce outputs, and developed a specific I-O process model.

Using a similar approach Albino et al. (2000) have formulated input-output models to map production activities, to interrelate and estimate flows of energy and materials, including use and consumption of fuels and production of pollutants within supply chains. Defined a *production process* as the transformation of input flows in output flows, both global and local supply chains have been modelled therein. In particular, a *global supply chain* was considered as the network of processes that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. For a given supply chain the relationships among all processes (global) as well as among processes located inside (local) and outside a given area can be analysed and modelled.

Consider a given geographic area and the supply chain related to a final product. The input-output approach can be used to analyse the flows (of raw materials, energy, products, pollution, imports and exports) relative to the chosen supply chain that take place inside the region, or which, at the most, cross its borders. This is the case of a *local supply chain*.

In this case, the model permits to investigate local processes interdependencies as well as the relationships among local processes and processes of the supply chain directly connected to them through the border line.

The input-output approach based on production processes, as described in details in Albino et al. (2000) can be used: i) to recognise functional relationships among flows of processes in a local supply chain, ii) to determine the processes that contribute more to environmental pollution, and, iii) to evaluate how one can change the input mix or the imports rate (for instance of energy sources) in order to respect environmental constraints (e.g., to reduce pollution, keeping other output flows constant).

3 Input-output model for tourism-related businesses

Any tourism-related business can be described as a supply chain. It can be composed of a variety of processes which can be treated as the production processes described in the previous section and represented via physical flows as in *Figure 1* where a simplified two processes supply chain is presented; boxes represent processes and arrows represent flows.

For example, to give accommodation (and other services for tourism) is herein considered a process that produces outputs (e.g. tourists accommodated per year) due to various inputs (e.g. energy inputs to run the activity, tourists that look for accommodation, food, etc.). All the typical hotel processes which range from accommodation to catering, all the processes needed to produce food (e.g., bakeries, dairy farms), guides, banking services and other activities are systems that produce main product outputs due to various inputs. In order to have a tool simple to use a main hypothesis is set: only one main product (X_i) per process is allowed.

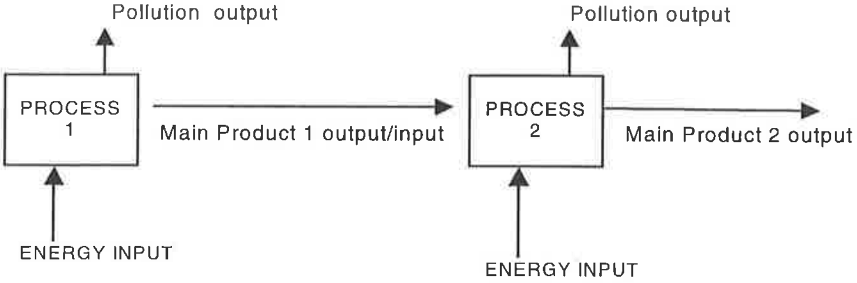

Figure 1. Simple scheme of a two-process supply chain

In particular, the supply chain of a hotel which provides accommodation in a natural park can be effectively analysed using a specific input-output process model.

The following notation is used in order to write balance equations for the different flows. Z_{ii} indicates the main product output of the i-th process, Z_{ij} $i \neq j$ is the fraction of the i-th process output to the j-th process, Y_i is the fraction of the i-th process output which may be sold outside the local supply chain (final output), P_{kj} is the purchased input (e.g., raw materials) of type k to the j-th process, M_{ij}, is the import of the same main product produced by the i-th process to the j-th process, W_{kj} is the output of by-products and unwanted materials (i.e. waste, pollution, by-products or energy and materials residuals generated in production processes) of type k to the j-th process.

In matrix notation:

$Z = [Z_{ij}]$ = Production and intermediate consumption of main products;

$A = [A_{ij}]$ = Direct input-output coefficients for main product outputs;

$P = [P_{kj}]$ = Purchased inputs;

$W = [W_{kj}]$ = Output of by-products and unwanted materials;

$X = [X_i] = Z_{ii}$ = Gross output of main products;

$Y = [Y_i] = \sum_j Z_{ij}$ = Final output of main products;

$\mathbf{M} = [M_i] = \sum_j M_{ij}$ = Total imports;

$\mathbf{P} = [P_k] = \sum_j P_{kj}$ = Total consumption of purchased inputs;

$\mathbf{W} = [W_k] = \sum_j W_{kj}$ = Total output of by-products/waste;

$V = [V_{kj}]$ = Primary inputs (in this work k = labour employment);

$\mathbf{V} = [V_k] = \sum_j V_{kj}$ = Total labour employment required.

It is possible to estimate direct input-output coefficients A_{ij}, referred to all the input main products of type i. For $i \neq j$ the direct input-output coefficient A_{ij} can be defined as the ratio of the total input, sum $Z_{ij} + M_{ij}$ (if there are imports) to the total output of the j-th process. A_{ij} can be estimated using actual data related to a given supply chain; in the model it is assumed constant over time (i.e., the input requirements for each process are assumed to be an unchanging characteristic of the production technology). So, if the gross output of the j-th process X_j is considered, the direct coefficient can be expressed as:

$$Z_{ij} + M_{ij} = A_{ij} X_j \tag{1}$$

and in matrix notation:

$$Y + \mathbf{M} = A \cdot X$$

let A_{ii} equal to one. Also purchased inputs (e.g. energy inputs, raw materials), pollution outputs and primary inputs (i.e., labour employment) can be expressed in terms of direct input-output coefficients, B_{kj}, as the ratio of input P_{kj} to the total output of the j-th process, C_{kj}, as the ratio of output W_{kj} to the total output of the j-th process, D_{kj} as the ratio of input V_{kj} to the total output of the j-th process, respectively:

$$\forall k, \forall j \qquad P_{kj} = B_{kj} X_j; \quad W_{kj} = C_{kj} X_j \quad \text{and} \quad V_{kj} = D_{kj} X_j \ . \tag{2}$$

In matrix notation they become, respectively:

$$\mathbf{P} = B \cdot X \qquad \mathbf{W} = C \cdot X \qquad \mathbf{V} = D \cdot X \ ,$$

where:

$B = [B_{kj}]$ = Direct input-output coefficients for purchased inputs;

$C = [C_{kj}]$ = Direct input-output coefficients for by-product and waste outputs;

$D = [D_{kj}]$ = Direct input-output coefficients for labour employment.

As described in the next section, the model is applied to study functional relationships among flows and then in particular to evaluate the new amount of energy inputs needed when the final demand is changed. Also, how to satisfy the demand of final product with a different mix of energy sources in the respect of given waste/pollution constraints can be analysed.

4 Case examples

The case examples deal with tourism-related businesses located in an Italian natural park, the Pollino Natural park, situated between Basilicata and Calabria, regions in the South of Italy. The park extension is of about 1930 km^2 and it is the largest natural park in Europe. Large forests characterise the Park whose average height is about 1000 m. The area has suffered from the increased urbanisation in the seventies, before the natural park was established (November 1993).

From the economic point of view, tourism-related businesses are considered essential for the local development. Hence, in the economic plan of the park (in the development phase) supply chains related to tourism activities are taken into consideration to enhance their efficiency and effectiveness. However, the planners have to take care of the environmental impact of such businesses. In particular, energy sources and pollution seem to constrain size and location of hotels, restaurants, laundries, etc. The model is applied in the following sections to support both accounting and planning activity.

4.1 Accounting

A simplified supply chain whose final product is the lodge service is modelled as a network of processes. In *Figure 2*, the scheme of materials and energy flows is drawn. The input-output technique described in the previous section, used herein as an accounting tool, is applied to processes 1 to 3, all located in the park area and described in *Table 1*. They compose a supply chain related to basic accommodation activities.

Process	Main product output in a year
1 – Laundry located in the park area	Number of cleaned linen modules
2 – Lodge Hotel (it provides accommodation)	Number of beds let
3 – Transport service	Number of linen modules transported
1^0 – Laundry not located in the park area	Number of cleaned linen modules

Table 1. Processes and relative main products for the case example in Figure 2

The following hypotheses are set:

i) Only flows represented in Figure 2 are accounted for (e.g., transport service needed for the outside Laundry is not considered);

ii) The model parameters are estimated on the basis of a specific supply chain. Data are collected through interviews with the process owners. Each process is assumed to be statistically representative of processes embedded in similar lodge hotel and laundry supply chains located in the park. In case the processes performed by other lodge-hotels, laundries, and transport services are equal to those analysed herein increasing the number of beds let per year means increasing the number of hotels, laundries and lorries actually used;

iii) Linear proportionality between the number of beds let (i.e., tourists who spend the night in the area) and the quantity of inputs and outputs of the processes is assumed;

iv) Imports of cleaned linen from the laundry process located outside the park, process 1^0, are considered. Because they are imported products equal to the main products produced by the internal Laundry, the flow M_{1^02} is termed M_{12} and it contributes to the direct coefficient A_{12} (as explained also hereafter).

Based on Figure 2, and upon the notation given in section 3, *Table 2* presents balance equations of material/energy flows written for process outputs, purchased inputs, pollution outputs, imports and labour employment.

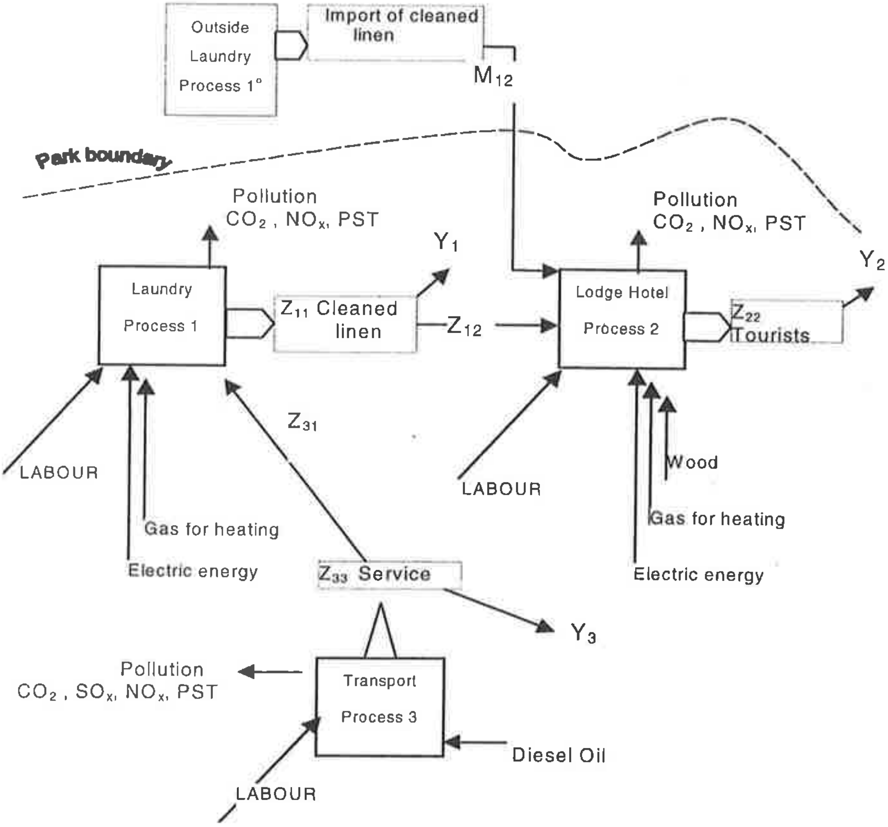

Figure 2. Simplified supply chain in the present situation

Process outputs	$Z_{11} + Z_{12} + 0 = Y_1$ $0 + Z_{22} + 0 = Y_2$ $Z_{31} + 0 + Z_{33} = Y_3$
Purchased inputs	$P_{e1} + P_{e2} + 0 = P_e$ $P_{w1} + P_{w2} + 0 = P_w$ $P_{g1} + P_{g2} + 0 = P_g$ $0 + 0 + P_{D3} = P_D$
Pollution outputs	$W_{CO21} + W_{CO22} + W_{CO23} = W_{CO2}$ $0 + 0 + W_{Sox3} = W_{Sox}$ $W_{NOx1} + W_{Nox2} + W_{Nox3} = W_{NOx}$ $W_{PST1} + W_{PST2} + W_{PST3} = W_{PST}$
Imports of main product	$M_{1{}^{0}2} = M_{12} = M_1$
Labour employment	$V_{L1} + V_{L2} + V_{L3} = V_L$

Table 2. Balance equations based on flows in Figure 2

$A_{11} = Z_{11}/Z_{11}$	$A_{12} = (Z_{12} + M_{12})/Z_{22}$	$A_{13} = Z_{13}/Z_{33}$
$A_{21} = Z_{21}/Z_{11}$	$A_{22} = Z_{22}/Z_{22}$	$A_{23} = Z_{23}/Z_{33}$
$A_{31} = Z_{31}/Z_{11}$	$A_{32} = Z_{32}/Z_{22}$	$A_{33} = Z_{33}/Z_{33}$

Table 3. Direct input-output coefficients A_{ij}

In particular, the direct coefficients are presented in Table 3. It should be noticed that when imports of main products occur they contribute to the direct coefficients referred to main products (and not to each input flow). Note in particular coefficient A_{12} where both Z_{12} and M_{12} appear.

In *Table 4* are shown the present data (in physical units) for the three process hotel supply chain illustrated in Figure 2. They are distributed in five sections: main products, main product imports, purchased inputs, pollution and labour employment. Main Products of Process 1 are measured in cleaned linen modules, as they are generally called. The last line of the table is a recall of the main products of each process and is comprised of the diagonal elements of the matrix of the first section.

Each row in Table 4 describes production (positive number, i.e., production of pollution, or of main products) and consumption (negative number, i.e., use of energy) of main products, purchased inputs, pollutants. For example, the third row in the main products section describes the use of the transport service: 1800 modules transported are the service offered (produced) and −1800 modules are transported to and from (i.e., consumed by) the laundry in the park.

Each column provides information on inputs and outputs for each production process. For example, to transport 1800 modules per year the transport process (process 3) consumes 925 litres of diesel oil, produces 2430 kg of CO_2, 3.41 kg of SO_x, 10.08 kg of NO_x and 1.94 kg of solid particles (PST) and needs 5 employees.

In this way, a complete accounting of the local supply chain model considered in this section is given in Table 4.

	Process 1 Laundry	Process 2 Lodge Hotel	Process 3 Transport service	Final Output / Total Demand
Main Products Z_{ij}				Y_i
Laundry: 1 cleaned linen module per bed	900	-900	0	$Y_1 = 0$
Lodge Hotel: beds let	0	1200	0	$Y_2 = 1200$
Transport service: transported modules	-1800	0	1800	$Y_3 = 0$
Main Product Import M_{ij}				$\mathcal{M}_i$
External Laundry, 1°, cleaned modules	0	-300	0	$M_1 = -300$
Purchased Inputs P_{kj}				$\mathcal{P}_k$
Electric energy [kWh]	- 3600	- 5770	0	$P_e = -9370$
Wood [kg]	0	- 20000	0	$P_w = -20000$
Heating gas [Nmc]	- 231	- 1385	0	$P_g = -1616$
Diesel oil [l]	0	0	- 925	$P_D = -925$
Pollution* [kg] W_{kj}				$\mathcal{W}_k$
CO_2 (wood)	0	19000	0	$W_{w,CO_2} = 19000$
CO_2 (heating gas)	444	2659	0	$W_{g,CO_2} = 3103$
CO_2 (diesel oil)	0	0	2430	$W_{D,CO_2} = 2430$
CO_2 (total)	–	–	–	$W_{CO_2} = 24533$
SO_x (wood)	0	4	0	$W_{w,SO_x} = 4$
SO_x (heating gas)	0	0	0	$W_{g,SO_x} = 0$
SO_x (diesel oil)	0	0	3.41	$W_{D,SO_x} = 3.41$
SO_x (total)	–	–	–	$W_{SO_x} = 7.41$
NO_x (wood)	0	26	0	$W_{w,NO_x} = 26$
NO_x (heating gas)	0.578	3.46	0	$W_{g,NO_x} = 4.04$
NO_x (diesel oil)	0	0	10.08	$W_{D,NO_x} = 10.08$
NO_x (total)	–	–	–	$W_{NO_x} = 40.12$
PST (wood)	0	346	0	$W_{w,PST} = 346$
PST (heating gas)	0.028	0.169	0	$W_{g,PST} = 0.197$
PST (diesel oil)	0	0	1.94	$W_{D,PST} = 1.94$
PST (total)	–	–	–	$W_{PST} = 348.1$
Labour employment V_{Lj}				
Number of employees	−3	−5	−3	$V_L = -11$
Process Main products	900 modules	1200 beds let	1800 transp. linen	

* Emission Factor values sources: US-EPA & OAQPS (1998)

Table 4. Flows balance table, accounting of the present situation

4.2 Planning

In this section the model is used as a planning tool for the same supply chain of Figure 2, in two limit cases:

1. Case B: no imports of cleaned linen, M, allowed, i.e., process 1 produces all the needed linen (see *Table 5*);
2. Case C: cleaned linen only imported from a laundry external to the park area, (see *Table 6*).

As expected, comparing with the present situation (Table 4), in case B pollution emissions in the area increase, but also labour employment (by two units); in case C pollution emissions decrease because are only those due to process 1, therefore this alternative may comply better with sustainability issues, but labour employment decreases by more than half when compared to the present situation.

For the assumed proportionality, these values double if an increment by two of the final demand is considered.

Because as stated previously both environmental and economic impact are equally essential for the park development, a case example that allows to plan a pollution decrease and an employment increase (when comparing with the present situation described in section 4.1) represents the ideal scenario to be pursued, this is called Case D.

	Process 1 Laundry	Process 2 Lodge Hotel	Process 3 Transport service	Final Output / Total Demand
Main Products Z_{ij}				
Laundry: 1 cleaned linen module per bed	1200	-1200	0	$Y_1 = 0$
Lodge Hotel: beds let	0	1200	0	$Y_2 = 1200$
Transport service: transported modules	-2400	0	2400	$Y_3 = 0$
Main Product Imports M_{ij}				
External Laundry, 1°, cleaned modules	0	0	0	0
Purchased Inputs P_{kj}				
Electric energy [kWh]				$P_e = -10570$
Wood [kg]				$P_w = -20000$
Heating gas [Nmc]				$P_g = -1693$
Diesel oil [l]				$P_D = -1233$
Pollution* [kg] W_{kj}				
CO_2				$W_{CO_2} = 25488$
SO_x				$W_{SO_x} = 8.55$
NO_x				$W_{NO_x} = 43.67$
PST				$W_{PST} = 348.8$
Labour employment V_{Lj}				
Number of employees	-4	-5	-4	$V_L = -13$
Process Main products	1200 modules	1200 beds let	2400 transp. linen	

* Emission Factor values sources: US-EPA & OAQPS (1998)

Table 5. Case study B, with same supply of lodge service as in Table 4, and no Imports

	Process 1 Laundry	Process 2 Lodge Hotel	Process 3 Transport service	Final Output / Total Demand
Main Products Z_{ij}				
Laundry: 1 cleaned linen module per bed	0	0	0	$Y_1 = 0$
Lodge Hotel: beds let	0	1200	0	$Y_2 = 1200$
Transport service: transported modules	0	0	0	$Y_3 = 0$
Main Product Imports M_{ij}				
External Laundry, 1°, cleaned modules	0	−1200	0	$M_{12} = -1200$
Purchased Inputs P_{kj}				
Electric energy [kWh]				$P_e = -5770$
Wood [kg]				$P_w = -20000$
Heating gas [Nmc]				$P_g = -1385$
Diesel oil [l]				$P_D = 0$
Pollution* [kg] W_{kj}				
CO_2				$W_{CO_2} = 21659.2$
SO_x				$W_{SO_x} = 4$
NO_x				$W_{NO_x} = 29.46$
PST				$W_{PST} = 346.17$
Labour employment V_{Lj}				
Number of employees	0	−5	0	$V_L = -5$
Process Main products	0 modules	1200 beds let	0 transp. linen	

* Emission Factor values sources: US-EPA & OAQPS (1998)

Table 6. Case study C, with same supply of lodge service and only Imports M.

The strength of the model is in fact that it may also help examine alternative options to produce energy in a cleaner way. For example, substituting the natural gas boiler and the wood fireplace used in case B, with solar panels, case D, results in emissions reductions. This is evident when comparing the results presented in Table 5 with those in Table 7.

Moreover, comparing the present situation, Table 4, with Table 7 again, which corresponds to no imports and solar thermal panels, shows that an increment in the production of the laundry process requires two additional labour units, and decreases emissions. See *Table 8* for the comparisons.

Further development of the model takes account of another primary input in Table 3, indicating capital costs. So, accounting for financial costs, the model serves as a tool to support investment decisions when substituting traditional energy technologies in favour of sustainable ones. In fact, it is often difficult to examine alternative pollution control measures and evaluate costs and returns of environmental quality improvements.

Furthermore, because conventional enterprise accounting systems record little (or none) information on environmental performance it is difficult to control and to incentive the minimisation of environmental pollution. These models based on input-output techniques can help. In fact they allow to take account of the non-used or non-desired energy outputs, and to decide how to reduce or reuse some portions.

	Process 1 Laundry	Process 2 Lodge Hotel	Process 3 Transport service	Final Output / Total Demand
Main Products Z_{ij}				
Laundry: 1 cleaned linen module per bed	1200	−1200	0	$Y_1 = Z_{11} + Z_{12} = 0$
Lodge Hotel: beds let	0	1200	0	$Y_2 = 1200$
Transport service: transported modules	−2400	0	2400	$Y_3 = 0$
Main Product Imports M_{ij}				
External Laundry, 1°, cleaned modules	0	0	0	0
Purchased Inputs P_{ij}				
Electric energy [kWh]				$P_e = -10570$
Wood [kg]				$P_w = 0$
Heating gas [Nmc]				$P_g = -1462$
Diesel oil [l]				$P_D = -1233$
Pollution* [kg] W_{ij}				
CO_2				$W_{CO_2} = 6045$
SO_x				$W_{SO_x} = 4.55$
NO_x				$W_{NO_x} = 17.08$
PST				$W_{PST} = 2.77$
Labour employment V_{Lj}				
Number of employees	−4	−5	−4	$V_L = -13$
Process Main products	1200 modules	1200 beds let	2400 transp. linen	

* Emission Factor values sources: US-EPA & OAQPS (1998)

Table 7. Case study D, no Imports M and solar panels

	Case studies			
	Accounting, present situation	B no Imports M	C only Imports M	D no Imports M, solar panels
Pollution produced [kg]				
Total CO2	24533	25488	21659.2	6045
Total SOx	7.41	8.55	4	4.55
Total NOx	40.12	43.67	29.46	17.08
Total PST	348.1	348.80	346.17	2.77
Labour				
Total number of employees	11	13	5	13

Table 8. Summary and direct comparison of the four cases considered

5 Conclusions

The input-output approach described herein is based upon processes and their input-output relationships. This is used to develop a specific model for the hotel supply chain located in a natural park area recently established in South Italy whose economic development plan accounts for tourism as the main economic activity to be expanded for future development of the area, as long as it complies with sustainable development issues. Tourism increased demand may present some drawbacks because the new need of energy may increase pollution. The input-output model presented in this work is very easy to implement and flexible and allows to evaluate the environmental impact of the main lodging companies already existing in the park. Also, as a planning tool it allows to estimate the effects of environmental and energy constraints on production processes and to examine alternative energy sources use. Many environmental problems may in fact be solved with a higher degree of self-sufficiency at local level, and higher use of renewable energy sources.

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LABOR PRODUCTIVITY DECOMPOSITION: GENERATION AND BENEFIT SPILLOVER

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Industrial sectoral productivity may be decomposed into the causes behind its generation, *labor reduction* and *output expansion*. Another decomposition may be in its *induced*, *direct* and *indirect* components using the Taylor expansion of output. Such a decomposition may be applied to production and allocation of gross output. Production indicates the *generation* and allocation the *benefit spillover* of productivity. Each round of Taylor's expansion indicates identical overall productivity in both activities that differs in terms of its decomposition. The *change* and the *magnitude* of productivity are examined in a comparative aspect. Furnished empirical evidence is based on Turkish interindustry data.

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Keywords: Input-Output, Labor Productivity.

1 Methodology

Labor productivity (π) of a given sector (j) is measured as the gross output (x) produced by a unit of labor (L)[3] at a given time (t), as:

$$\pi = x_j / L_j \qquad \text{or} \qquad \pi = \langle \mathbf{L} \rangle^{-1} \mathbf{x} \tag{1}$$

Gross output of sector (j) is generated by a process involving the interdependence among all sectors in the economy in terms of the direct and indirect inputs of this sector, that are sales from other sectors, the sectoral final use and value added. Defining $\mathbf{A}$ as the direct input requirement matrix (value of purchases per unit of output), $\mathbf{B}$ as the direct output allocation matrix (value sales per unit of output), $\mathbf{y}$ as the column vector of final use, and $\mathbf{v}^T$ as the row vector of value added, then gross output is:

$$\mathbf{x} = [\mathbf{I} - \mathbf{A}]^{-1} \mathbf{y} \qquad \text{or} \qquad \mathbf{x}^T = \mathbf{v}^T [\mathbf{I} - \mathbf{B}]^{-1} \tag{2}$$

In accounting terms, gross output is viewed either as intermediate output and final use, $\mathbf{x} = \mathbf{X}\mathbf{i} + \mathbf{y}$, or as intermediate input and value added, $\mathbf{x}^T =$

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[3] $\langle \mathbf{L} \rangle$ indicates a diagonal matrix.

$\mathbf{i}^T\mathbf{X}+\mathbf{v}^T$. In analytical terms, the interdependence among various sectors in terms of gross output may be broken down into the *induced*, $\mathbf{Iy}$, *direct*, $\mathbf{Ay}$, and *indirect*, $\mathbf{A}^*\mathbf{y} = \mathbf{A}^2\mathbf{y}+\mathbf{A}^3\mathbf{y}+\ldots+\mathbf{A}^n\mathbf{y}$, components of the production-final use approach as

$$\mathbf{x} = [\mathbf{I}-\mathbf{A}]^{-1}\mathbf{y} = \mathbf{Iy}+\mathbf{Ay}+\mathbf{A}^2\mathbf{y}+\mathbf{A}^3\mathbf{y}+\ldots+\mathbf{A}^n\mathbf{y} \qquad (3.1)$$

or equivalently, the allocation-value added approach as

$$\mathbf{x}^T = \mathbf{v}^T[\mathbf{I}-\mathbf{B}]^{-1} = \mathbf{v}^T\mathbf{I}+\mathbf{v}^T\mathbf{B}+\mathbf{v}^T\mathbf{B}^2+\mathbf{v}^T\mathbf{B}^3+\ldots+\mathbf{v}^T\mathbf{B}^n \qquad (3.2)$$

with the *induced*, $\mathbf{v}^T\mathbf{I}$, *direct*, $\mathbf{v}^T\mathbf{B}$, and *indirect* components[4] $\mathbf{v}^T\mathbf{B}^* = \mathbf{v}^T\mathbf{B}^2+\mathbf{v}^T\mathbf{B}^3+\ldots+\mathbf{v}^T\mathbf{B}^n$.

Sectoral productivity π then may be analyzed (column-wise) by substituting gross output with the various rounds of production process as they relate labor to final use, direct and indirect input requirement aspects of gross output as

$$\pi = \left(\langle\mathbf{L}\rangle^{-1}\mathbf{Iy}\right)+\left(\langle\mathbf{L}\rangle^{-1}\mathbf{Ay}\right)+\left(\langle\mathbf{L}\rangle^{-1}\mathbf{A}^2\mathbf{y}+\ldots+\langle\mathbf{L}\rangle^{-1}\mathbf{A}^n\mathbf{y}\right) \qquad (4.1)$$

or (row-wise) by relating labor to value added, direct and indirect allocation aspects of gross output, as:

$$\pi = \left(\mathbf{v}^T\mathbf{I}\langle\mathbf{L}\rangle^{-1}\right)+\left(\mathbf{v}^T\mathbf{B}\langle\mathbf{L}\rangle^{-1}\right)+\left(\mathbf{v}^T\mathbf{B}^2\langle\mathbf{L}\rangle^{-1}+\ldots+\mathbf{v}^T\mathbf{B}^n\langle\mathbf{L}\rangle^{-1}\right) \quad (4.2)$$

Although there is not a one-to-one correspondence between respective vector elements defined in (4.1) and (4.2), the sectoral summation, on the left hand side of the equations, i.e. the respective column (4.1) or row (4.2) elements are the same. *Table 1* shows productivity rates of the Turkish economy for the 1990 based on the (4.1) and (4.2) formulas.

Induced productivity may be seen either from its final use or value added point of view. Although there is a balance between the two approaches, variations exist between the two aspects of their decomposition. Productivity rate induced by final use $(\langle\mathbf{L}\rangle^{-1}\mathbf{Iy})$ measures the final use part of gross output per sectoral employment. The direct input requirement part of gross output related to employment is the direct input productivity rate $(\langle\mathbf{L}\rangle^{-1}\mathbf{Ay})$, while the indirect input requirement part of gross output related to employment is the indirect input productivity rate $(\langle\mathbf{L}\rangle^{-1}\mathbf{A}^*\mathbf{y})$. The same value of gross output $\mathbf{x}$ viewed from the allocation point of view provides the value added induced productivity rate $(\mathbf{v}^T\mathbf{I}\langle\mathbf{L}\rangle^{-1})$, the direct allocation (sales) productivity rate $(\mathbf{v}^T\mathbf{B}\langle\mathbf{L}\rangle^{-1})$, and the indirect allocation (sales) productivity rate $(\mathbf{v}^T\mathbf{B}^*\langle\mathbf{L}\rangle^{-1})$.

The proposed methodology in this paper, although accepting the conceptual difference between direct and total labor productivity, clarifies previous work[5] on the subject. Previously, direct sectoral productivity was

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[4] The related discussion on p. 28 of Adamou (1995) and the numerical evidence in the following sections refute the statement "*Taylor's expansion is an extreme implausible case limited to uneven sector growth in allocation model*" on p. 207 of Oosterhaven (1988).

[5] Panethymitakis A. (1993). The same results are reported in Greek in Panethymitakis (1992) p. 61 and p. 69.

measured as $\alpha = 1/\gamma = \mathbf{x}/\mathbf{L}$, and total productivity was evaluated as $\eta = \mathbf{i}\langle\mathbf{L}/\mathbf{x}\rangle[\mathbf{I}-\mathbf{A}]^{-1}$. Applying such measurements yield total productivity estimates (p. 86) lower than direct productivity (p. 83) estimates, implying negative indirect productivity for all manufacturing sectors of the Greek economy for the years 1958, 1966, 1970 & 1980, as well as all manufacturing sectors for 1970 for France, Germany, Italy, Holland and Belgium.

The clarified methodology associates sectoral total productivity to sectoral total gross output, and direct productivity to output that comes out from direct requirement (allocation) coefficients. Consequently, sectoral indirect productivity is associated to the sectoral indirect requirement (allocation) coefficients. As a result, in this study $\mathbf{x}/\mathbf{L} = \pi$ measures total and not direct productivity.

The assumed total productivity of previous work is the summation of the column elements of the Leontief inverse premultiplied by the diagonal matrix of the employment coefficients

$$\eta = \mathbf{i}\langle\hat{\gamma}\rangle[\mathbf{I}-\mathbf{A}]^{-1} = \begin{pmatrix}1 & 1\end{pmatrix}\begin{pmatrix}l_1/x_1 & 0\\ 0 & l_2/x_2\end{pmatrix}\begin{pmatrix}z_{11} & z_{12}\\ z_{21} & z_{22}\end{pmatrix}$$

This yields a summation of ratios with different denominators that a computer may add it numerically without an identification of this fact

$$\begin{pmatrix}\frac{l_1}{x_1}z_{11}+\frac{l_2}{x_2}z_{21} & \frac{l_1}{x_1}z_{12}+\frac{l_2}{x_2}z_{22}\end{pmatrix}$$

An algebraic summation of ratios however requires the same denominators. In this case, the resulted formula

$$\begin{pmatrix}\frac{x_2l_1z_{11}+x_1l_2z_{21}}{x_1x_2} & \frac{x_2l_1z_{12}+x_1l_2z_{22}}{x_1x_2}\end{pmatrix}$$

lacks of a meaning.

The *rate of productivity change* is measured by the natural logarithm of the productivity ratio between two time periods,

$$\lambda_{t,t+T} = \log\frac{\pi_{t+T}}{\pi_t} \tag{5}$$

while the *annual average rate of labor productivity* change for the period weights the rate of productivity change by the length of the examined time interval, as

$$\Lambda_{t,t+T} = \frac{\lambda_{t,t+T}}{T} \qquad \text{or} \qquad \Lambda_{t,t+T} = \frac{\log\left(\frac{x_{t+T}/L_{t+T}}{x_t/L_t}\right)}{T}. \tag{6}$$

It is important to identify sectors with high labor productivity as well as sectors with significant annual average rate of labor productivity change.

Furthermore, it is useful to decompose the average annual rate of productivity change into average annual rate of productivity change due to *employment reduction*, and average annual rate of productivity change due to *output expansion*. *Figure 2* depicts such a classification. There is an additive relationship between the above two components

$$\Lambda_{t,t+T} = \frac{\log L_t - \log L_{t+T}}{T} + \frac{\log x_{t+T} - \log x_t}{T} \ . \tag{6.1}$$

When attempting to compute average annual rates of productivity change of the induced, direct and indirect elements of gross output of production and allocation approaches, one must be careful since there is not additive principle here that leads to the average annual rate of the overall productivity change.

A summary index for the examined period is provided utilizing the Mahalanobis distance. Mahalanobis distance is the distance of each point from the multivariate mean (centroid) (Stevens, 1992, p. 39). Mahalanobis distance takes into account the correlation structure of the involved data as well as their individual scales, and it is calculated as:

$$d_i = \sqrt{(q_i - \overline{q})^T S^{-1} (q_i - \overline{q})} \ , \tag{7}$$

where q_i is the data of the *i*th row, $\overline{q}$ is the row of means, and S^{-1} the estimated covariance matrix. Since the extreme multivariate outliers can be identified by the highlighting points with the largest distance values, it is useful to identify the sectors where most of the productivity, productivity change, output and employment occur.

2 An Empirical Perspective: Productivity in Turkey

The 1973, 1979, 1985 and 1990 input-output tables for Turkey in constant 1973 prices of 23 sectors provide an empirical evidence for the above methodological arguments. The sectoral composition of the employment structure does not show significant changes throughout the examined period. One of the characteristics of the import substitution era is low employment generation due to capital intensive technology adoption in industry partly in response to the high ratio of labor cost to capital cost. The liberal era produced a similar outcome regarding employment; suppressed real wages in the early years have not encouraged a shift to labor intensive production. There was indeed a manufacturing exports boom during the '80s, but employment generation in the manufacturing industry was lowest when compared to agriculture and services (Senses, 1990).

Table 1 provides the productivity rates for the last Turkish interindustry table for 1990 based on the formulas (4.1) and (4.2). The ranking of industrial sectors is based on the magnitude of the overall labor productivity rate. The overall productivity rate is decomposed into the productivity rate induced by final demand, productivity rate of direct purchases and productivity rate of the indirect purchases from one side and into the productivity rate induced by value added, productivity rate of direct sales and productivity rate of indirect sales on the other.

		Total	(4.1)			(4.1)		
			Induced by Final Demand	Direct Purchases	Indirect Purchases	Induced by Value Added	Direct Sales	Indirect Sales
8	Oil Refining	0.887	0.041 5%	0.499 56%	0.346 39%	0.740 83%	0.107 12%	0.040 4%
5	Wood-Furnit.	0.454	0.160	0.219	0.075	0.149	0.177	0.128
16	Other Manuf.	0.369	0.315	0.037	0.017	0.264	0.065	0.040
17	Utilities	0.322	0.079	0.113	0.130	0.220	0.072	0.031
9	Rubber-Plast.	0.279	0.109	0.102	0.068	0.169	0.072	0.038
3	Food-Bever.	0.259	0.186	0.050	0.023	0.100	0.102	0.057
11	Iron-Steel	0.253	0.046	0.132	0.076	0.146	0.068	0.039
7	Chemicals	0.241	0.113	0.072	0.056	0.143	0.064	0.034
14	Electrical M.	0.232	0.152	0.053	0.027	0.151	0.051	0.030
20	Transp Serv.	0.199	0.130	0.043	0.026	0.136	0.043	0.019
12	Metal Prod.	0.192	0.124	0.044	0.023	0.081	0.067	0.043
15	Transport V.	0.170	0.091	0.050	0.029	0.079	0.051	0.040
13	Machinery	0.168	0.131	0.022	0.015	0.089	0.047	0.032
6	Paper-Print.	0.151	0.063	0.046	0.042	0.060	0.051	0.040
18	Construction	0.126	0.126	0.000	0.000	0.064	0.036	0.026
4	Textiles	0.118	0.081	0.025	0.012	0.042	0.042	0.033
19	Trade	0.084	0.059	0.016	0.009	0.059	0.017	0.008
10	Glass-Cement	0.081	0.014	0.059	0.008	0.043	0.025	0.013
23	Public Serv.	0.075	0.075	0.000	0.000	0.075	0.000	0.000
2	Mining	0.067	0.027	0.019	0.021	0.052	0.010	0.005
22	Pers Serv&H.	0.065	0.041	0.015	0.009	0.054	0.008	0.004
21	Banking	0.053	0.005	0.030	0.019	0.038	0.011	0.004
1	Agriculture	0.029	0.018	0.007	0.004	0.022	0.005	0.002
	Over All	0.078	0.050	0.018	0.010	0.050	0.018	0.010

Table 1. Sectoral Productivity Rates (x/L) in Turkey - 1990

It is noticeable that the distribution of sectors according to their productivity is skewed, with few productive, and other not very productive sectors. The sector with the highest productivity rate is Oil Refining. Figures 1-A and 1-B provide the intertemporal view of the productivity rates of Oil Refining. *Figure 1-A* presents the double view of the formation of productivity's magnitude, while *Figure 1-B* reveals the percentage unit decomposition. The right side of each figure presents the production (cost) aspect of productivity's decomposition while the left side the allocation (revenue) side. Production and allocation aspects of the analysis are equivalent. The symmetrical similarity of the two approaches (Adamou, 1995) resolves the discussion about the plausibility of the supply side model in its relation to the original Leontief ones. Since the value of gross output appears as revenue from sales (row transactions) or cost from purchases (column transactions).

The productivity rate of Oil Refining [8] is outstanding, indeed quite above average. This sector is highly capital intensive employing qualified labor, and not only is the sector reflecting the highest productivity, but it has larger productivity fluctuations as well. Labor productivity declines in 1979 and 1990, while it is much higher in 1973 and 1980. Total productivity decomposition of Oil Refining from its demand side indicates that direct requirements dominate the picture, holding from 47% to 56%.

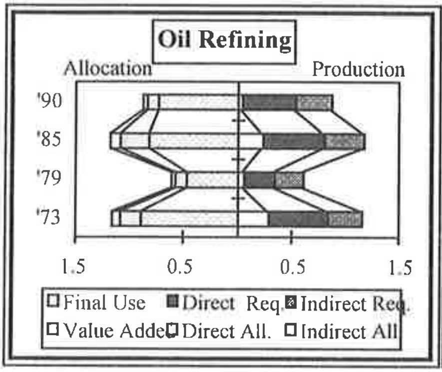

Figure 1-A

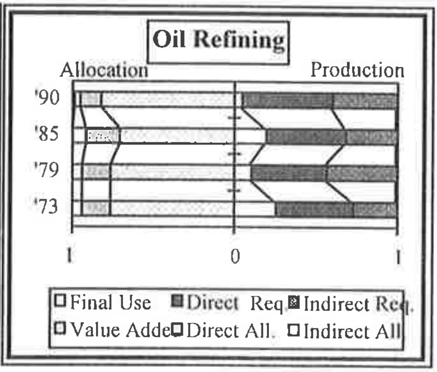

Figure 1-B

On the other hand, there is a significant increase of the indirect productivity from 28% to 39%, and reduction of the final use induced productivity from 26% to 5%. On the allocation side, the high productivity in Oil Refining results in a significant portion of value added, that increases from 77% to 83%. A single common characteristic of the examined above sectors indicating high productivity is that all furnish a serious component of value added, and all, with the exception of Oil Refining, have their highest productivity in 1990. This reveals that the change in economic policies did have an impact on the sectors with the highest productivity.

Highly productive sector may not necessarily indicate significant productivity change, like Wood & Furniture [5] and Utilities [17]. Thus, we can identify highly productive sectors from the above analysis, but the change with respect to sub-periods calls for further analysis. Besides the fact that productivity declined for Oil Refining, Oil Refining is still the sector with the highest total productivity in all examined years, and the sector with the largest average annual rate of productivity change. On the other hand, Rubber & Plastics [9], Construction [18], and Other Manufacturing [16] turn out to be those sectors with the highest productivity increases in the long run. As noted above the sub-period 1973-1979 suffers from the bottlenecks due to foreign exchange unavailability, which hit payments for petroleum most, a commodity Turkey has to import for more than 75% of its consumption. The recovery for Oil Refining during 1979-1985 is partly offset by declines in the other subperiods.

Figure 2 syntheses the Mahalanobis distances of total productivity and the Mahalanobis distances of annual rate of total productivity change over the entire period under examination. Sectors Oil refining [8], Other Manufacturing [16], Iron & Steel [11], Rubber & Plastics [9] and Electrical Machinery [14] are those with the higher overall productivity and at the same time larger annual rate of productivity change. Although Wood & Furniture [5] and Utilities [17] show high productivity they do not have significant productivity changes.

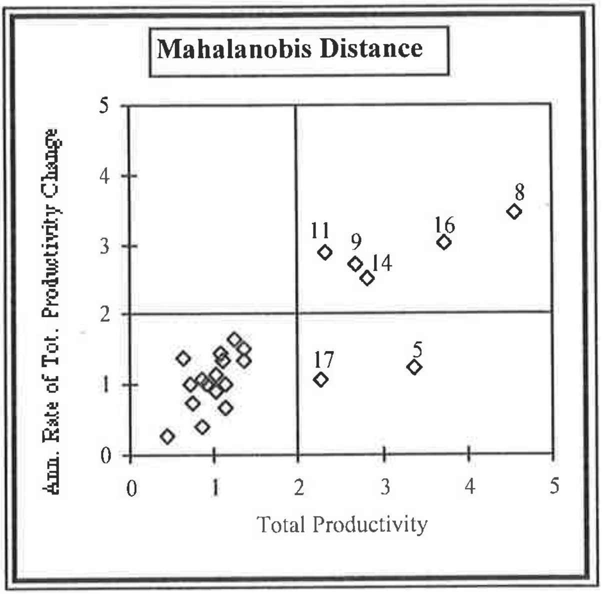

Figure 2

The decomposition of *average annual rate of productivity change* into the two aspects that contribute to productivity, *output expansion* and *labor reduction*, shows that all sectors show significant gains in average annual rate of productivity change with respect to output expansion, but not to labor reduction (*negative results*). While Electrical Machinery [14] for example had the highest change in productivity due to output expansion, it had the second largest reduction in productivity rate due to labor increase. Utilities [5], although the third highest sector in terms of productivity and the forth sector in terms of average annual rate of productivity change due to output expansion, indicates the highest (negative) rate of change in labor increase.

Figure 3 summarizes average annual rate of productivity change of output expansion and labor reduction in terms of their Mahalanobis distance. All sectors do not indicate employment reduction as a source for productivity change for the period 1973-1990, with the exception of Agriculture [1] for the first two subperiods and Mining [2] and Food & Beverage [3] for the last subperiod. The sectors with the most output expansion are Electrical Machinery [14] and Other Manufacturing [16], while those with the largest change in employment are Rubber and Plastics [9] and Oil Refining [8].

Figure 4 provides a different view of the above picture, focusing on the annual average change of the labor productivity rates for the entire period under examination. Data of the labor productivity rates and not the Mahalanobis distance based upon them are sorted in this picture from the largest to the smallest overall annual average change in the labor productivity rate.

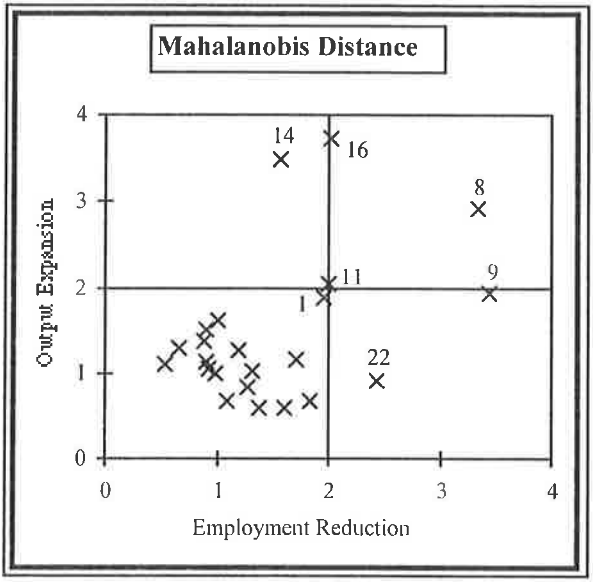

Figure 3

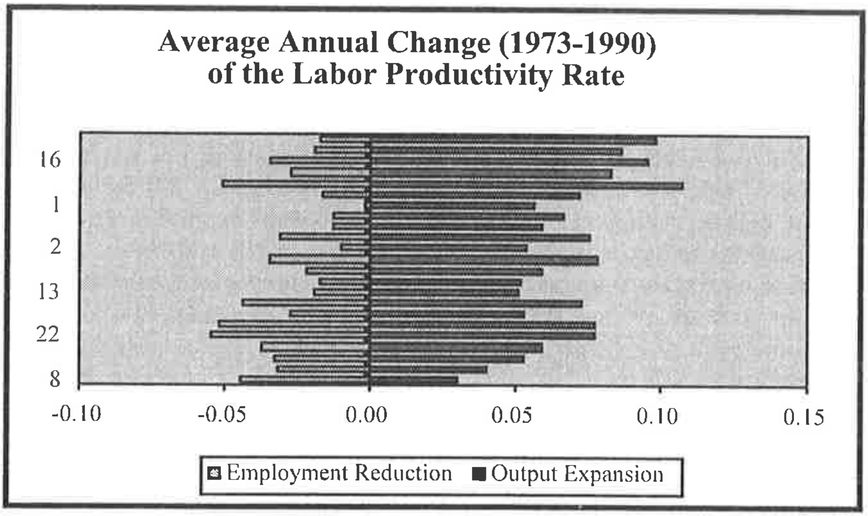

Figure 4

The three general results of our step-wise type of analysis are as follows: Firstly, dominant sectors in the economy in terms of gross output and employment are not necessarily high productive sectors. Secondly, dominant sectors in terms of productivity (π) in selected years are not necessarily leading in productivity changes (Λ). Thirdly, sources of both productivity rates and productivity changes might not be the same for the sectors. Depending on their significant roles as purchasers and/or sales of intermediate inputs and/or as final use suppliers and/or value added generators, sectors have differing impacts in the dynamics of the production system.

The findings of previous research on Turkish productivity are not directly comparable to this study (e.g., Aydogus, 1990; Eser and Eser, 1995; Günlük-Senesen, 1998; Özmucur and Karatas, 1990; Senesen and Erol, 1995; Yildirim, 1989). It should be noted that a general increase of productivity in the economy is observed, mainly due to the increased capacity utilization in the post-1980 era, with a downward investment trend, mainly in public investments. Findings of Karakayali (1995) regarding total factor productivity change in the post 1980 era show that Oil Refining, Iron & Steel, Rubber & Plastics and Electrical Machinery are significant sectors, Oil Refining being the most significant. The relationships of total productivity with scale, capital per worker and exports are found to be insignificant. A tentative conclusion then would be that the export-promotion era has had little impact on productivity, investment being stagnant, while increased labor productivity might be considered as a very significant contributing factor in productivity.

The Turkish production system is highly import dependent in intermediate inputs besides oil. A foreign exchange bottleneck hit the production system very severely as was observed in 1979. The post-1980 period is marked by accumulated foreign debt. This phenomenon then calls for an examination of productivity focusing on the contribution of imports. Such research would also facilitate an evaluation of the performance of the import substitution policies.

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ECONOMIC-ECOLOGICAL MODEL FOR POLAND

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Applied mathematical models are tools used to support policy and decision making processes in economy. In the late sixties and at the beginning of the seventies, following the rising interest of economists in environmental results of economic activities, first economic-ecological models appeared. They concerned economies at various level of aggregation, such as:

- regional level (e.g. Cumberland 1966),
- interregional level (e.g. Isard 1968, 1971),
- country level (e.g. Daly 1968, Victor 1972),
- global level (e.g. Leontief 1973, Carter at. al. 1976).

There are more and more applied mathematical models which depict the economic structures linked with the environment (e.g. Conrad and Schmidt 1995, Meyer 1998, Barker 1999). Input-output techniques are widely used in models of this type because of their simplicity and the clarity of depicting links between elements in complex systems. The possibility of dividing economy as well as the environment into many sectors is crucial however.

Economic modeling has over thirty year tradition in Poland, but until mid-1990s no empirical economic-ecological models had been built. The explanation of this is that in the past in Poland, like in all countries under the centrally planned economy regime, the environment was not metered as the most important task was to "fulfill" the production plans. The situation changed in the nineties, when the transition from a centrally planned economy to a market one was started. The rising interest in the environmental effects of economic activity is caused not only by the rising awareness in the society but also by the necessity to fulfill high standards which is a precondition of the accession process to the European Union.

The economic-ecological model presented in the paper is the pioneer approach to build a versatile model of this type for Poland. The model is an IMPEC extension being a macroeconomic sectoral model of the Inforum type for Poland (Orłowski and Tomaszewicz 1991), so the main features of the IMPEC model are described first. Then approaches to economic-ecological modeling are discussed and the environmental block of the IMPEC model[1] is characterized. Finally, to exemplify the model use, government plans to reduce CO_2 emissions are verified using the model results.

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[1] IMPEC is an acronym standing for Interindustry Model of the Polish EConomy.

1 The inforum-type model of Polish economy

The model IMPEC is a multisectoral macro model. This means that both industrial and macroeconomic variables are considered within the model. The model builds macroeconomic variables using industrial details (a "bottom up" approach). It is constructed around an input-output core but it also makes use of behavioral equations. The author of the approach is Clopper Almon who developed this model for the US economy in the early 1960s, and continues his effort within the project INFORUM (Almon 1991).

The history of the IMPEC model started in the early eighties. From the beginning the model builders have collaborated with the INFORUM team. In the near future IMPEC will be integrated into the INFORUM International Forecasting System.

IMPEC uses much of INFORUM philosophy. On the other hand, there are some areas where IMPEC differs from the INFORUM approach. In 1980's the differences resulted mainly from different economic systems being described by the original model (market economy) and the IMPEC (centrally planed economy). Although market economy regulations were introduced in Poland in 1990's, but Poland is still in transition from one economic regime to another. The main reasons for the modeling of economies in transition being different from the modeling of developed economies are listed below (Balcerak at al. 1997).

1. The *lack of the transfition period theory*, hence the problem to what extent the theory of market economy can be applied, when the economy is described by means of econometric equations. This problem should be taken into account when analyzing the proposed specification of equations in the IMPEC model.

2. *Unavailability of long enough time-series data* on the new economic regime, as the "old" time series reflect the period of the supply economy.

    - The lack of time series is also due to the switch from the old classification of economy (Classification of National Economy) to the new one (NACE). Since the beginning of the '90s the official statistical system has been adjusted to the new social and economic environment and harmonized with standards applied in international statistics. Old methodologies, classifications and terminology are replaced by the UN, Eurostat and the OECD.
    - The use of the previous data makes it necessary to adopt special procedures in order to unify the statistical information, for example: guess-estimates disequilibrium indicators, procedures aimed at reducing the number of explanatory variables, etc. In the model presented below we adopt some of the procedures mentioned above with different lengths of time-series for different categories.

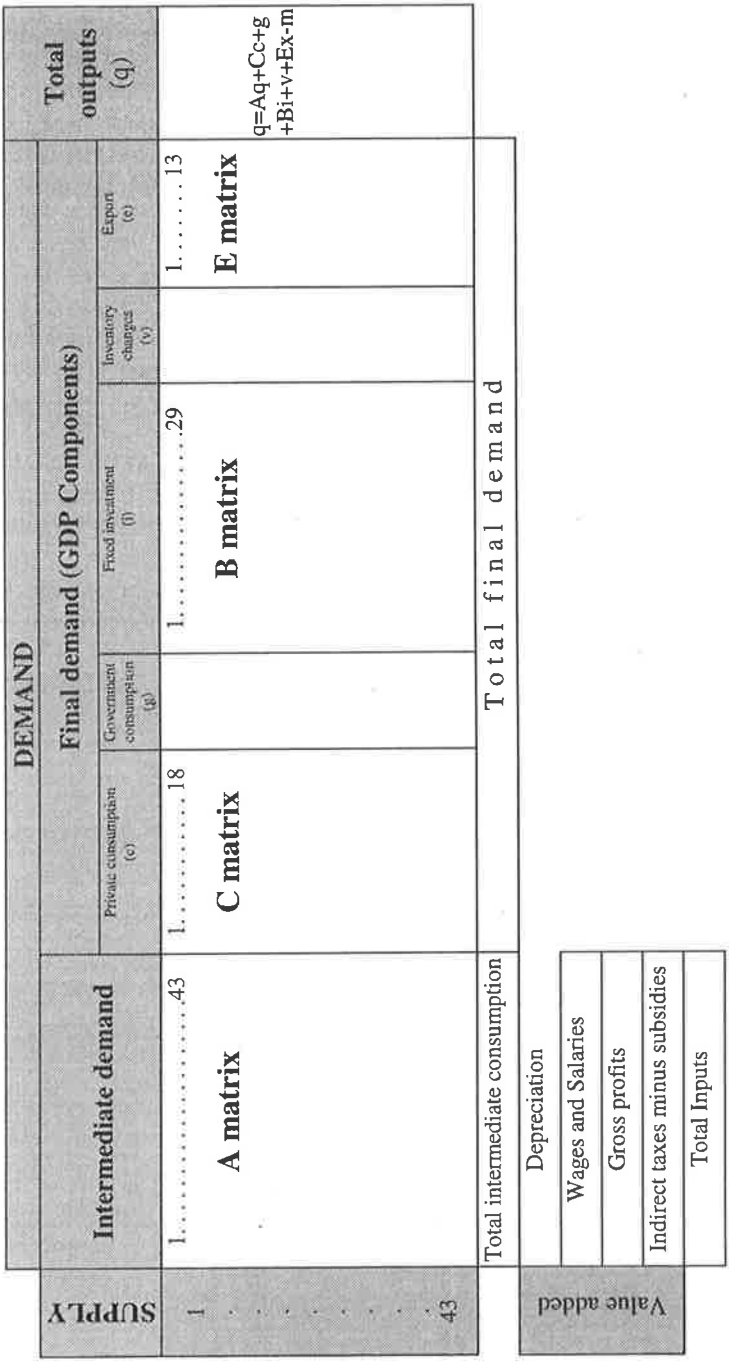


Figure 1. Input-output accounting framework for the IMPEC model

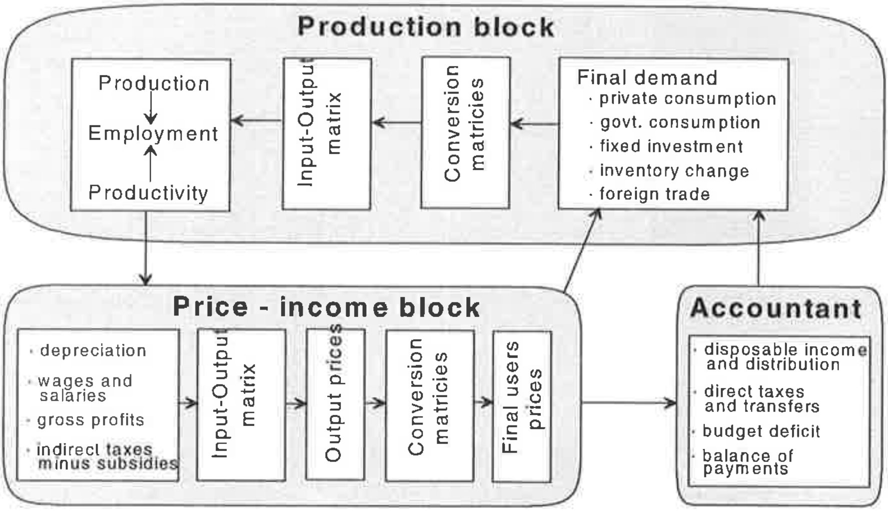
3. Unavailability of new input-output tables. The switch from MPS to SNA, which poses especially difficult tasks for the input-output modelers. In the case of the IMPEC model, we used an input-output table close to the 1990 SNA statistics. It was constructed by the Center of Economic and Statistical Research, Central Statistical Office, on IMPEC-group's special order. Official SNA input-output tables were unavailable until 1999, when the matrix of interindustry flows for the year of 1995 was published.

The input-output accounting framework of the IMPEC model is shown in *Figure 1*. The current version of the model consists of 38 types of activities in the sphere of the so-called material production and 5 activities belonging to the sphere of non-material services. The disaggregation is in agreement with the sector-activity classification for Polish economy to be found in the SNA input-output table for 1990.

Equations for the final demand elements are either at the level of categories typical of a given group of final users' (households' consumption – 18 categories, exports by 13 groups of products, investment demand in 29 groups of sectors) or they are expressed globally (inventories, government expenditures). Relevant conversion matrices (or vectors) link categories of final demand (households', government, investment and export demand) with sectors of economic activity.

Value added is disggregated into the following categories: wages, depreciation, gross profits and indirect taxes minus subsidies.

The model operates as follows (*see Figure 2*):



Source: Prepared by the author

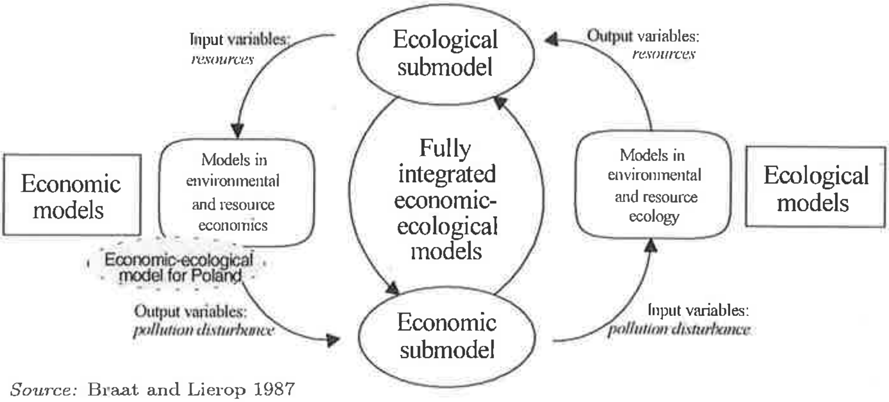
Figure 2. The solution process of the IMPEC model

- Final demand categories are generated:
  - household demand, "driven" by incomes and relative prices,
  - investment demand, determined by changes in economic activity, the foreign direct investment and the lagged investment outlays,
  - inventories, determined by the volume of output,
  - exports, determined by the world demand, relative prices and foreign direct investment,
  - government demand (exogenous).
- Demand for products is generated using input-output relationships.
- Imports, which depend on the volume of output and relative prices, are obtained in a feedback with the volume of output.
- Labor productivity is computed as the function of capital efficiency and time variable.
- Demand for products and labor productivity determines employment.
- Wages by industry depend on inflation and labor productivity.
- Unit value added by industry is the sum of its components and depends mainly on labor costs.
- To determine both producers prices and prices of final demand categories the input - output price approach is used.
- Incomes (households, corporations and government) are determined by a set of identities. The elements of the identities are calculated in other parts of the model or found using given parameters (such as tax rates) some of them are completely exogenous to the model.

2 Economic-ecological models

There are different ways to build a model accounting for both economic and environmental problems. The difficulty in overcoming the building problems of such a model is that economic variables are usually measured in monetary units whereas ecological variables require to be measured in natural units. Typically economic-ecological models are developed as extensions of the existing models. This situation is shown in *Figure 3*.

At the extreme left and right hand sides of the figure two different mono disciplinary models are shown: economic and ecological models, respectively. In the center of the figure there are fully integrated economic-ecological models. They can be treated as separate sub models, linked by the resource and pollution data flow.



Source: Braat and Lierop 1987

Figure 3. Mono disciplinary and multidisciplinary model types

The economic-ecological model for Poland considered in the paper is an IMPEC extension which is a typical economic model. That is why the economic-ecological model for Poland is marked to the left from the central point of Figure 3.

As it was mentioned above flows between the environment and economy relate to resources used and pollutants emitted by the economic system. This is shown in *Figure 4*.

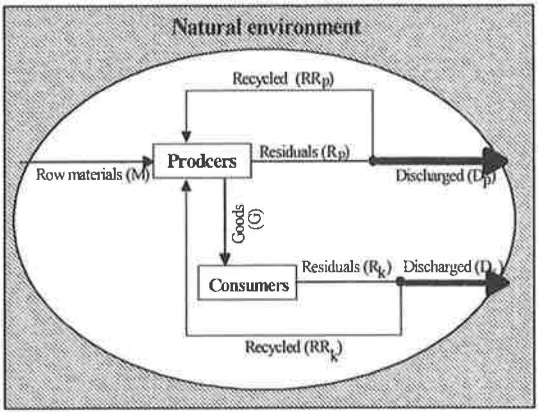
The present economic-ecological model for Poland only includes the pollution block and the resource block will be developed in the future. There are no "recycling" sectors in the input-output table used in the model. This means that now only discharged parts of residuals are included in the model, which is depicted in Figure 4 using thick lines. Nevertheless, the changes in the recycling activity of the economy can be reflected in the model by changes in the emission coefficients.

Economy both depends on and influences all the natural environment components, that is

- lithosphere (soil, rocks),
- hydrosphere (waters),
- atmosphere (air).

This means that the components are used by the economy as resource "containers" (dependency of economy on environment) as well as "containers" for externalities (pollution) being a result of production and consumption (influence of economy on the environment) — see Figure 4. Using the environment as the container for pollution may have many negative effects on its components. Generally, they are classified as:

- local
- regional
- global



Source: Field 1997

Figure 4. The Environment and the Economy

The larger geographical area the problem concerns, the more difficult it is to solve. The difficulties become extreme, when the problem affects more countries. That is why global environmental problems seem to be particularly hazardous for the mankind. Air pollution is seldom the local problem, because various kinds of air pollutants may be easily carried for long distances, from one place to another. They can travel across the continents. They can circulate in the Earth's atmosphere. In addition they can be raised to the stratosphere and violate its natural composition. This is why air pollution control is treated as one of the most vital problems that the mankind confronts today.

The possible dangers which result from an uncontrolled emission of gases are shown in *Table 1*.

	Global			Regional	Local
	Greenhouse effect		Ozone layer depletion		
	directly	indirectly			
CO_2	●				
CH_4	●	●			
N_2O	●		●		
CFCs	●	●	●		
NO_x		●	●	●	●
CO		●		●	●
NMVOC		●		●	●
SO_2	●			●	●
NH_2	●			●	●
Dust	●			●	●

Source: Air Pollution..., 1997

Table 1. Influence of air pollutants on the environment

3 Environmental block of the IMPEC model

The first stage to build a simple emission block for an existing sectoral model is to use the data on emissions and the output by sectors to estimate direct pollutants coefficients (emission factors):

$$ec_{zjt} = \frac{e_{zjt}}{X_{jt}} , \tag{1}$$

where:

ec emission coefficient,
e emission (in natural units),
X value of output,
z pollutant,
j sector of economy,
t time.

Changes of the emission factors over time can be estimated econometrically and then forecasted. Future changes of the coefficients can be also estimated by experts from different branches of economy. Emissions can be easily calculated as the product of the emission coefficients and output:

$$E_t = EC_t \cdot X_t , \tag{2}$$

where:

$\mathbf{E}$ vector of emissions,
$\mathbf{EC}$ direct pollutants coefficients matrix,
$\mathbf{X}$ vector of output taken from the sectoral model.

This used to be the way of modeling and forecasting emissions, especially concerning the air, within the model for Poland (Plich 1995). Data on pollution were compiled with the data on the Polish economy used in the IMPEC model. Due to the differences in sector classifications a lot of estimations had to be performed to arrive at the final result. Classification of pollutants and sectors used in the first environmentally extended version of the IMPEC model can be found in *Tables 2* and *3*.

Pollutant of...	Name	Abbreviation
Air	Dust	Dust
Air	Sulphur dioxide	SO_2
Air	Carbon oxide	CO
Air	Carbon dioxide	CO_2
Water	Waste water treated mechanicly	MechTreated
Water	Waste water treated chemically	ChemTreated
Water	Waste water treated biologically	BioTreated
Water	Crude waste water	Waste water
Land	Utilized waste	Utilized waste
Land	Neutralized waste	NeutralWaste
Land	Stored waste	Stored waste

Source: Prepared by the author

Table 2. Classification of pollutants in the model

No.	Name of the sector	Abbreviation
1	Coal mining	Coal
2	Fuel industry	Fuel
3	Power engineering	Power
4	Ferrous metallurgy	Ferrous
5	Nonferrous metallurgy	Nonferrous
6	Metal products	Metal
7	Machinery	Machinery
8	Precise equipment	Precise
9	Transportation means	TranspMeans
10	Electrical and electronic app.	ElectrElectronic
11	Chemicals (I)	Chemicals (I)
12	Chemicals (II)	Chemicals (II)
13	Construction materials	BuildMaterials
14	Glass	Glass
15	Ceramics	Ceramics
16	Wood products	WoodProd
17	Paper products	PaperProd
18	Textiles	Textiles
19	Clothing	Clothing
20	Leather	Leather
21	Food processing - animal	FoodAnimals
22	Food processing - plant	FoodPlant
23	Feed and utilization	Fodder
24	Printing	Printing
25	Other branches of industry	OthManuf
26	Residential building	ResConstr
27	Industrial construction	IndConstr
28	Special constructions	SpecConstr
29	Other branches of building construction	OtherConst
30	Agriculture - plant production	AgrPlant
31	Agriculture - animal production	AgrAnimal
32	Agricultural services	AgrServ
33	Forestry	Forestry
34	Transportation	Transport
35	Communication	Comme
36	Trade	Trade
37	Other industries	OtherInd
38	Municipal services	MunicServ
39	Housing	Housing
40	Education services	Education
41	Health services	Health
42	Other market services	MarketServ
43	Government services	GovtServ

Source: Prepared by the author

Table 3. Classification of sectors in the model

Lately, a new and more sophisticated modeling approach to air pollutants has been introduced. It follows the experiences of the German Inforum team in the construction of their PANTA RHEI model (Meyer and Ewerhart 1998).

Sources of air pollution

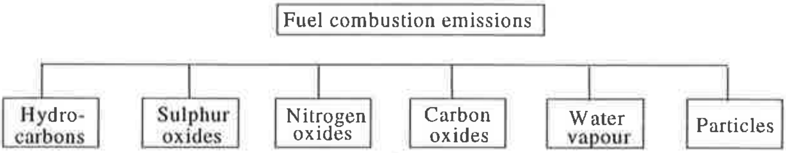
Sources of air pollution can be classified using a number of classification criteria. The most general partitions are the following:

- natural and anthropogenic (man-made) sources,
- stationary and mobile sources.

Anthropogenic sources of air pollution can be subdivided using types of economic activity as the criteria:

- energy production (fuels combustion, volatile fuel emission),
- industrial processes,
- solvent application,
- agriculture,
- changes in land use and forestry,
- wastes (waste sites, sewage treatment plants, waste combustion).

Taking into account only the anthropogenic sources it is easy to prove that the energy processes give off most of air pollution regardless of the methodology used in a survey, so in air pollution modeling one can concentrate on emissions from fuel combustion. Possible pollutants resulting from fuel combustion are shown in Figure 5.



Source: Air Pollution... 1997

Figure 5. Emissions resulting from the combustion processes

Emission from stationary sources

The emission of pollutants from stationary sources depends on many factors:

- Fuel type and quality,

– the content of carbon, sulfur, nitrogen and mineral matters,

– heating value.

- Method for reducing pollutant emission

- Type of technology:
- type of installation (boiler, furnace, gas turbine),
- type of burner,
- size, age and technical condition of the installation.

- Operating conditions:
- load,
- temperature,
- excess air,
- additions (water, ammonia, lime).

Emissions from mobile sources

Most means of transport (road, water and air) are defined as mobile sources of emissions. Means of transport are numbered among the greatest polluters of CO_2, NO_x, CO and VOCs as well as Pb (in the case leaded benzines are used).

As in the case of stationary sources emissions from mobile sources depend on many factors:

- engine size,
- age,
- emission reduction technology,
- type of fuel used
- other, such as: traffic conditions, average speeds, weather conditions, etc.

In our model only some of the emission determinants mentioned above are taken into consideration. The total emission of any pollutant under consideration depends on two factors:

- emission coefficients
- amount of fuel used

Only two main determinants of emission coefficients are taken into account:

- type of fuel
- sector of economy.

The equation for the volume of emission of any pollutant discharged by any sector using any energy carrier is the following:

$$e_{zkjt} = ec_{zkjt} \cdot f_{kjt} \ , \tag{3}$$

where:

e emission (in natural units),
ec emission factor (coefficient) - emission per unit of fuel used,
f fuel consumption (in energy units),
z type of pollutant,
j sector of economy,
k fuel type,
t year.

Other factors determining emission which are not explicitly taken into consideration in the above equation, such as the pollution reduction method at the end of pipe or the combustion method, can induce emission coefficients change. Their influence can be estimated using econometric methods.

The amount of fuel used by an individual installation or machine depends on the technical parameters. One of the parameters is the kind of fuel beeing used. Installations and machines in the sectors of economy can be grouped by the combusted fuel. "Average" technical parameters can be assigned to the groups (e.g., unit fuel use). The total amount of energy used by a sector of economy depends on the number of installations and machines and their "average" technical parameters. Additionally, the amount of emissions in a sector depends on the structure of fuel used in the sector. This structure can change over time varying market conditions (availability of particular fuel, prices) and the environmental protection legislation.

In the model the fuel use is determined on the basis of the following equation:

$$f_{kjt} = ff_{kjt} \cdot a^{(k)}_{ijt} X_{jt} \ , \tag{4}$$

where:

ff fuel factor
f fuel consumption (in energy units),
a fuel input coefficient
X value of output taken from the sectoral model
j sector of economy,
k fuel type,
t year.

Fuel factors and fuel input coefficients are defined as follows:

$$ff_{kjt} = \frac{f_{kjt}}{x^{(k)}_{ijt}} \qquad \text{and} \qquad a^{(k)}_{ijt} = \frac{x^{(k)}_{ijt}}{X_{jt}} \ , \tag{5}$$

where $x^{(k)}$ is the value of an interindustry flow from the energy sector which produces fuel k.

Changes in the fuel input coefficients can be estimated with econometric methods:

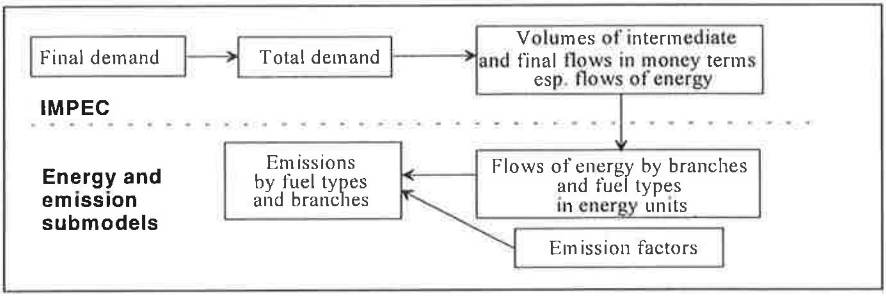
$$a_{ijt}^{(k)} = f\left(\frac{p_{kt}}{p_{Kt}}, t\right) , \tag{6}$$

where:

p prices,

K other fuels.

The links between the IMPEC model and the energy and emission submodels are presented in *Figure 6*.



Source: Prepared by the author

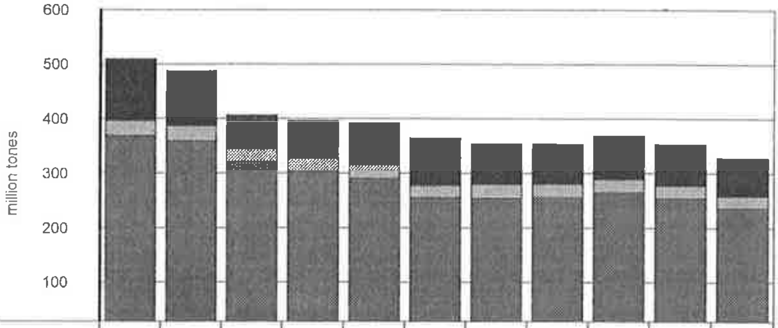
Figure 6. From final demand to emissions

4 CO_2 emission in Poland – evidence and scenarios

Let us concentrate on one pollutant – carbon dioxide, which is considered to be the main gas causing the greenhouse effect. In the past in Poland, like in all countries under a centrally planned economy regime, the emissions were not metered as the most important task was to "fulfill" production plans.

Environmental charges were introduced in Poland in the seventies, but in a centrally planned economy financial instruments failed due to the administered allocation of inputs and low price responsiveness of economic agents. Because in the 1970s and 1980s the environmental policy was ineffective, the charges were always treated as "too low" regardless of how high they really were (Zylicz 1994). It seems that the situation changed in 1990s, when the transition from a centrally planned to a market economy started. Despite very high fees introduced in 1990, in 1990 and 1991 the high rate of inflation and the rule of collecting charges after the end of the year in which they were assessed caused that the situation did not change. A modified legislation, which became effective in 1992, caused that positive changes can be observed. Now Poland belongs to the group of countries with the highest rates of pollution fees.

We illustrate the problem mentioned above in *Figures 7* and *8*. Figure 7 shows CO_2 emission between 1988 and 1998.

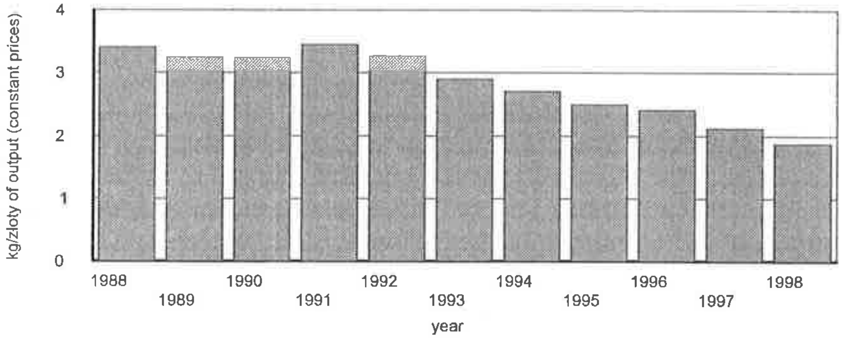


	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
▩ Industry	369,2	359,9	322,9	304,4	291,3	255,5	254,9	256,7	265,6	254,9	237,0
▨ Transport	27,2	27,2	22,6	23,8	25,0	23,2	25,1	24,3	23,9	22,9	21,3
■ Other sources	113,1	100,9	61,4	68,7	76,8	87,4	75,7	74,5	80,4	77,2	71,7

Source: Prepared by the author on the basis of Air Pollution... 1991-1997

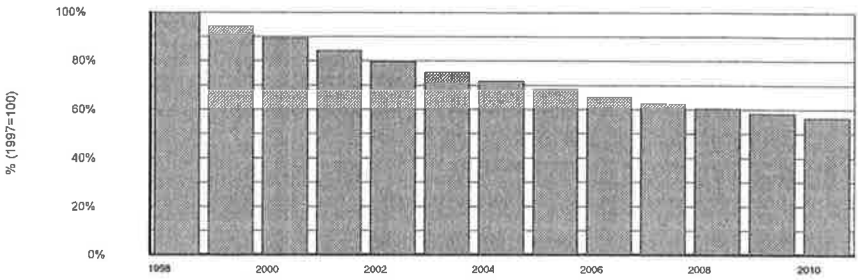
Figure 7. Emission of CO_2 in Poland

The decline in emissions observed between 1988 and 1991 is mainly due to the declining activity of Polish economy in that period. Another fall in the period 1992-1995 was due to positive changes (decline) in unit emission, which are shown in Figure 8. Although in Poland there are no charges on CO_2 emission but there are charges on other air pollutants such as carbon monoxide and sulfur dioxide, emitted together with carbon dioxide in fuels combustion processes. As we can see in Figure 8 the only reason for the increase in the level of emission after 1995 is the high activity of Polish economy.



Source: Prepared by the author on the basis of model's results

Figure 8. CO_2 emission/output ratio in Poland



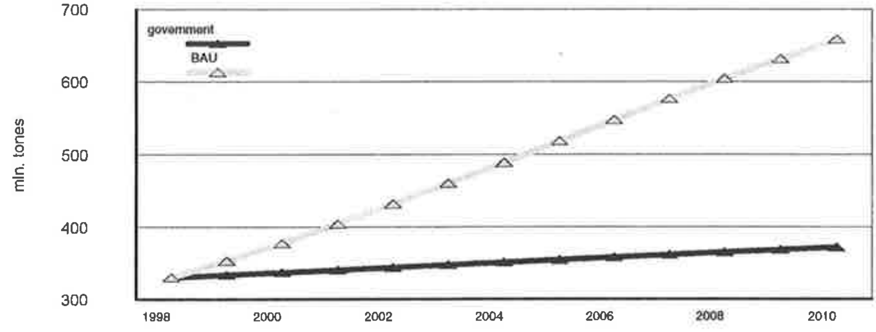
Source: Prepared by the author on the basis of model's results

Figure 9. CO_2 emission coefficients' decline according to governmental plans

According to the Polish governmental documents (Energy Policy Assumptions ... 1995), CO_2 emission in Poland in 2010 will be at the level of 372 million tons, that is almost 10% below the 1990 level.

In that document no policy measures to achieve the ambitious plans are presented. To see how daring the plans are, especially taking into account the high growth rate of the economy (5% to 6% annually) forecasted for the next ten years, we have to investigate how they translate into CO_2 emission coefficients. *Figure 9* shows a time path of those coefficients to achieve the government plans.

As we can see, the CO_2 emission coefficients have to do down almost by half in the period 1999-2010 to fulfill the plans (data for 1999 has been not published yet). This means that they should be declining more or less at the rate of the output growth. An opposite assumption could be formulated such as a "business as usual" (BAU) scenario, in which the coefficients remains unchanged in the period under consideration. Emissions under the BAU scenario as well as under "governmental" scenario are shown in *Figure 10*.



Source: Prepared by the author on the basis of model's results

Figure 10. Scenarios of CO_2 emission for Poland

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INEQUALITY OF VALUE IN INTERNATIONAL TRADE: AN INPUT-OUTPUT APPROACH

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International trade may be defined —in contrast to interregional trade— as trade involving, besides goods, an exchange of national currencies, the transactions of which are collected on, and described by, national balances of payment. The exchange of currencies not only distinguishes international from national trade, but brings in an additional factor of influence, in that trading prices can be determined only at given rates of exchange of the involved currencies. The choice of a national currency as means of payment must be settled between two international trading partners, and in the aggregate it may determine where the gains from trade finally accrue. Money is not an invisible veil, but a very impressive hand of control, in international trade.

The choice of a currency is governed by its value, and this again is based on expectations about its future value, just as with any other financial asset, a highly self-referential system of markets managed by international banks and national monetary authorities. There are two ways of determining the value of a currency. It may be expressed in terms of another currency, in its rate of exchange and may thus be treated like the price of a commodity when this is expressed in terms of another commodity (relative price). Or the value of a currency may be expressed in terms of the amount of products it buys, and this is its purchasing power parity (absolute price). The paper is concerned with the deviation between the two measures of value when applied to traditional trade balances.

1 The background: New institutional economics

Can trade be unequal? Ignoring allusions to common sense such as expressed, perhaps, in Grimms' tales[1], in professional economics the answer is not fully unanimous. While the economic main-stream voices a clear "no", critical writers bring up differing hypotheses for an affirmative position, every once in a while. Mainstream denies inequality, because it is the market that determines value. The value of two commodities is equal if the commodities are exchanged against each other, by definition, so that under condition of free trade, at least, inequality is logically impossible. Hence it is also no issue in standard literature.

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[1] The tale of "Jack in good luck" (Hans im Glück) goes about a country farmer who setting out to the town to sell his horse returns home after a series of trades, each of which increase his individual utility, a happy man and with no money.

Motivation for digging into the question comes rather from outside of academia. Political concerns about persistent underdevelopment in spite of global market integration naturally transform into a question of this type, dressing it, in this way, although non-voluntarily, with a taste of normativity and unscientific intention. Well known is the school of thought that developed in Latin America around Raoul Prebish and Hans Singer, who were men of politics just as much as of science, indeed, and the African writer Samir Amin is not far from them either.

In retrospect the cleavage of non-communication separating the mainstream from the outsiders had a certain rationale. The mainstream was securely contained in the bed of the general equilibrium market model of an economy, working on the assumption that these markets were perfect. Inequality theorists had thus no community-accepted theoretical ground for building their hypotheses, but had to work with ad hoc constructs such as terms of trade or differences in profit rates. This gave their analysis a touch of arbitrariness adding to the suspicion of political interest, and depriving their arguments of the force that would have been required for entering into a comprehensive dialogue with the mainstream.[2]

The situation has changed today. Perfect markets are no longer considered as the only useful model of economic analysis. The increasing attraction of economists to what is roughly called new institutionalism paves the way for rigorous analyses of imperfect markets within the mainstream. The concept of transaction costs generated in organising and using markets gives rise to new ideas such as bounded rationality and non-pareto-optimal outcomes that were not accepted before. This paper is placed in the framework of new stream of institutional economics, drawing on its results where it is convenient. It is helpful, for instance, to point out that the definitorial equality of the value of two commodities at mutual exchange resides on the assumption that markets are perfect. All partners are fully informed about the contract in question and share a common knowledge of all relevant facts. Under this condition, their values are defined equal. But what happens if information is asymmetric, and if control is incomplete? Then clearly, inequality of value is not excluded, on logical grounds, but becomes a sensible matter of investigation. The particular asymmetry of control studied in this paper relates to the means of payment employed in international transactions. If the value of this money is fully determined endogenously by the conditions of production, consumption and trade it need not be considered separately. If, however, money has a market of its own with intrinsic forces determining its value, it cannot be considered as neutral, but may exert a significant influence on the setting of trading values.

Apart from theory, inequality of value is an accepted phenomenon of every-day observation even in traditional economics. Everyone knows the effect of a commodity tax or a sales tax which splits the price of a commodity in two, the price the purchaser pays, on the one side, and the price the seller

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[2] As was brought about at the occasion of a problem of much lesser importance by way of the Cambridge capital controversy.

actually receives, on the other side. What is the true value of the good under these conditions, is not an easy question, the producers' or the purchasers' price, or something in between? Commodity taxes do not fit the perfect market model, and are looked at unfavourably in economic theory. But they exist, and provide a first hand demonstration that inequality of value in exchange is not an out-of-the-world phenomenon.

On the political side the problem of fair trade, or its opposite, in a way, the problem of dumping practices are every-day-concerns in international trade as witnessed by the corresponding regulations of the GATT. And Fair Trade shops spreading out over the developed world selling products of the developing world insinuate a similar concern. From a methodological point of view there are only two positions tenable in this respect. Either one considers such views as value judgements, and thus inaccessible to scientific investigation. Then there is no room for a theoretical statement about the possibility or impossibility of inequality in world trade. Or one makes such a statement. Then one implicitly admits that at least part of the question lies outside value judgement and is suitable for scientific investigation. This is what we endeavour now. Previous research on inequality in world trade will not be dealt with in this paper for reasons of brevity.[3] Individual features will be drawn upon in brief for purposes of comparison.

2 Explanation of national price levels

The fact that purchasing power parities differ from exchange rates in a persistent and systematic way has been established ever since the completion of phases I–III of the great United Nations International Comparison Project, initiated and carried out by Kravis, Heston an Summers. Yet, the observation of Kravis and Lipsey in 1983 that "It would only be a slight exaggeration to claim that a theory of comparative price levels does not exist", still holds, today. The theory of international trade works with the general assumption that price levels between countries tend towards equality through the exchange rate mechanism of currencies (see, for example, Winters 1991). Kravis and Lipsey challenge this "law of one price" on the basis of the empirical data of the ICP project, and in a small, thoughtful paper they look for factors of influence that may explain their empirical observation. Their findings represent an important step in the determination of asymmetry in trade. *Table 1* is reproduced directly from their paper.

Table 1 demonstrates two fundamental facts. Nominal exchange rates sit far from purchasing power parities in international trade, and currencies of poor countries are systematically under-valued. The finding is a challenge to international trade theory in that it forbids speculation about the advantage or disadvantage of such trade on the assumption of neutrality of the involved operation of currency exchange.

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[3] For an overview and critical assessment see Raffer, K. (1987).

Income Class	Number of Countries	Mean Nominal GDP per Capita	Mean Real GDP per Capita	GDP Price Level
1	8	3.7	9.0	40.7
2	6	12.1	23.1	51.7
3	6	24.2	37.3	64.5
4	4	38.7	52.4	73.6
5	9	82.3	76.0	107.4
6	1	100.0	100.0	100.0

Source: Kravis and Lipsey (1983), p. 2.

Table 1. National Price Levels for 34 Countries. Classified by Real GDP per Capita, 1975. (US = 100)

On the contrary, the lower the productivity of a country the less it can rely on this mechanism. The question comes to mind of whether the mechanism determining exchange rates might not produce terms of trade not in accordance with its own domestic price system so that a poor country exchanges goods less favourably, an impossibility under the assumption of perfect markets, of course, but given the degree of imperfection displayed by Table 1 the question cannot be suppressed.

The observed correlation between price level and real income per capita is what Kravis and Lipsey undertake to measure and to explain. The correlation of the two variables is so obvious from Table 1 that it requires no econometric corroboration. Nevertheless Kravis and Lipsey perform the calculation finding:

$$PL = 0.3081 + 0.9365\,r\,, \tag{1}$$

where PL are the price level and r the real GDP per capita of a country, both measured in relation to the United States. The regression predicts a price level of 30.81 percent of the level of the US for a country with zero GDP per capita, and for the US itself, with $r = 100$ the price level would come out at 1.2446. The explained variance $R^2 = 0.801$ and both coefficients are highly significant. A percentage point difference in real income translates almost one-to-one into a percentage point difference in price level. Crude and linear as this estimate is, it carries an enormous significance. If the purchasing power of the dollar is inversely dependent on the income per capita of a country, buying abroad is so much more advantageous for the rich country as it is disadvantageous for the poor one.

The explanation of the phenomenon adhered to by Kravis and Lipsey, which has meanwhile become standard in textbooks, goes under the name of differential productivity model. Assume that not all products can be internationally traded, but only some. For the tradable products holds the law of one price, i.e., the nominal price based on exchange rates is the same in every country. They are commodities of the world market. The non-tradable goods are produced and consumed only internally in an economy, and their prices may thus differ between countries. With similar prices for tradable goods in all countries, wages in the industries producing tradable goods in each country depend on productivity. The wage level established in the tradable goods industries prevails also in the non-tradable goods industries, but international productivity differences are smaller for the latter. This means that in poor countries the low wages established in the low-productivity tradable goods industries apply also to the not-so-low-productivity non-tradable-goods industries. The consequence is low prices in low-income countries for non-tradable goods (Kravis and Lipsey 1983, p. 5). Indeed, partitioning their price sample in tradables and non-tradables Kravis and Lipsey find *Table 2*.

Income Class	Number of Countries	GDP Price Level	Price level of Tradables	Price Level of Non-tradables
1	8	40.7	60.0	24.9
2	6	51.7	70.7	37.2
3	6	64.5	86.6	46.5
4	4	73.6	97.9	53.4
5	9	107.4	118.5	96.7
6	1	100.0	100.0	100.0

Source: Kravis and Lipsey (1983), p. 12.

Table 2. Price Indices for Tradable and Nontradable Goods 34 Countries, 1975 (U.S. = 100)

Table 2 verifies the distinction between the two sorts of goods in that the price level of non-tradables is roughly on half that of tradable goods for all countries under investigation. And indeed, the regression of the price level of non-tradable goods comes out favourably:

$$PN = 0.0502 + 0.9893\,r + 0.1733\,OP\ . \tag{2}$$

The absolute term is reduced to insignificance, the linear terms increase from 93 to 99 percent, with a higher significance and more variance explained which indicates that the model of wage level determining the price level of non-tradables might well be holding. The variable OP stands for openness of an economy measured by the ratio of foreign trade to GDP. It is tested by the authors, but comes out with little significance, and is therefore ignored here. Now if the connection of the labour market mechanism to foreign trade holds as exposed in the differential productivity model, the law of one price should apply for the tradable products in as much as it does not hold for the others. The price level of tradables should be independent of income per capita, forming as it were the driving lever in the model forcing national wages down. Table 2 however, contradicts this hypothesis. The price level of tradable goods clearly varies with real income per capita, the corresponding regression being

$$PT = 0.4732 + 0.7619\,r + 0.1590\,OP\ . \tag{3}$$

So the question remains of why is the national price level strongly correlated to income per capita. The question is even framed more sharply now, since for tradable goods the law of one price should surely hold, even without any differential productivity model.

But the fundamental problem arising from this analysis lies on the theoretical level. If the differential productivity model assumes low productivity in the tradables sector, then, apart from the necessity of this proposition being empirically tested, it evokes the question of why a country should participate in international trade at such terms at all. If a country deploys resources to an export sector that works at lower productivity than the rest of the economy this is an inefficiency or a disadvantage in allocation of resources as against fully domestically oriented production. The differential productivity explanation of national pricel levels, it seems, is not in line with the Ricardian comparative advantage theory. Thus in order to clarify the productivity argument it is necessary to look into the meaning of the term productivity more closely and to study the methods by which it is being determined. This will be done in the next chapter.

3 A simple input-output account of international trade

Input-output technique is predominantly applied to describing the production structure within a country, leaving exports and imports as additional rows and columns (or matrices), which are detailed in their commodity composition but have only a one-sided link to production. They either come from nowhere, — imports as primary inputs, or they go to nowhere, — exports as final outputs. Globalisation calls for a table of the whole world where commodities serve as identical stores of value between any two countries linked by trade, showing the overall interrelationship of this trade. In *Table 3* such an interrelationship has been estimated for the year 1997 on the basis of readily available information and in a crude form. Partitioning the countries of the world into 6 groupings the table describes the value of trade between them in current US$.

Table 3 is denominated in US$ and it should add up to a total trade balance of naught under the assumption of a global market for the traded commodities. Trade balances should correspond to the figures shown in the national balances of payment, in principle, showing the need for, or the surplus in, external finance. Actually the aggregation in Table 3 grossly underestimates the needed finance, because it shows only the balances between these groupings of countries. These are, however, fictitious, because only individual country's have trade balances, and not any of their statistical groupings, and the aggregated balances suppress the flows within each aggregate. In order to gain a correct impression of the means needed to finance international trade a flow table between all countries coining their own currency must be established. This is beyond our means here. Table 3 serves just as an illustration of the larger and correct exercise.[4]

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[4] It also may serve as a kind of political grouping, because trade imbalances occuring between members of different groupings might be treated in a different way than imbalances within each of these groupings.

Exports to Exports from	[1]	[2]	[3]	[4]	[5]	[6]	All exports
1 Developed countries – Europe	1453	275	42	76	81	267	2194
2 Other developed economies	251	606	6	5	34	522	1424
3 Former USSR – Europe	35	8	20	13	1	27	104
4 Other Eastern European economies	56	3	7	12	2	8	88
5 OPEC	53	74	3	2	10	57	199
6 Other developing economies	247	480	14	10	52	532	1335
All imports	2095	1446	92	118	180	1413	5344
All exports	2194	1424	104	88	199	1335	
Trade balance	99	−22	12	−30	19	−78	

Source: IMF (1998) and own estimates

Table 3. World Trade by Regions (in billion U.S. dollars f.o.b.)

The main finding of international price comparison being that national price levels are correlated to national income per capita we begin our input-output accounting in such a way so as to investigate only this effect, bringing in other effects at a later stage. We distinguish three goods and three production processes. Two goods are tradable, T1 and T2, the third one is not, NT. We look at two countries A and B. To further simplify the matter we assume that country A produces T1 as its export good (EX), while country B produces and exports T2. Consumption (C) in both countries consists of their non-tradables, and their production uses the imports (IM) as intermediate input. One might think of energy (T1) and software (T2) as two possible inputs in services (NT). *L* is the value of labour input, which we assume to be the only production factor. This is an extremely simple model, but in its simplicity it highlights the subject in question. An input-output account of this international trade might look like *Table 4*.

Country A produces A$ 420 worth of T1 which it exports to country B, and it imports the same value of T2 in return from country B. Consumption makes up GDP from the expenditure side with A$ 1400 and B$ 600 in each country respectively, while value added figures add up to the same values, showing GDP under the output aspect. Foreign trade is balanced in both economies in their respective national currencies.

Type of Good	T1	T2	NT	C	EX
Country A (in A$)					
T1					420
T2			420		
NT				1400	
IM		420			
L	420		980		
Country B (in B$)					
T1			60		
T2					60
NT				600	
IM	60				
L		60	540		

Table 4. A simple input-output account of international trade

Roughly as the table is, it shows an important law. Two input-output tables balanced in their respective national currencies imply one and only one exchange rate in order to balance against each other. In this case the implied exchange rate is A\$ 7 to 1 \$B. The law is important because it derives from nominal variables only, and holds without any information about underlying prices and productivities. In particular, any inverse price-quantity movement of elasticity 1 in either economy leaves the nominal exchange rate unaffected.

In order to study the balancing problem more closely, let us assume some prices and their derived quantities. In country A:

$$P1 = 1 \text{ A\$/unit } 1, \qquad P2 = 2 \text{ A\$/unit } 2, \qquad P3 = 3 \text{ A\$/unit } 3,$$

where the first two prices stand for the tradable and the last price for the non-tradable product, each measured in A\$ per respective physical unit. Dividing these prices into the nominal values shown in Table 4 yields an input-output table in quantities, the normal point of departure for quantity input-output models.

The choice of prices and quantity units in country A has an implication for county B. Given the values of Table 4 it follows that in country B the prices are now also given, namely

$$P1 = 1/7 \text{ B\$/unit } 1, \qquad P2 = 2/7 \text{ B\$/unit } 1, \qquad P3 = 3/7 \text{ B\$/unit } 3\,.$$

Otherwise the system would not balance, again an important accounting constraint. It says that if a balanced economy wants to incur balanced international trade with another economy, the prices in both economies must be the same, after application of the implied exchange rate, of course. This is the law of one price. And equally so for changes in these variables, of course. Applying the Geary-Khamis index for comparison of purchasing power parity (SNA 1993 par. 16.92) to our account is simple, because GDP, the commodity basket employed as the value standard of the national currency contains only one good in each country namely the non-tradable good. One obtains $PPP\$A/PPP\$B = 1/7$, the purchasing power parity is thus one, the exchange rate reflects the purchasing power of the two currencies. How then can we construct a case of differing purchasing power parities from this model?

Wages are equal in both countries, as the model now stands. This expresses the situation of a common labour market for the two economies. International trade is defined, however, as a trade when labour markets do not merge. We have barriers between the national labour markets segregating the national labour force into their national markets each. The global labour market is imperfect, by definition. Consequently our model becomes truly international if we assume different wage rates in each country. If the wage rate in country A is 4 A\$/man-year that of country B must necessarily be 4/7 B\$/man-year under a homogeneous labour market. From the data in Table 1 it may not be an exaggeration to cut the wage rate of country A in half, say 2 A\$/man-year. If the cut is introduced simply on the one line of labour input of country A in Table 1, this table will not be balanced anymore.

Balance along columns is achieved if prices in country A are cut in half. In order to simplify the argument and avoid cumbersome recalculations let us assume that balance along rows is achieved by a corresponding increase in quantities. Twice as much labour is employed as before, and with the same technology twice as much quantity of each product is produced. This leaves the nominal table unchanged, and hence the nominal exchange rate of 7 A$ to 1 B$ remains the same, too. The nominal accounts are the same for both situations. But in quantities, the figures of situation A' are twice those of situation A. In particular country A' now exports twice the quantity of T1 to country B in return for the same quantity of T2 as before. *Table 5* compares the full accounts.

How are the two economic states to be interpreted? The difference between situation A and situation A' is that all internal prices have dropped to half, while internal quantities have doubled. Only the import quantity into A has not changed so that, at an equal exchange rate as before, double the quantity of T1 is exported from A'. Terms of trade have deteriorated for A, obviously, and we are interested in the effect on purchasing power. Due to the simplicity of the model the purchasing power effect is easy to determine. When a citizen of country B exchanges B$ into A$ he can buy as many units of NT in country A as at home, but twice as many in country A'. The purchasing power parities are 1 and 2, respectively. The traded goods T1 and T2 do not count in the purchasing power calculation, because their trade is balanced. GDP consists of consumption C only.

Note that we are working in terms of comparative statics. We are not stating that due to a wage drop in country A the economy changes to state A'. We are simply comparing two different quantity situations corresponding to the same nominal figures. Situation A' is different from A in several aspects. The wage rate is half, labour input doubles, so does output in goods T1 and NT. Technology is also different between the two situations in that in situation A' less of good T2 is used for production of a unit NT than before. Thus the deterioration of terms of trade is being matched by an increase of productivity. Furthermore, this production is less capital intensive and more labour intensive than before. Traditional theory holds, however, that the lower wage in developing countries is due to a low level of productivity. The argument of productivity must thus be submitted to a closer scrutiny, which we will undertake in the next chapter.

	Country A Wage rate equal to country B					Country A' Wage rate half of country B				
Type of Good	T1	T2	NT	C	EX	T1	T2	NT	C	EX
T1 (in units 1)					420					840
T2 (in units 2)			210					210		
NT (in units 3)				487					974	
IM (in units 2)		210					210			
L (in man-years)	105		245			210		490		

Table 5. Quantity input-output table for country A under different wage regimes

A first conclusion from this chapter can already be drawn. The differential productivity model explains purchasing power imparities first of all by differing productivity between countries in the sector of tradables. It seems that the model simply assumes this difference. Neither low productivity in tradables nor relatively higher productivity in non-tradables are necessary to produce differing purchasing power parities in correlation with differing wages. Our investigation has shown that a low wage level in terms of exchange rates corresponds to a low price level, and is not necessarily caused by, or an indicator of, low productivity. It then reflects not an internal production structure, but a relationship of external exchange. Put the other was around, it is possible that industries or countries of even productivity may still be linked together in a relationship of uneven exchange. For, compared to situation A, situation B is uneven in that A delivers twice as many goods T1 in exchange for its imports of T2 than before, and, yet, concerning productivity it is not worse.

This analysis seems to incorporate a subjective judgement in the sense that the opposite interpretation might also be tried. Situation A - B may be defined as uneven, and favourable for A, and situation A'- B be called the fair or even situation. So it looks as if there were arbitrariness in assumptions to be resolved only through moral judgement. But there is a purely economic argument behind. Economic efficiency in the allocation of resources is achieved through markets, in particular those in goods and services. In international trade, these markets are separated through national currencies. But an even purchasing power parity of the national currencies may be taken as an indicator of equilibrium in the sense that the national markets function in co-ordination as if they were one market. If purchasing powers are not at par, markets are obviously not co-ordinated, overall equilibrium is not attained, hence there is room for inefficiency and misallocation of resources, and one-sided advantages and disadvantages going hand in hand with it. Our intention is to measure the inefficiency.

On the assumption that situation A - B, and not A' - B, is the equilibrium state a loss of real resources through international trade can be calculated for Tables 4 and 5. In situation A' country A exports twice the real resources to B as under conditions A of equal purchasing power parity. Its nominal exports of A$ 420 are worth twice this sum in terms of real resources. Consequently country A' exports another A$ 420 or 30 percent of its GDP abroad without compensation. Note that this finding does not contradict Ricardo's theory about the reason for trade. It may still be that the decision of A to export T1 to B, and to import T2 from it is based on differences in comparative costs, however slight they may be. But Ricardo's theory stops short of the determination of the actual terms at which trade is then to be performed. So even if his conditions are satisfied, uneven trade due to imperfection in the corresponding markets is possible.

It is also interesting to observe that the cutting in half of the wage is compensated by a double participation of the labour force, the real income of which has not changed. They produce twice as much NT as before, only at half the international value. In this sense uneven trade 'generates' employment, indeed, and applies the export multiplier.

Finally, the little exercise enhances the role of purchasing power comparisons in international trade. Comparing the nominal tables of the two countries reveals no information about value inequality, balanced as they are in every respect. Even the price comparison between the two traded goods T1 and T2 would not raise doubts, because prices between different goods cannot be compared anyhow. It is only after compiling, from these prices, an index of purchasing power parity of the means of payment and storage of value that an evaluation of foreign trade in terms of value inequality is at hand.

4 An analytical table of resource flows in international trade

The Purchasing Power Comparison of countries participating in international trade raises two questions:

a) Why does purchasing power vary between countries?

b) Why is the variance mainly correlated to the national standard of living?

As said above the main argument explaining international discrepancies in purchasing power parities is based on productivity. Low productivity in the tradables sector combined with a nationally homogeneous labour market depresses general wages so that even high productivity sectors sell under value. Our input-output account has shown that low productivity is not a necessary condition of differing purchasing power parities. In other words even under conditions of equal productivity purchasing power imparities may occur. But Table 2 shows that the premise of the explanation does not hold. The premise is that there exist a unified world market for the goods that are tradable. A unified market is characterised by a unique market price. Poor countries, however, earn 40 percent less for their products than rich countries. Even between the high income countries, which are mainly U.K., France, Germany, Japan, on the one side, and U.S. on the other, price differences of almost 20 percent exist for tradable goods on the average. This is a clear indication that there are barriers to entry for consumers to buy at the cheaper source, and, more likely, for producers to reap profits from the more favourable markets. It is an inefficiency in resource allocation, and a disadvantage for the low price countries' producers, and in as much as production creates income also for their consumers.

Another reason for the observed variation of purchasing power may be found in the markets determining factors exchange rate of national currencies. A national currency is not just a means of payment, but it performs this function in connection with its ability to serve as a storage of value. The expectation of the future selling price of an asset determines its demand today. Without going into the details of monetary economics it is plausible that strong economies attract more investors than weak ones. Investing in financial assets of a strong currency may entail risk of devaluation, of course, but for weak economies the risk is generally higher. The financial interest in a currency as a store of value dominates the forces that work on the exchange rate from the production side, and this may explain, why purchasing power parity deviates from the market exchange rate in correlation with the living standard of a country. For the world's product markets this financial factor creates another imperfection, of course, and constitutes a barrier to entry for those countries that have to pay highly valued foreign products with low valued domestic products.

If we interpret variance in purchasing power of national currencies as caused by market imperfections we can measure these distortions by means through an analytical revaluation. This does not mean to find the exchange rates that would prevail in case equilibrium between countries were installed, a question that could only be answered by means of a full fledged general equilibrium model. We simply assume that the average is the equilibrium, more precisely we assume that the purchasing power GDP measures the average productivity of a country and the real value of the resources it employs, and that this productivity includes the exports of a country so that their real value must also be measured in terms of purchasing power. Countries of equal purchasing power are thus in mutual equilibrium, exchanging an even share of real resources. Countries of unequal purchasing power are not in equilibrium with each other, and the purchasing power parity measures the degree of disequilibrium. Re-valuing all exports in this way using purchasing power estimates from Table 1 changes Table 4 in the following way:

	[1]	[2]	[3]	[4]	[5]	[6]	
GDP Price Level (estimated from Kravis and Lipsey 1983)	1,10	1	0,7	0,6	0,5	0,4	

Trade in real terms (valued at equal purchasing power of currencies)							
Exports to Exports from	[1]	[2]	[3]	[4]	[5]	[6]	All exports
1 Developed countries – Europe	1321	250	38	69	74	243	1995
2 Other developed economies	251	606	6	5	34	522	1424
3 Former USSR – Europe	50	11	29	19	1	39	149
4 Other Eastern European economies	93	5	12	20	3	13	147
5 OPEC	106	148	6	4	20	114	398
6 Other developing economies	618	1200	35	25	130	1330	3338
All imports	2439	2220	125	142	262	2261	7449
All exports	1995	1424	149	147	398	3338	
Resource balance	–444	–796	23	5	136	1077	

Table 6. Resource flows in world trade 1997 (billions of US$)

Comparing *Table 6* to the Table 3 of nominal flows the imbalances ruling world trade become quite revealing. Countries of low productivity are punished not by low wage levels, - that would be natural, but in addition by low prices they receive for their resources when they devote them to exports. Purchasing power parity analysis leads to a revival of the discussion about inequality of trade, as contained in the classical Prebisch-Singer hypothesis. But contrary to that method of looking into the change of terms of trade, the result of which is dependent on the choice of time interval and inconclusive in dealing with the effect of productivity improvements, an analysis in terms of purchasing power, which yields a direct comparison in terms of standard commodities, a more consistent picture of resource flows through the world can be drawn.

You also find that the weight of developing countries in international trade is much larger when measured in nominal exchange rates. So there is a case for renegotiating the terms of trade if these are to reflect resource use an their productivity. This is not to say that market exchange rates are wrong and purchasing power parities are the correct exchange rates, in their place. Both together are the results of disequilibrium. The question of how to pave the way for equilibrium of production and exchange in world trade cannot be answered through this analysis.

It is clear that the figures in Table 6 are far from being exact. They are very rough estimates serving only the purpose of illustrating the structure of the argumentation. A thorough investigation would have to deal with each country and its currency, separately, and work in a detailed break-down of commodities, probably with an elaborated labour-input matrix, distinguishing different qualifications (social accounting matrix). This is another project.

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ACCOUNTING FOR DEMAND-EFFECTS IN INPUT-OUTPUT PRICE-MODELS

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Input-output price-models traditionally concentrate on the cost-component of price formation rules. This includes a mechanism determining which factors' costs and/or returns will be built into the price of the products. Prices which do not fit to this standard treatment are given either exogenously or determined residually. Demand or pull-effects are treated explicitly only by general equilibrium models or similar models determining prices and quantities simultaneously. However, even the transparent, simple, linear input-output models can represent most of the demand effects in a way which is not less realistic than the results of complex 'black box' models which usually contain untested and dubiously uniform price elasticities. Therefore, so-called reference prices are introduced which in the first place represent the prices of the competitors, i.e., the price of the import or the price of the substitutes. In addition, reference prices can be the exchange rate the wage level or the price of any commodity which can be used as an argument or excuse for the price increases of government set or monopolised products. More generally, by weighting the individual possible reference prices one can derive baskets of reference prices. In the final step of generalization one can weight together the cost-effects and the reference prices in the following way:

$$\mathbf{p} = (\mathbf{p} \cdot \mathbf{C} + \mathbf{z}) \cdot \langle \mathbf{w} \rangle + \mathbf{p} \cdot \mathbf{Q} \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) \ ,$$

where $\mathbf{p}$ is the vector of all prices, $\mathbf{z}$ is the vector of expected nominal unit profits, $\mathbf{C}$ is the matrix of the input coefficients augmented by the rate of returns, $\mathbf{Q}$ is the matrix of the weights of the reference prices, $\mathbf{I}$ is the identity matrix and $\mathbf{w}$ is the vector of the weight of the cost-formula in the price formation of the given product. The paper discusses several special cases of this general formula which usually can be achieved by setting many of the parameter values to zero or by exempting some of the prices from this price formation rule completely. Some prices can be set exogenously and in the case of the closed homogenous price model at least one price must be exogenous and one rate of return must be endogenized. After the theoretical part, the paper presents the results of a plausible scenario for Hungary. In this scenario, in accordance with the government policy, the exchange rate is devalued by 5% and a 30% oil and gas price increase is assumed at the world market relative to their average price in 1999. For the individual sectors different price formation rules i.e. different parameter values of the above general formula are assumed. As a result the model predicts a 8% consumer price increase for 2000 which is 1% higher than the original official progno-

sis (which counts on lower oil prices) but is in accordance with the general expectation of the economic research institutes and the public opinion. The author's view is that such transparent models can be used widely and effectively in the process of labor disputes and macroeconomic policy analyses and can be easily modified to include even more sophisticated and relevant price formation mechanisms.

1 Theoretical background

Economic theory has developed many (sometimes conflicting) theories of profits, wages and prices. Demand side considerations refer to price and income elasticities which in turn sometimes are derived from utility maximization. However, on the market there are rather different users. The government, the foreign buyers, the different industries and different social groups have rather different consumer behavior. Therefore, models mostly describe the demand of these agents separately which makes the model large and less transparent. However, in the case of a single commodity not all these agents are significant buyers. So the demand of the individual commodities can be characterized in a much simpler way. It suggests the elaboration of various partial equilibrium models. However, one should not forget to take into account the price-*interdependencies*. I-O price models are the widely used tools to take into account the repercussion of changes in the unit costs of the various products.

Input-output price-models traditionally concentrate on the *cost-component* of price formation rules. This includes a mechanism determining which factors' costs and/or returns will be built into the price of the products. Prices which do not fit to this standard treatment are given either exogenously or determined residually.

To take into account the *demand* side effects too, I introduced so-called *reference prices*, which in the first place represent the prices of the competitors, i.e. the world market prices of the same commodity (more directly represented by the import or export prices) or the price of the substitutes. In addition, reference prices can be the exchange rate the wage level or the price of any commodity which can be used as an argument or excuse for the price increases of government set or monopolised products. More generally, by weighting the individual possible reference prices one can derive baskets of reference prices. In the final step of generalization one can *weight* together the cost-effects and the reference prices.

Note, that the suggested weighted-price concept has different assumptions about the demand. In the case of the exogenous prices, change in the demand is not considered at all. In the case of the monopolistic prices one can assume that they maximize profits subject to social tolerance. Finally, in the case of the commodities facing strong competition the computed weighted price estimates the price level which *partially* would not change the share of the suppliers of the total supply, which in turn should equal to total demand of the given commodity. Obviously, the simultaneous solution of the price system and the possible (presumably not too significant) feedback of the changing consumption patterns on the relevant price indices requires more theoretical discussion and clarification of the definitions, but in practice it probably can be handled by the distinction of further cases, without fundamentally changing the mathematical characteristic of the solution method, which we are going to review in the next section.

2 The formal presentation of the general price model

The result of the above generalizations can be formalised in the following way:

$$\mathbf{p} = (\mathbf{p} \cdot \mathbf{C} + \mathbf{z}) \cdot \langle \mathbf{w} \rangle + \mathbf{p} \cdot \mathbf{Q} \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) \ , \tag{1}$$

where

$\mathbf{p}$ is the vector of all prices (products and factors alike),

$\mathbf{C} = \mathbf{U} + \langle \mathbf{r} \rangle \cdot \mathbf{D} + \langle \mathbf{s} \rangle$ is the sum of the input coefficients ($\mathbf{U}$, which is the technology matrix supplemented with the rows of the unit factor inputs and with the columns of the consumption, investment and export patterns) and the basis of the price proportional returns,

$\mathbf{z}$ is the vector of expected nominal unit profits,

$\mathbf{Q}$ is the matrix of the weights of the reference prices,

$\mathbf{I}$ is the identity matrix, and

$\mathbf{w}$ is the vector of the weight of the cost-formula in the price formation of the given product ($\langle \mathbf{w} \rangle$ is its diagonal matrix equivalent).

The formula of $\mathbf{C}$ requires some more explanation. Above the costs of the inputs a part of the surplus is expected to be generated as given percentages of the costs. Costs, as can be seen, are the products of prices and quantities (volumes). Therefore, in the first round we can compute the expected returns at constant prices and multiply them by the prices only afterwards (mathematically: $\mathbf{r} \cdot \langle \mathbf{p} \rangle \cdot \mathbf{D} = \mathbf{p} \cdot \langle \mathbf{r} \rangle \cdot \mathbf{D}$). Similarly, prices may include a certain kind of cost-independent but still output-price proportional term ('mark up' or *ad valorem* indirect tax) which in effect is a given percent of the current output *value*. These percentages are included in the vector denoted by $\mathbf{s}$.

Note that $\mathbf{D}$ can differ from $\mathbf{U}$ at least for two reasons. First, while the corresponding rows of the $\mathbf{U}$ input coefficient matrix contain the quantity of the *consumed* capital and labor, in $\mathbf{D}$ we may replace these rows by the total *stock* of the physical and human capital required for producing one unit output. These latter categories can be (and in the case of the capital usually are) the basis of the return expectations. More generally, we can modify the basis of the return calculations according to our ideas about their relevance in the price formation of the given product. Setting them to zeros will exempt them completely from the return generation requirement, even if for the given category a positive standard rate of return (corresponding element of **r**) applies. In general **D** renders possible the differentiation of the return expectations accross users.

Moreover, the whole cost-based formula can be dropped by setting the corresponding element of **w** to zero.

Turning our attention to the second part of (1), let us discuss the meaning and role of the **Q** matrix. For example, a value of 0.5 at the intersection of row 1 and column 2 means that half of the first price (multiplied subsequently by the corresponding element of $\langle \mathbf{1} - \mathbf{w} \rangle$) will be built into the price of the 2nd good. Generally, in regard of price homogeneity, the sum of each column of **Q** must be 1. Otherwise an e.g. 10% inrease of each reference prices would result in a different increase in the dependent price which is rather difficult to justify.

The role of the reference prices are particularly important in open market economies where prices have to accommodate to world market prices and the exhange rate. If the import prices do not guarantee sufficient profitability for the domestic producers they should improve their efficiency or by closing down the less efficient factories they should contract.

Pull-effects of higher household incomes can be taken into account by using the general wage index as a reference price. Wage income is the owerwhelming component of household incomes so this trick captures most of the income effects. Note that this kind of use of the wage index is different from the wage-cost consideration which belongs to the supply analysis.

The possible cases of the reference prices are so numerous that we do not attempt to disscuss them all. Instead, in section 3 we present an application which was elaborated for the currently rather important and much debated issue of the effect of the big jump of the world market oil prices.

2.1 The solution of the general price model

By rearranging (1) we obtain the following:

$$\mathbf{p} \cdot \left\{ (\mathbf{I} - \mathbf{C}) \cdot \langle \mathbf{w} \rangle + (\mathbf{I} - \mathbf{Q}) \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) \right\} = \mathbf{z} \cdot \langle \mathbf{w} \rangle \ . \tag{2}$$

Note, that if **z** is different from zero, then the *inhomogenous* price model can be solved by multiplying the equation by the (normally existing) inverse of the matrix in the { } brackets. Otherwise, we get the so called *closed* price model, in which the price level can not be determined from (2), therefore one has to select some exogenous prices (at least a numeraire), and by endogenizing (rescaling) some of the elements of **r** make sure that the system has a non-trivial solution.

Returning to the inhomogenous case, after permutating (reordering) the elements of **p** and similarly the corresponding rows of the compounded matrix in the { } brackets appropriately, we can derive the following relationship:

$$[\mathbf{p}_n, \mathbf{p}_x] \cdot \mathbf{M} = \mathbf{b} \ , \tag{3}$$

where $\mathbf{p}_n$, $\mathbf{p}_x$ are the vectors of the endogenous and exogenous components of $\mathbf{p}$ respectively, $\mathbf{b} = \mathbf{z} \cdot \langle \mathbf{w} \rangle$ and $\mathbf{M}$ is the permutated matrix. By partitioning $\mathbf{M}$ to an $\mathbf{M}_n$ and $\mathbf{M}_x$ upper and lower part respectively, we get

$$\mathbf{p}_n \cdot \mathbf{M}_n + \mathbf{p}_x \cdot \mathbf{M}_x = \mathbf{b} \,, \tag{4}$$

formula. This has a unique solution if we drop so many columns (price equations) that the remaining $\mathbf{M}_{nn}$ matrix becomes a square matrix and invertible. Then the solution will be the following:

$$\mathbf{p}_n = (\mathbf{b}_n - \mathbf{p}_x \cdot \mathbf{M}_{xn}) \cdot \mathbf{M}_{nn}^{-1} \,. \tag{5}$$

where $\mathbf{M}_{xn}$ and $\mathbf{b}_n$ denote the similarly truncated $\mathbf{M}_x$ matrix and $\mathbf{b}$ vector respectively, and the -1 exponent represents the matrix inversion.

3 Estimating the effect of the oil price increase

3.1 Formation of the scenario

For the analysis I choose the latest I-O table for Hungary i.e., the 1996 table. In this table one can find 21 sectors. Unfortunately, energy sectors are not separated out of the mining, chemical industry and utilities. However, since imports of mining products consists almost exlusively natural gas and crude oil I just assumed that the import price (in dollars) of the mining industry products increase by 30%. Note that in 1999 the average import price was \$18/barrel while from the beginning of this year it has increased from cca. \$25/barrel to \$30/barrel. So even by taking into account that natural gas prices lag behind the oil price fluctuations, the 30% increase seems to be a rather modest (optimistic) assumption (especially knowing that the forint is pegged to the euro and the dollar has appreciated considerably against the euro).

In the last 5 years the exhange rate served as an inflation anchor in Hungary. In every year, the forint has been appreciated in real terms (cca. around 2-3% a year). In any case, the crawling peg system with the pre-announced future nominal devaluation rate makes the exhange rate as a practically exogenous and predictable price of the Hungarian price system. For year 2000 the yearly average nominal devaluation will be around 5%. So in the price model the exchange rate index is set exogenously to 1.05. Next, the price index of the mining industry products is set to $1.3 \cdot 1.05 = 1.36$.

For the rest of the 21 sectors and the labor and capital I assumed that there is no 'money illusion', i.e., they try to maintain the *real* value of their surplus. I did not want to assume any conceptual change in the existing price formation mechanisms.

Therefore, I simply assumed that the sectors will try to maintain their observed surplus/output value ratio. Here the 'surplus' is defined as the value added less the wage cost, which means that (due to lack of data) capital costs are not separated out.

However, these desired cost-based prices can be put into practice only in the case of government protected or monopolistic sectors where the demand is inelastic. Note that although the demand for certain agricultural products is elastic, the government provides large export subsidies and imposes import quotas and prohibitive tariffs to create artificial shortages in the domestic market. In addition, the inputed price of the non-market services absorbs all cost increase by definition. Into this category belong the services produced by budgetary institutions and provided free to the households and the inputed rent of the housing stock. Note that in the latter case I assumed that prices follow directly (and exclusively) the price of capital (which is in turn determined by the investment price index). After all these and similar considerations, I selected sectors No. 1, 2, 8, 11, 16, 17, 19, 20 and 21 as sectors which can pass all their cost increases to the users. On the other extreme, sectors No. 5 and 9 are assumed to be just takers of the world market prices. Since I did not consider any other world market price movements (which is again a little bit optimistic approach), their price index is simply equal to the exchange rate index. The rest of the sectors differ in the weight of the cost-plus formula in their price formation rule and in the name(s) of their reference prices as shown by *Table 1*.

	Weight of the			
Sector name	cost formula	wage	capital	exch.rate
1. Agriculture	1			
2. Forestry	1			
3. Mining	exogenous			1
4. Food-industry	0.5	0.5		
5. Light industry	0			1
6. Chemical industry	1			
7. Building materials	0.6	0.2		0.2
8. Metallurgy	1			
9. Engineering	0			1
10. Other manufacturing	0.4	0.3		0.3
11. Utilities	1			
12. Construction	0.4	0.6		
13. Trade	0.5	0.5		
14. Hotels-restaurants-catering	0.7	0.3		
15. Transportation	0.6	0.4		
16. Telecommunication	1			
17. Financial services	1			
18. Business and personal serv.	0		1	
19. Public services	1			
20. Education	1			
21. Health and welfare services	1			
Wages	1			
Capital	1			
Foreign Exchange	exogenous			

Table 1. The assumed prices formation rules

	Sector name	Price increase %
1.	Agriculture	8.1
2.	Forestry	8.3
3.	Mining	36.0
4.	Food-industry	8.0
5.	Light industry	5.0
6.	Chemical industry	12.8
7.	Building materials	8.6
8.	Metallurgy	9.1
9.	Engineering	5.0
10.	Other manufacturing	6.9
11.	Utilities	15.7
12.	Construction	8.1
13.	Trade	7.9
14.	Hotels-restaurants-catering	7.9
15.	Transportation	8.1
16.	Telecommunication	7.7
17.	Financial services	7.3
18.	Business and personal services	7.1
19.	Public services	8.0
20.	Education	8.0
21.	Health and welfare services	8.1
	Wages (=Consumer Price Index)	8.0
	Capital (=Investment Price Ind.)	7.1
	Foreign Exchange	5.0

Table 2. The resulting price indices

3.2 The results

The main results can be seen in *Table 2*. Apart from mining, the highest price index is that of the sector of 'utilities'. This is due to the fact, that utilities contain the heat and electricity production, which use considerable amount of natural gas. As specified above, all the price increases are assumed to be passed over to the consumers. In the second place we find the chemical industry which contain the refinery too. The refinery sector uses crude oil while the heavy chemical industry (which produces fertilizers, polivinilchlorids, olefins etc.) uses much of the refinery products and natural gas. Note that for the heavy chemical industry the price index would be much higher, but the not energy intensive light chemical industry (pharmaceutical products, cosmetics, etc.) partly counterbalances this effect.

From the above weight one may compute how the above changes affected the average profitability of the individual sectors. Since wages were assumed to be fully indexed to inflation, the observed 8% wage increase represents the consumer price index, too (by assuming that the effective consumption tax rates do not change which, however, may be questioned in the case of the gasoline tax). More precisely, we could just say that the wage index is equal to the average producer price index weighted by the household consumption structure. Investment (i.e., capital) price index shows a little lower average price index. As known, the investment price index is practically the weighted average of the price of the engineering industry and the construction industry.

The simulation results show that the government's 6-7% prognosis for this year's consumer price index seems to be difficult to reach. Of course, efficiency improvement may help in reducing the costs, but then workers may demand higher real wages, too (not just mere indexation). Our doubt is in accordance with the general expectation of the economic research institutes and the public opinion. As a further check, I run similar scenarios with the only operating Hungarian applied general equilibrium (CGE) model (Révész-Zalai, 1999) which was calibrated for 1998.

Depending on the macroeconomic closure of the model and assuming downward rigidity or stickiness of certain prices I could compute a 2-3% increase in the price level as a result of the 30% increase of the world market oil and gas prices. Note that these scenarios do not take into account the internal inflationary pressures which was represented by the 5% nominal devaluation in the I-O model. Hence, by adding the internal component (i.e., the 5%) of inflation, we may say that the CGE model predicts also a 7-8% price increase in 2000.

The author's view is that such transparent models can be used widely and effectively in the process of labor disputes and macroeconomic policy analyses and can be easily modified to include even more sophisticated and relevant price formation mechanisms.

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