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Input-output in Europe: Trends in research and applications

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1. Historical background

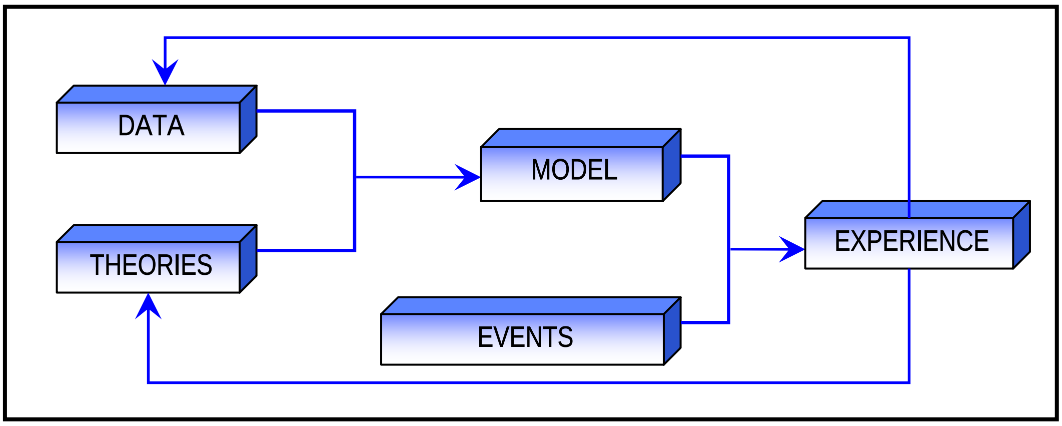
During the XIX century, economic science was developed with a basically deductive methodology from the fundamentals established by classic economists at the end of the XVIII century.

The early developments of a quantitative economic science took place at the beginning of the XX century. It started with the statistical verification of the considerations derived from qualitative reasoning. So, for example, in the field of demand analysis, the first estimates of a model for coffee that used multiple regressions was elaborated by Benini (1907), and Pigou (1910) developed a method that estimated elasticities from results of family expenditure surveys.

In the 1930´s, when the development of econometrics and its applications consolidated (The Econometric Society was established in 1930), the connection between deductive qualitative economics and a more inductive quantitative economics, was focused on the development of both the multiequational models of macroeconomic relations of Tinbergen (1935), and the multiequational model of sectorial mesoeconomic relations of Leontief (1936). Tinbergen used theoretical developments about cyclical fluctuations of the economy, and Leontief about the static general equilibrium of Walras.

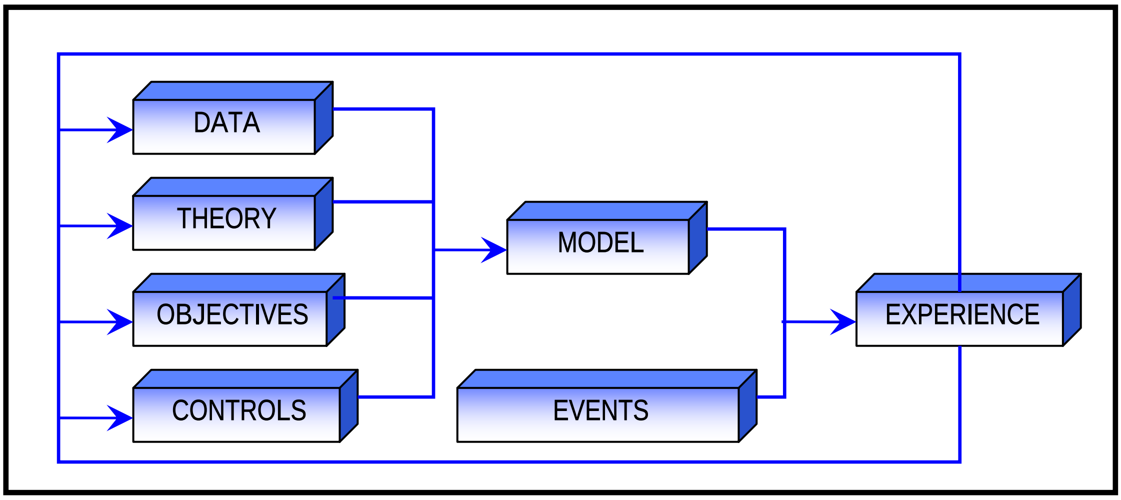
In both cases we find methodological enquiring systems that synthetize both deduction and induction and promote the concept of pseudo-experimentation that Stone (1981) described with the following diagram:

Descriptive Model



This "experimental laboratory" (Fontela, 1990), enriches itself even more when the economy comes to be considered as a science for action, and modelling is used in a context of planning which Stone (1981), described with the following diagram that represents both linear programming (Kantorovich, 1939), and Tinbergen's targets and instruments approach(1952).

Planning model



Both input-output analysis and national accounting have provided during the past years some of main technical tools to elaborate economic models, both descriptive and planning, in spite of the obvious limitations of these tools at the level of data and of their theoretical base.

According to Stone (1977) the first XXth Century attempt to build a type of input-output table refers to 1922-23 and was developed in 1923 for the USSR by Groman, but there is no available reference of this pioneering work. The first official table of the Soviet Central Statistical Administration was elaborated for 1923-24 by a team of statisticians directed by P.I. Popov, and was published in 1926.

Spulber and Dadkhah (1974) provide an analysis of this early research in the USSR that was discontinued when Stalin in 1929 stated:

> "What the Central Statistical Administration published in 1926 as a balance sheet of the national economy is not a balance but a game with figures."

It is only in the early sixties that a new official table for the USSR was published for the year 1960, and that input-output work developed as part of central planning activities.

Was the 1923-24 Soviet Balance a reasonable approximation of what Leontief will later on call an input-output table? For Spulber and Dadkhah the Balance is "identical in nature to modern input-output tables." The authors did adopt the principle of homogeneity of outputs and considered aggregation possibilities; they did also clearly establish the difference between intermediate transactions (related to "productive consumption") and final demands (in the sense of "nonproductive consumption").

Spulber and Dadkhah further show that shortly after the publication of the Balance, in 1929, Barengol'ts developed technical coefficients relating intermediate expenditures in each branch to the total output of that branch, and while it should be noted that the authors of the Balance were conscious of the fact that their work did not provide a total conceptual explanation of the processes at work in a national economy, Popov stated that the balance provided material for a theory, something that was to be developed not in the framework of Marxian economics, but in the competing scheme of neo-classical economics. There was probably nobody at the time in Russia to develop the following statement of Stalin (also mentioned by Spulber and Dadkhah):

> "The schema of the balance of the national economy must be worked out by revolutionary Marxists if they desire at all to devote themselves to the problems of the economy of the transition period".

Thus, input-output research in theory and in practice migrated to America where Wassily Leontief (1936) developed the foundations of computable Walrasian general equilibrium, conceived the open input-output system and established as well the multiplier characteristics of the input-output inverse. Many of these ideas can be traced to earlier authors (Kurz and Salvadori, 2000), but, as pointed out by Baumol (2000):

> "Leontief's contribution is revolutionary, not incremental. It transforms closely targeted abstractions of doubtful applicability into an operational, widely employable analytic instrument."

Input-output return to Europe had to wait the end of the Second World War and the introduction of various forms of economic planning and forecasting practices. Of particular importance was the creation of ASEPELT, the Association Scientifique Européenne de Programmation Economique a Long Terme, created around leading applied quantitative economists such as Tinbergen, Stone, Frish, Cao Pinna, Barna, Kirschen, Besnard, Malinvaud, Paelinck, Waelbroeck, or Gehrig, that promoted several collective research projects and launched the European Economic Review.

The post-war history of input-output in Europe cannot be dissociated from the history of national accounting (Kenessey, 2000). While measurement of national income is one of the tasks of many statistical offices since the early thirties, and while double-entry book-keeping was well known since the middle-ages, the idea of national accounting had to wait for its full understanding the end of the Second World War. American researchers like Robert Martin, Morris Copeland, Simon Kuznetz and Irving Fisher helped to design the emerging concept of national accounting in the late 30's and early 40's, and their work was well known to James Meade and John Hicks in

Britain as well as to Ragnar Frish in Norway, or Jan Tinbergen in Holland, but it is finally to Richard Stone (1947) that the greater credit is to be given for producing the admirable architecture of modern accounts.

Stone said in his autobiography that he had taken advantage of a three-month research period in 1945 at Princenton to write:

> "… my ideas of a social accounting system for the measurement of economic flows, a thing I had wanted to do for years but had not had time for during the war."

In the early 50's the development of input-output tables in western Europe gained momentum, as reported at the Input-output international conferences held in the Netherlands in 1950 (NEI, 1953) and in Italy in 1954 (Barna 1955), and tables were produced for most of the countries, often by national statistical offices; eastern Europe followed track soon afterwards in the academies of science providing research results to the socialist planning organizations.

The necessary linkage between input-output and national accounts became fully operational after a Stone (1961) report to the OECD, showing that an inter-industry product flow table emerges "if the product account in a system of national accounting is subdivided by industry."

In the late 50's, Richard Stone and Alan Brown had started the Cambridge Growth Project with the aim of producing a computable model of economic growth.

The model structure relied on a social accounting matrix with a production account including both commodities and industries a "make" table (commodities produced by industries) and an "use" table (industries absorbing commodities) an idea that was officially adopted by the statistical community in the 1968 SNA of the United Nations. The Make and the Use matrices provided most of the information required to compute an input-output matrix.

The 1960's were years of strong development in Europe for input-output applications, and in particular for the use of input-output as the core for large econometric models often classified as Keynes-Leontief models. The fundamental structure of these models consisted on explaining econometrically the final demand elements of the open Leontief model, using as explanatory variables either current or lagged results of the input-output computations (closing endogeneisation), as well as some exogenous variables relating to the world environment or, even better, to policy instruments. This is the essence of the Cambridge model, and of many national models used in "indicative" planning contexts in the Netherlands, Norway, France and several other European countries; the French experience is described in Aujac (2004). Often these models were used to develop long term alternative scenarios. In the more coercitive context of socialist planning the aims were rather different as planning moved in an opposite direction, from production possibilities and factor availability to the satisfaction of final demands.

In the Netherlands (Verbruggen and Zalm, 1993), Sandee and Schulten (1953) had provided the initial stimulus to the work on integration of macro-economic and input-output models that was taking place at the Central Planning Bureau (CPB) directed at the time by Jan Tinbergen; of particular relevance are the long term projections developed with the first multisectorial model (Netherlands, Central Planning Bureau, 1955), that started a tradition lasting several decades. The CPB, supported by research institutions like NEI (Netherlands Economic Institute) and a continuously growing academic interest, provided the basis for a Dutch long-lasting leading position in Europe in both input-output and applied econometric modelling.

In the same way the Cambridge model continued improving and expanding on its dynamic aspects under the leadership of Terry Barker and other experiences such as those of the INFORUM international system of input-output models (with several research groups in Europe), confirmed that input-output can provide the nucleous of long-term modelling efforts associated to the coherence of national accounts.

In the early seventies input-output was in Europe a strong component of the "experimental laboratory" of economics, an essential tool for structural consistency in economic decision-making in public administrations, and with even some relevance in private enterprises.

The crisis of the seventies (oil, financial fluctuations, structural unemployment), brought greater shortermism into decision-making processes and input-output lost momentum: it was associated to planning and structural change in a social market economy, at a time when economics was promoting more free-market solutions and flexibilities, less thinking on goals and objectives and more belief on "rational" expectations.

The input-output community, increasingly anchored in national accounts, lost some of its academic attractiveness, but resisted to criticism by deepening its theoretical basis and widening its area of applications; it often accepted in this process more modest roles in the final research contributions, in line with the always discreet role of national accounting in economic modelling and economic policy.

2. The situation of input-output in the eighties

After nearly half century of active development, in the mid-eighties, some attempts were made to summarize the situation of the input-output field, one with a more European flavour (Stone, 1984) and another with more American references (Rose and Miernyk, 1989).

Richard Stone described the following situation:

- The construction of input-output tables had been systematized in connection with the development of national accounting, and included the development of Make and Use Tables;

- Regarding the statistical issues raised by this development, Stone cited several studies about stability, adjustment and projection of input-output coefficients, about prices, about capital coefficient's matrices and about regional tables
- Regarding the development of Leontief´s open input-output model, Stone referred to the endogenization process of final demand components (in particular household consumption), the generalization of production functions (using changes in coefficients, functions with intermediate and primary factors, or cost functions following the proposal of a generalized Leontief function of Diewert, 1971), and the research on dynamic aspects of the model, both theoretical and applied to the context of simulation, control and optimization. All these developments of endogenization for aspects of the open input-ouptput model helped to get a stronger connection between Tinbergen and Leontief initial approaches, and allowed the development of large descriptive models of the mesoeconomy.
- Regarding the extensions of the input-output model, Stone pointed out subjects such as environment pollution (with coefficients of polluting emissions and depolluting industries), income distribution (in the widest context of Social Accounting Matrices), capital accounts and financial flows, as well as of international trade relations (in the context of multinational/multisectorial models, such as Leontief's world economy model, recently analyzed by Fontela, 2004)
- Finally, Stone suggested for the future the development of social and demographic input-output models, the improvement of the estimation procedure for social accounting matrices and, in general, of the statistical processes for constructing matrices, automating model building and analysis, and developing condensed forms of the larger models to facilitate their interpretation. Since then, many of these suggestions seem to have received little attention.

When a few years later, Rose and Miernyk (1989) summarized the progress achieved by input-output over the last fifty years they stressed:

- The extensions of the model on its dynamic aspects, on prices, the extended models with income distribution (Miyazawa) or with social accounting matrices and Gosh's supply model; Rose and Miernyk also pointed out among these extensions the connections of the input-output model with linear programming, with econometrics and with computable general equilibrium models;
- Among the applications they identified some consolidated fields such as the study of technological change, development planning, regional and interregional models, environment, energy and natural resources;
- Finally, in the area of empirical considerations, they collected and analyzed research on compilation and estimation of matrices.

Nowadays, it is difficult to have a view of the situation of input-output as complete as those that Stone, Rose and Miernyk had thirty years ago. However, we can make a comment about the obvious continuity in time of the consolidated fields, and about what can be considered as the more recent "innovations", that focus on the field of computable general equilibrium modelling, to whose beginnings Rose and Miernyk referred to.

In fact, in recent years input-output has been setting closer to some developments in economic theory that recover the initial idea of interaction among economic agents, and incorporate explicitly theoretical microeconomics as foundation of mesoeconomic models. The starting point of these GEM's (General Equilibrium Models) is, as Stone suggested, the social accounting matrix, which allows to extend the idea of technical coefficients beyond the sectorial flows; GEM's theoretical innovation stays in the introduction of utility maximizing behaviours by the institutional agents of the economic system (households, enterprises, public administrations).

In the context of the meso-macro or micro-meso-macro models, as it happens in the descriptive context of social accounting matrices and national accounting, the input-output tables are a discreet but indispensable element of a wider observation and modeling system. At the same time, the Leontief's closed model, as a compact mathematical formulation of the Walras' model, provides the main methodological substratum of all this group of scientific developments of the synthetic type (deductive-inductive).

All this explains that input-output, having achieved a century of quantitative applied economics research, remains the object of interesting endeavours, direct (focused on the methods of data elaboration, or on the deepening and extending Leontief's models), as well as indirect (in fields such as social accounting matrices and general equilibrium models, in which input-output is an intermediate product rather than a final product).

3. Recent quantitative evolution of research on input-output techniques

Although it seems obvious that input-output has contributed specially to the development of applied economics, Leontief's initial approach was theoretical, inspired on Walras and Quesnay's works; for Leontief input-output could not be separated from economic theory and its traditional deductive base. That is why Leontief thought it was appropriate that researchers in the input-output area should communicate their results in the traditional fora of economic science, and he resisted for many years ideas such as creating an input-output research journal..

The International Conferences on Input-Output Techniques, started in the 50's, with the purpose of exchanging experiences and spreading new theoretical and applied developments, but the consolidation of the specific area did not take place until the creation in 1986 of the International Input-Output Association (at the eighth Conference) and the publication in 1989 of the first issue of the Association's Journal, Economic Systems Research (ESR).

The development of input-output research is reflected in the quantitative evolution of publications concerning this topic in the wider framework of scientific and economic publications not specialised in input-output. In this sense, the evolution of articles referring to input-output in the Journal of

Economic Literature (JEL) is very significant, as can be seen in the following table:

Journal of Economic Literature: articles published on input-output	
1960-1969	3
1970-1979	12
1980-1989	18
1990-1999	70
(2000-2004)	(85)

But without doubt, today the main source of information on the evolution of input-output analysis is Economic Systems Research, a scientific journal that selects and evaluates contributions in a framework of specialization stimulating considerable progress in the quality of research.

Over the past fifteen years, ESR has published 379 articles, the majority of which deal directly or indirectly with topics related to input-output research.

With the objective of analysing the main characteristics of this important set of scientific contributions, a database has been set up for each article, containing the following information:

- Title;
- Authors and their origin;
- Key words given by the authors;
- Publication date.

Andrew Brody edited ESR up until the end of 1993, when ESR transferred its scientific editorial infrastructure to Holland and become a Journal with double referring blind evaluation, with the editors Jan Oosterhaven (1996-1998) and Erik Dietzenbacher (from 1999).

This evolution suggest dividing the period of analysis 1990- 2004 in two or three sub periods, according to the question considered. The distribution of the articles in sub periods is as follows:

1990-1993	114 articles
1994-1998	122 articles
1999-2004	143 articles
Total	*379 articles*

a) Distribution by nationality

The aspect of generic technology which characterises input-output allows it to be developed in many countries, to such an extent that the authors of the articles in ESR come from 39 countries, among which the United States, representing 22.7% of the total, Holland with 12.4% and the United Kingdom with 8.7%, the three countries with more research activity in this field.

The complete distribution of the articles by country and by year is found in Annex 1. In table 1 which follows, we look at the aggregated evolution of publications in ESR by world zones and by sub periods.

Table 1

ECONOMIC SYSTEM RESEARCH

(nº of articles arranged by world zones and periods)

Geographic zones	PERIOD			
	1990-1993	1994-1998	1999-2004	Total 1990-2004
US and Canada	33	39	34	106
UE-25	56	64	82	202
Rest of the World	25	19	27	71
Total	*114*	*122*	*143*	*379*
	%/total 1990-1993	%/total 1994-1998	%/total 1999-2004	%/total 1990-2004
US and Canada	28,9	32,0	23,8	28,0
UE-25	49,1	52,5	57,3	53,3
Rest of the world	21,9	15,6	18,9	18,7
Total	100	100	100	100

To complete this information, we have also considered the communications and reports presented at the three last input-output conferences held in New York (1998), Macerata, Italy (2000) and Montreal (2002) which include work from 37 countries(among which the Netherlands with 12.1% of the total, the United States with 11.9% and Germany with 9.9%).

Table 2 Communications presented in the last three International Input-Output Conferences (1998-2000-2002), distribution by geographic zone		
	Communications	%
United Status and Canada	47	14,3
Europe (UE-25)	203	61,5
Rest of the world	80	24,2
Total	*330*	*100*

These two sets of information coincide in pointing out the large and increasing weight of the European contributions to research in the field of input-output. Although two of the last Conferences have taken place in North America, the European presence is clearly larger, probably because the input-output contributions are predominantly national and that the large number of European countries contributes to the increase in the volume of papers (in other words the geographical distribution of research activity in this area cannot be independent from the institutional organisation of the territories). This also can explain the relatively high percentage of European papers in ESR.

b) Distribution by the nature of the topics discussed.

The information on key words provided by the authors of the articles presents certain difficulties in interpretation when one tries to deduce from them the possible content of the article. In fact, since there is no previous classification of the key words, the initial results of a simple list are hardly significant.

Therefore, it was necessary to aggregate the initial key words in a group of 30 subjects derived from the structures of the research fields mentioned above (Stone, 1985; Rose and Miernyk, 1989). These 30 subjects refer to:

I. Theoretical and methodological aspects

- I. 1 Input-output model (general)
- I. 2 Price model and primary inputs
- I. 3 Dynamic model
- I. 4 Extended model (Miyazawa)
- I. 5 Supply (allocation) model (Gosh)
- I. 6 Inverse and multipliers
- I. 7 Vertical integration
- I. 8 CGEM and econometric projection models
- I. 9 Linear programming
- I.10 Econometrics and mathematical methods
- I.11 Structural decomposition
- I.12 Qualitative and causal structures

II. Empirical considerations

- II.1 Construction methods
- II.2 RAS and updating
- II.3 National accounting and statistics
- II.4 Make and use matrices
- II.5 Technical and Value Added coeficients
- II.6 Production, productivity, total factor productivity(TFP)
- II.7 SAM (Social Accounting Matrices)

III. Aplications

- III. 1 Consumption and demand
- III. 2 Trade and terms of trade
- III. 3 Urban, regional, interregional
- III. 4 Industries, sectors
- III. 5 Countries
- III. 6 Development planning
- III. 7 Enterprise
- III. 8 Energy
- III. 9 Natural resources, environment and pollution
- III.10 Science and technology
- III.11 Spillover effects

The complete distribution by geographic zones and conceptual subjects can be found in annex 2, and by years and conceptual subjects in annex 3.

Table 3 depicts the evolution sorted out by the three aggregated subject areas and by periods of time.

Table 3

ECONOMIC SYSTEM RESEARCH

(nº of quoted subject areas sorted out by periods of time)

SUBJECT	PERIOD			
	1990-1993	1994-1998	1999-2004	Total 1990-2004
I. Theoretical and methodological aspects	64	136	117	317
II. Empirical considerations	83	73	91	247
III. Applications	31	170	150	351
Total	*178*	*379*	*358*	*915*
	%/total 1990-1993	%/total 1994-1998	%/total 1999-2004	%/total 1990-2004
I. Theoretical and methodological aspects	36,0	35,9	32,7	34,6
II. Empirical considerations	46,6	19,3	25,4	27,0
III. Applications	17,4	44,9	41,9	38,4
Total	*100*	*100*	*100*	*100*

In this case, the totals are higher than those directly related to in the articles since in general each article contains several key-words, and, in consequence, they often have more than one thematic conceptual subjects (an average of 2.4 subjects by article).

Information in table 3 shows a significant change between the first ESR period (1990-93) with a strong interest in empirical considerations related to the creation and treatment of the statistic information, and the following periods in which the central interest moves to the applications. This evolution is probably related to the important changes that took place in the editorial line (it is interesting to remember that the double-blind evaluation principle was adopted at the beginning of the second period), but it may also reflect a general change of the research model. Input-output, as a modern scientific field, seems to increase readiness to deal with concrete problems of the economic world.

However, it is interesting to observe in annex 3 that the relative European presence is higher in the theoretical and methodological field – i.e. representing 73% of the articles about the dynamic model and the 67% of those about the econometric and mathematical methods – a consideration that is in line with the observation made by numerous analysts of European research systems. These analysts think that Europe, in all scientific and technological research fields, attributes relatively more importance to basic research aspects than to applied subjects.

Table 4, divides the information by major subjects, and confirms the different position of European input-output research as compared to North America and the rest of the world.

Table 4

ECONOMIC SYSTEM RESEARCH

(nº of articles sorted out by major subjects and countries)

SUBJECT	COUNTRY			
	USA and Canada	EU-25	Rest of the world	Total
I. Theoretical and methodology aspects	61	198	58	317
II. Empirical considerations	87	128	32	247
III. Applications	99	176	76	351
Total	*247*	*502*	*166*	*915*
	%/total USA and Canada	%/total EU-25	%/total Rest of the world	% Total
I. Theoretical and methodological aspects	24,7	39,4	34,9	34,6
II. Empirical Considerations	35,2	25,5	19,3	27,0
III. Applications	40,1	35,1	45,8	38,4
Total	*100*	*100*	*100*	*100*

c) European research specialization

In order to try to identify possible changes in research specialization within Europe, the data on key subjects has been rearranged by group of countries in the following manner:

- Benelux: The Netherlands and Belgium,
- Central Europe: Germany, Austria, Switzerland, Hungary, Poland, Slovakia,
- United Kingdom, Ireland,
- Nordic countries: Norway, Sweden, Finland, Denmark,
- Southern Europe. France, Italy, Spain Greece.

As to key subjects areas, the 30 topics have been aggregated into six main groups, with two groups on theoretical and methodological aspects:

- Input-output models: subjects I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_{11}, I_{12}
- Wider models: subjects I_8, I_9, I_{10}

Two other groups on empirical considerations

- Data construction: subjects II_1, II_2, II_5, II_6
- National, and Soc. accounting: subjects II_3, II_4, II_7

and finally the last two groups on applications

- National, Regional, trade models: subjects III_2, III_3, III_5, III_6
- Resources, technology, others: subjects III_1, III_4, III_7, III8, III_9, III_{10}, III_{11}

The results of these rearrangements are shown for the three time-periods considered (1990-93, 1994-98, 1999-2004) in Annex 4 (with percentages of totals for the groups of countries), and Annex 5 (with percentages of totals for the new main subject areas).

Inspection of these two tables point to some interesting changes in specialization over time, that may be partly due to the change in editorial rules, but that probably do also reflect changes in research policies and orientations.

Some points may be outlined:

- There is a clear leadership of the UK during the first period in four of the main subjects areas, but this leadership fades away in the second and third period (an evolution that may also be correlated to changes in the rules of University research financing and management in Great Britain):
    - research on the traditional input-output model moves more towards central and southern Europe and the wider models incorporating input-output tend to concentrate in Germany and Central Europe;
    - national an social accounting and modelling, as well as trade modelling concentrate in the Netherlands, with a large number of applications also in Nordic Countries
- In all periods, the papers on data compilation and treatment account for 10-15% of the total of subjects analyzed, and are rather evenly distributed among groups of countries
- From period to period, the share of resource and other applications increase (from 5% in the first to 26.6% in the third), with a key role played by the Nordic Countries since the initial period, but with the rest of Europe evenly participating in the increase

3.- Final considerations

The input-output analysis field has been characterized by the quality of the initial boost of Wassily Leontief and Richard Stone, two Nobel Prizes that have marked modelling and statistical development at the mesoeconomic level (sectors, territories, institutions). The specialized schools of Harvard and New York (around Leontief) and Cambridge (around Stone) do not hold anymore the leadership of research and, in this moment, there are multiple focal points of research excellence distributed around the world. Together with the more traditional British and North American references, today the strength of input-output research is consolidated in Japan, India, Germany, Austria and the Scandinavian countries and of course in the Netherlands: input-output is a global product of applied economics.

The quality of the statistical information keeps being a source of problems when the technique evolves as a synthetic methodology with applications to specific problems of economic policy.

Of course, the institutional situation has improved with the official generalization of make and use matrices as the main source of information for input-output - in the modern systems of national accounting. But it is obvious that the volume of information requested from companies, is and will remain a key problem despite the progress of computing technology.

When the observed reality makes reference to the complex field of interdependence among productive activities, it is evident that the statistical effort to obtain coherence from information of diverse nature will be always unclear; it might even be more artistic than scientific, often inspired by intuitive rather than objectively measurable considerations, finally dependent on conventional agreements among statisticians rather than on exact specifications by analytical economists.

These characteristics of the input-output information, of which any researcher is conscious as soon as he tries to do comparative analyses among tables, requires a special attention when research moves from descriptive analysis to modeling, that is, when the theorical deductions are combined with the available observations. Input-output is a statistical field in which time series are scarce and carry methodological traps, which hinder the identification of possible errors.

These observations about the quality of input-output information either national or regional do not have influence on restraining modeling or applications.

Despite its weakness, the statistical material of input-output is important for mesoeconomic analysis, and, obviously, in the frame of the national accounting, it is indispensable for the construction of macroeconomic aggregates. In consequence, almost every scientific interpretation of the economy, in a synthetic, deductive-inductive process, has to rely on input-output analysis. There is little doubt on the importance of the progress in input-output research in recent years, and it should continue to be a priority field for research activities in applied economics. Europe is not different from the rest of the world at this respect.

References

Aujac H. (2004), Leontief's input-output and the French Development Plan, in Wassily Leontief and input-output economics (ed. Dietzenbacher E. and Lahr M.) Cambridge University Press, Cambridge.

Barna, T. (1955), The Structural Interdependence of the Economy, report of an international conference held in Italy in 1954, Wiley, New York.

Baumol W.J (2000), Leontief's great leap forward: Beyond Quesnay, Marx and von Bortkiewicz, Economic Systems Research, 12, 2, 141-152.

Benini, R. (1907), Sull'uso delle formole empiriche nell'economía applicata, Giornale degli Economisti, 35 (nov.), pp.1053-1063.

Brown, A. Stone, R. (1962), A Computable Model of Economic Growth, Cambridge Growth Project.

Diewert, W. (1971), An application of the Shephard Duality Theorem: A generalized Leontief Production Function, Journal of Political Economy, 79, 4, pp. 481-507.

Fontela, E. (1990), Fundamentos históricos de la economía aplicada, Economistas, 43, pp. 52-57.

Fontela, E. (2004), Leontief and the Future of the World Economy, in *Wassily Leontief and input-output economics* (ed. E. Dietzenbacher, and M. Lahr), Cambridge University Press, Cambridge.

Kantorovich, L. (1939, traducido al ingles en 1960), Mathematical Methods in the Organisation and Planning of Production, Management Science 6, 4, pp. 366-422.

Kenessey, Z. (1993), Postwar Trends in National Accounts in the Perspective of Earliers Developments, in *The Value Added of National Accounting*, Netherlands Central Bureau of Statistics, Voorburg /Heerlen

Kurz H.D., Salvadori, N. (2000), Classical Roots of Input-output Analysis: A Short Account of its Long Prehistory, Economic Systems Research, 12, 2, 153-180.

Leontief, W. (1936), Quantitative Input and Output relations in the Economic System of the United States, The Review of Economic Statistics, 18, 3, pp 105-125.

Netherlands Economic Institute (1953), Input-output Relations, report of an international conference held in the Netherlands in 1950, H.E. Stefert Kroese N.V. Leiden.

Netherlands, Central Planning Bureau (1955), Een Verkenning der Economische yoe Konst-Mogelifkneden van Nederland 1950-70 (A reconnaissance of the economic possibilities of the future for the Netherlands 1950-70), CPB, The Hague.

Pigou, A.C. (1910), A Method of Determining the Numerical Value of Elasticities of Demand, Economic Journal, 20, 80, pp. 636-640.

Polenske, K.H. (2004), Leontief "Magnificent Machine" and the Contribution to Applied Economies, in Dietzenbacher E. and Lahr M. (eds.), *Wassily Leontief and Input-output Economics*, Cambridge University Press.

Rose, A; Miernyk, W. (1989), Input-output Analysis, the First Fifty Years, Economic Systems Research, 1, 2, pp. 229-268.

Sandee, J. and D.B.J., Schouten, (1953), A combination of a macro-economic model and a detailed input-output system, NET (1953).

Stone, R. (1947), Measurement of National Income and the Constitution of Social Accounts, Appendix to the Report of the Sub-Committee on National Income Statistics, Studies and Reports on Statistical Methods Nº 7, United Nations, Geneva.

Stone R. (1961), Input-output and National Accounts, OECD, Paris.

Stone, R. (1981), *Aspects of Economics and Social Modelling*, Drcz, Geneva.

Stone, R (1984), Where are we now? A Short Account of Input-output Studies and their Present Trends, in UNIDO, Proceedings of the Seventh International Conference on Input-Output Techniques, UN Publication E 84 II B 9, New York.

Stone, R., and G. (1997), National income and Expenditure, Tenth Edition (First edition of Meade and Stone's National Income and Expenditure rewritten 1961), Bowes and Bowes, London.

Tinbergen, J. (1935), Quantitative Fragen der Konjunkturpolitik, Weltwirshaftliches Archive, 42, 1, pp. 316-399.

Tinbergen, J. (1952), *On the Theory of Economic Policy*, North-Holland, Amsterdam.

Verbruggen, J.P., Zalm G. (1993), National Accounts and modelling at the Central Planning Bureau, in *The Value Added of National Accounting*, Netherlands Central Bureau of Statistics, Voorburg/Heerlen

Annex 1

ECONOMIC SYSTEM RESEARCH: papers published (1990-2004) by country/year

COUNTRY	YEAR																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	%
Germany	1			1	4	2	1		2	1	2	1		2		17	4,5
Australia	1	1	1		1	1		1				1			1	8	2,1
Austria		1	1		2			2	1	2	5		1		2	17	4,5
Belgium								1			1				1	3	0,8
Brazil												1				1	0,3
Canada			3		4	2	4	2		1	1			1	2	20	5,3
China	1	2		1								1	1			6	1,6
Cyprus			1													1	0,3
Korea															1	1	0,3
Denmark	1			1					1	1	3	1	3		1	12	3,2
USA	8	9	7	6	4	5	4	9	5	4	5	4	3	6	7	86	22,7
Egypt		1														1	0,3
Slovakia			1													1	0,3
Spain		2	1		1				2		2		1	1		10	2,6
Finland	2	1		1				1	2	1			1			9	2,4
France	1		1		1	1	1		2			1				8	2,1
Greece				1						1						2	0,5
Netherlands	4	2	2	2	4	5	1	5	3	3	3	5	5	3		47	12,4
Hungary	1		1	2		1		1	1	2	1				1	11	2,9
India	1		2	1					1	1			1	1		8	2,1
Iran														1		1	0,3
Ireland											1					1	0,3
Israel				2			1				1					4	1,1
Italy	3	1			1	3	2			3	1	2	1	1	3	21	5,5
Japan		1		1	1	1		2			2	1	3	2	3	17	4,5
Kenya				1												1	0,3
Mexico							2						1			3	0,8
Norway			1										1			2	0,5
New Zealand							1									1	0,3
Pakistan		1	1	1												3	0,8
Poland		1		1			1		1			1				5	1,3
Puerto Rico							1									1	0,3

COUNTRY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	*Total*	%
United Kingdom	5	4	3	4	2	2	3			4	2	1		3		33	8,7
Russia	1	1														2	0,5
Singapore									1							1	0,3
Sweden			1	1					1		1					4	1,1
Switzerland	1				1					1				1		4	1,1
Taiwan						1	1									2	0,5
Turkey				1	1			1				1				4	1,1
Total	31	28	27	28	27	24	23	25	23	25	31	21	22	22	22	379	
%	8,2	7,4	7,1	7,4	7,1	6,3	6,1	6,6	6,1	6,6	8,2	5,5	5,8	5,8	5,8		100

Annex 2

ECONOMIC SYSTEM RESEARCH: papers published (1990-2004) by content and countries/regions

SUBJECT	COUNTRY-REGION			Total	%	EU25/Total
	EU-25	North America	Rest of the world			
I. Theoretical and methodological aspects	198	61	58	317	34,6	62,5
I. 1 Input-output model (general)	24	7	5	36	3,9	66,7
I. 2 Price model and primary inputs	18	4	8	30	3,3	60,0
I. 3 Dynamic model	19	4	3	26	2,8	73,1
I. 4 Extended model (Miyazawa)	2	1	1	4	0,4	50,0
I. 5 Supply (allocation) model (Gosh)	1	1	0	2	0,2	50,0
I. 6 Inverse and multipliers	6	1	5	12	1,3	50,0
I. 7 Vertical integration	3	0	0	3	0,3	100,0
I. 8 CGE and econometric projection modes	20	9	6	35	3,8	57,1
I. 9 Linear programming	5	1	2	8	0,9	62,5
I.10 Econometrics and mathematical methods	67	20	13	100	10,9	67,0
I.11 Structural decomposition	14	8	7	29	3,2	48,3
I.12 Qualitative and causal structures	19	5	8	32	3,5	59,4
II. Empirical considerations	128	87	32	247	27,0	51,8
II.1 Construction methods	27	15	4	46	5,0	58,7
II.2 RAS and updating	8	20	2	30	3,3	26,7
II.3 National accounting and statistics	9	4	2	15	1,6	62,5
II.4 Make and use matrices	22	10	1	33	3,6	66,7
II.5 Technical and VA coefficients	26	16	11	53	5,8	49,1
II.6 Production, productivity TFP	16	11	7	34	3,7	47,1
II.7 SAM	20	11	5	36	3,9	55,6
III. Aplications	176	99	76	351	38,4	50,1
III. 1 Consumption and demand	6	4	1	11	1,2	54,5
III. 2 Trade and terms of trade	26	17	12	55	6,0	47,3
III. 3 Urban, regional, interregional	16	3	7	26	2,8	61,5
III. 4 Industries, sectors	13	13	13	39	4,3	33,3
III. 5 Countries	31	23	19	73	8,0	42,5
III. 6 Development planning	2	0	3	5	0,5	40,0
III. 7 Enterprise	4	0	0	4	0,4	100,0
III. 8 Energy	12	3	5	20	2,2	60,0

III. 9 Natural resources, environment and pollution	30	9	4	43	4,7	69,8
III.10 Science and technology	28	19	9	56	6,1	50,0
III.11 Spillover effects	8	8	3	19	2,1	42,1
Total	502	247	166	915		54,9
%	54,9	27,0	18,1		100	

Annex 3

ECONOMIC SYSTEM RESEARCH: papers published (1990-2004) by subject/year

SUBJECTS	YEAR																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	%
I. Theoretical and methodological aspects																	
I. 1 Input-output model (general)	0	0	0	0	5	4	8	1	3	5	7	0	1	1	1	36	3,9
I. 2 Price model and primary inputs	1	1	1	3	8	3	3	1	1	1	3	0	3	0	1	30	3,3
I. 3 Dynamic model	0	0	0	0	1	2	3	5	2	4	3	2	2	2	0	26	2,8
I. 4 Extended model (Miyazawa)	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	4	0,4
I. 5 Supply (allocation) model (Gosh)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	0,2
I. 6 Inverse and multipliers	0	0	0	0	1	0	0	1	3	0	1	4	2	0	0	12	1,3
I. 7 Vertical integration	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	3	0,3
I. 8 CGE and econometric projection modes	2	3	3	3	5	7	1	0	5	0	0	1	1	3	1	35	3,8
I. 9 Linear programming	0	0	0	0	2	0	1	0	0	2	0	2	0	1	0	8	0,9
I.10 Econometrics and mathematical methods	17	5	11	9	2	3	8	4	7	9	8	7	3	1	6	100	10,9
I.11 Structural decomposition	0	0	0	0	2	4	4	2	4	3	2	4	2	0	2	29	3,2
I.12 Qualitative and causal structures	0	1	2	2	5	5	2	0	3	1	3	1	5	1	1	32	3,5
Total I	20	10	17	17	33	28	32	14	29	25	28	22	19	10	13	317	34,6
% /Total I	37,7	24,4	34,0	50,0	38,8	39,4	49,2	16,3	40,3	34,7	33,7	43,1	33,3	20,0	28,9		
% /Total	2,2	1,1	1,9	1,9	3,6	3,1	3,5	1,5	3,2	2,7	3,1	2,4	2,1	1,1	1,4		
II. Empirical considerations																	
II.1 Construction methods	12	2	3	6	4	2	2	5	1	2	2	2	1	1	1	46	5,0
II.2 RAS and updating	0	0	0	0	2	1	0	0	1	3	4	3	0	2	14	30	3,3
II.3 National accounting and statistics	0	0	3	0	2	1	1	0	1	1	2	0	0	2	2	15	1,6
II.4 Make and use matrices	4	1	5	0	5	2	2	0	2	4	2	3	1	1	1	33	3,6
II.5 Technical and VA coeficients	12	13	3	4	3	0	4	1	4	0	6	0	1	2	0	53	5,8

CONTENT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	%
II.6 Production, productivity TFP	0	0	4	0	3	3	2	7	2	3	4	2	0	4	0	34	3,7
II.7 SAM	1	5	3	2	3	3	0	3	1	2	3	4	1	5	0	36	3,9
Total II	29	21	21	12	22	12	11	16	12	15	23	14	4	17	18	247	27,0
% /Total II	54,7	51,2	42,0	35,3	25,9	16,9	16,9	18,6	16,7	20,8	27,7	27,5	7,0	34,0	40,0		
% /Total	3,2	2,3	2,3	1,3	2,4	1,3	1,2	1,7	1,3	1,6	2,5	1,5	0,4	1,9	2,0		
III. Aplications																	
III. 1 Consumption and demand	0	0	0	1	2	0	0	1	1	1	0	2	0	2	1	11	1,2
III. 2 Trade and terms of trade	0	3	3	0	4	4	6	2	6	4	5	4	9	3	2	55	6,0
III. 3 Urban, regional, interregional	0	0	0	1	4	3	4	1	2	4	2	1	0	2	2	26	2,8
III. 4 Industries, sectors	1	1	3	2	3	2	2	4	1	3	2	1	7	5	2	39	4,3
III. 5 Countries	1	5	3	1	5	14	5	12	5	6	5	2	5	2	2	73	8,0
III. 6 Development planning	0	1	2	0	0	1	0	0	0	0	1	0	0	0	0	5	0,5
III. 7 Enterprise	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	0,4
III. 8 Energy	0	0	0	0	0	3	0	1	4	6	4	0	0	2	0	20	2,2
III. 9 Natural resources, environment and pollucion	0	0	0	0	8	2	1	2	11	4	5	4	1	2	3	43	4,7
III.10 Science and technology	2	0	1	0	4	1	4	20	1	3	7	0	10	3	0	56	6,1
III.11 Spillover	0	0	0	0	0	1	0	13	0	1	1	1	1	1	0	19	2,1
Total III	4	10	12	5	30	31	22	56	31	32	32	15	34	23	14	351	38,4
% /Total III	7,5	24,4	24,0	14,7	35,3	43,7	33,8	65,1	43,1	44,4	38,6	29,4	59,6	46,0	31,1		
% /Total	0,4	1,1	1,3	0,5	3,3	3,4	2,4	6,1	3,4	3,5	3,5	1,6	3,7	2,5	1,5		
Total I, II, III	53	41	50	34	85	71	65	86	72	72	83	51	57	50	45	915	
%	5,8	4,5	5,5	3,7	9,3	7,8	7,1	9,4	7,9	7,9	9,1	5,6	6,2	5,5	4,9		100

Annex 4

European I/O research by group of countries, main subject areas and time periods
(percentages by group of countries)
Period 1990-1993

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, III_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	0	50,0	25,0	12,5	6,3	6,3	100
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	10,5	15,8	47,4	15,8	5,3	5,3	100
United Kindom, Ireland	8,6	45,7	22,9	11,4	11,4	0	100
Denmark, Finland, Norway, Sweden	0	28,6	42,9	7,1	7,1	14,3	100
Cyprus, Spain, France, Greece, Italy	6,3	25,0	50,0	12,5	0	6,3	100
Total of Europe	6,0	35,0	35,0	12,0	7,0	5,0	100
USA	4,5	20,5	34,1	20,5	13,6	6,8	100
Rest of the World	8,8	26,5	26,5	8,8	20,6	8,8	100
Total	6,2	29,8	33,1	13,5	11,2	6,2	100

Annex 4

European I/O research by group of countries, main subject areas and time periods
(percentages by group of countries)
Period 1994-1998

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, II_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	6,7	11,7	15,0	20,0	21,7	25,0	100
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	36,1	26,2	8,2	1,6	9,8	18,0	100
United Kindom, Ireland	42,9	14,3	0	14,3	19,0	9,5	100
Denmark, Finland, Norway, Sweden	6,7	13,3	13,3	0	6,7	60,0	100
Cyprus, Spain, France, Greece, Italy	39,2	2,0	11,8	3,9	31,4	11,8	100
Total of Europe	26,9	13,9	10,6	8,7	19,2	20,7	100
USA	17,3	9,9	13,6	4,9	21,0	33,3	100
Rest of the World	23,3	8,9	15,6	4,4	23,3	24,4	100
Total	24,0	11,9	12,4	6,9	20,6	24,3	100

Annex 4

European I/O research by group of countries, main subject areas and time periods
(percentages by group of countries)
Period 1999-2004

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, II_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	17,0	9,4	13,2	18,9	20,8	20,8	100
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	24,6	23,0	13,1	4,9	6,6	27,9	100
United Kindom, Ireland	30,8	3,8	11,5	15,4	23,1	15,4	100
Denmark, Finland, Norway, Sweden	8,8	5,9	8,8	11,8	26,5	38,2	100
Cyprus, Spain, France, Greece, Italy	29,5	13,6	13,6	2,3	11,4	29,5	100
Total of Europe	22,0	12,8	12,4	10,1	16,1	26,6	100
USA	8,8	11,8	30,9	13,2	17,6	17,6	100
Rest of the World	25,0	12,5	12,5	4,2	19,4	26,4	100
Total	20,1	12,6	15,9	9,5	17,0	24,9	100

Annex 5

European I/O research by group of countries, main subject areas and time periods
(percentages by subject areas)
Period 1990-1993

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, II_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	0	15,1	6,8	8,3	5,0	9,1	9,0
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	18,2	5,7	15,3	12,5	5,0	9,1	10,7
United Kindom, Ireland	27,3	30,2	13,6	16,7	20,0	0	19,7
Denmark, Finland, Norway, Sweden	0	7,5	10,2	4,2	5,0	18,2	7,9
Cyprus, Spain, France, Greece, Italy	9,1	7,5	13,6	8,3	0	9,1	9,0
Total of Europe	54,5	66,0	59,3	50,0	35,0	45,5	56,2
USA	18,2	17,0	25,4	37,5	30,0	27,3	24,7
Rest of the World	27,3	17,0	15,3	12,5	35,0	27,3	19,1
Total	100	100	100	100	100	100	100

Annex 5

European I/O research by group of countries, main subject areas and time periods
(percentages by subject areas)
Period 1994-1998

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, II_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	4,4	15,6	19,1	46,2	16,7	16,3	15,8
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	24,2	35,6	10,6	3,8	7,7	12,0	16,1
United Kindom, Ireland	9,9	6,7	0	11,5	5,1	2,2	5,5
Denmark, Finland, Norway, Sweden	1,1	4,4	4,3	0	1,3	9,8	4,0
Cyprus, Spain, France, Greece, Italy	22,0	2,2	12,8	7,7	20,5	6,5	13,5
Total of Europe	61,5	64,4	46,8	69,2	51,3	46,7	54,9
USA	15,4	17,8	23,4	15,4	21,8	29,3	21,4
Rest of the World	23,1	17,8	29,8	15,4	26,9	23,9	23,7
Total	100	100	100	100	100	100	100

Annex 5

European I/O research by group of countries, main subject areas and time periods
(percentages by subject areas)
Period 1994-1998

	Input-output	Wider models (I_8, I_9, I_{10})	Data construction and estimation (II_1, II_2, II_5, II_6)	Nation and social accounting (II_3, II_4, II_7)	National, regional and trade models (III_2, III_3, II_5, III_6)	Resources, technology, sectors and others (rest)	Total
Netherlands, Belgium	12,5	11,1	12,3	29,4	18,0	12,4	14,8
Germany, Austria, Slovakia, Hungary, Poland, Switzerland	20,8	31,1	14,0	8,8	6,6	19,1	17,0
United Kindom, Ireland	11,1	2,2	5,3	11,8	9,8	4,5	7,3
Denmark, Finland, Norway, Sweden	4,2	4,4	5,3	11,8	14,8	14,6	9,5
Cyprus, Spain, France, Greece, Italy	18,1	13,3	10,5	2,9	8,2	14,6	12,3
Total of Europe	66,7	62,2	47,4	64,7	57,4	65,2	60,9
USA	8,3	17,8	36,8	26,5	19,7	13,5	19,0
Rest of the World	25,0	20,0	15,8	8,8	23,0	21,3	20,1
Total	100	100	100	100	100	100	100