Input-Output in Europe: Trends in Research and Application

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Input-output in Europe: Trends in research and applications

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To Emilio Fontela

Input-output analysis is definitely one of the main social technologies of the 20th century; it could belong to the mythologies of the last century –in the features of Roland Barthes' *Mythologies*: the myth of the Welfare State and of the possibility of social planning. But, what have happened to input-output analysis since the end of its Golden Age between 1940 and 1980?

This paper shows that input-output's evolution path is marked by a transfer from its original hometowns, Harvard University in Cambridge (Mass.) – around Wassily Leontief and his team – and Washington – with the federal administrations and the US Army, to Europe. Exactly ten years after Wassily Leontief (1905-1999) passed away, and twenty years after the creation of the International Input-Output Association which first president was Anne P. Carter and also the creation of the first Journal exclusively dedicated to input-output studies (1989-), *Economic System Research*, it is time to ask the question: what happened to input-output analysis? The answer might be found in Europe we argue.

Indeed, indubitably born in the USA, input-output analysis has an important European history, from its very beginnings in the Soviet Union to the postwar huge development of I/O techniques in West and North Europe. This paper studies the European experience of input-output analysis by surveying and analyzing some of the national experiences and especially the works in Great-Britain of Richard Stone and his team. We show in particular how European economists have taken leadership in I/O research since the 1950s and more recently with the creation of *Economic System Research*. In the latter European influence tends to focus works on theoretical and methodological issues more than empirical issues and applications.

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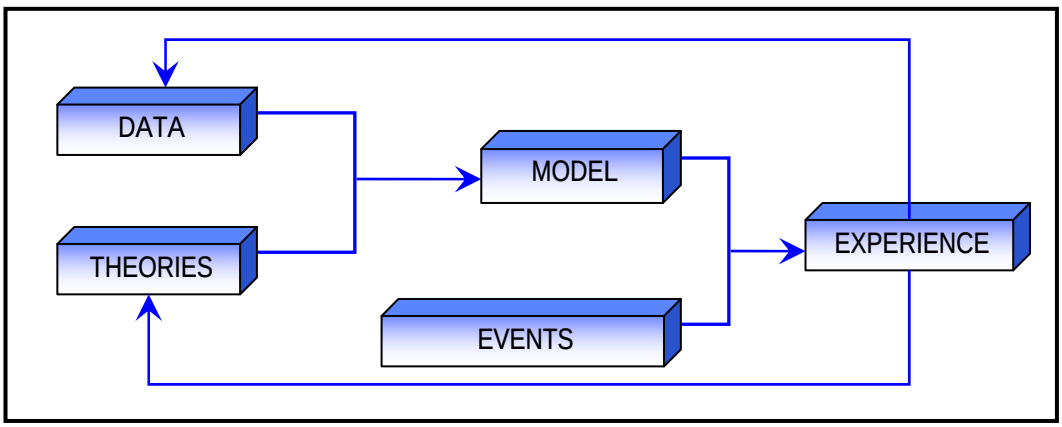
The paper contains three parts. We first go back to the European history and some methodological issues of I/O analysis and Stone's social accounting matrices for the period 1920-1970. In the second part we present the situation of input-output analysis in the 1980s. The last part presents some important features of recent developments of I/O among countries through to a systematic study of *Economic System Research*'s publications.

I. A short overview of input-output analysis' European side, 1926-1975

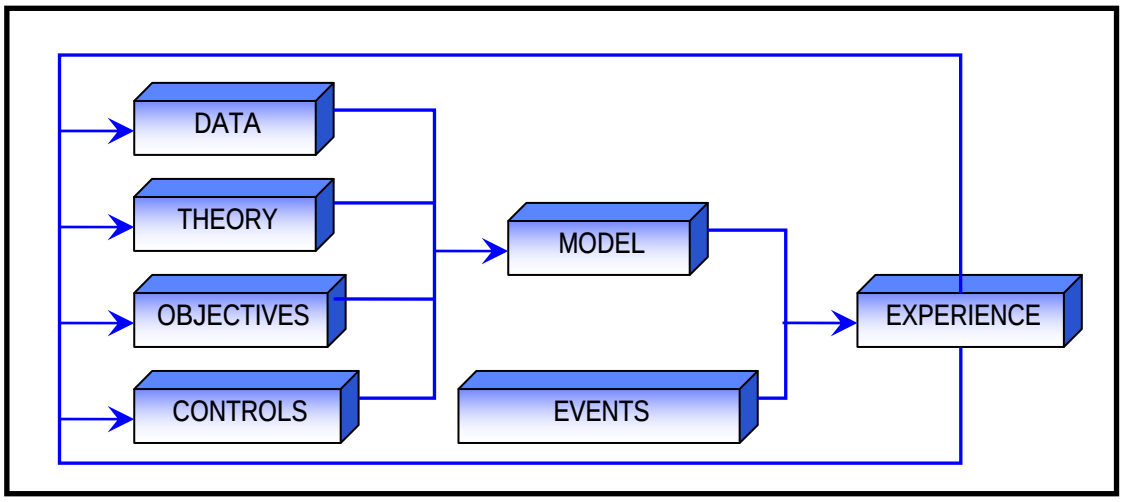
During the last two centuries, economic science was developed with a basically deductive methodology from the fundamentals established by classic economists at the end of the 18th century. The early developments of a quantitative economic science took place at the beginning of the 20th century. It started 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 were elaborated by Benini (1907), and Pigou (1910) developed a method that estimated elasticities from results of family expenditure surveys. In the 1930s, 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 multi-equation models of macroeconomic relations of Tinbergen (1935) and of Frisch (1933), and the multi-equation 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 (often in a classical feature). In both cases we find methodological enquiring systems that synthesize 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[1], and modelling is used in a context of planning which Stone described with the following diagram that represents both linear programming and Tinbergen's targets and instruments approach (1952).

Planning model



Both input-output analysis and national accounting have provided during the past decades some of the main technical tools to elaborate economic models, both descriptive and planning, despite the obvious limitations of these tools at the level of data and of their theoretical base. According to Stone (1997b), the first 20th 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 (1975) provided 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." (p. 27) 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 was very shyly 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 matrices" (*ibid.*, p. 29). Even if this last assertion is disputable because the Soviet Balance is a table of intersectorial relations but not a matrix, it remains that the Soviet Balance is very close to input-output rectangular tables. Indeed, the authors of the Balance did adopt the principle of homogeneity of outputs and considered aggregation possibilities[2]; they did also clearly establish the difference between intermediate transactions

[1] An activity Jacob Marschak, a colleague of Leontief in Kiel (Germany) during the 1920s, used to call social engineering.

[2] Which was clearly not a Marxian principle. In this respect, the Popov Balance is different from the usual physical tables developed later in the USSR. See the remarkable book of Dowidar (1964).

(related to "productive consumption") and final demands (in the sense of "non-productive consumption"). More recent research showed that the principle of row-column intersectorial flow exchange was represented in the Soviet Balance but did not take a matrix shape, a critical innovation that was the prerogative of Frisch and Leontief separately. Indeed, the 1926 Soviet Balance was a statistical table but did not use matrix algebra or coefficients. Spulber and Dadkhah further showed that in 1929, shortly after the publication of the Balance, 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 to be developed in the framework of Marxian economics but not in an orthodox Soviet framework[3]. There was few people at the time in the USSR to follow Stalin's statement: "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." (*ibid.*, p. 27)[4]. Popov's 1926 balance was followed by some works on multisectoral issues in Western Europe and especially in German speaking areas. Works at the Institut für Konjunkturforschung (IfK, Berlin), for instance, were inspired by both Schumpeter's Austrian economic theory of business cycles and the soviet works on multisectoral issues. Moreover one finds in Jacob Marschak's, Ragnar Frisch's and Ferdinand Grünig's works interindustrial tables and multisectoral models. In his lectures, Frisch developed major theoretical improvements of production modelling and matrix analysis of circular flow processes[5]. Theoretical work was done on structural theory and circular flow analysis at the Institut für Weltwirtschaft in Kiel (see the works of Alfred Kahler[6], Wassily Leontief and Adolph Löwe). However, data on production were not collected in a systematic way in Germany[7] nor in most of European countries, in contrast with the USA. Finally, in Europe, interindustrial tables and models didn't pass the experimental stage.

Thereafter, in the 1930s, input-output research in theory and in practice migrated to America where Wassily Leontief developed the foundations of computable Walrasian general equilibrium, conceived the closed and 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." (p. 142)

Input-output's 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 (including for the management of the Marshall Plan, 1947-51). Of particular importance was the UNO national accounts programs (SNA) and the creation of the OEEC (later OECD) and, in some

[3] See Akhabbar (2007).
[4] For a last try to make a macroeconomic accounting table in the USSR, see Wheatcroft and al. (2005).
[5] About the nexus between Frisch and input-output analysis, see Bjerkholt and Knell (2006). For the link between Marschak and the input-output table, see Akhabbar (2010).
[6] See Gehrke (2000).
[7] See Tooze (2001).

respects, the ASEPELT (1961-), the *Association Scientifique Européenne de Programmation Economique à Long Terme*, created around leading applied quantitative economists such as Tinbergen, Stone, Frisch, Cao-Pinna, Barna, Kirschen, Besnard, Malinvaud, Paelinck, Waelbroeck, or Gehrig, that promoted several collective research projects and launched the *European Economic Review*[8]. At the same period, development of input-output analysis in the USA was discouraged by both McCarthyism and, also, federal budget cuts (see Duncan and Shelton 1979). As noticed Leontief (in Rosier 1986), after the Driebergen 1950 conference on input-output techniques, the USA lost their leadership in I/O government research and development. However, in the academic field, the works of Leontief's institute in Harvard, the Harvard Economic Research Project (HERP), were instrumental in improving I/O theory during the period 1948-1975.

In contrasts with the USA, the post-war history of input-output in Europe cannot be dissociated from the history of national accounting (Kenessey 1993). 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 1930s and early 1940s, and their work was well known to James Meade and John Hicks in Britain as well as to Ragnar Frisch 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 Princeton 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." (Stone 1984b)

In the early 1950s 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 (Netherlands Economic Institute 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 an OEEC (1961) publication report written by Stone, 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 early 1950s, Richard Stone and Alan Brown (1962) 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" (SAM) with a production account including both commodities and industries, a "make" table (commodities produced by industries) and, a "use" table (industries absorbing commodities), an idea that was officially adopted by the statistical community in the 1968 SNA of the United Nations but remained a second best solution for national accountants (see

[8] At the same period development of input-output analysis in the USA was discouraged by the political troubles met by American scientists and administrators during McCarthyism. After the Driebergen 1950 conference on input-output techniques the USA lost their leadership in I/O research and development.

Vanoli 2002). The Make and the Use matrices provided most of the information required to compute an input-output matrix and contained full information on joint production –an issue of great importance for linear programming and national accounting.

The 1960s 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 restrictive context of social 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 (The 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[9]. 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[10] international system of input-output models (with several research groups in Europe), confirmed that input-output can provide the nucleus 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. Moreover, the UNO system of national account published in 1968 (SNA 68) under the direction of Richard Stone integrated input-output tables and was structured by Leontief's matrix analysis and developed the general framework of social accounting matrices (SAM). However, 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 social 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. I/O and SAM were dissolved in Computable General Equilibrium Models' routine

[9] See also Johansen (1960).
[10] Founded in 1967 by Clopper Almon at the University of Maryland in the USA.

constructions notably under the influence of economists at the World Bank. 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.

II. 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 1984a) and another with more American references (Rose and Miernyk 1989)[11].

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 quoted 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-output model helped to get a stronger connection between Tinbergen and Leontief's 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 Carter-Petri-Leontief's 1977 world economy-environment model, recently analyzed by Fontela (2004)[12]).

- 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.

[11] See also Carter and Petri (1986).
[12] See also in this issue, Akhabbar's "Anne P. Carter: A biographical note".

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 twenty 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 (CGE Models), to whose beginnings Rose and Miernyk referred to. Actually, 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 CGE models is, as Stone suggested, the social accounting matrix, which allows extending the idea of technical coefficients beyond the sectorial flows. In CGE models the theoretical innovation stays in the introduction of utility maximizing behaviours by the institutional agents of the economic system (households, enterprises, public administrations). As noticed by Showen and Whalley (1984) "the [computable general equilibrium] models reported here extend Wassily Leontief's empirical Walrasian models based on fixed input-output coefficients by incorporating substitution effects in both production and demand and by including more than one consumer" (p. 1008). This simple innovation breakaways from the classical-like feature of the price system in the model of Leontief in favour of a basic supply-demand price mechanism. 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 simple Walras' model[13], provides the main methodological substratum of all this group of scientific developments of the synthetic type (deductive-inductive). In comparison with large econometric models, in the CGE models parameters are mostly not estimated but result from a calibration mechanism.

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

[13] The simple model of Walras is the one with constant technical coefficients.

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).

III. Recent quantitative evolution of research on input-output techniques, 1989-2009

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, Quesnay and Marx'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 because it would mean isolation of I/O studies from general economics. The International Conferences on Input-Output Techniques, started in the 1950s, 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)[14] and which first president was Anne P. Carter, and the publication in 1989 of the first issue of the Association's Journal, *Economic Systems Research* (ESR)[15].

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 specialized 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 referring directly on input-output analysis[16]		
1960-1969	3	4.6%
1970-1979	19	29.2%
1980-1989	18	27.7%
1990-1999	19	29.3%
(2000-2006)	(6)	(9.2%)
Total	**65**	**100**

The previous table shows that number of publications related to input-output economics, in the JEL, grew up quickly from the 1960s to 2000 and then gives signs of a decrease. Without doubt, today one of the main sources 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 specialization and development in the quality of

[14] For further information see Akhabbar's biographical note on Anne P. Carter in this issue.
[15] Published by Routledge.
[16] JStor database.

research. Over the past twenty years, ESR has published more than 472 articles, the majority of which deal directly or indirectly with topics related to input-output research. In this section we will analyze the evolution of publications in ESR as an indicator of input-output analysis' evolution. Our sample to study recent trends of input-output analysis is biased as far as we don't take into consideration public and private administrations' publications except ESR publications, but we guess it is a first step in analysing vitality of input-output communities.

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: (1) Title; (2) Authors and their origin; (3) Keywords given by the authors; (4) Publication date[17]. 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 (1994-1998) and Erik Dietzenbacher (from 1999; he already co-edited the journal between 1994 and 1998)[18]. This organisational evolution suggests dividing the period of analysis 1990-2008 in two or four subperiods, according to the question considered. The distribution of the articles in subperiods is as follows:

	Economic System Research ***1990 - 2008***	
1990-1999 (236 articles)	1990-1993	114 articles
	1994-1998	122 articles
2000-2008 (236 articles)	1999-2004	143 articles
	2005 -2008	93 articles
Total	***1990-2008***	**472 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 20.76%[19] of the total, The Netherlands with 12.7%[20] and the United Kingdom with 7.83%[21], the three countries with more research activity in this field. In table 1 which follows, we look at the aggregated evolution of publications in ESR by world zone and by subperiod.

Table 1

ECONOMIC SYSTEM RESEARCH

(nº of articles arranged by world zones and periods)

Geographic zones	**PERIOD**				
	1990-1993	**1994-1998**	**1999-2004**	**2005-2008**	**Total 1990-2008**

[17] And for the period 2004-2008 the geographic origin of database (USA, Asia, Europe, Africa, etc.).
[18] Since 2008, volume 4 of ESR, Bart Los and Manfred Lenzen have been the new editors of the Journal.
[19] With a decreasing trend: 22.7% in 1990-2004 and 12.9% in 2005-2008.
[20] With a growth trend: 12.4% in 1990-2004 and 16.13% in 2005-2008.
[21] With a critically decreasing trend: 8.7% in 1990-2004 and 4.3% in 2005-2008.

US and Canada	33	39	34	14	120
Europe	56	64	82	57	259
Rest of the World	25	19	27	22	93
Total	*114*	*122*	*143*	*93*	*472*
	%/total 1990-1993	**%/total 1994-1998**	**%/total 1999-2004**	**%/total 2005-2008**	**%/total 1990-2008**
US and Canada	28,9	32,0	23,8	15	25.4
Europe	49,1	52,5	57,3	61,3	54,9
Rest of the world	21,9	15,6	18,9	23,7	19,7
Total	100	100	100	100	100

To complete this information, we have also considered the communications and reports presented at four among the six last input-output conferences held in New York (1998), Macerata, Italy (2000), Montreal (2002), Beijing (2005), Istanbul (2007) and Sao Polo (2009), which include works from 37 countries[22].

Table 2

Communications presented in the last four International Input-Output Conferences (1998-2000-2002-2007), distribution by geographic zone

	Communications	**%/total**
United States and Canada	70	9,5[23]
Europe (EU-25)	409	55,6[24]
Rest of the world	257	34,9[25]
Total	*736*	*100*

These two sets of information, communications and publications, 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. Nevertheless tables 1 & 2 show that Americans publish more than Europeans (under the assumption that one individual or one team can present one communication but can publish more than one paper). It appears clearly that production of input-output analysis is nowadays

[22] Because of a lack of data on the countries of participants, we didn't take under consideration neither the 2005 International Conference in Beijing (China) nor the Sao Polo conference.
[23] To be compared with the 20% of North American publications during the same period.
[24] To be compared with the 58% of European publications during the same period.
[25] To be compared with the 22% of R-O-W publication during the same period.

mainly European (55.6%) and not North American (9.5%). We have to understand the meaning of such a European domination.

b) Distribution by the nature of the topics discussed.

The information on keywords 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 keywords, the initial results of a simple list are hardly significant. Therefore, it was necessary to aggregate the initial keywords in a group of 30 subjects derived from the structures of the research fields mentioned above (Stone 1984a, Rose and Miernyk 1989).

These 30 subjects refer to:

I. Theoretical and methodological aspects	II. Empirical considerations	III. Applications
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.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 coefficients II.6 Production, productivity, total factor productivity (TFP) II.7 SAM (Social Accounting Matrices)	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

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

Table 3

ECONOMIC SYSTEM RESEARCH

(number of quoted subject areas sorted out by periods of time)

SUBJECT	**PERIOD**				
	1990-1993	**1994-1998**	**1999-2004**	**2005-2008**	**Total 1990-2008**
I. Theoretical and methodological aspects	64	136	117	82	399
II. Empirical considerations	83	73	91	50	297
III. Applications	31	170	150	65	416
Total	*178*	*379*	*358*	*197*	*1112*
	%/total 1990-1993	**%/total 1994-1998**	**%/total 1999-2004**	**%/total 2005-2008**	**%/total 1990-2008**

I. Theoretical and methodological aspects	36,0	35,9	32,7	41,6	35.9
II. Empirical considerations	46,6	19,3	25,4	25,4	26.7
III. Applications	17,4	44,9	41,9	33	37,4
Total	*100*	*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 2.36 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 statistical information, and the two following periods in which the central interest moved to the applications. During the last period we notice an increase of theoretical papers but then, between 2005 and 2008, there is a balance between theoretical papers and applications. This evolution is presumably 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 and European authors prefer theoretical subjects to empirical ones.

Indeed, it is interesting to observe (data not published here[26], for 1990-2004) 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 with North America and the rest of the world.

Table 4

ECONOMIC SYSTEM RESEARCH

(n° of quoted subjects by major subjects and countries)

SUBJECT	**COUNTRY**			
	USA and Canada	**Europe**	**ROW**	**Total**
I. Theoretical and methodological aspects	71	244	84	399
II. Empirical considerations	96	161	40	297
III. Applications	109	216	91	416
Total	*276*	*621*	*215*	*1112*

[26] amanar.akhabbar@unil.ch may be asked about data.

	%/total USA and Canada	**%/total Europe**	**%/total ROW**	**% Total**
I. Theoretical and methodological aspects	25,7	39,3	39	35,9
II. Empirical Considerations	34,8	25,9	18,6	26,7
III. Applications	39,5	34,8	42,4	37,4
Total	*100*	*100*	*100*	*100*

Indeed, while theoretical and methodological issues represent nearly 26% of North American publications in ESR, it represents approximately 40% of European ones, which makes a significant difference reinforcing the idea of a traditional preference of Europeans for analytical issues. However, applications represent roughly 40% of American publications and roughly 35% of European ones, which means that Europeans are not obsessively dedicated to the "Great Analytic" –using Clapham's expression.

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 groups of countries in the following manner:

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

Inspection of the results points 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 over the period 1990-2004:

- There is a clear leadership of the UK during the first period in theoretical and empirical subjects, but this leadership fades away in the second and third periods (an evolution that may also be correlated to changes in the rules of university research financing and management in Great Britain). The Golden Age of Great-Britain, marked by Stone and the Cambridge Growth Project seems over;

- Research on the traditional input-output model[27] moves more towards central and southern Europe and the wider models[28] incorporating input-output tend to concentrate in Germany and Central Europe;

- National and social accounting and modelling, as well as trade modelling (see category III.2) 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

[27] The traditional input-output model corresponds to our classification I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_{11}, I_{12}.
[28] The Wider model corresponds to the categories I_8, I_9, I_{10}.

- 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.

Final considerations

The input-output analysis field has been characterized by the quality of the initial boost of Wassily Leontief and later by 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 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[29]. 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"[30] 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, require a special attention when research moves from descriptive analysis to modelling, that is, when the theoretical 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 modelling 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 and social accounting matrices. Nowadays it is mostly linear programming models or computable

[29] See also the recent report of the OECD on the usefulness of I/O in a globalized world (2006).
[30] On this issue about the way to construct statistical "reality", see Leontief (1958).

general equilibrium, models that use I/O and SAMs but some countries go on developing I/O and SAM analytical framework like in Japan or North and central Europe.

This paper showed that big changes appeared in the geographical origin of production of I/O analysis. Indeed, North American authors represented 30.5% of publications in ESR in the period 1990-1998 and only 20.3% in 1999-2008 –and only 15% during 2004-2008. Hence, there is a clear accelerating decrease of North American influence in the I/O community. At the opposite, European authors represented 50.8% of publications between 1990 and 1998 and 58.8% in the next period (and this trend was accelerating, as European publication represented 61.3% of total during 2005-2008).

In contrast with Americans, Europeans made a very close connection between I/O and national accounting. Stone's work is a good example of this close cooperation: to make a model and make the I/O come into the UN System of National Accounts. This difference is critical and leaves room to misunderstandings: in Europe, especially in France, I/O analysis means "national accounting" while in the USA it is simply part of general equilibrium and linear programming analysis. In American Universities I/O was taught in relationship with linear programming and general equilibrium theory. Hence, I/O models were considered as a particular case of Arrow-Debreu general equilibrium models: linear models, like the model of Leontief, were presented as a prelude to general equilibrium theory. In Europe, input-output analysis in a mix of national accounting, linear programming and a tool for planning; the relationship with general equilibrium theory is weaker. Stone was the sole economist with Kuznets and Frisch to get the Nobel Prize for development of "national accounting", and he was a British economist. However, paradoxically, while in Europe input-output analysis is considered as a social accounting and policy-oriented tool, publications of Europeans in Economic System Research are more theoretical than American publications. Applications, in Europe and in the US, concern environment, technology, regional studies, productivity, structural decomposition analysis, etc.

Nowadays, in the highly specialized field of economics, I/O and SAMs are mostly a step in the routine of CGEM construction. That is why International Conferences on Input-Output Techniques host so many papers on CGEM applications. However a "pure" tradition in I/O and SAM is still living, but –as Leontief feared – at the margin of general economics. The revival of I/O with the IIOA and ESR is firstly due to Europeans. Within Europe the map of I/O is very heterogeneous: countries that used to be major producers of I/O techniques like France and Italy are now out of the business. We argue that countries that founded I/O mainly on national accounting are the same where I/O failed to pass the eighties successfully, while countries who combined model-building and I/O making keep a lively tradition in I/O; as a matter of facts, France was in the first case while North, Benelux and Central Europe were in the second case, but UK doesn't match this assumption.

Obviously the United-States and United-Kingdom played the main role in the development of I/O: the first was the departure point of I/O analysis and the latter played a crucial role in Europe and for application of I/O techniques to the UN System of National Accounts (SNA). Alain Desrosières, the sociologist of statistics, noticed that statistical information required in centralized systems was different from the one needed in liberal ones. According to him,

France was an example of a (quite-) centralized economy: I/O analysis was the ideal statistical information for that way of making economic policy. Indeed, "polytechnicians became accustomed to overseeing large segments of the French economy from a technical rather than a market point of view ... This saying points to a technical conception of economics and of national accounting, whose principal tool was input-output analysis, following Leontief's table of industrial exchange ... This example reveals the historical specificity of the statistics required by the *Etat Ingénieur*, which are comparable to the information needed by the general of an army ... (At the opposite) in its most abstract formulation, the pure theory of the market renders statistics superfluous" (2003, p. 555-557). In Desrosières view, examples of liberal systems are the USA and UK. However, it appears that both of them were leading countries in the making and evolution of I/O techniques, from the Leontief matrices to social accounting matrices and CGEM. Moreover, in France, decrease of research and production of I/O material was much more important than in the USA and UK. Obviously Desrosières' analysis doesn't fit our data. This gap may be explained by Desrosières' under-estimation of the need of statistical information in market systems in order to make possible reliable forecasts by public and private agents, given the radical uncertainty. Private or non-governmental demand for I/O techniques was and remains an important part of the making of I/O techniques.

However, if European economists dominate currently the production of input-output ideas and tools, Asian countries' participation is growing. For instance, in the 2007 Istanbul conference, approximately 26% of communications were due to Asian authors, and 35.5% two years later at the Sao Polo conference. Another example: Asian authors in the ESR represented 15% of the total in the years 2005-2006 and 28.5% during the period 2007-2008. There is a trend to migration of production of I/O ideas and tools towards Asia, that is to say the Postmodern Eldorado.

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