# Assessing Economic Complexity in some OECD countries with Input-Output Based Measures

**J. Carlos Lopes*, J. Dias and J. Ferreira do Amaral**

ISEG (School of Economics and Management) - Technical University of Lisbon,
and UECE (Research Unit on Complexity and Economics)

Paper to be presented at the:

**ECOMOD2008 - International Conference on Policy Modeling**
Berlin, Germany, July 2-4, 2008

*Draft: do not quote without permission*

**ABSTRACT:**

Economic complexity can be defined as the level of interdependence between the component parts of an economy. In input-output systems intersectoral connectedness is a crucial feature of analysis, and there are many different methods of measuring it. Most of the measures, however, have important drawbacks to be used as a good indicator of economic complexity, because they were not explicitly made with this purpose in mind. In this paper, we present, discuss and compare empirically different indexes of economic complexity as sectoral connectedness, using the inter-industry tables of several OECD countries.

***Keywords:*** *input-output analysis; intersectoral connectedness; economic complexity*

* Corresponding author:

**e-mail:** jcflopes@iseg.utl.pt

**Full address:**
Prof. João Carlos Lopes
ISEG
Rua Miguel Lupi, nº 20
1249-078 Lisboa
Portugal

---

Financial support by FCT (*Fundação para a Ciência e a Tecnologia*), Portugal is gratefully acknowledged. This paper is part of the Multi-annual Funding Project (POCTI/0436/2003)

## 1. Introduction

Complexity is a multidimensional phenomenon with several approaches and many theoretical definitions that we will not discuss in detail here (see e. g., Waldrop 1992 and Adami 2002). Originated in the physical and biological sciences the notion of complexity has been usefully extended to the analysis of social and economic systems (see e. g., Arthur 1999, Rosser 1999 and Durlauf 2003).

In the economic context, one interesting dimension of complexity is the level of interdependence between the component parts of an economy. The Leontief input-output model is, by its very nature, one of the best theoretical and empirical methodologies for studying it.

In fact, inter-sectoral connectedness is the central feature of input-output analysis, and there are, as expected, many different ways of measuring it, from the earlier and classical indicators of Chenery and Watanable(1958), Rasmussen(1956) and Hirschman(1958), to more sophisticated methods as the interrelatedness measure of Yan and Ames (1963), the cycling measure of Finn(1976) and Ulanovicz(1983), the dominant eigenvalue measure of Dietzenbacher(1992) and many others. Among the more recent examples of interconnectedness measures, proving the resurgence of interest in this kind of research, are the average propagation length (weighted or unweighted) proposed by Dietzenbacher and Romero (2007) and the complexity as interdependence measures of Amaral et al (2007).

The study of economic complexity in an input-output framework has been an interesting subject for economic analysis and policy making purposes (see e.g., Robinson and Markandya 1973, Sonis et al 1998 and Dridi and Hewings 2002). For example, in a more complex economy the effects of (global) policy measures tend to be easily and rapidly propagated and more evenly distributed among sectors, and the same goes for unexpected (desirable or undesirable) shocks of any nature (see e.g., Sonis et al 1995, Dietzenbacher and Los 2002, Steinback 2004 and Okuyama 2007)

On the other hand, it can be expected that the complexity of an economy is negatively correlated with the relative weight of its so-called key sectors and this may eventually make (dominant sectors directed) policy interventions less efficient. (see e.g., Laumas 1975, Dietzenbacher, 1992, Sonis et al, 1995 and Muñiz et al, 2008).

For comprehensive reasons, it is also expectable that, in general, regional economies are less complex than national economies, small economies less complex than large economies and open economies less complex than closed economies, but the exhaustive study of these comparisons would need a careful theoretical and empirical research, well beyond the scope of this paper.

It is also predictable that the effects of measurement errors in collecting interindustry data and the robustness of input-output projections from ESA and SNA Table are in some sense related to the complexity of an economy. This may be an important issue for empirical researchers and statistical unities, and so an appropriate measure of sectoral complexity can be supplemented with these input-output tables, in line with the robustness measure proposed by Wolff (2005).

The inter-sectoral measures of complexity analyzed and quantified in this paper can also be useful in other fields of research, namely for studying the ecological complexity of natural (living) systems (Finn 1976, Zucchetto 1981, Bosserman 1982 and Ulanovicz 1983) and the complexity of social networks (Wasserman and Faust 1994, Jackson 2006).

These measures were chosen among those input-output methodologies directly giving (or allowing to deduct) holistic indexes of connectedness that can be considered good indicators or proxies of complexity as sectoral interdependence. In order to fully understand and quantify economic complexity in this sense, these measures should be complemented with other forms of uncovering structure, like the qualitative input-output analysis based in the theory of directed graphs (Czamansky 1974; Campbell 1975; Aroche-Reys 2003), the minimum flow analysis (Schnable 1994; 1995), the fields of influence and feedback loops analysis (Sonis and Hewings 1991; Sonis et al 1997; van der Linden et al. 2000), the concept of important coefficients (Jensen and West, 1980; Aroche-Reys 1966), the fundamental economic structure (Simpson and Tsukui 1965; Jensen et al 1987; Thakur 2008), the neural network approach to input-output analysis (Wang 2001), among others.

The structure of this paper is as follows: in section 2 the measures of complexity are presented and briefly discussed; in section 3 a detailed quantification of economic complexity as connectedness is made, applying the rich menu of (input-output) measures presented in the previous section and confronting them empirically, using the inter-industry tables of several OECD countries; and section 4 concludes the paper.

**2. Measures of Input-Output Connectedness**

There are several measures of connectedness in input-output analysis. Although not explicitly made for that purpose, they can be considered as alternative measures of economic complexity as sector interrelatedness. And it is an interesting exercise *per se* to rank the economies according to the level of interrelatedness obtained for each of them.

In this section, we present a (not exhaustive) list of measures, from the traditional ones to some recent and more theoretically elaborated. Most of these measures were proposed by authors in economics but there are also some proposed by biologists, and have an ecological content (useful surveys of some of these measures are Hamilton and Jensen 1983, Szyrmer 1985,  Basu and Johnson1996, Cai and Leung 2004, and Amaral et al, 2007).

One of the first indicators of connectedness of an input-output system is the Percentage Intermediate Transactions (M1 – PINT) of Chenery and Watanable(1958), defined as “the percentage of the production of industries in the economy which is used to satisfy needs for intermediate inputs”, and defined as:

$$\text{PINT} = 100\frac{i'\mathbf{A}x}{i'x} \qquad (1)$$

where **A** is the production (technical) coefficients matrix, $x$ is the vector of sectoral gross outputs, $i$ is a unit vector of appropriate dimension, and ‘ means transpose.

Another classical measure of connectedness is the Average Output Multiplier (M2 – AVOM) based on Rasmussen(1956) and Hirschman(1958):

$$\text{AVOM} = \frac{1}{n} i'(\mathbf{I} - \mathbf{A})^{-1} i \tag{2}$$

with *n* the number of sectors and **I** the unit matrix.

A similar measure is used by Blin and Murphy(1974), with $n^2$ in the denominator.

Useful only in very disaggregate matrices is the Percentage of Nonzero Coefficients measure (M3 – PNZC) of Peakock and Dosser (1957):

$$\text{PNZC} = \frac{100}{n^2} i'\mathbf{K}i \tag{3}$$

with **K** a Boolean matrix, such as: $k = [k_{ij}], k_{ij} = \begin{cases} 1, a_{ij} \neq 0 \\ 0, otherwise \end{cases}$

A simple but useful measure is the Mean Intermediate Coefficients Total per Sector (M4 – MICT, Jensen and West, 1980):

$$\text{MIPS} = \frac{1}{n} i'\mathbf{A}i \tag{4}$$

Based on the work of Wang(1954) and Lantner(1974) is the idea that the smaller the value of the determinant of the Leontief matrix, |**I-A**|, the larger the elements of the Leontief inverse and the interrelatedness of the IO system, and so we can use the (Inverse) Determinant measure (M5 – IDET):

$$\text{IDET} = \frac{1}{|\mathbf{I} - \mathbf{A}|} \tag{5}$$

A more elaborate one is the Yan and Ames(1963) interrelatedness measure (M6 – YAAM), defined as:

$$\text{YAAM} = \frac{1}{n^2} \sum_{i,j} \frac{1}{\mathbf{O}_{ij}^{YA}} \tag{6}$$

where $\mathbf{O}_{ij}^{YA}$ is the Order Matrix, with each entry representing the smallest order of interrelatedness between i and j, that is, given the series $\mathbf{A}$, $\mathbf{A}^2$, $\mathbf{A}^3$, …, $\mathbf{A}^k$, $k$ consisting of the exponent necessary to convert the corresponding cell to nonzero.

Dietzenbacher(1992) proposed as an alternative measure of connectedness the Dominant Eigenvalue of Matrix **A** (M7 – DEVA):

$$\text{DEVA} = \lambda \qquad (7)$$

with $\lambda$: the dominant eigenvalue of matrix **A**. This measure has recently been used and refined by Midmore et al (2006).

With particular importance for the study of ecological systems are the following measures of connectedness proposed by Finn(1976) and Ulanovics(1983): the Mean Path Length and the Cycling Index.

The Mean Path Length (M8 – MPLE) is:

$$\text{MPLE} = \frac{i'\mathbf{X}i}{i'y} \qquad (8)$$

where $i'\mathbf{X}i = t$ , is the total system (gross) output and $i'y$ is the system final demand flow (with $y$ representing the vector of sector final demands).

The Cycling Index (M9 – CYCI) is:

$$\text{CYCI} = \frac{b}{t} \qquad (9)$$

where: $b = \sum_j (1 - \frac{1}{l_{jj}}) x_j$ is the sum of the cycling flows, $l_{ii}$ are the main diagonal elements of the Leontief inverse matrix and $t$ was defined above.

A recent measure of input-output connectedness that can be used as an indicator of economic complexity is the Average Path Length (unweighted or weighted) proposed in Dietzenbacher et al (2005) and Dietzenbacher and Romero(2007).

This measure is based on matrices **L** = (**I**-**A**)$^{-1}$ and **H**, with **H** being defined as:

$$\mathbf{H} = 1 \times \mathbf{A} + 2 \times \mathbf{A}^2 + 3 \times \mathbf{A}^3 + \ldots$$

Dietzenbacher and Romero(2007) show that:

$$\mathbf{H} = \mathbf{L}(\mathbf{L} - \mathbf{I})$$

and define the Sectoral Average Propagation Lengths (APL's, that we can represent on a *n*x*n* matrix; let us call it the **APL** matrix ):

$$APL_{ij} = \frac{h_{ij}}{l_{ij}}, for : i \neq j$$

$$APL_{ii} = APL_{jj} = \frac{h_{ii}}{(l_{ii} - 1)} = \frac{h_{jj}}{(l_{jj} - 1)}, for : i = j$$

These values are the base of the M12 - APLU: Average Propagation Lengths (Unweighted) measure:

$$\frac{1}{n}\sum_i \left[\frac{1}{n}\sum_j APL_{ij}\right] = \frac{1}{n}\sum_j \left[\frac{1}{n}\sum_i APL_{ij}\right] \tag{10}$$

Another recent measure, explicitly made for quantifying economic complexity as input-output interdependence, is proposed by Amaral et al (2007), based on Amaral(1999).

This measure considers i) a "network" effect, that gives the extent of direct and indirect connections of each part of the system with the other parts, more connections corresponding to more complexity; and ii) a "dependency" effect, that is, how much of the behavior of each part of the system is determined by internal connections between the elements of that part – which means more autonomy and less dependency – and how much that behavior is determined by external relations, that is, relations with other parts of the system – which means less autonomy and more dependency.

A brief description of this measure is presented here, following closely Amaral et al (2007).

Consider a system represented by a square matrix **A**, of order *N* and with all values non negative. A part of the system of order *m* (*m* = 1, …,*N*-1), is a square block **A*** of order *m* which has its main diagonal formed by *m* elements of the main diagonal of **A**.

Let **A*** be a part of the system. For example:

$$\mathbf{A}^* = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

**A*** can be considered a sub-system of the system **A**. This sub-system is the more autonomous (or, equivalently, the less dependent) the greater the values of its elements ($a_{11}$, $a_{12}$, $a_{21}$, $a_{22}$) are relative to the elements ($a_{1j}$, $a_{2j}$, $a_{j1}$ $a_{j2}$), for all *j*>2.

In order to measure the greater or lesser autonomy of the sub-system **A***, it can be defined the autonomy degree of **A*** as:

$$G_a(\mathbf{A}^*) = \frac{\|\mathbf{A}^*\|}{\|\mathbf{A}^*\| + \|\mathbf{A}^{**}\| + \|\mathbf{A}^{***}\|}$$

where $\|\mathbf{M}\|$ means "sum of the elements of matrix **M**", **A**** is the block of all the elements of the columns belonging to **A*** with the exception of the elements of **A*,** and **A***** means the same for the rows. For example, if **A*** is the block defined above:

$$\|\mathbf{A}^{**}\| = \sum(a_{j1} + a_{j2}) \text{ and } \|\mathbf{A}^{***}\| = \sum(a_{1j} + a_{2j}) \text{ for } j = 3, 4, \ldots, N$$

Based in the autonomy degree it can be defined a block dependency degree as:

$$G_d(\mathbf{A}^*) = 1 - G_a(\mathbf{A}^*)$$

It is easy to see that in a matrix **A** of order *N* there are $2^N - 2$ blocks **A*** (because there are $\sum\binom{N}{k}$ blocks **A*** with *k* = 1, ... , *N*-1).

So, the (raw) dependency degree of system **A** is defined as:

$$G^*(\mathbf{A}) = \frac{\sum_k G_d(\mathbf{A}_k^*)}{2^N - 2}$$

for which k varies from 1 to $2^N - 2$ and $\mathbf{A_k^*}$ represents a square block that includes the main diagonal.

After correcting by the scaling factor given by the maximum value of *G**(**A**) (that is a function of *N*):

$$\frac{2^N - 2^{N-2} - 1}{2^N - 2}$$

the **dependency degree** *G*(**A**) of **A** is:

$$G(\mathbf{A}) = \frac{(2^N - 2)G^*(\mathbf{A})}{2^N - 2^{N-2} - 1}$$

The **network effect indicator**, *H*(**A**) is:

$$H(\mathbf{A}) = 1 - h(\mathbf{A})$$

with $h(\mathbf{A}) = \frac{Z(\mathbf{A})}{N^2 - N}$,

in which *Z*(**A**) is the number of zeros of matrix $\mathbf{L} = \mathbf{(I-A)^{-1}}$.

Finally, the complexity as interdependence index combining the dependency and the network effects is:

$$I(\mathbf{A}) = G(\mathbf{A}) \times H(\mathbf{A}) \qquad (11)$$

This measure can be based on the technical coefficients matrix, **A** (M11 – CAIA) or on the Leontief inverse, substituting, in *G*(**A**), **L** for **A** (M12 – CAIL).

## 3. Measuring connectedness and complexity with OECD IO data

From the previous section we end up with 12 measures of complexity as input-output connectedness, listed in the table presented in Appendix 1.

In this section we present the results of an empirical application of all these measures using the Input-Output Tables of nine OECD economies in the early seventies and the early nineties of the previous century.

For convenience of analysis the original data is aggregated in the 17 sectors presented in the table of Appendix 2.

Tables 3 and 4 show the main results, that is, the values of all the measures for all the countries in early 70's and early 90's.

A broad inspection of these values confirms the expected conclusions that the large economies (Japan and USA) are in fact more complex, and smaller economies tend to be less complex (the Netherlands and Denmark), both at the 70's and the 90's.

This is clearly seen in Tables 5 and 6, where we present the rankings of countries for each measure (9 points for the largest value, 1 point for the smallest) and the final ranking considering all the measures (total number of points and relative position of each country).

Looking to the absolute values of the connectedness measures and its percent changes (Table 7) we also see a (perhaps unexpected) slight reduction in the average economic complexity, with a decreasing dispersion of countries along the "interrelatedness scale function" but no significant relative changes, except UK, upgrading from 8$^{th}$ in the 70's to 4$^{th}$ in the 90's.

A closer inspection of the absolute values and rankings calls for a careful association of measures corresponding to different methodologies or conceptualizations of economic complexity. This task can be better accomplished analyzing the correlation coefficients presented in Tables 8 and 9 and using the following definitions and results.

Let M be the set of the measures $m_i$, r(i,j) the absolute value of the correlation coefficient between $m_i$ and $m_j$ and *c* the number $0 \leq c \leq 1$.

**Definition 1:** A **bundle B** of measures of M is a set of elements of M such that for every pair ($m_i$ , $m_j$ ) of B we have r(i,j) ≥ c and for every $m_k$ of M-B we have at least one $m_i$ of B such that r(i,k) < c.

Two bundles $B_1$ and $B_2$ are **perfectly separated** when for every $m_k$ of $B_1$ we have r(k,i) < *c* for every $m_i$ of $B_2$.

**Definition 2:** An **isolated measure** $m_l$ is one such that the bundle where it belongs is the **degenerate** bundle {$m_l$}.

It is easy to see that the family of bundles of the measures of M is a partition of M as the union of disjoint sets. However the set M may be partitioned in several ways.

**Assumption (emergent concepts***):* For a set M that is partitioned in perfectly separated bundles, each bundle B is interpreted as the emergence at the surface of a hidden concept of interrelatedness.

When the bundles are not perfectly separated the hidden concepts of interrelatedness are called fuzzy concepts.

It is easy to see that if there is a perfectly separated partition it is the only perfectly separated partition that exists.

Applying these concepts to the results of tables 8 and 9 and taking for the value of *c* for each of the years respectively the average of all the correlation coefficients, we have for the 90's two perfectly separated bundles:

$B_1$ = {PINT, AVOM, MICT, IDET, DEVA, MPLE, CYCI, APLU, CAIA, CAIL}

$B_2$ ={ PNZC, YAAM}.

This result indicates a clear distinction (at this level of aggregation - 17 sectors) between measures based on Boolean ($B_2$) and non Boolean ($B_1$) methods, that is probably only interesting, or useful, for very disaggregate matrices.

Another, more useful, distinction is obtained considering, in the domain of strongly correlated non Boolean measures, the correlation coefficients with positive and negative signs, pointing to a further separation of bundles of this kind:

$B_{11}$ = {PINT, AVOM, MICT, IDET, DEVA, MPLE, APLU, CAIL}

$B_{12}$ = {CYCI, CAIA}

The close behavior of measures CYCI and CAIA is supposedly explained by the fact that they explicitly exclude (direct) intra-dependence flows (the values of self-supplying inputs or the coefficients in the main diagonal of matrix A) and in the sense of complexity as (sectoral) interdependence, these are probably the most appropriate measures.

To explore this distinction further, it is useful to make the rankings of economic complexity based on bundle $B_{11}$ (Tables 10 and 11) and bundle $B_{12}$ (Tables 12 and 13).

The interesting result is of course that, according to this particular notion of complexity as interdependence, large economies appear to be less complex than small ones and complexity does not necessarily augments as economies grow and develop. But the full understanding of all the forces behind this surprising result would need further research.

Looking at the correlation coefficients of the early 70’s, a degenerate bundle with the isolated measure M11 - CAIA exist, pointing to an autonomous emergent concept of economic complexity, that does not persist in the 90’s.

**4. Conclusions**

Connectedness is a crucial feature of input-output analysis that can be used for studying economic complexity as sectoral interdependence.

There are many ways to quantify connectedness, and it is a useful exercise to confront different measures, both theoretically and empirically.

In this paper, a menu of twelve measures is presented and briefly discussed. All these measures are quantified using an input-output database of nine OECD countries in the early 70's and 90's, which gives us an interesting inter-country comparison and two decades evolution of economic complexity as sectoral interrelatedness.

Looking at the absolute values of the measures it appears that large economies (Japan and USA) are more "intensely connected" (and so, more complex) than small ones (Netherlands, Denmark). It also appears that there exist a slight reduction in complexity and a decreasing dispersion of countries along the "interrelatedness scale", with one peculiar exception of complex upgrading (UK).

A closer inspection of the values, applying a method of identifying emergent concepts using the correlation coefficients, points to the emergence of three bundles of measures: a Boolean based group of two measures with weak correlation with all the others; a group of eight measures based on all technical coefficients (and production multipliers) with strong positive correlations between them and weak positive correlations with the Boolean group; a bundle of two measures that explicitly exclude intra-sectoral flows, negatively correlated with all the others, but probably the most appropriate to measure complexity as (sectoral) inter-dependence.

According to the majority bundle of (more conventional) measures of connectedness, large economies seem to be more complex than small ones. The bundle of two measures excluding (direct) intra-sectoral flows, on the other hand, points to the inverse conclusion, but this surprising result needs confirmation with further theoretical and empirical research.

**References**


Adami, C. 2002. What is complexity?. *BioEssays* 24: 1085-1094.

Amaral, J. F. 1999. Complexity and Information in Economic Systems. In *Perspectives on Complexity in Economics.* Ed. F. Louçã, ISEG-UTL, Lisbon Technical University.

Amaral, J. F., J. Dias, and J. Lopes. 2007. Complexity as Interdependence: A new Measure of Connectedness of Input-Output Systems. *Environment and Planning A* 39: 1170-82.

Aroche-Reyes, F. 1996, Important coefficients and structural change: a mlti-layer approach, *Economic Systems Research* 8: 235-46.

Aroche-Reyes, F. 2003. A qualitative input-output method to find basic economic structures. *Papers in Regional Science.* 82, 581-590.

Arthur, B. 1999. Complexity and the Economy. *Science* 284: 107-9.

Basu, R., and T. G. Johnson. 1996. The development of a measure of intersectoral connectedness by using structural path analysis. *Environment and Planning A* 28: 709-30.

Blin, J. M., and F. H. Murphy. 1974. On measuring economic interrelatedness. *Review of Economics and Statistics* 41**:** 437-40.

Bosserman, R. W. 1982. Complexity measures for evaluation of ecosystems networks. *International Society for Ecological Modeling Journal* 4: 37-59.

Cai, J., and P. Leung, 2004. Linkage measures: A revisit and a suggested alternative. *Economic Systems Research* 16: 65-85.

Campbell, J. 1975. Application of Graph Theoretic Analysis to Interindustry Relationships. *Regional Science and Urban Economics.* 5: 91-106.

Chenery, H. B., and T. Watanabe. 1958. Interregional comparisons of the structure of production. *Econometrica* 26**:** *487-521*.

Czamansky, S. 1974. *Study of Clustering of Industries.* Institute of Public Affairs, Dalhousie University, Halifax, Canada.

Dietzenbacher, E. 1992. The measurement of interindustry linkages: Key sectors in the Netherlands. *Economic Modelling* 9: 419-37.

Dietzenbacher, E., and B. Los. 2002. Externalities of R&D Expenditures. *Economic Systems Research* 14: 407-25.

Dietzenbacher, E., I. Romero Luna, and N. S. Bosma. 2005. Using average propagation lengths to identify production chains in the Andalusian economy. Estudios de Economía Aplicada 23: 405-22.

Dietzenbacher, E., and I. Romero. 2007. Production Chains in an Interregional Framework: Identification by Means of Average Propagation Lengths. *International Regional Science Review* 30: 362-83.

Dridi, C., and G. Hewings. 2002. Industry Associations, Association Loops and Economic Complexity: Application to Canada and the United States. *Economic Systems Research* 14: 275-96.

Durlauf, S. 2003. Complexity and Empirical Economics. Santa Fe Institute Working Paper.

Finn, J. T. 1976. Measures of ecosystem structure and function derived from analysis of flows. *Journal of Theoretical Biology* 56: 363-80.

Hamilton, J. R., and R. C. Jensen.1983. Summary measures of interconnectedness for input-output models. *Environment and Planning A* 15: 55-65.

Hirshman, A. O. 1958. *The Strategy of Economic Development.* Yale University Press, New Haven, CT.

Jackson, M. 2006. The Economics of Social Networks. In *Advances in Economics and Econometrics, Theory and Applications: Ninth World Congress of the Econometric Society,* eds. R. Blundell, W. Newey and T. Persson. Cambridge University Press.

Jensen, R. C., G. West. 1980. The effect of relative coefficient size on input-output multipliers. *Environment and Planning A* 12**:** 659-70.

Jensen, R. C., G. Hewings, and G. West. 1987. On a Taxonomy of Economies, *Australian Journal of Regional Studies* 2: 3-24.

Lantner, R. 1974. *Théorie de la Dominance Economique.* Dunod, Paris.

Lantner, R., and R. Carluer. 2004. Spatial dominance: a new approach to the estimation of interconnectedness in regional input-output tables. *The Annals of Regional Science,* 38: 451-67.

Laumas, P. S. 1975. Key sectors in some underdeveloped countries, *Kyklos* 28: 62-79.

Midmore, P., M. Munday, and A. Roberts. 2006. Assessing Industry Linkages Using Regional Input-Output Tables. *Regional Studies* 40: 329-43.

Muñiz, A., A. Raya, and C. Carvajal. 2008. Key Sectors: A New Proposal from Network Theory. *Regional Studies*: online/08/000001-18.

Okuyama, Y. 2007. Economic Modeling for Disaster Impact Analysis. *Economic Systems Research:* 19: 115-24.

Peackock, A. T., and D. Dosser. 1957. Input-output analysis in an underdeveloped country: a case study. *The Review of Economic Studies* 25: 21-4.

Rasmussen, P. N. 1957. *Studies in Intersectoral Relations.* North-Holland, Amsterdam.

Robinson, S., and A. Markandya. 1973. Complexity and adjustment in input-output systems. *Oxford Bulletin of Economics and Statistics* 35: 119-34.

Rosser, Jr. J. 1999. On the Complexity of Complex Economic Dynamics. *Jounal of Economic Perspectives.* 13: 169-92.

Schnabl, H. 1994. The evolution of production structures analysed by a multi-layer procedure. *Economic Systems Research* 6: 51-68.

Schnabl, H. 1995. The Subsystem-MFA: A Qualitative Method for Analyzing National Innovation Systems – The Case of Germany. *Economic Systems Research* 7: 383-96.

Simpson, D., and M. Tsukui. 1965. The Fundamental Structure of Input-Output Tables,An International Comparison, *Review of Economics and Statistics* 47: 434-46.

Sonis, M., and G. J. D. Hewings. 1991. Fields of influence and extended input-output analysis: a theoretical account. In Anselin L., M. Madden, eds. *New Directions in Regional Analysis: Integrated and Multiregional Approaches.* Pinter, London.

Sonis, M., J. Guilhoto, G. J. D. Hewings, and E. Martins. 1995. *Linkages, key sectors and structural change: some new perspectives. Developing Economies* 33: 233-70.

Sonis, M., G. J. G. Hewings, and E. Haddad. 1996. A typology of propagation of changes on the structure of a multiregional economic system: The case of the European Union, 1975-1975. *Annals of Regional Science,* 30: 391-408.

Sonis, M., and G. J. D. Hewings. 1998. Economic complexity as network complication: Multiregional input-output structural path analysis. *Annals of Regional Science,* 32: 407-36.

Steinback, S. R. 2004. Using ready-made regional input-output models to estimate backward-linkage effects of exogenous output shocks. *Review of Regional Studies* 34: 57-71.

Szyrmer, J. M. 1985. Measuring connectedness of input-output models: 1. Survey of the measures. *Environment and Planning A* 17: 1567-600.

Szyrmer, J. M. 1986. Measuring connectedness of input-output models: 2. Total flow concept. *Environment and Planning A* 18: 107-21.

Takur, S. 2008. Identification of temporal fundamental economic structure (FES) of India: An input-output and cross-entropy analysis. *Structural Change and Economic Dynamics* 19: 132-51.

Ulanovicz, R E. 1983. Identifying the structure of cycling in ecosystems, *Mathematical Biosciences.* 65: 219-37.

Van Der Linden, J., J. Oosterhaven, F. Cuello, G. Hewings, and M. Sonis. 2000. Fields of influence of productivity cxhange in EU intercountry input-output tables, 1970-1980. *Environment and Planning A* 32: 1287-305.

Wang, S. 2001. The Neural Network Approach to Input-Output Analysis for Economic Systems, *Neural Computing & Applications* 10: 22-8.

Waldrop, M. 1992. *Complexity: The Emerging Science at the Edge of Order and Chaos,* Penguin Books, London.

Wasserman, S., and K. Faust. 1994. *Social Network Analysis. Methods and Applications, Structural Analysis in the Social Sciences,* Cambridge University Press, New York.

Wong, Y. K. 1954. Some mathematical concepts for linear economic models. In *Economic Activity Analysis,* ed. O. Morgenstern, 283-341. Wiley, New York.

Yan, C., and E. Ames. 1965. Economic Interrelatedness. *The Review of Economic Studies* 32: 290-310.

Zucchetto, J. 1981. Energy diversity of regional economies. In *Energy and Ecological Modeling,* eds. W. S. Mitsch, R. W. Bosserman, and J. M. Klopatek, 543-48. Elsevier, Amsterdam.

**Appendix 1:**

**Table 1: Input-Output Connectedness Measures**

| Number: | Designation: | Formula: | Proponents: |
|---|---|---|---|
| M1 | PINT | $100\frac{\text{i}'\text{Ax}}{\text{i}'\text{x}}$ | Chenery and Watanable (1958) |
| M2 | AVOM | $\frac{1}{n}i'(I-A)^{-1}i$ | Rasmussen-Hirschman (1958) |
| M3 | PNZC | $\frac{100}{\text{n}^2}\text{i}'\text{Ki}$ | Peakock and Dosser (1957) |
| M4 | MICT | $\frac{1}{\text{n}}\text{i}'\text{Ai}$ | Jensen and West (1980) |
| M5 | IDET | $\frac{1}{\lvert \text{I}-\text{A} \rvert}$ | Wang(1954)<br>Lantner(1974) |
| M6 | YAAM | $\frac{1}{\text{n}^2}\sum_{\text{i,j}}\frac{1}{\text{O}_{\text{ij}}^{\text{YA}}}$ | Yan and Ames (1963) |
| M7 | DEVA | $\lambda$: dominant eigenvalue of A | Dietzenbacher (1992) |
| M8 | MPLE | $\frac{\text{i}'\text{Xi}}{\text{i}'\text{y}}$ | Finn (1976)<br>Ulanovicz(1983) |
| M9 | CYCI | $\frac{b}{t}$ | Finn (1976)<br>Ulanovicz(1983) |
| M10 | APLU | $\frac{1}{n^2}\sum_i\left[\sum_j APL_{ij}\right]$ | Dietzenbacher (2007) |
| M11 | CAIA | $G(A)\times H(A)$<br>$A_{based}$ | Amaral, Dias and Lopes (2007) |
| M12 | CAIL | $G(L)\times H(L)$<br>$L_{based}$ | Amaral, Dias and Lopes (2007) |

**Appendix 2.**

**Table 2: Aggregate sectors**

| | |
|---|---|
| 1 | Agriculture, mining & quarrying |
| 2 | Food, beverages & tobacco |
| 3 | Textiles, apparel & leather |
| 4 | Wood and paper |
| 5 | Chemicals, drugs, oil and plastics |
| 6 | Minerals and metals |
| 7 | Electrical and non-elect. equipment |
| 8 | Transport equipment |
| 9 | Other manufacturing |
| 10 | Electricity, gas & water |
| 11 | Construction |
| 12 | Wholesale & retail trade |
| 13 | Restaurants & hotels |
| 14 | Transport & storage |
| 15 | Communication |
| 16 | Finance & insurance |
| 17 | Other sectors |

**Appendix 3:**

**Table 3: Connectedness Measures - early 70's values**

| Country | Year | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | CYCI | APLU | CAIA | CAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1968 | 44,667 | 1,742 | 91,004 | 0,420 | 8,539 | 0,955 | 0,428 | 1,807 | 0,864 | 2,188 | 0,747 | 0,406 |
| Canada | 1971 | 42,287 | 1,685 | 100,000 | 0,395 | 5,231 | 1,000 | 0,416 | 1,733 | 0,899 | 2,041 | 0,779 | 0,404 |
| Denmark | 1972 | 31,755 | 1,473 | 99,654 | 0,318 | 3,381 | 0,998 | 0,329 | 1,465 | 0,926 | 1,705 | 0,786 | 0,328 |
| France | 1972 | 41,030 | 1,678 | 96,886 | 0,407 | 8,639 | 0,984 | 0,395 | 1,691 | 0,869 | 1,959 | 0,737 | 0,381 |
| Germany | 1978 | 40,939 | 1,757 | 99,308 | 0,424 | 10,537 | 0,997 | 0,458 | 1,693 | 0,857 | 2,046 | 0,732 | 0,402 |
| Japan | 1970 | 50,524 | 1,956 | 97,232 | 0,484 | 15,087 | 0,986 | 0,501 | 2,021 | 0,825 | 2,272 | 0,740 | 0,450 |
| Netherlands | 1972 | 29,758 | 1,449 | 91,350 | 0,304 | 4,298 | 0,957 | 0,368 | 1,424 | 0,909 | 1,735 | 0,754 | 0,301 |
| UK | 1968 | 37,560 | 1,683 | 93,426 | 0,393 | 9,180 | 0,967 | 0,427 | 1,602 | 0,868 | 2,014 | 0,729 | 0,379 |
| USA | 1972 | 41,916 | 1,898 | 100,000 | 0,478 | 18,285 | 1,000 | 0,465 | 1,722 | 0,858 | 2,187 | 0,712 | 0,430 |

**Table 4: Connectedness Measures - early 90's values**

| Country | Year | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | CYCI | APLU | CAIA | CAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1989 | 38,391 | 1,722 | 100,000 | 0,429 | 6,629 | 1,000 | 0,399 | 1,623 | 0,897 | 1,919 | 0,767 | 0,410 |
| Canada | 1990 | 40,764 | 1,686 | 100,000 | 0,399 | 6,068 | 1,000 | 0,414 | 1,688 | 0,891 | 2,037 | 0,765 | 0,400 |
| Denmark | 1990 | 31,656 | 1,532 | 99,654 | 0,356 | 3,638 | 0,998 | 0,315 | 1,463 | 0,922 | 1,725 | 0,791 | 0,355 |
| France | 1990 | 37,051 | 1,683 | 95,848 | 0,416 | 8,087 | 0,979 | 0,411 | 1,586 | 0,883 | 1,914 | 0,748 | 0,386 |
| Germany | 1990 | 41,064 | 1,769 | 99,654 | 0,446 | 8,737 | 0,998 | 0,416 | 1,697 | 0,864 | 1,963 | 0,753 | 0,416 |
| Japan | 1990 | 45,999 | 1,912 | 95,502 | 0,483 | 18,497 | 0,978 | 0,473 | 1,852 | 0,844 | 2,212 | 0,719 | 0,432 |
| Netherlands | 1986 | 29,986 | 1,473 | 91,696 | 0,324 | 3,601 | 0,959 | 0,330 | 1,428 | 0,921 | 1,728 | 0,782 | 0,324 |
| UK | 1990 | 40,389 | 1,743 | 100,000 | 0,428 | 9,562 | 1,000 | 0,421 | 1,678 | 0,859 | 1,944 | 0,737 | 0,403 |
| USA | 1990 | 40,153 | 1,849 | 100,000 | 0,468 | 12,871 | 1,000 | 0,442 | 1,671 | 0,864 | 2,077 | 0,732 | 0,429 |

**Table 5: Connectedness Measures - early 70's rankings**

| Country | Year | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | *CYCI* | APLU | *CAIA* | CAIL | Total | **FR** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1968 | 8 | 6 | 1 | 6 | 4 | 1 | 6 | 8 | *4* | 8 | *6* | 7 | 65,0 | **5º** |
| Canadá | 1971 | 7 | 5 | 8,5 | 4 | 3 | 8,5 | 4 | 7 | *7* | 5 | *8* | 6 | 73,0 | **3º** |
| Denmark | 1972 | 2 | 2 | 7 | 2 | 1 | 7 | 1 | 2 | *9* | 1 | *9* | 2 | 45,0 | **7º** |
| France | 1972 | 5 | 3 | 4 | 5 | 5 | 4 | 3 | 4 | *6* | 3 | *4* | 4 | 50,0 | **6º** |
| Germany | 1978 | 4 | 7 | 6 | 7 | 7 | 6 | 7 | 5 | *3* | 6 | *3* | 5 | 66,0 | **4º** |
| Japan | 1970 | 9 | 9 | 5 | 9 | 8 | 5 | 9 | 9 | *1* | 9 | *5* | 9 | 87,0 | **1º** |
| Netherlands | 1972 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | *8* | 2 | *7* | 1 | 30,0 | **9º** |
| UK | 1968 | 3 | 4 | 3 | 3 | 6 | 3 | 5 | 3 | *5* | 4 | *2* | 3 | 44,0 | **8º** |
| USA | 1972 | 6 | 8 | 8,5 | 8 | 9 | 8,5 | 8 | 6 | *2* | 7 | *1* | 8 | 80,0 | **2º** |
| Total | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | ***45*** | 45 | ***45*** | 45 | | |

**Table 6: Connectedness Measures - early 90's rankings**

| Country | Year | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | *CYCI* | APLU | *CAIA* | CAIL | Total | **FR** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1989 | 4 | 5 | 7,5 | 6 | 4 | 7,5 | 3 | 4 | *7* | 4 | *7* | 6 | 65,0 | **6º** |
| Canadá | 1990 | 7 | 4 | 7,5 | 3 | 3 | 7,5 | 5 | 7 | *6* | 7 | *6* | 4 | 66,5 | **5º** |
| Denmark | 1990 | 2 | 2 | 5 | 2 | 2 | 4,5 | 1 | 2 | *9* | 1 | *9* | 2 | 41,0 | **8º** |
| France | 1990 | 3 | 3 | 3 | 4 | 5 | 3 | 5 | 3 | *5* | 3 | *4* | 3 | 43,5 | **7º** |
| Germany | 1990 | 8 | 7 | 5 | 7 | 6 | 4,5 | 6 | 8 | *2* | 6 | *5* | 7 | 71,0 | **3º** |
| Japan | 1990 | 9 | 9 | 2 | 9 | 9 | 2 | 9 | 9 | *1* | 9 | *1* | 9 | 78,0 | **2º** |
| Netherlands | 1986 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | *8* | 2 | *8* | 1 | 28,0 | **9º** |
| UK | 1990 | 6 | 6 | 7,5 | 5 | 7 | 7,5 | 7 | 6 | *3* | 5 | *3* | 5 | 68,0 | **4º** |
| USA | 1990 | 5 | 8 | 7,5 | 8 | 8 | 7,5 | 8 | 5 | *4* | 8 | *2* | 8 | 79,0 | **1º** |
| Total | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | | |

**Table 7: Percent changes of absolute values, between the 70's and the 90's**

| Country | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | CYCI | APLU | CAIA | CAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | -14,051 | -1,179 | 9,886 | 1,987 | -22,371 | 4,710 | -6,872 | -10,187 | 3,828 | -12,264 | 2,669 | 1,103 |
| Canada | -3,601 | 0,086 | 0,000 | 1,099 | 16,001 | 0,000 | -0,556 | -2,570 | -0,883 | -0,205 | -1,809 | -1,043 |
| Denmark | -0,312 | 3,975 | 0,000 | 11,956 | 7,596 | 0,000 | -4,353 | -0,145 | -0,356 | 1,179 | 0,703 | 8,362 |
| France | -9,699 | 0,350 | -1,071 | 2,007 | -6,387 | -0,527 | 4,140 | -6,182 | 1,658 | -2,304 | 1,562 | 1,320 |
| Germany | 0,304 | 0,681 | 0,348 | 5,249 | -17,082 | 0,174 | -9,262 | 0,211 | 0,908 | -4,053 | 2,887 | 3,639 |
| Japan | -8,956 | -2,266 | -1,779 | -0,178 | 22,601 | -0,877 | -5,684 | -8,379 | 2,277 | -2,632 | -2,799 | -4,187 |
| Netherlands | 0,764 | 1,627 | 0,379 | 6,547 | -16,214 | 0,181 | -10,211 | 0,325 | 1,268 | -0,405 | 3,712 | 7,702 |
| UK | 7,533 | 3,554 | 7,037 | 8,853 | 4,170 | 3,399 | -1,262 | 4,747 | -0,999 | -3,465 | 1,117 | 6,333 |
| USA | -4,205 | -2,560 | 0,000 | -1,991 | -29,611 | 0,000 | -4,960 | -2,945 | 0,665 | -5,037 | 2,817 | -0,282 |

**Table 8: Correlation coefficients - 70's**

| | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | CYCI | APLU | CAIA | CAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PINT | 1,000 | 0,910 | 0,181 | 0,905 | 0,665 | 0,181 | 0,848 | 0,992 | -0,847 | 0,938 | -0,370 | 0,951 |
| AVOM | 0,910 | 1,000 | 0,277 | 0,993 | 0,906 | 0,277 | 0,948 | 0,897 | -0,912 | 0,956 | -0,635 | 0,972 |
| PNZC | 0,181 | 0,277 | 1,000 | 0,294 | 0,250 | 1,000 | 0,142 | 0,152 | -0,001 | 0,080 | 0,112 | 0,341 |
| MICT | 0,905 | 0,993 | 0,294 | 1,000 | 0,905 | 0,294 | 0,921 | 0,881 | -0,904 | 0,949 | -0,659 | 0,972 |
| IDET | 0,665 | 0,906 | 0,250 | 0,905 | 1,000 | 0,250 | 0,850 | 0,656 | -0,838 | 0,796 | -0,817 | 0,797 |
| YAAM | 0,181 | 0,277 | 1,000 | 0,294 | 0,250 | 1,000 | 0,142 | 0,152 | -0,001 | 0,080 | 0,112 | 0,341 |
| DEVA | 0,848 | 0,948 | 0,142 | 0,921 | 0,850 | 0,142 | 1,000 | 0,845 | -0,928 | 0,923 | -0,668 | 0,900 |
| MPLE | 0,992 | 0,897 | 0,152 | 0,881 | 0,656 | 0,152 | 0,845 | 1,000 | -0,844 | 0,919 | -0,334 | 0,925 |
| CYCI | -0,847 | -0,912 | -0,001 | -0,904 | -0,838 | -0,001 | -0,928 | -0,844 | 1,000 | -0,881 | 0,749 | -0,843 |
| APLU | 0,938 | 0,956 | 0,080 | 0,949 | 0,796 | 0,080 | 0,923 | 0,919 | -0,881 | 1,000 | -0,568 | 0,961 |
| CAIA | -0,370 | -0,635 | 0,112 | -0,659 | -0,817 | 0,112 | -0,668 | -0,334 | 0,749 | -0,568 | 1,000 | -0,489 |
| CAIL | 0,951 | 0,972 | 0,341 | 0,972 | 0,797 | 0,341 | 0,900 | 0,925 | -0,843 | 0,961 | -0,489 | 1,000 |

Note: mean absolute values below main diagonal = 0.637

**Table 9: Correlation coefficients - 90's**

| | PINT | AVOM | PNZC | MICT | IDET | YAAM | DEVA | MPLE | CYCI | APLU | CAIA | CAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PINT | 1,000 | 0,943 | 0,357 | 0,914 | 0,834 | 0,357 | 0,953 | 0,996 | -0,912 | 0,953 | -0,850 | 0,930 |
| AVOM | 0,943 | 1,000 | 0,351 | 0,991 | 0,909 | 0,351 | 0,957 | 0,937 | -0,931 | 0,938 | -0,913 | 0,966 |
| PNZC | 0,357 | 0,351 | 1,000 | 0,398 | 0,012 | 1,000 | 0,224 | 0,301 | -0,222 | 0,221 | -0,087 | 0,553 |
| MICT | 0,914 | 0,991 | 0,398 | 1,000 | 0,873 | 0,398 | 0,931 | 0,900 | -0,913 | 0,890 | -0,888 | 0,973 |
| IDET | 0,834 | 0,909 | 0,012 | 0,873 | 1,000 | 0,012 | 0,875 | 0,860 | -0,895 | 0,889 | -0,933 | 0,777 |
| YAAM | 0,357 | 0,351 | 1,000 | 0,398 | 0,012 | 1,000 | 0,224 | 0,301 | -0,222 | 0,221 | -0,087 | 0,553 |
| DEVA | 0,953 | 0,957 | 0,224 | 0,931 | 0,875 | 0,224 | 1,000 | 0,943 | -0,937 | 0,959 | -0,940 | 0,909 |
| MPLE | 0,996 | 0,937 | 0,301 | 0,900 | 0,860 | 0,301 | 0,943 | 1,000 | -0,910 | 0,958 | -0,851 | 0,907 |
| CYCI | -0,912 | -0,931 | -0,222 | -0,913 | -0,895 | -0,222 | -0,937 | -0,910 | 1,000 | -0,868 | 0,962 | -0,857 |
| APLU | 0,953 | 0,938 | 0,221 | 0,890 | 0,889 | 0,221 | 0,959 | 0,958 | -0,868 | 1,000 | -0,872 | 0,888 |
| CAIA | -0,850 | -0,913 | -0,087 | -0,888 | -0,933 | -0,087 | -0,940 | -0,851 | 0,962 | -0,872 | 1,000 | -0,803 |
| CAIL | 0,930 | 0,966 | 0,553 | 0,973 | 0,777 | 0,553 | 0,909 | 0,907 | -0,857 | 0,888 | -0,803 | 1,000 |

Note: mean absolute values below main diagonal = 0.719

**Table 10: Connectedness Measures - early 70's rankings – $B_{11}$ (all interindustry flows)**

| Country | Year | PINT | AVOM | MICT | IDET | DEVA | MPLE | APLU | CAIL | Total | **FR** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1989 | 4 | 5 | 6 | 4 | 3 | 4 | 4 | 6 | 36,0 | **6º** |
| Canadá | 1990 | 7 | 4 | 3 | 3 | 5 | 7 | 7 | 4 | 39,5 | **5º** |
| Denmark | 1990 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 14,0 | **8º** |
| France | 1990 | 3 | 3 | 4 | 5 | 5 | 3 | 3 | 3 | 28,5 | **7º** |
| Germany | 1990 | 8 | 7 | 7 | 6 | 6 | 8 | 6 | 7 | 55,0 | **3º** |
| Japan | 1990 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 72,0 | **1º** |
| Netherlands | 1986 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 10,0 | **9º** |
| UK | 1990 | 6 | 6 | 5 | 7 | 7 | 6 | 5 | 5 | 47,0 | **4º** |
| USA | 1990 | 5 | 8 | 8 | 8 | 8 | 5 | 8 | 8 | 58,0 | **2º** |
| Total | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | | |

**Table 11: Connectedness Measures - early 90's rankings: $B_{11}$ (all interindustry flows)**

| Country | Year | PINT | AVOM | MICT | IDET | DEVA | MPLE | APLU | CAIL | Total | **FR** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 1989 | 4 | 5 | 6 | 4 | 3 | 4 | 4 | 6 | 36,0 | **6º** |
| Canadá | 1990 | 7 | 4 | 3 | 3 | 5 | 7 | 7 | 4 | 39,5 | **5º** |
| Denmark | 1990 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 14,0 | **8º** |
| France | 1990 | 3 | 3 | 4 | 5 | 5 | 3 | 3 | 3 | 28,5 | **7º** |
| Germany | 1990 | 8 | 7 | 7 | 6 | 6 | 8 | 6 | 7 | 55,0 | **3º** |
| Japan | 1990 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 72,0 | **1º** |
| Netherlands | 1986 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 10,0 | **9º** |
| UK | 1990 | 6 | 6 | 5 | 7 | 7 | 6 | 5 | 5 | 47,0 | **4º** |
| USA | 1990 | 5 | 8 | 8 | 8 | 8 | 5 | 8 | 8 | 58,0 | **2º** |
| Total | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | | |

**Table 12: C.M. - early 70's rankings: $B_{12}$: (off-main diagonal flows)**

| Country | Year | CYCI | CAIA | Total | **FR** |
|---|---|---|---|---|---|
| Australia | 1968 | *4* | *6* | 10,0 | **4º ea** |
| Canadá | 1971 | *7* | *8* | 15,0 | **2º ea** |
| Denmark | 1972 | *9* | *9* | 18,0 | **1º** |
| France | 1972 | *6* | *4* | 10,0 | **4º ea** |
| Germany | 1978 | *3* | *3* | 6,0 | **7º ea** |
| Japan | 1970 | *1* | *5* | 6,0 | **7º ea** |
| Netherlands | 1972 | *8* | *7* | 15,0 | **2ºea** |
| UK | 1968 | *5* | *2* | 7,0 | **6º** |
| USA | 1972 | *2* | *1* | 3,0 | **9º** |
| Total | | ***45*** | ***45*** | | |

**Table 13: C.M. - early 90's rankings: $B_{12}$: (off-main diagonal flows)**

| Country | Year | CYCI | CAIA | Total | **FR** |
|---|---|---|---|---|---|
| Australia | 1989 | *7* | *7* | 14,0 | **3º** |
| Canadá | 1990 | *6* | *6* | 12,0 | **4º** |
| Denmark | 1990 | *9* | *9* | 18,0 | **1º** |
| France | 1990 | *5* | *4* | 9,0 | **5º** |
| Germany | 1990 | *2* | *5* | 7,0 | **6º** |
| Japan | 1990 | *1* | *1* | 2,0 | **9º** |
| Netherlands | 1986 | *8* | *8* | 16,0 | **2º** |
| UK | 1990 | *3* | *3* | 6,0 | **7º ea** |
| USA | 1990 | *4* | *2* | 6,0 | **7º ea** |
| Total | | 45 | 45 | | |