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AN INPUT-OUTPUT ANALYSIS: LINKAGES VS LEAKAGES

Hugo Reis
António Rua

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Please address correspondence to
António Rua
Economic Research Department
Banco de Portugal, Av. Almirante Reis no. 71, 1150-012 Lisboa, Portugal;
Tel.: Tel. 351-213130841; email: antonio.rua@bportugal.pt

An input-output analysis: linkages vs leakages*

Hugo Reis
Banco de Portugal

António Rua
Banco de Portugal

Abstract

Resorting to input-output analysis, intersectoral linkages are investigated. For such assessment, the distinction between imported and domestically supplied inputs, which has been disregarded so far in empirical analysis, is crucial. Besides improving the measurement of domestic linkages, it also allows to evaluate the importance of international trade in the production process. Moreover, the interaction between domestic linkages and leakages resulting from international trade can also be analysed. Using as case study a small open economy, the Portuguese one, we assess sectoral interdependence and trade effects for individual sectors as well as for the economy as a whole.

Keywords: Input-output analysis; intersectoral linkages; coefficient of interdependence; coefficient of leakage.

JEL classification: C67, D57, F14.

1 Introduction

Input-output analysis, inspired by the work of Wassily Leontief, has been considered one of the major contributions to economics in the 20^{th} century (see Baumol (2000)[1]). In particular, it provides the tools to assess structural changes in the economy, in terms of linkages between economic sectors. After the seminal work of Chenery and Watanabe (1958) and Rasmussen (1956) on establishing linkage measures, a growing body of literature has developed,

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[1]See also, the Journal of Policy Modelling 1989 special issue in honor of Wassily Leontief.

both in theoretical and empirical grounds (see, for example, Jones (1976), Cella (1984), Clements (1990), Dietzenbacher (1992) among others)[2].

However, too few attention has been paid on the distinction between imported and domestically produced inputs in applied input-output analysis. When linkages are measured in order to make comparisons across countries regarding the economic structure, one may consider total intermediate transactions, that is, purchases of product i by sector j, whether it comes from domestic producers or is imported. This is because, usually, the focus is on how things are made in different countries, not where the inputs come from. However, when the interest is on a single country, one should consider only domestically supplied inputs since it is the impact on the domestic economy that is of concern. As recently pointed out by Dietzenbacher *et al.* (2005), disregarding this issue has important empirical implications and may bias the results. Dietzenbacher *et al.* (2005) show that by neglecting such distinction one, naturally, overestimates the multiplier effect of a given sector. Therefore, to assess domestic linkages, that is, the interaction between domestic production sectors one should consider the matrix of domestically supplied inputs only.

In practice, there are two possible cases in terms of data availability. On the one hand, the most common one, both imports and domestically produced inputs are included in the intermediate transactions matrix, that is, only total intermediate transactions are known (as, for example, for the US). On the other hand, a separate import matrix is also available [3]. However, the traditional input-output analysis only holds in the latter case (see Dietzenbacher *et al.* (2005)). Despite of that, it has been current practice in the literature to proceed in the former case in the same way.

Once the distinction between imported and domestically produced inputs is taken into account in such framework, besides improving the measurement of domestic linkages, one can add a new dimension to the analysis. In particular, one can investigate the impact of international trade on those linkages and how it influences the overall interdependence of an economy. For example, a higher import dependence may result in lower linkages among domestic production sectors. Naturally, in an increasingly integrated world such issue should not be disregarded. Therefore, emphasis is put on measuring those effects for individual sectors and a measure for the economy as a whole is proposed. Using as case study a small open economy, the Por-

[2] See, for example, Lahr and Dietzenbacher (2001) for a survey on the wide range application of input-output analysis.

[3] See, for example, Guo and Planting (2000) for an attempt on obtaining a separate import matrix for the US.

tuguese one, we measure linkages and leakages for individual sectors and for the economy as a whole over the last decades.

The paper is organized as follows. In section 2, measurement of linkages and associated leakages is addressed. Data is described in section 3 and the resulting empirical results are presented in section 4. Finally, section 5 concludes.

2 Measuring linkages and leakages

Within input-output framework, there are two kinds of economic linkages between sectors[4]. On the one hand, if sector i increases its output, then there is increased demand on the sectors whose products are used as inputs to production in i. This demand relationship is referred to as backward linkage. On the other hand, increased output in sector i also means that additional amounts of product i are available to be used as inputs to production in the other sectors. This supply relationship is referred to as forward linkage. The analysis of the strenghts of backward and forward linkages allows to identify the most important sectors in the economy. That is, if the backward linkage of sector i is higher than that of sector j then an expansion of its output is more beneficial to the economy, in terms of causing other productive activities, than an equal expansion in sector j's output. Similarly, if the forward linkage of sector i is higher than that of sector j, then an expansion of its output is more essential to the economy, in terms of productive activity that it would support, than an equal expansion in sector j's output.

Obviously, in an open economy, imported products may also be used in the production process. Hence, when increasing production it will also generate additional imports to support it. That kind of imports is called an economic leakage (see Guo and Planting (2000)) in the sense that it represents a leakage to the multiplier effect.

2.1 Backward linkages and leakages

Let one assume that there are n sectors in the economy and consider the equilibrium between total supply and total demand for each good i

$$x_i + m_i = z_{i1} + z_{i2} + ... + z_{in} + y_i \tag{1}$$

[4]See, for example, Miller and Blair (1985) for a comprehensive discussion on input-output analysis.

where x_i is the output of sector i, m_i denotes imports of product i, z_{ij} is sector i´s product absorbed by sector j whether it comes from domestic producers or is imported $\left(z_{ij} = z_{ij}^d + z_{ij}^m\right)$ and y_i is total final demand for sector i´s product, which includes both domestic and imported final demand $\left(y_i = y_i^d + y_i^m\right)$. Since

$$m_i = \sum_{j=1}^{n} z_{ij}^m + y_i^m \tag{2}$$

then (1) can be written as

$$x_i = z_{i1}^d + z_{i2}^d + ... + z_{in}^d + y_i^d. \tag{3}$$

For the n sectors we have a set of n equations

$$\begin{array}{c} x_1 = z_{11}^d + z_{12}^d + ... + z_{1n}^d + y_1^d \\ x_2 = z_{21}^d + z_{22}^d + ... + z_{2n}^d + y_2^d \\ \vdots \\ x_n = z_{n1}^d + z_{n2}^d + ... + z_{nn}^d + y_n^d. \end{array} \tag{4}$$

Define a_{ij}^d, the domestic direct input coefficient, as

$$a_{ij}^d = \frac{z_{ij}^d}{x_j} \tag{5}$$

and substitute (5) into (4),

$$\begin{array}{c} x_1 = a_{11}^d x_1 + a_{12}^d x_2 + ... + a_{1n}^d x_n + y_1^d \\ x_2 = a_{21}^d x_1 + a_{22}^d x_2 + ... + a_{2n}^d x_n + y_2^d \\ \vdots \\ x_n = a_{n1}^d x_1 + a_{n2}^d x_2 + ... + a_{nn}^d x_n + y_n^d. \end{array} \tag{6}$$

In matrix terms, one can write (6) as

$$X = A^d X + Y^d \tag{7}$$

with

$$A^d = \begin{bmatrix} a_{11}^d & a_{12}^d & \cdots & a_{1n}^d \\ a_{21}^d & a_{22}^d & \cdots & a_{2n}^d \\ \vdots & \vdots & & \vdots \\ a_{n1}^d & a_{n2}^d & \cdots & a_{nn}^d \end{bmatrix} \quad X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \quad Y^d = \begin{bmatrix} y_1^d \\ y_2^d \\ \vdots \\ y_n^d \end{bmatrix} \tag{8}$$

and I a $n \times n$ identity matrix. Matrix A^d is the domestic direct input coefficients matrix. Solving (7) for X, one obtains

$$X = (I - A^d)^{-1} Y^d \tag{9}$$

where $\left(I - A^d\right)^{-1}$ is known as the Leontief or input inverse matrix. The interpretation of the elements in the Leontief inverse matrix $\left(B = \left(I - A^d\right)^{-1}\right)$ become more clear writing (9) as

$$\begin{array}{c} x_1 = b_{11} y_1^d + b_{12} y_2^d + ... + b_{1n} y_n^d \\ x_2 = b_{21} y_1^d + b_{22} y_2^d + ... + b_{2n} y_n^d \\ \vdots \\ x_n = b_{n1} y_1^d + b_{n2} y_2^d + ... + b_{nn} y_n^d. \end{array} \tag{10}$$

The coefficient b_{ij} indicates by how much the output of the i^{th} sector, x_i, would increase if final demand for sector j's output, y_j^d, had been increased by one unit (that is, $\partial x_i / \partial y_j^d = b_{ij}$). Then, the sum of the elements in the j^{th} column of the Leontief inverse matrix measures the total output from all sectors generated from one unit final demand of sector j's output. That is,

$$b_{\bullet j} = \sum_{i=1}^{n} b_{ij} \tag{11}$$

gives the output multiplier and reflects the backward linkage of sector j (see Rasmussen (1956)). A unitary increase in sector j's output requires $b_{\bullet j}$ units in increased output for the economy as a whole, consisting of one unit in sector j's output plus both direct and indirect inputs. That is, the output multiplier measures the effects of one monetary unit change in the final demand for each sector on total output of all sectors (including the sector itself).

In a similar fashion, define a_{ij}^m, the imports direct input coefficient, as

$$a_{ij}^m = \frac{z_{ij}^m}{x_j}. \tag{12}$$

that is, the imports of product i absorbed by sector j per unit of output of sector j, and the corresponding matrix

$$A^m = \begin{bmatrix} a_{11}^m & a_{12}^m & \cdots & a_{1n}^m \\ a_{21}^m & a_{22}^m & \cdots & a_{2n}^m \\ \vdots & \vdots & & \vdots \\ a_{n1}^m & a_{n2}^m & \cdots & a_{nn}^m \end{bmatrix}. \tag{13}$$

As shown by Dietzenbacher *et al.* (2005), the element (i, j) of the matrix $A^m \left(I - A^d\right)^{-1}$ gives the additional imports of product i if final demand for sector j's output increases by one unit. The total leakage resulting from one unit increase in the final demand for sector j's output is given by the sum of the elements in the j^{th} column of the matrix $A^m \left(I - A^d\right)^{-1}$.

2.2 Forward linkages and leakages

Instead of relating output to final demand, as in the previous section, one can look at the relationship between output and primary inputs. That is, alternatively to the demand-side view, one can consider the supply-side perspective

$$x_j = z_{1j}^d + z_{2j}^d + ... + z_{nj}^d + w_j \tag{14}$$

where w_j includes imports used by sector j and value-added items. For the n sectors we have a set of n equations

$$\begin{array}{c} x_1 = z_{11}^d + z_{21}^d + ... + z_{n1}^d + w_1 \\ x_2 = z_{12}^d + z_{22}^d + ... + z_{n2}^d + w_2 \\ \vdots \\ x_n = z_{1n}^d + z_{2n}^d + ... + z_{nn}^d + w_n. \end{array} \tag{15}$$

Define a_{ij}^{*d}, the domestic direct output coefficient, as

$$a_{ij}^{*d} = \frac{z_{ij}^d}{x_i} \tag{16}$$

and substitute (16) into (15),

$$\begin{array}{c} x_1 = a_{11}^{*d} x_1 + a_{21}^{*d} x_1 + ... + a_{n1}^{*d} x_1 + w_1 \\ x_2 = a_{12}^{*d} x_2 + a_{22}^{*d} x_2 + ... + a_{n2}^{*d} x_2 + w_2 \\ \vdots \\ x_n = a_{1n}^{*d} x_n + a_{2n}^{*d} x_n + ... + a_{nn}^{*d} x_n + w_n. \end{array} \tag{17}$$

In matrix terms, one can write (17) as

$$X' = X' A^{*d} + W' \tag{18}$$

with

$$A^{*d} = \begin{bmatrix} a_{11}^{*d} & a_{12}^{*d} & \cdots & a_{1n}^{*d} \\ a_{21}^{*d} & a_{22}^{*d} & \cdots & a_{2n}^{*d} \\ \vdots & \vdots & & \vdots \\ a_{n1}^{*d} & a_{n2}^{*d} & \cdots & a_{nn}^{*d} \end{bmatrix} \quad W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \tag{19}$$

where A^{*d} is the domestic direct output coefficients matrix. Solving (18) for X', one obtains

$$X' = W'(I - A^{*d})^{-1} \tag{20}$$

where $\left(I - A^{*d}\right)^{-1}$ is the output inverse matrix. To ease the understanding of the output inverse matrix $\left(B^* = \left(I - A^{*d}\right)^{-1}\right)$ one can write (20) or equivalently $X = B^{*\prime}W$ as

$$\begin{array}{c} x_1 = b_{11}^* w_1 + b_{21}^* w_2 + ... + b_{n1}^* w_n \\ x_2 = b_{12}^* w_1 + b_{22}^* w_2 + ... + b_{n2}^* w_n \\ \vdots \\ x_n = b_{1n}^* w_1 + b_{2n}^* w_2 + ... + b_{nn}^* w_n. \end{array} \tag{21}$$

The coefficient b_{ij}^* measures the effect on sector j output of one unit change in the availability of primary inputs to sector i (that is, $\partial x_j / \partial w_i = b_{ij}^*$). Thus, the sum of the elements in the i^{th} row of the output inverse matrix gives the effect on total output throughout all sectors of a unit change in primary inputs for sector i. For example, a decrease of primary inputs to sector i results in a decrease in sector i's output and in the output of all sectors that depend on sector i's product to produce. Hence,

$$b_{i\bullet}^* = \sum_{j=1}^{n} b_{ij}^* \tag{22}$$

reflects the forward linkage of sector i (see Jones (1976)) (also termed as input multiplier). Hence, the input multiplier measures the effects of one monetary unit change in primary inputs of each sector on total output of all sectors (including the sector itself).

Define a_{ij}^{*m} as

$$a_{ij}^{*m} = \frac{z_{ij}^m}{x_i} \tag{23}$$

and the corresponding matrix

$$A^{*m} = \begin{bmatrix} a_{11}^{*m} & a_{12}^{*m} & \cdots & a_{1n}^{*m} \\ a_{21}^{*m} & a_{22}^{*m} & \cdots & a_{2n}^{*m} \\ \vdots & \vdots & & \vdots \\ a_{n1}^{*m} & a_{n2}^{*m} & \cdots & a_{nn}^{*m} \end{bmatrix}. \tag{24}$$

Following Dietzenbacher *et al.* (2005), it can be shown that in this case the leakage matrix is $\left(I - A^{*d}\right)^{-1} A^{*m}$. Thus, the total leakage resulting from one unit change in the primary inputs for sector i is given by the sum of the elements in the i^{th} row of the matrix $\left(I - A^{*d}\right)^{-1} A^{*m}$.

2.3 Key sector analysis

In the spirit of Rasmussen (1956), one can normalize the backward and forward linkage measures, $b_{\bullet j}$ and $b_{i\bullet}^{*}$, respectively, according to the overall measure for the economy as a whole (let BL and FL be the normalized measures). If $BL_j > 1$, then a unitary increase in final demand for sector j's output will generate an above average increase in activity in the economy. Similarly, if $FL_i > 1$, then a unitary decrease in the availability of primary inputs to sector i will lead to an above average decrease in economic activity. A sector is classified as key sector if $BL_j > 1$ and $FL_i > 1$, as forward linkage oriented sector if $BL_j < 1$ and $FL_i > 1$ and as backward linkage oriented sector if $BL_j > 1$ and $FL_i < 1$.

Additionally, as suggested by Boucher (1976), one can use of a measure of dispersion, the coefficient of variation, to assess how spread are the effects across the economy associated with individual sectors. The backward coefficient of variation of a sector is given by

$$V_j = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(b_{ij} - \frac{1}{n}\sum_{i=1}^{n} b_{ij}\right)^2}}{\frac{1}{n}\sum_{i=1}^{n} b_{ij}} \tag{25}$$

and the forward coefficient of variation by

$$V_i^{*} = \frac{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left(b_{ij}^{*} - \frac{1}{n}\sum_{j=1}^{n} b_{ij}^{*}\right)^2}}{\frac{1}{n}\sum_{j=1}^{n} b_{ij}^{*}}. \tag{26}$$

A high V_j means that sector j draws heavily on a small number of sectors while a low V_j means that it draws evenly from the other sectors. A high V_i^{*} means that a small number of sectors draw heavily on sector i while a low V_i^{*} means that the other sectors draw evenly on sector i.

2.4 Overall linkages and leakages

Though the traditional focus in linkage analysis is on the effects related with individual sectors, it is also important to assess the degree of sectoral interdependence of the economy as a whole and how it has changed over time. In this respect, Jones (1976) has proposed a measure called the coefficient of interdependence. The coefficient of interdependence is the output weighted average of either backward or forward linkages. That is,

$$\sum_{j=1}^{n} \phi_j b_{\bullet j} \tag{27}$$

or

$$\sum_{i=1}^{n} \phi_i b^*_{i\bullet} \tag{28}$$

where the weights are given by

$$\phi_k = \frac{x_k}{\sum_{k=1}^{n} x_k}. \tag{29}$$

It has the appealing feature of whether one looks at backward or forward linkages one gets a single result for the economy as a whole, thus providing a summary measure of overall sectoral interdependence. To see that, one can write, in matrix form, (27) as $b\Phi$ and (28) as $\Phi' b^*$ with

$$\Phi = \begin{bmatrix} \phi_1 \\ \phi_2 \\ \vdots \\ \phi_n \end{bmatrix} \quad b^* = \begin{bmatrix} b^*_{1\bullet} \\ b^*_{2\bullet} \\ \vdots \\ b^*_{n\bullet} \end{bmatrix} \quad b = \begin{bmatrix} b_{\bullet 1} & b_{\bullet 2} & \cdots & b_{\bullet n} \end{bmatrix}. \tag{30}$$

Let *1* be a unit column vector, $/X/$ a diagonal matrix whose diagonal elements are those of the X vector, that is,

$$/X/ = \begin{bmatrix} x_1 & 0 & \cdots & 0 \\ 0 & x_2 & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & x_n \end{bmatrix} \tag{31}$$

and

$$Z^d = \begin{bmatrix} z_{11}^d & z_{12}^d & \cdots & z_{1n}^d \\ z_{21}^d & z_{22}^d & \cdots & z_{2n}^d \\ \vdots & \vdots & & \vdots \\ z_{n1}^d & z_{n2}^d & \cdots & z_{nn}^d \end{bmatrix}. \tag{32}$$

Note that $A^d = Z^d/X/^{-1}$ and $A^{*d} = /X/^{-1}Z^d$. Then,

$$\begin{aligned} b\Phi &= 1'(I - A^d)^{-1}\Phi \\ &= 1'(I - A^d)^{-1}X(1'X)^{-1} \\ &= 1'(I - Z^d/X/^{-1})^{-1}X(1'X)^{-1} \\ &= 1'[(/X/ - Z^d)/X/^{-1}]^{-1}X(1'X)^{-1} \\ &= 1'/X/(/X/ - Z^d)^{-1}X(1'X)^{-1} \\ &= X'(/X/ - Z^d)^{-1}X(1'X)^{-1} \\ &= X'(/X/ - Z^d)^{-1}/X/1(1'X)^{-1} \\ &= X'[/X/^{-1}(/X/ - Z^d)]^{-1}1(1'X)^{-1} \\ &= X'(I - /X/^{-1}Z^d)^{-1}1(1'X)^{-1} \\ &= X'(I - A^{*d})^{-1}1(1'X)^{-1} \\ &= (1'X)^{-1}X'(I - A^{*d})^{-1}1 \\ &= \Phi'(I - A^{*d})^{-1}1 \\ &= \Phi'b^*. \end{aligned}$$

An unaddressed issue so far is how to measure the leakage for the economy as whole. This is obviously a relevant question in an increasingly integrated world where international linkages have become more and more important. The measure we propose here is the analog to the coefficient of interdependence for measuring leakage, that is, the imports weighted average of either backward or forward leakages. However, in this case, the weights are not the same for both backward and forward measures. In the previous case, the weights are based on output and, by definition, the output of good i is equal to the output of the corresponding production sector resulting in the same weights for backward and forward linkages. Now, the weighting scheme draws on imports and naturally the imports of good i are not necessarily the same as the imports of the corresponding production sector. Therefore, one has to weight the backward leakages by good imports and the forward leakages by sector imports. Let l_j be the sum of the elements in the j^{th} column of the matrix $A^m \left(I - A^d\right)^{-1}$ and l_i^* the sum of the elements in the i^{th} row of the matrix $\left(I - A^{*d}\right)^{-1} A^{*m}$. The coefficient of leakage can be computed as

$$\sum_{k=1}^{n} \theta_k l_k \tag{33}$$

with

$$\theta_i = \frac{\sum_{j=1}^{n} z_{ij}^m}{\sum_{i=1}^{n}\sum_{j=1}^{n} z_{ij}^m} \tag{34}$$

or

$$\sum_{k=1}^{n} \psi_k l_k^* \tag{35}$$

with

$$\psi_j = \frac{\sum_{i=1}^{n} z_{ij}^m}{\sum_{i=1}^{n}\sum_{j=1}^{n} z_{ij}^m}. \tag{36}$$

Either way, the result is the same. Let us sketch the proof. One can write (33) as $l\Theta$ and (35) as $\Psi' l^*$ with

$$\Theta = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \vdots \\ \theta_n \end{bmatrix} \quad \Psi = \begin{bmatrix} \psi_1 \\ \psi_2 \\ \vdots \\ \psi_n \end{bmatrix} \quad l^* = \begin{bmatrix} l_1^* \\ l_2^* \\ \vdots \\ l_n^* \end{bmatrix} \quad l = \begin{bmatrix} l_1 & l_2 & \cdots & l_n \end{bmatrix}. \tag{37}$$

Define

$$Z^m = \begin{bmatrix} z_{11}^m & z_{12}^m & \cdots & z_{1n}^m \\ z_{21}^m & z_{22}^m & \cdots & z_{2n}^m \\ \vdots & \vdots & & \vdots \\ z_{n1}^m & z_{n2}^m & \cdots & z_{nn}^m \end{bmatrix} \tag{38}$$

and note that $A^m = Z^m/X/^{-1}$ and $A^{*m} = /X/^{-1}Z^m$. Then,

$$\begin{aligned} l\Theta &= 1' A^m (I - A^d)^{-1}\Theta \\ &= 1' A^m (I - A^d)^{-1} Z^m 1 (1' Z^m 1)^{-1} \\ &= 1' Z^m /X/^{-1} (I - Z^d /X/^{-1})^{-1} Z^m 1 (1' Z^m 1)^{-1} \\ &= 1' Z^m /X/^{-1} [(/X/ - Z^d)/X/^{-1}]^{-1} Z^m 1 (1' Z^m 1)^{-1} \\ &= 1' Z^m /X/^{-1} /X/ (/X/ - Z^d)^{-1} Z^m 1 (1' Z^m 1)^{-1} \\ &= 1' Z^m (/X/ - Z^d)^{-1} Z^m 1 (1' Z^m 1)^{-1} \end{aligned}$$

$$
\begin{aligned}
&= 1'Z^m(/X/ - Z^d)^{-1}/X//X/^{-1}Z^m 1(1'Z^m 1)^{-1} \\
&= 1'Z^m[/X/^{-1}(/X/ - Z^d)]^{-1}A^{*m}1(1'Z^m 1)^{-1} \\
&= 1'Z^m(I - /X/^{-1}Z^d)^{-1}A^{*m}1(1'Z^m 1)^{-1} \\
&= 1'Z^m(I - A^{*d})A^{*m}1(1'Z^m 1)^{-1} \\
&= (1'Z^m 1)^{-1}1'Z^m(I - A^{*d})A^{*m}1 \\
&= \Psi'(I - A^{*d})A^{*m}1 \\
&= \Psi' l^*.
\end{aligned}
$$

Hence, the suggested leakage measure retains the attractive feature of the corresponding analog proposed by Jones (1976). That is, a single result for the economy as a whole is still provided. The coefficient of interdependence together with the coefficient of leakage allow one to characterize the economy as a whole both in terms of linkages and leakages and to assess how it has changed over time.

3 Data

In order to assess the above mentioned linkages and the importance of leakages, the empirical analysis is done for a small open economy, the Portuguese one. In particular, we consider input-output tables for the years 1980, 1986 and 1992 according to ESA79 and 1995, 1999 and 2002 according to ESA95, with the intermediate transactions matrix split according to the source, domestic or foreign. The 1995 and 1999 tables were released by Department of Prospective and Planning based on National Statistics Office (INE) data while the remaining tables are from INE. All input-output tables are available at basic prices, and hence not affected by taxes.

In the ESA79 and ESA95 (1995 basis) as financial intermediation services indirectly measured (FISIM) are not allocated to user sectors, the whole value of output of FISIM is treated as intermediate consumption of a sector with zero output and negative value added equal in size but opposite in sign to intermediate consumption. In order to avoid biased conclusions regarding the financial sector we reallocate the use of FISIM to user sectors, as suggested by INE. For the years 1980, 1986 and 1992, we use the 1995 structure (which is the earliest year for which there is such allocation, according to ESA95 (2000 basis)), where around 70 per cent of the FISIM is allocated to intermediate consumption. Further, FISIM is broadly reallocated according to the Gross Value Added (GVA) structure excluding real estate activities, public administration and defense, education and health and social works sectors. For these sectors, which GVA share is not a good

proxy, the 1995 (2000 basis) FISIM weights have been used. Since for the years 1995 and 1999, the input-output tables are only available according ESA95 (1995 basis), we also had to reallocate the use of FISIM in a similar fashion as for the ESA79 tables.

The 2002 input-output table, the latest one released by INE with similar detail, do not comprise the distinction between domestic and imported products. Thus, the 1999 imports structure was used in order to construct the two separate tables.

To ease the comparison over time, some aggregation has been performed on the original data. We end up with 29 sectors/products from the original data arranged accordingly to the two digits NACE rev.2 disagregation level and resorting to the correspondence of sectors between ESA79 and ESA95 (see Appendix A). This breakdown level provides a noteworthy degree of sectoral heterogeneity.

4 Empirical results

From a first look at the Portuguese production structure over the period considered (see Table 1), it pops up the decreasing importance of primary and secondary sectors, in terms of production, in contrast with the tertiary sector. Within industry, one should note the reduction in Food and Textiles sectors while within services, the major increases are in Renting and business activities and Real estate. Conditional on the level of disaggregation considered, the Trade sector presents the highest production share. Regarding intermediate demand, its weight on production is higher for industry than for services and for the economy as whole it represents around 50 per cent. In terms of imported content of intermediate demand, industry is also more dependent from outside than services. The sectors that present the highest imported content are Fuel and mining, Transport equipment and Chemicals. For the economy as a whole, the imported content of intermediate demand is, on average, around 25 per cent presenting a slight decrease over the period considered. This behaviour reflects, to a large extent, the decreasing importance of Fuel and mining, in terms of intermediate demand.

Regarding backward linkages (see Table 2), the sectors that present, on average, the highest figures are Food and Wood while the one with lower backward linkage is Education. The Communications sector recorded the highest increase of the output multiplier over the period considered, reflecting the dynamism of this kind of activities. Note also the increase observed in Renting and business activities and Other manufacturing while in terms

of reduction, one should point out the sector Electricity, gas and water.

In what concerns leakage, absolute or relative (leakage ratio), the Fuel and mining sector stands out, reflecting the foreign dependence in terms fuel products, as well as the Transport equipment sector. In general, services present a lower leakage than the other sectors. Within services, the sector that records, on average, the highest leakage is Transportation, most probably because of its dependence on fuel products, although presenting a decrease over the period considered.

Interestingly, for industrial sectors, there seems to be a negative relationship between backward linkage and leakage, that is, a higher backward linkage is associated with a lower leakage, whereas for service sectors it is the opposite (Figures 1 and 2). Regarding industry, it suggests that a lower foreign dependence is related with higher domestic synergies. For example, if a sector imports less to produce then it has to resort more to domestic production, that is, a lower leakage results in a higher backward linkage (the same reasoning holds if the decrease happens in any sector with which that sector is related to, directly or indirectly). Concerning services, the sectors that present higher backward linkages are the ones more connected with industrial sectors, where, in general, there is a stronger foreign link (for example, Transportation sector is closely related with Fuel and mining sector). Hence, for services, a higher backward linkage is associated with a higher leakage.

Regarding forward linkages, which reflect the importance of products in production, the sectors that record, on average, the highest figures are Electricity, gas and water and Renting and business activities (note also Paper, Fuel and mining and Agriculture) (see Table 3). Among the sectors that present lower forward linkages, one should mention Public Administration, Education and Health. Renting and business activities is the sector that records the highest increase of the input multiplier over the period considered, reflecting a rising penetration of this kind of activities in the production process. Although still among the most important, Electricity, gas and water and Fuel and mining stand out in terms of reduction.

Fuel and mining is again the sector that evidences the highest leakage. Moreover, services also present, in general, a lower leakage than the other sectors, with Renting and business activities recording, on average, the highest leakage.

In contrast with the observed for backward linkage, it does not appear to be a clear relationship between forward linkage and leakage for industrial sectors (Figure 3). This may result from the fact that a product can be important in the production process of sectors that can be more or less de-

pendent from outside resulting in an unclear relationship between forward linkage and leakage. For example, a product may be essential to the production of a sector and if that sector imports less of the other products used in production, then it will result in a lower leakage but the forward linkage will not change. Hence, an ambiguous relationship may show up. Nevertheless, for services, there seems to be a positive relationship between forward linkage and leakage (Figure 4). Again, this is due to the fact that the services that present higher forward linkages also have a stronger link with industrial sectors, where, in general, there is a higher foreign dependence.

Briefly, in relative terms, the sectors that present both higher backward and forward linkages over the period considered are Electricity, gas and water, Paper, Other minerals and Agriculture (see Table 4 and Figure 5). In the most recent period, Renting and business activities stands out as being one of the most influential sectors in the production process.

Additionally, to assess how spread are the effects of a sector across the economy one can compute the coefficient of variation (see Table 5). A higher coefficient of variation means that the effects are more concentrated in a few sectors while a lower coefficient of variation denotes that the effects are more spread out over the economy.

Regarding the backward coefficient of variation, the sector that presents, on average, the lowest one is Hotels and restaurants, reflecting its widespread nature as user, whereas the highest figure is recorded by Education. In terms of forward coefficient of variation, the highest one is observed for Tobacco and the lowest one for Renting and business activities, reflecting the importance of such services across the economy. Furthermore, there is evidence of a negative relationship between the coefficient of variation and the linkage strength, both in the backward and forward cases (Figures 6 and 7). That is, a higher backward or forward linkage is associated with a lower concentration of the linkage. In other words, the multiplier effect is higher when the linkages are more spread out over the economy.

For the economy as a whole, sectoral interdependence seems to have increased slightly during the period considered (resorting to the coefficient of interdependence, see Table 6). This increase is due, to a large extent, to services behaviour. Note, however, that the change of the relative weight of sectors on production had a negative impact on the sectoral interdependence measure, since services continue to present, on average, lower linkages than the other sectors (see, for example, Khayum (1995) for similar findings for the US). That is, the growing importance of the service sector in the Portuguese economy has moderated the increase of sectoral interdependence.

In terms of leakage for the economy as a whole, there was a decrease, both

absolute and relative, over the period considered, despite a slight increase in the last decade. The decrease is related to the lost of relative importance of Fuel and mining, in terms of imported intermediate demand. However, as expected, Fuel an mining continues to be the major contributor to overall leakage.

Furthermore, the evidence suggests a negative relationship between the coefficient of interdependence and the coefficient of leakage. That is, an increase (decrease) of sectoral interdependence has been, in general, associated with a decrease (increase) of leakage.

5 Conclusions

In this paper, we resort to input-output analysis to assess intersectoral linkages over time. Such assessment can be improved by separating the intermediate transactions matrix according to the source of products, domestic or foreign. On the one hand, it allows better measurement of both backward and forward linkages since one can properly account for domestic linkages. On the other hand, the importance of international trade in the production process can be evaluated. Furthermore, the interaction between domestic linkages and leakages steaming from international trade can also be studied.

Considering as case study a small open economy, the Portuguese one, where such data is available, some interesting findings come out. Regarding individual sectors, services present, in general, lower backward and forward linkages as well as lower leakages than industry. That is, the domestic multiplier effect of services is lower than that of industry but it is also less dependent from outside. Interestingly, for industry, it appears to be a negative relationship between backward linkage and leakage, whereas for the forward case no clear link exists. In contrast, for services, there seems to be a positive relationship between linkage and leakage in both backward and forward cases. Moreover, and this result seems to hold across the economy, the multiplier effect of a sector is higher when the linkages are more spread out over the economy.

For the economy as whole, one can compute the coefficient of interdependence and the suggested analog measure for leakage, the coefficient of leakage. In this respect, an increase of the coefficient of interdependence seems to be associated with a decrease of the coefficient of leakage and vice-versa. Furthermore, the growing importance of the service sector has moderated the increase of Portuguese sectoral interdependence over the last decades.

References

[1] Baumol, W. J. (2000) "What Marshall didn't know: on the twentieth century's contributions to economics", The Quarterly Journal of Economics, vol. 115, no. 1, 1-44.

[2] Boucher, M. (1976) "Some further results on the linkage hypothesis", The Quarterly Journal of Economics, vol. 90, no. 2, 313-318.

[3] Cella, G. (1984), "The input-output measurement of interindustry linkages", Oxford Bulletin of Economics and Statistics, 46, no. 1, 73-84.

[4] Chenery, H. B. and Watanabe, T. (1958) "International comparisons of the structure of production", Econometrica, vol. 26, 487-521.

[5] Clements, B. J. (1990) "On the decomposition and normalization of interindustry linkages", Economics Letters, 33, 337-340.

[6] Dietzenbacher, E. (1992) "The measurement of interindustry linkages: Key sectors in the Netherlands", Economic Modelling, 9, 419-437.

[7] Dietzenbacher, E. , Albino, V. and Kuhtz, S. (2005) "The fallacy of using US-type input-output tables", mimeo (paper presented at the 15^{th} International Conference on Input-Output Techniques).

[8] Guo, J. and Planting, M. A. (2000) "Using input-output analysis to measure U.S. economic structural change over a 24 year period", Bureau of Economic Analysis Working Paper no 2000-01, US Department of Commerce.

[9] Jones, L. P. (1976) "The measurement of Hirschmanian linkages", The Quarterly Journal of Economics, vol. 90, no. 2, 323-333.

[10] Khayum, M. F. (1995) "The impact of service sector growth on intersectoral linkages in the United States", The Service Industries Journal, vol. 15, no. 1, 35-49.

[11] Lahr, M. L. and Dietzenbacher, E. (eds) (2001) "Input-Output Analysis: Frontiers and Extensions", Palgrave Macmillan.

[12] Miller, R. E. and Blair, P. D. (1985) "Input-Output Analysis, Foundations and Extensions", Prentice-Hall, Englewood Cliffs.

[13] Rasmussen, P. (1956) "Studies in inter-sectoral relations", Copenhagen, Einar Harks.

Appendix A - Sectoral classification

Sectors	ESA 79	*ESA 95*
1 - Agriculture	01 - Agriculture and hunting	*01 - Agriculture, hunting and related service activities*
	02 - Forestry, logging and related service activities	*02 - Forestry, logging and related service activities*
2 - Fishing	03 - Fishing	*05 - Fishing, aquaculture and service activities incidental to fishing*
3 - Fuel and mining	04 - Coal	*10 - Mining of coal and lignite; extraction of peat*
	05 - Fuel	*11 - Extraction of crude petroleum and natural gas;* *23 - Manufacture of coke, refined petroleum products and nuclear fuel*
	07 - Metalliferous and non-metalliferous ores	*13 - Mining of metal ores*
	08 - Non-metallic mineral products	*12 - Mining of uranium and thorium ores* *14 - Other mining and quarrying*
4 - Food	17 - Processing and preserving of meat 18 - Dairy products 19 - Processing and preserving of fish 20 - Vegetable and animal oils and fats 21 - Fruit and vegetables 22 - Other food products 23 - Beverages	*15 - Manufacture of food products and beverages*
5 -Tobacco	24 - Tobacco	*16 - Manufacture of tobacco products*
6 - Textiles	25 - Textiles and clothing	*17 - Manufacture of textiles* *18 - Manufacture of wearing apparel; dressing and dyeing of fur*
7 - Leather	26 - Leather and leather products	*19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear*
8 - Wood	27 - Wood and cork	*20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials*
9 - Paper	28 - Paper, printing and publishing	*21 - Manufacture of paper and paper products* *22 - Publishing, printing and reproduction of recorded media*
10 - Chemicals	12 - Chemical products	*24 - Manufacture of chemicals and chemical products*
11 - Rubber and plastics	29 - Rubber and plastics products	*25 - Manufacture of rubber and plastics products*
12 - Other minerals	09 - Ceramic products 10 - Glass and glass products 11 - Other construction materials	*26 - Manufacture of other non-metallic mineral products*
13 - Metals	13 - Metal products	*27 - Manufacture of basic metals* *28 - Manufacture of fabricated metal products, except machinery and equipment*
14 - Machinery	14 - Non-electrical machinery	*29 - Manufacture of machinery and equipment n.e.c.*
	15 - Machinery and other electrical machinery	*30 - Manufacture of office, accounting and computing machinery* *31 - Manufacture of electrical machinery and apparatus n.e.c.* *32 - Manufacture of radio, television and communication equipment and apparatus* *33 - Manufacture of medical, precision and optical instruments, watches and clocks*

Sectors	ESA 79	*ESA 95*
15 - Transport equipment	16 - Transport equipment	*34 - Manufacture of motor vehicles, trailers and semi-trailers* *35 - Manufacture of other transport equipment*
16 - Other manufacturing	30 - Manufacturing, nec	*36 - Manufacture of furniture; manufacturing n.e.c.* *37 - Recycling*
17 - Electricity, gas and water	06 - Electricity, gas and water	*40 - Electricity, gas, steam and hot water supply* *41 - Collection, purification and distribution of water*
18 - Construction	31 - Construction	*45 - Construction*
19 - Trade	32 - Maintenance and repairs 33 - Wholesale and retail trade	*50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel* *51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles* *52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods*
20 - Hotels and restaurants	34 - Hotels and restaurants	*55 - Hotels and restaurants*
21 - Transportation	35 - Land transport	*60 - Land transport; transport via pipelines*
	36 - Water and air transport	*61 - Water transport* *62 - Air transport*
	37 - Auxiliary transport activities	*63 - Supporting and auxiliary transport activities; activities of travel agencies*
22 - Communications	38 - Communications	*64 - Post and telecommunications*
23 - Financial Intermediation	39 - Banks and financial institutions	*65 - Financial intermediation, except insurance and pension funding* *67 - Activities auxiliary to financial intermediation*
	40 - Insurance	*66 - Insurance and pension funding, except compulsory social security*
24 - Real estate	41 - Real estate	*70 - Real estate activities*
25 - Renting and business activities	42 - Renting and business activities	*71 - Renting of machinery and equipment without operator and of personal and household goods* *72 - Computer and related activities* *74 - Other business activities*
26 - Education	43 - Education and research market services 47 - Education and research non-market services	*73 - Research and development* *80 - Education*
27 - Health	44 - Health market services 48 - Health non-market services	*85 - Health and social work*
28 - Public administration	46 - Public administration non-market services	*75 - Public administration and defence; compulsory social security* *90 - Sewage and refuse disposal, sanitation and similar activities*
29 - Other services	45 - Other market services 49 - Other non-market services	*91 - Activities of membership organizations n.e.c.* *92 - Recreational, cultural and sporting activities* *93 - Other service activities* *95 - Activities of private households as employers of domestic staff*

Table 1 - Portuguese production structure - Some descriptive statistics

In percentage

	Production share						Weight of intermediate demand on production						Imported content of intermediate demand					
Sector	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
1	7.3	6.7	4.8	3.6	2.8	2.8	40.7	47.0	52.6	40.4	46.2	47.0	8.0	6.8	9.1	9.2	10.2	10.1
2	0.7	0.6	0.4	0.3	0.2	0.2	34.6	39.4	31.3	28.9	24.3	27.3	7.9	8.3	9.4	8.4	8.4	7.7
3	6.3	4.3	2.6	1.4	1.3	1.5	87.7	78.3	84.0	86.7	85.3	86.0	78.1	66.9	57.7	72.2	73.0	78.5
4	10.2	10.6	8.3	6.8	5.8	4.7	81.9	77.0	65.5	79.7	75.1	78.8	21.7	15.0	20.4	20.4	24.8	24.4
5	0.1	0.2	0.2	0.1	0.1	0.1	56.0	54.0	48.1	40.2	38.7	56.2	53.2	35.6	31.0	33.6	43.2	41.8
6	8.3	8.6	6.4	5.6	4.5	3.9	64.8	59.4	62.5	67.5	65.9	67.6	25.3	29.0	32.0	31.2	34.7	32.3
7	0.9	1.4	1.8	1.6	1.2	1.1	60.8	67.8	60.2	70.0	67.4	67.5	33.5	44.3	38.6	35.7	38.8	38.0
8	2.4	1.7	1.7	1.3	1.3	1.2	62.2	63.7	67.7	68.9	67.6	74.4	17.6	16.5	21.9	17.0	20.5	19.7
9	2.1	2.5	2.2	2.7	2.1	1.9	64.5	61.9	64.4	66.4	67.9	61.0	13.3	16.7	16.7	22.5	24.1	27.2
10	3.6	4.6	3.0	2.1	1.6	1.5	80.2	74.1	66.8	69.5	74.2	73.0	57.0	53.0	47.2	48.2	45.5	49.6
11	1.0	0.9	0.7	0.9	0.9	0.8	68.0	65.1	68.5	71.0	72.3	69.6	60.1	54.9	51.5	43.7	42.0	39.5
12	1.9	1.6	1.6	1.9	1.9	1.9	60.9	56.6	54.6	61.2	60.5	60.7	9.1	14.8	16.0	15.4	16.2	17.0
13	2.3	1.7	1.8	1.8	1.6	2.2	54.9	57.5	66.5	69.4	65.8	67.4	35.1	33.7	30.3	43.1	48.0	49.6
14	2.4	2.3	3.2	3.4	3.5	3.4	59.4	62.1	58.2	73.7	74.7	72.1	56.2	49.2	55.8	55.6	54.7	56.1
15	2.5	2.1	2.2	2.0	2.4	2.2	63.5	63.2	71.1	79.1	77.5	78.2	70.7	66.0	61.3	57.0	62.6	62.2
16	0.6	0.4	0.5	1.2	1.1	1.2	71.1	63.0	62.9	66.3	65.5	68.7	60.8	63.2	45.7	33.8	34.8	36.1
17	2.5	4.0	4.2	3.4	3.1	3.1	64.0	61.4	48.3	52.0	54.2	62.3	4.1	12.6	13.1	13.2	17.5	21.5
18	8.6	7.1	7.0	9.3	10.8	10.8	55.8	57.6	57.2	63.0	63.5	63.1	8.4	12.6	22.1	11.0	12.2	12.3
19	12.4	11.8	12.4	11.9	12.1	11.7	33.7	38.7	42.1	42.2	45.6	44.6	16.1	16.0	15.1	15.0	15.4	11.6
20	3.5	3.5	4.4	3.7	3.7	4.2	54.1	57.9	46.1	64.6	61.2	52.1	3.3	4.3	11.9	13.3	14.7	13.7
21	4.2	5.0	4.4	3.3	3.3	3.8	53.2	47.0	45.5	41.4	42.5	47.1	25.7	18.5	16.0	14.8	15.7	11.8
22	0.9	1.3	1.5	1.7	2.1	3.0	16.5	18.0	22.9	38.5	41.6	49.4	10.7	18.3	20.1	18.7	14.4	17.8
23	2.8	3.1	4.5	3.7	4.1	4.6	19.6	26.0	27.1	27.0	30.7	32.0	9.6	9.9	19.5	12.0	9.0	7.4
24	0.9	0.4	1.4	4.1	4.4	4.7	23.6	55.8	17.1	28.0	31.6	24.1	0.5	1.8	2.2	2.8	2.5	1.0
25	2.0	2.4	3.8	6.8	7.8	6.0	26.1	30.1	49.2	50.0	50.1	49.3	8.2	9.8	10.9	12.4	14.0	13.9
26	1.9	2.5	3.9	3.8	4.0	4.0	9.6	10.1	8.2	15.5	15.6	12.9	8.1	5.5	8.7	9.1	8.1	7.9
27	1.9	2.7	2.7	4.2	4.4	4.9	29.6	35.1	23.6	36.6	36.1	36.5	18.0	18.0	22.2	16.5	21.2	17.7
28	4.3	4.4	5.3	4.6	4.8	5.7	28.4	32.4	22.6	14.5	16.2	20.6	8.9	13.4	12.7	17.2	12.9	13.4
29	1.4	1.4	3.0	2.7	2.9	2.7	33.0	36.8	32.0	44.5	40.9	45.2	16.8	14.0	25.0	10.7	11.6	9.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	53.9	53.3	48.4	51.8	51.5	51.0	28.5	24.6	25.3	23.0	23.8	23.5

Table 2 - Backward linkages and leakages

	Output multiplier						Leakage						Leakage ratio (per cent)					
Sector	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
1	1.7	1.8	1.8	1.7	1.7	1.8	0.2	0.1	0.1	0.1	0.1	0.1	10.0	8.0	7.9	7.1	8.3	8.0
2	1.4	1.5	1.4	1.4	1.3	1.4	0.2	0.1	0.1	0.1	0.1	0.1	13.1	9.0	9.4	5.0	4.2	5.5
3	1.3	1.4	1.6	1.4	1.4	1.3	0.8	0.6	0.6	0.7	0.7	0.7	60.9	45.6	37.0	49.1	49.2	57.7
4	2.1	2.2	1.9	2.1	2.0	2.1	0.3	0.2	0.2	0.3	0.3	0.3	15.8	11.1	11.8	12.7	14.6	14.8
5	1.4	1.6	1.5	1.4	1.4	1.6	0.4	0.3	0.2	0.2	0.2	0.3	24.6	16.0	13.0	11.8	14.4	19.7
6	1.8	1.7	1.7	1.8	1.7	1.8	0.3	0.3	0.3	0.3	0.3	0.3	17.5	17.0	18.2	18.8	20.1	19.2
7	1.7	1.6	1.6	1.8	1.7	1.7	0.3	0.4	0.3	0.4	0.4	0.4	20.1	26.2	20.3	22.0	23.1	22.4
8	1.8	1.9	1.9	2.0	2.0	2.1	0.2	0.2	0.3	0.2	0.2	0.3	11.8	10.8	13.0	11.0	12.4	13.0
9	2.0	1.9	1.9	1.9	1.9	1.8	0.3	0.2	0.2	0.2	0.3	0.3	13.0	11.8	10.7	12.8	13.7	14.6
10	1.5	1.5	1.6	1.6	1.7	1.6	0.6	0.5	0.4	0.4	0.4	0.5	37.2	32.5	25.4	26.4	25.6	28.5
11	1.4	1.5	1.5	1.6	1.7	1.7	0.5	0.4	0.4	0.4	0.4	0.4	35.2	30.2	28.2	25.5	24.7	23.9
12	1.8	1.8	1.7	1.9	1.9	1.8	0.3	0.2	0.2	0.2	0.2	0.3	17.7	12.9	10.8	12.2	12.6	14.5
13	1.5	1.6	1.7	1.7	1.6	1.6	0.4	0.4	0.3	0.4	0.4	0.4	25.6	22.6	18.5	23.8	25.1	27.3
14	1.4	1.5	1.4	1.5	1.5	1.5	0.4	0.4	0.4	0.5	0.5	0.5	30.5	27.1	27.7	33.0	32.4	32.6
15	1.3	1.3	1.4	1.6	1.5	1.5	0.5	0.5	0.5	0.6	0.6	0.6	41.4	37.0	36.3	35.6	39.4	39.8
16	1.4	1.4	1.5	1.8	1.7	1.8	0.6	0.5	0.4	0.3	0.3	0.4	39.6	34.7	24.6	18.7	19.1	21.0
17	2.1	2.0	1.7	1.8	1.8	1.9	0.3	0.2	0.1	0.1	0.2	0.3	13.9	11.0	7.4	8.2	10.1	13.8
18	1.8	1.8	1.7	2.0	2.0	2.0	0.2	0.2	0.2	0.2	0.2	0.2	13.3	12.1	13.7	10.0	10.2	10.7
19	1.4	1.5	1.6	1.6	1.6	1.7	0.1	0.1	0.1	0.1	0.1	0.1	9.8	8.8	7.7	7.7	8.4	7.1
20	1.9	2.1	1.7	2.0	1.9	1.8	0.1	0.1	0.1	0.2	0.2	0.2	7.7	6.6	7.4	9.9	10.6	9.2
21	1.6	1.6	1.6	1.6	1.6	1.7	0.3	0.2	0.1	0.1	0.1	0.1	19.4	11.6	8.4	7.6	8.4	7.7
22	1.2	1.2	1.3	1.5	1.6	1.7	0.1	0.1	0.1	0.1	0.1	0.2	4.1	4.3	5.5	7.9	6.6	8.9
23	1.2	1.3	1.3	1.4	1.5	1.5	0.0	0.0	0.1	0.1	0.1	0.1	3.0	3.7	5.9	4.3	4.3	3.9
24	1.4	1.9	1.3	1.5	1.5	1.4	0.1	0.1	0.0	0.0	0.0	0.0	3.6	5.9	2.5	3.0	3.1	2.2
25	1.4	1.4	1.7	1.7	1.7	1.7	0.1	0.1	0.1	0.1	0.1	0.1	5.2	5.2	7.2	7.2	7.9	7.8
26	1.1	1.1	1.1	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.0	1.7	2.9	2.8	2.5
27	1.4	1.5	1.3	1.5	1.5	1.5	0.1	0.1	0.1	0.1	0.1	0.1	7.8	8.8	6.7	8.3	9.4	8.7
28	1.4	1.5	1.3	1.2	1.2	1.3	0.1	0.1	0.1	0.0	0.0	0.1	7.2	7.0	5.4	3.9	3.8	4.8
29	1.4	1.5	1.4	1.7	1.6	1.7	0.1	0.1	0.1	0.1	0.1	0.1	8.2	7.2	9.0	6.5	6.4	6.5

Note: The leakage ratio is defined as the ratio between leakage and output multiplier.

Table 3 - Forward linkages and leakages

	Input multiplier						Leakage						Leakage ratio (per cent)					
Sector	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
1	2.1	2.1	2.0	2.2	2.2	2.2	0.4	0.3	0.3	0.4	0.4	0.4	19.6	16.7	15.4	17.6	18.8	17.2
2	1.5	1.4	1.5	1.5	1.4	1.3	0.2	0.5	0.5	0.1	0.1	0.1	12.0	34.9	36.3	6.1	8.5	6.8
3	2.4	2.4	2.0	1.9	2.1	2.1	1.1	1.1	1.1	1.0	1.1	1.2	46.2	48.6	55.4	53.9	53.1	56.2
4	1.5	1.6	1.5	1.7	1.6	1.6	0.1	0.1	0.1	0.2	0.2	0.2	8.1	6.6	7.0	11.3	14.0	13.4
5	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	6.4
6	1.6	1.4	1.4	1.5	1.5	1.5	0.1	0.1	0.2	0.2	0.3	0.3	7.5	10.3	15.6	15.3	17.9	17.3
7	1.3	1.2	1.2	1.3	1.3	1.3	0.1	0.2	0.2	0.2	0.3	0.3	11.0	17.5	16.8	18.5	19.9	19.6
8	1.4	1.4	1.5	2.0	2.0	2.1	0.0	0.1	0.1	0.2	0.2	0.3	3.3	4.2	7.0	7.6	11.0	12.4
9	2.1	2.1	2.1	2.3	2.3	2.3	0.2	0.2	0.3	0.3	0.4	0.3	10.0	8.0	13.6	13.4	15.5	15.1
10	2.1	2.0	2.0	1.9	1.8	1.9	0.8	0.6	0.7	0.9	1.0	1.1	36.7	28.9	34.1	45.8	56.2	57.7
11	1.9	2.1	1.9	2.0	1.9	1.9	0.4	0.4	0.7	0.6	0.7	0.8	18.6	17.6	34.7	31.6	36.5	39.4
12	2.0	1.9	1.9	2.2	2.3	2.3	0.1	0.1	0.1	0.2	0.2	0.2	4.2	5.0	7.4	6.9	8.7	9.1
13	1.8	1.9	1.6	2.2	2.0	1.9	0.2	0.2	0.3	0.9	1.0	0.8	10.9	12.8	20.4	41.5	49.6	43.4
14	1.4	1.3	1.3	1.4	1.4	1.4	0.4	0.5	0.5	0.5	0.6	0.6	26.9	34.4	41.0	39.4	40.8	41.3
15	1.3	1.2	1.2	1.1	1.1	1.1	0.5	0.5	0.4	0.4	0.5	0.4	39.8	39.3	36.5	38.4	41.4	39.4
16	1.4	1.6	1.5	1.5	1.5	1.5	0.6	0.6	0.4	0.2	0.2	0.2	40.4	40.6	26.6	11.0	14.6	15.1
17	2.9	3.0	2.6	2.6	2.5	2.4	0.3	0.2	0.2	0.2	0.2	0.2	10.0	7.0	7.8	6.4	7.1	6.2
18	1.1	1.1	1.1	1.5	1.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.8	1.1	1.2	1.5
19	1.5	1.7	1.7	1.6	1.6	1.5	0.1	0.1	0.1	0.1	0.1	0.1	5.1	4.9	6.4	6.1	6.5	5.2
20	1.2	1.2	1.2	1.3	1.3	1.2	0.0	0.0	0.1	0.1	0.1	0.1	2.0	1.9	4.6	5.7	5.8	4.9
21	1.5	1.5	1.8	1.9	1.9	1.8	0.2	0.1	0.2	0.2	0.2	0.1	11.1	6.8	8.4	9.7	10.2	8.0
22	2.1	2.2	2.1	2.0	2.1	2.1	0.1	0.1	0.1	0.1	0.1	0.1	6.9	6.2	7.2	7.4	5.8	5.4
23	2.0	2.2	2.2	2.1	2.0	2.1	0.1	0.1	0.1	0.1	0.1	0.1	5.7	6.4	6.0	7.0	6.5	6.4
24	1.0	1.0	1.0	1.4	1.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	3.0	2.0
25	2.4	2.5	2.1	2.5	2.5	3.1	0.3	0.3	0.4	0.2	0.2	0.3	11.5	11.3	16.8	9.4	9.4	9.7
26	1.0	1.0	1.0	1.2	1.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.8	2.9	1.5
27	1.1	1.1	1.0	1.1	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.2
28	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6
29	1.1	1.0	1.3	1.5	1.6	1.4	0.0	0.0	0.1	0.1	0.1	0.0	1.1	1.1	4.6	5.4	5.8	3.2

Note: The leakage ratio is defined as the ratio between leakage and input multiplier.

Table 4 - Normalized backward and forward linkages

	1980		1986		1992		1995		1999		2002	
Sector	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL
1	1.02	1.27	1.08	1.25	1.16	1.23	1.00	1.32	1.04	1.32	1.06	1.32
2	0.89	0.95	0.92	0.85	0.90	0.91	0.83	0.91	0.80	0.84	0.83	0.78
3	0.79	1.47	0.83	1.41	0.98	1.27	0.82	1.10	0.82	1.24	0.77	1.25
4	1.28	0.95	1.30	0.95	1.20	0.95	1.26	0.99	1.19	0.94	1.23	0.95
5	0.89	0.62	0.95	0.60	0.93	0.63	0.85	0.59	0.81	0.60	0.93	0.60
6	1.14	0.98	1.01	0.85	1.06	0.85	1.07	0.90	1.03	0.88	1.08	0.89
7	1.04	0.83	0.97	0.73	1.00	0.73	1.05	0.80	1.01	0.78	1.02	0.78
8	1.13	0.85	1.14	0.84	1.21	0.94	1.21	1.19	1.18	1.19	1.27	1.23
9	1.20	1.32	1.13	1.27	1.20	1.31	1.13	1.34	1.13	1.38	1.06	1.37
10	0.94	1.27	0.92	1.18	0.98	1.24	0.94	1.14	1.00	1.09	0.96	1.14
11	0.88	1.17	0.88	1.26	0.96	1.20	0.98	1.18	1.01	1.15	1.01	1.15
12	1.12	1.23	1.06	1.16	1.10	1.21	1.11	1.28	1.11	1.36	1.10	1.36
13	0.92	1.11	0.93	1.16	1.09	1.01	0.98	1.28	0.93	1.19	0.94	1.15
14	0.85	0.84	0.88	0.80	0.88	0.79	0.90	0.82	0.92	0.81	0.91	0.83
15	0.78	0.77	0.79	0.74	0.89	0.75	0.92	0.67	0.87	0.65	0.88	0.67
16	0.88	0.84	0.82	0.93	0.97	0.97	1.04	0.86	1.03	0.91	1.05	0.91
17	1.29	1.78	1.20	1.78	1.06	1.63	1.05	1.56	1.05	1.51	1.12	1.44
18	1.11	0.67	1.08	0.67	1.09	0.71	1.21	0.88	1.22	0.92	1.21	0.94
19	0.88	0.93	0.90	1.03	0.98	1.09	0.94	0.95	0.98	0.94	0.99	0.90
20	1.19	0.75	1.23	0.73	1.07	0.78	1.20	0.76	1.15	0.78	1.08	0.75
21	0.96	0.95	0.94	0.91	1.00	1.15	0.93	1.12	0.95	1.16	1.01	1.05
22	0.75	1.31	0.73	1.30	0.81	1.30	0.87	1.20	0.94	1.28	1.00	1.23
23	0.77	1.22	0.80	1.34	0.84	1.41	0.81	1.22	0.87	1.20	0.89	1.25
24	0.86	0.62	1.15	0.60	0.79	0.63	0.87	0.81	0.91	0.86	0.84	0.79
25	0.85	1.45	0.86	1.51	1.06	1.33	1.03	1.46	1.03	1.47	1.02	1.83
26	0.70	0.62	0.69	0.60	0.70	0.64	0.73	0.70	0.74	0.70	0.72	0.65
27	0.84	0.67	0.87	0.66	0.81	0.64	0.90	0.63	0.88	0.65	0.89	0.66
28	0.87	0.62	0.88	0.60	0.83	0.63	0.71	0.59	0.74	0.60	0.78	0.61
29	0.88	0.65	0.91	0.62	0.86	0.82	0.99	0.89	0.96	0.94	1.01	0.81

Note: Shaded area denotes above one.

Table 5 - Coefficient of variation

	Backward coefficient of variation						Forward coefficient of variation					
Sector	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
1	3.6	3.5	3.4	3.6	3.5	3.6	3.2	3.3	3.4	3.1	3.1	3.1
2	3.7	3.5	3.8	4.1	4.3	4.0	3.7	3.9	3.8	3.9	4.1	4.3
3	4.7	4.5	3.8	4.0	4.0	4.4	2.5	2.6	2.9	3.0	2.7	2.7
4	3.2	3.2	3.4	3.3	3.3	3.1	4.2	4.2	4.2	4.1	4.1	4.0
5	3.7	3.4	3.6	3.7	3.9	3.5	5.4	5.4	5.4	5.4	5.4	5.4
6	4.4	4.3	4.0	4.1	4.2	4.1	5.1	5.1	5.0	4.9	4.9	5.0
7	3.7	3.7	3.8	4.0	4.1	4.0	4.7	5.0	5.3	5.3	5.3	5.2
8	3.2	3.1	3.3	3.5	3.5	3.4	4.3	4.2	4.2	3.6	3.6	3.6
9	3.6	3.6	3.3	3.6	3.4	3.7	3.2	3.2	3.0	3.0	2.8	2.8
10	3.7	3.8	3.6	3.8	3.4	3.6	2.8	3.0	2.8	3.1	3.1	3.0
11	3.7	3.7	3.5	3.4	3.3	3.2	2.9	2.6	2.8	2.8	2.8	2.8
12	3.2	3.2	3.4	3.4	3.4	3.3	3.4	3.3	3.4	3.4	3.4	3.3
13	3.8	3.6	3.2	3.7	3.6	3.8	3.1	3.0	3.5	2.9	2.9	3.1
14	3.9	3.7	3.9	3.8	3.7	3.7	4.0	4.1	4.4	4.2	4.2	4.1
15	4.3	4.1	4.0	3.7	3.8	3.8	4.3	4.4	4.9	5.1	5.2	5.1
16	3.8	4.0	3.5	3.2	3.3	3.3	3.9	3.5	3.5	3.8	3.7	3.8
17	4.2	4.6	4.8	4.6	4.5	4.4	2.9	3.0	3.1	3.1	3.1	3.4
18	3.0	3.0	3.1	3.5	3.6	3.6	4.9	4.8	4.7	4.8	4.8	4.7
19	3.9	3.8	3.8	3.6	3.5	3.4	3.7	3.4	3.4	3.6	3.7	3.7
20	2.9	2.8	3.2	2.7	2.8	3.0	4.4	4.4	4.3	4.2	4.1	4.3
21	3.7	3.7	3.7	3.8	3.7	3.7	3.8	3.8	3.3	3.1	3.1	3.6
22	4.4	4.4	4.2	4.1	4.3	4.2	2.5	2.4	2.6	3.0	3.1	3.4
23	4.5	4.2	4.3	4.2	4.0	4.0	2.8	2.5	2.5	2.8	2.8	2.8
24	3.9	2.9	4.3	3.8	3.7	3.9	5.4	5.4	5.4	4.0	3.8	4.1
25	4.1	4.1	3.4	3.9	3.9	4.2	2.4	2.3	2.7	2.7	2.7	2.3
26	4.7	4.7	4.8	4.3	4.3	4.5	5.4	5.4	5.3	4.5	4.6	4.9
27	4.2	4.1	4.3	3.6	3.8	3.9	5.4	5.4	5.4	5.2	5.2	5.3
28	3.8	3.6	4.0	4.5	4.3	4.1	5.4	5.4	5.4	5.4	5.4	5.3
29	3.7	3.5	3.9	3.5	3.6	3.5	5.2	5.2	4.2	3.9	3.6	4.3

Table 6 - Overall linkages and leakages

	1980	1986	1992	1995	1999	2002
Coefficient of interdependence	1.62	1.67	1.59	1.69	1.68	1.67
Coefficient of leakage	0.52	0.42	0.36	0.38	0.39	0.42
Leakage ratio *(per cent)*	31.9	24.8	22.3	22.3	23.2	25.0

Note: The leakage ratio is defined as the ratio between the coefficient of leakage and the coefficient of interdependence.

Figure 1 - Backward linkage and leakage for Industry

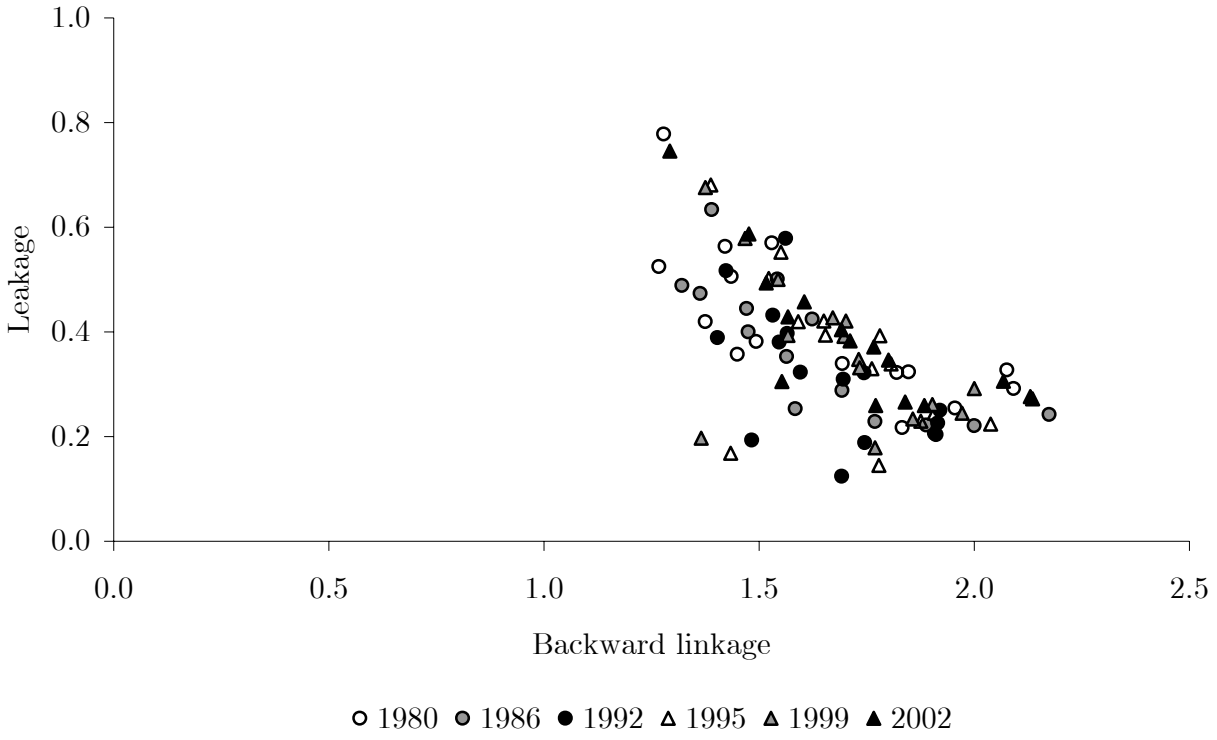


Figure 2 - Backward linkage and leakage for Services

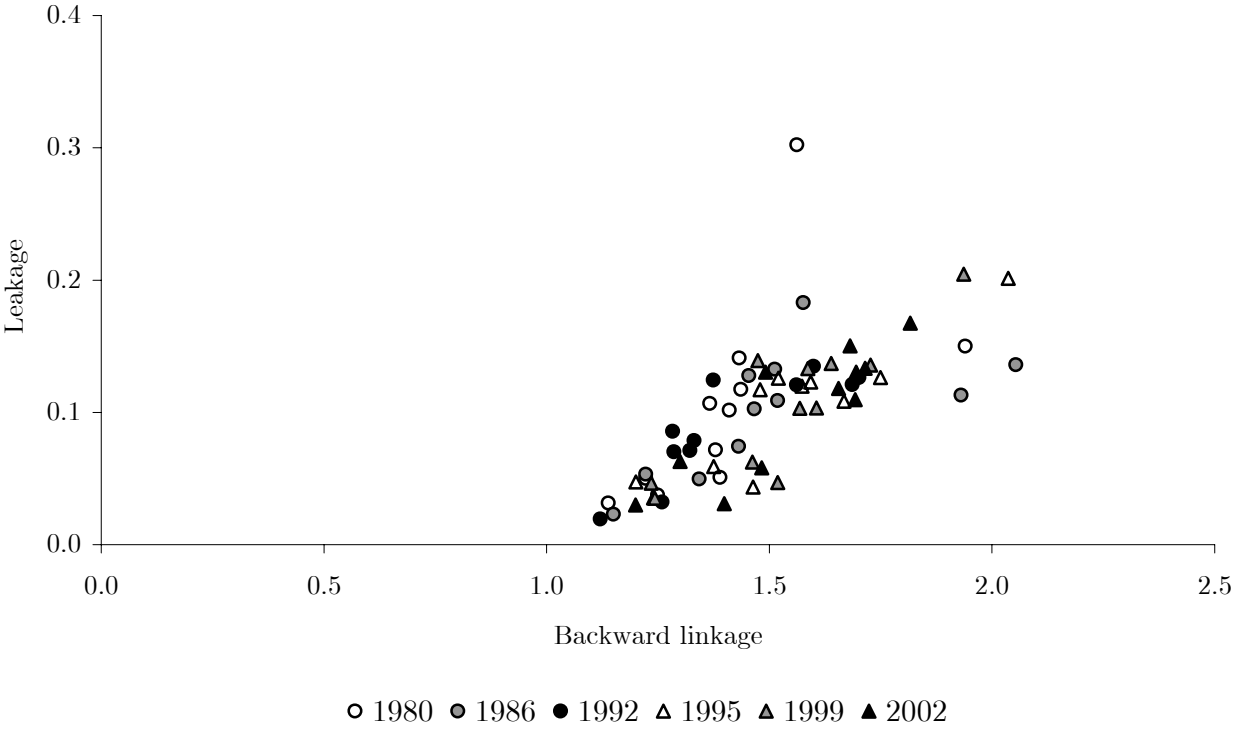


Figure 3 - Forward linkage and leakage for Industry

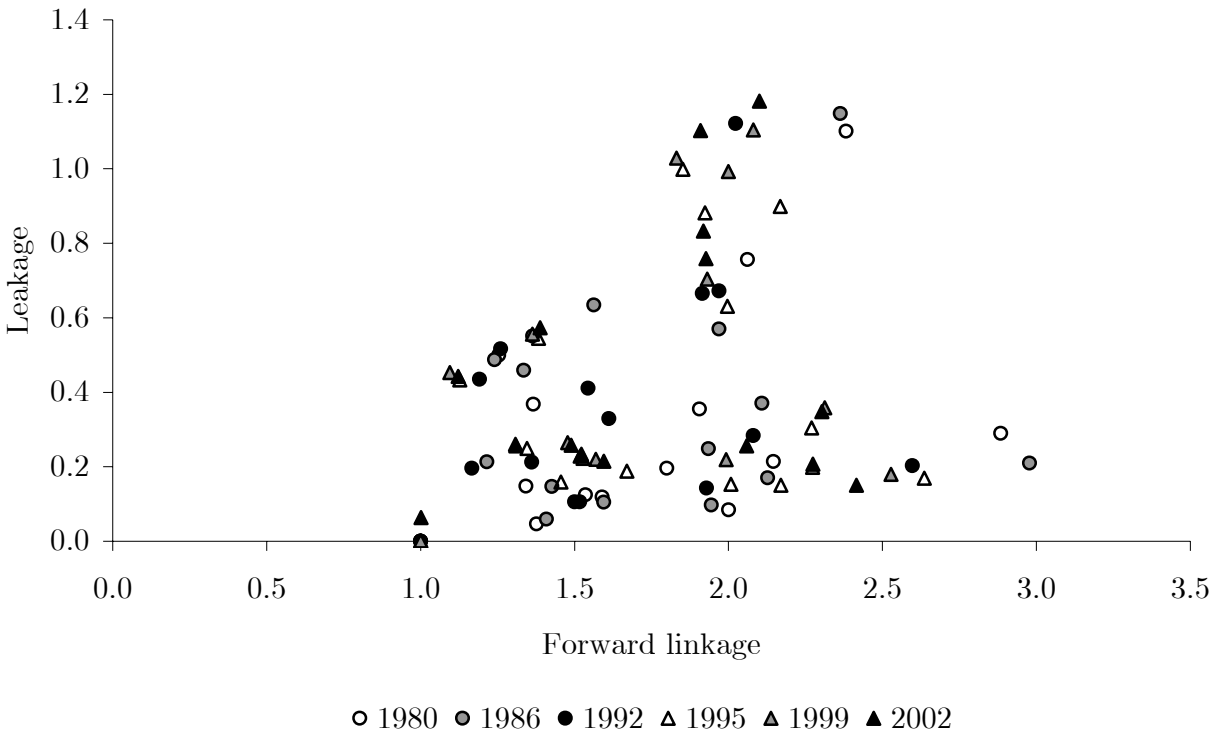


Figure 4 - Forward linkage and leakage for Services

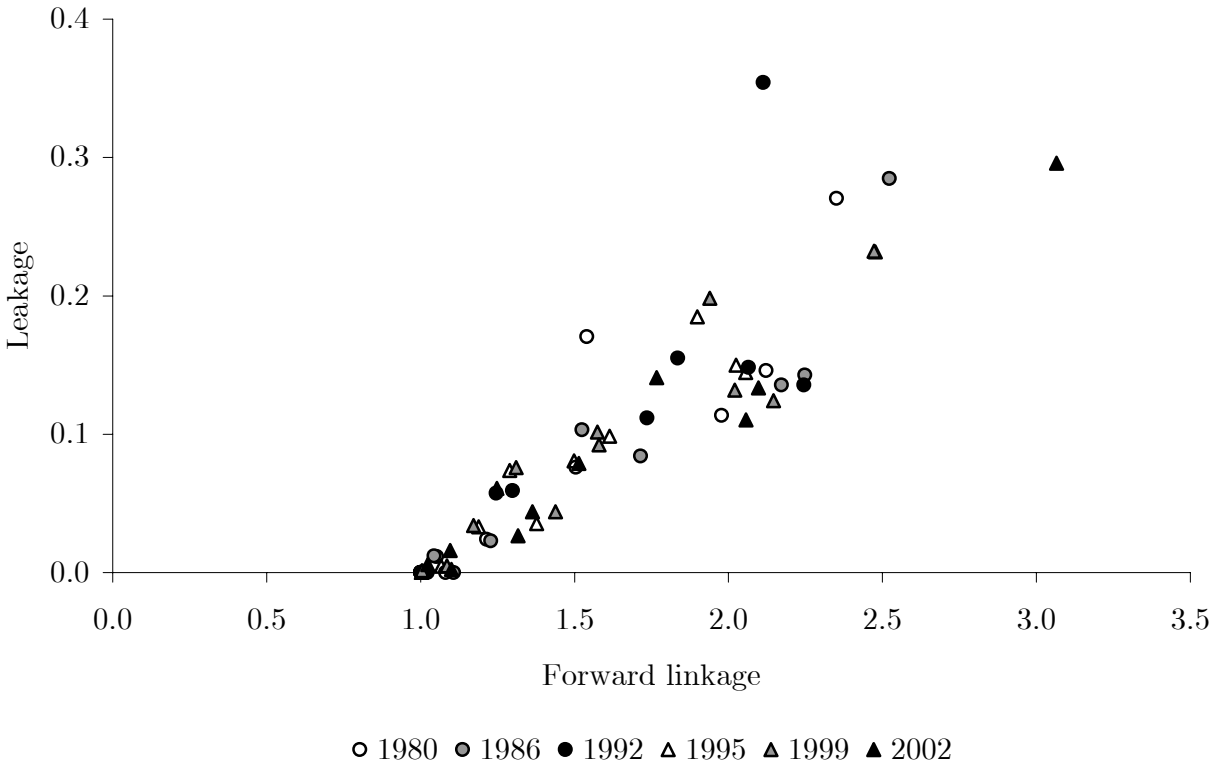
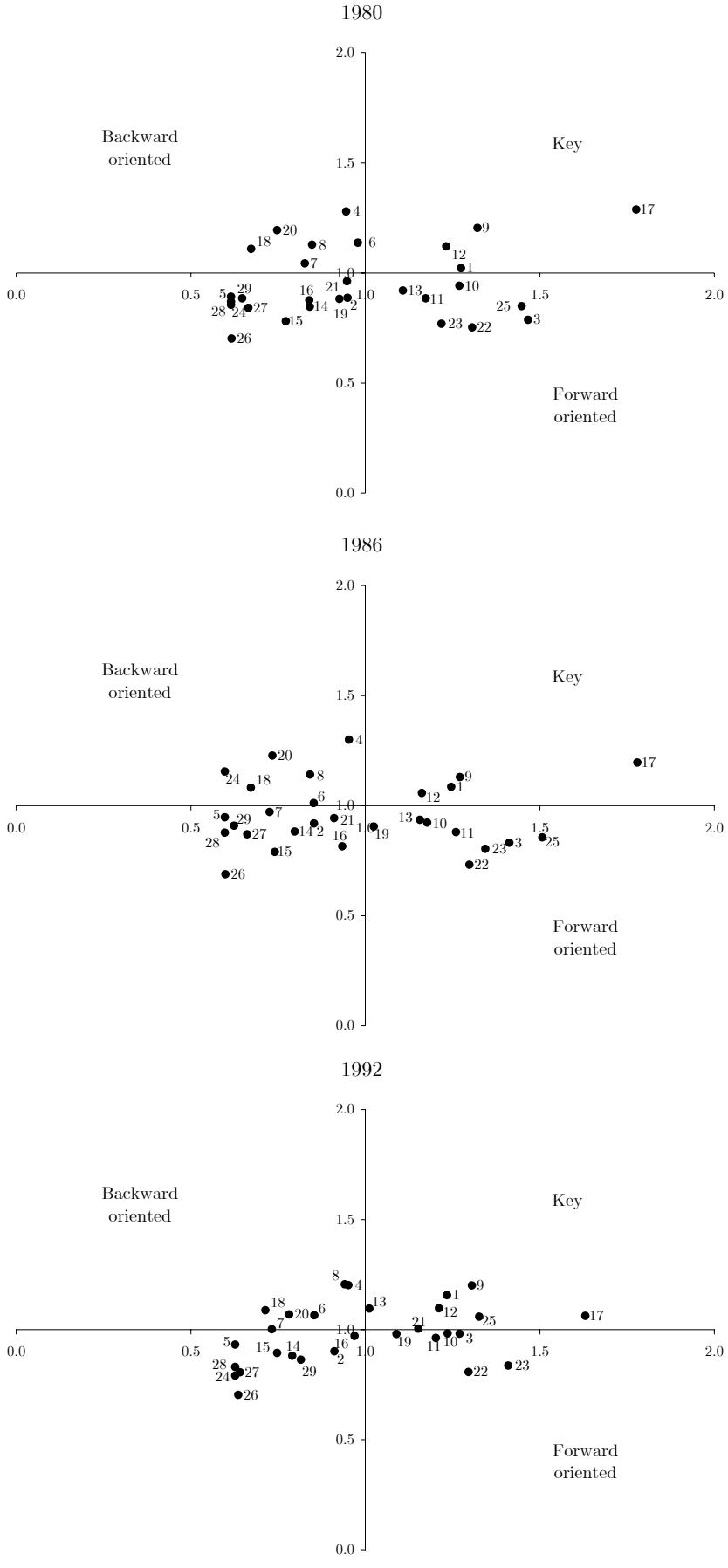
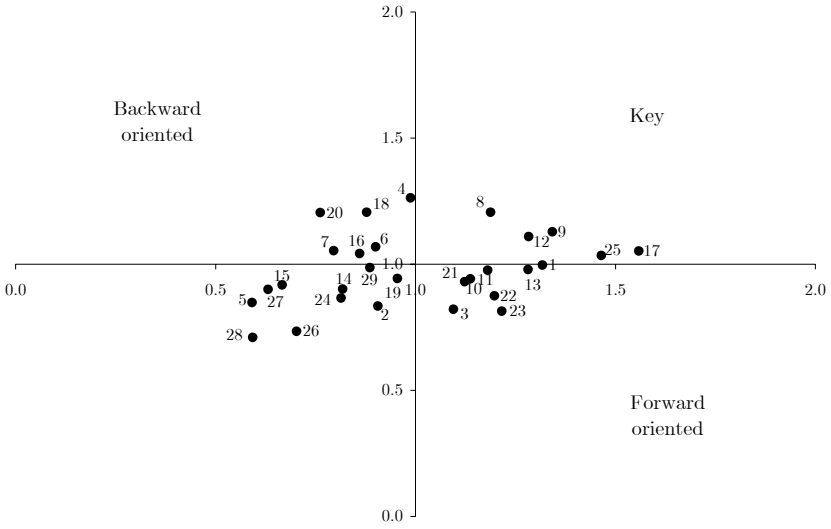


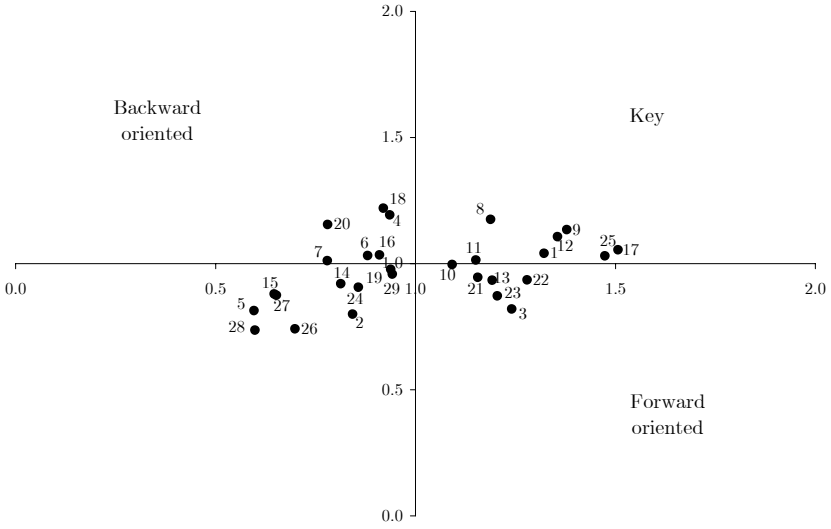
Figure 5 - Normalized backward and forward linkages



1995



1999



2002

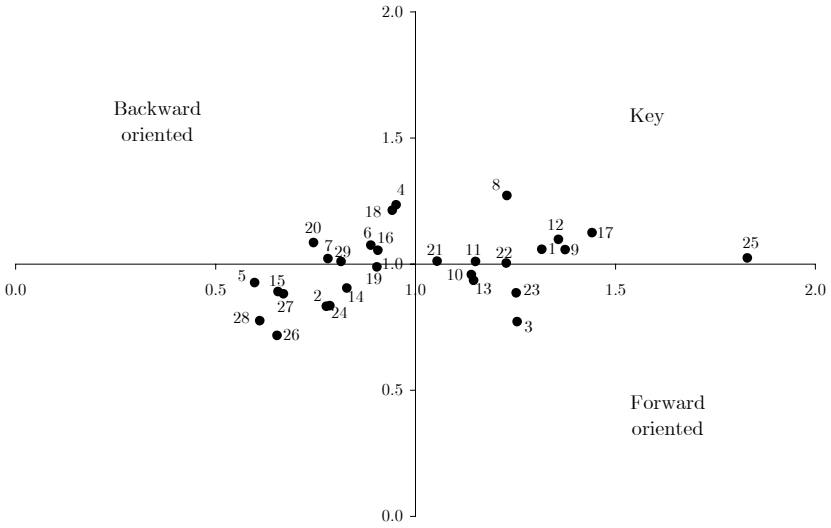


Figure 6 - Backward linkage and coefficient of variation

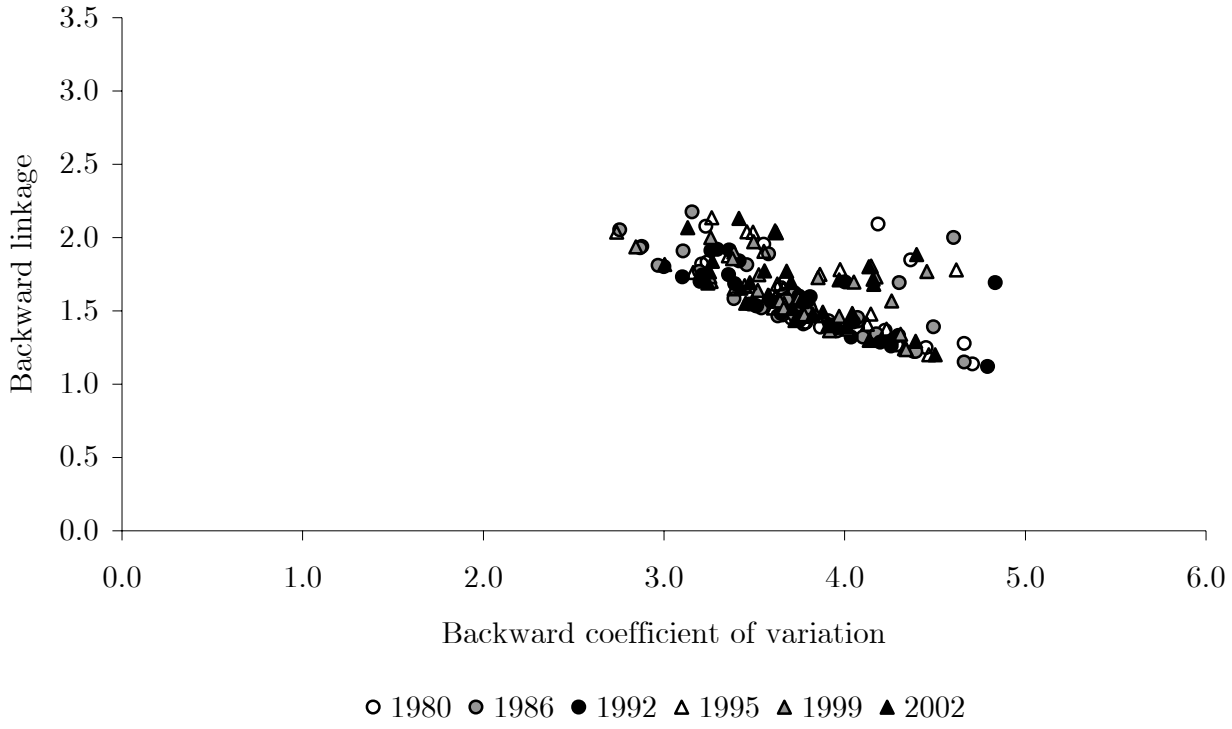


Figure 7 - Forward linkage and coefficient of variation