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LINKAGES, KEY SECTORS, AND STRUCTURAL CHANGE: SOME NEW PERSPECTIVES

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INTRODUCTION

WHILE there is general agreement about the importance of linkages among the sectors of any economy in the promulgation of economic growth stimuli, there seems to be little consensus about the ways in which "key sectors" (to use the Rasmussen-Hirschman term) or "pôles de croissance" (Perroux [22]) can be identified. Part of the confusion stems from difficulties in interpretation of such sectors as above average contributors to the economy from either an ex post or an ex ante perspective. However, there seems to be general agreement that the processes of economic change are often stimulated by a relatively small number of sectors initially, even if the whole economy ends up experiencing change. In this paper, some alternative perspectives are offered, perspectives that provide some potential for resolution of the debates that have continued between Cella [4], Guccione [10], Clements and Rossi [6][7] on Cella's decomposition technique and Clements and Rossi's criticism [7] of the application of traditional key sector techniques by Baer, Fonseca, and Guilhoto [1] to the Brazilian economy.

However, the major contribution of this paper is to place these debates into a broader context by revealing perspectives that enhance the rather narrow view of linkages that has become associated with key sector analysis. This paper only draws on a small set of these perspectives (see Sonis, Hewings, and Lee [32] for a more comprehensive evaluation), which adopt a hierarchy of micro, meso, and macro levels of economic analysis. Essentially, the focus will be on ways in which a meso-level perspective that describes the distribution of changes in direct coefficients on the whole economic system can be used to enhance the understanding and interpretation of key sectors. This interpretation is made by reference to a field of influence of change which may be considered for all combinations of direct and synergetic changes through the specification of additive components of the Leontief inverse. It is felt that this perspective will help clarify the nature of eco-

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nomic structure and, most critically, the ways in which the transmission of structural change penetrates the complex web of interactions that characterize an economy.

The paper is organized as follows. In the next section, a brief review of some of the more recent debates on key sector identification will be provided. Thereafter, the meso-level perspective will be presented and interpreted through the use of the field of influence. The major empirical evaluation will occur in the next section: here the link between the more traditional and the newer approaches will be made clear by reference to a set of tables for the Brazilian economy for selected years between 1959 and 1980. The paper will conclude with an evaluation and interpretation of the techniques.

I. KEY SECTORS, LINKAGES, AND DECOMPOSITION

There is a lengthy body of literature on the concept of key sector analysis. Rasmussen and Hirschman's notions have been the objects of widespread application and significant critical commentary (see, for example, McGilvray [18] and Hewings [12]). These debates will not be revisited in this paper; rather the focus will begin with a more recent exchange centering on a proposition by Cella [4] concerning a measurement of total, backward, and forward linkages that employs a matrix decomposition technique. Cella's technique, including a subsequent modification, was applied by Clements and Rossi [6][7] to the case of Brazil. Here, Clements and Rossi criticized an earlier application of the Rasmussen-Hirschman techniques by Baer, Fonseca, and Guilhoto [1], but were unaware of a subsequent paper (see Hewings et al. [13]) that extended the techniques in the directions that will be highlighted in the present paper.

Essentially, the concern of the present paper is to direct attention to alternative perspectives on the measurement and identification of key sectors (and associated concepts such as analytically important or inverse important parameters) and to suggest that the presentation of alternative visions about the structure of and structural change in economies will facilitate a more balanced view of economic transformation processes. To date, the literature on key sector analysis has tended to focus attention on the promotion of one technique as superior to others, rather than considering several procedures as complementary.

II. THE RASMUSSEN / HIRSCHMAN APPROACH

The work of Rasmussen [23] and Hirschman [14] led to the development of indices of linkage that have now become part of the generally accepted procedures for identifying key sectors in the economy.

Define b_{ij} as a typical element of the Leontief inverse matrix, B; B^* as the average value of all elements of B, and if $B_{\cdot j}$ and $B_{i\cdot}$ are the associated typical column and row sums, then the indices may be developed as follows:

Backward linkage index, U_j, for sector j (power of dispersion):

$$U_j = (B_{\cdot j}/n)/B^*. \tag{1}$$

Forward linkage index, U_i, for sector i (sensitivity of dispersion):

$$U_i = (B_{i\cdot}/n)/B^*. \tag{2}$$

One of the criticisms of the above indices is that they do not take into consideration the different levels of production in each sector of the economy. Based on that criticism, Cella developed the approach that is shown below [4]. His indices formed the basis for the improvements that are described in Section IV, where the notion of a "pure linkage" index is introduced.

III. THE CELLA / CLEMENTS APPROACH

Using the Leontief matrix of direct inputs coefficients (A), Cella defined the following block matrices [4]:

$$A = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix}, \tag{3}$$

and

$$\bar{A} = \begin{bmatrix} A_{jj} & 0 \\ 0 & A_{rr} \end{bmatrix}, \tag{4}$$

where A_{jj} and A_{rr} are square matrices of direct inputs, respectively, within sector j and within the rest of the economy (economy less sector j); A_{jr} and A_{rj} are rectangular matrices showing, respectively, the direct inputs purchased by sector j from the rest of the economy and the direct inputs purchased by the rest of the economy from sector j. A is a matrix of direct inputs coefficients, defined to confine interaction to those between establishments within sector j and, similarly, to interaction among the rest of the sectors, but excluding sector j. In essence, one can imagine these divisions to represent two separate economies with no trading relationships. Some of these ideas had their origin in an earlier paper by Miyazawa [19] and his notion of "internal" and "external" multipliers.

Following Sonis and Hewings [29] and drawing on earlier work by Miyazawa [19][20], equation (3) can be solved for the Leontief inverse resulting in:

$$L = [I - A]^{-1} = \begin{bmatrix} \tilde{\Delta}_j & \tilde{\Delta}_j A_{jr} \Delta_r \\ \Delta_r A_{rj} \tilde{\Delta}_j & \Delta_r (I + A_{rj} \tilde{\Delta}_j A_{jr} \Delta_r) \end{bmatrix}, \tag{5}$$

where

$$\tilde{\Delta}_j = [I - A_{jj} - A_{jr} \Delta_r A_{rj}]^{-1}, \quad \text{and} \tag{6}$$

$$\Delta_r = [I - A_{rr}]^{-1}. \tag{7}$$

In the same way equation (4) can be solved for the Leontief inverse yielding:

$$\bar{L} = [I - \bar{A}]^{-1} = \begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{bmatrix}, \tag{8}$$

where

$$\Delta_j = [I - A_{jj}]^{-1}. \quad (9)$$

Cella used this approach to define the total linkage effect (*TL*) in the economy: that is, what would be the production in the economy if sector *j* neither bought inputs from the rest of the economy nor sold its output to the rest of the economy [4]. In development terms, this might be regarded as the opposite of import substitution, namely, the disappearance of a whole industrial sector from an economy. Given this assumption, the following definition of *TL* may be derived:

$$TL = i'[L - \bar{L}]\,[f] = i'\begin{bmatrix} \tilde{\Delta}_j - \Delta_j & \tilde{\Delta}_j A_{jr} \Delta_r \\ \Delta_r A_{rj} \tilde{\Delta}_j & \Delta_r A_{rj} \tilde{\Delta}_j A_{jr} \Delta_r \end{bmatrix} \begin{bmatrix} f_{jj} \\ f_{rr} \end{bmatrix}, \quad (10)$$

where i' is a unit row vector of the appropriate dimension, and f, f_{jj}, f_{rr} are column vectors of final demand for, respectively, the total economy, sector *j* alone, and the rest of economy, excluding sector *j*.

Cella then defined the backward (*BL*) and forward (*FL*) linkage [4]:

$$BL = [(\tilde{\Delta}_j - \Delta_j) + i'_{rr}(\Delta_r A_{rj} \tilde{\Delta}_j)]\,[f_{jj}]\,, \quad (11)$$

$$FL = [(\tilde{\Delta}_j A_{jr} \Delta_r) + i'_{rr}(\Delta_r A_{rj} \tilde{\Delta}_j A_{jr} \Delta_r)]\,[f_{rr}]\,, \quad (12)$$

where i'_{rr} is a unit row vector of the appropriate dimension.

Clements argues that the second component of the forward linkage belongs to the backward linkage [5]. In his words, “it quantifies the stimulus given to supplying sectors caused by intermediate demand for a given sector” (p. 339). In this way, he proposed a definition of backward and forward linkage as:

$$BL = [(\tilde{\Delta}_j - \Delta_j) + i'_{rr}(\Delta_r A_{rj} \tilde{\Delta}_j)]\,[f_{jj}] + [i'_{rr}(\Delta_r A_{rj} \tilde{\Delta}_j A_{jr} \Delta_r)]\,[f_{rr}]\,, \quad (13)$$

$$FL = [\tilde{\Delta}_j A_{jr} \Delta_r]\,[f_{rr}]. \quad (14)$$

Cella’s original definition [4] for backward and forward linkage indices was applied by Clements and Rossi [6] for the Brazilian economy using the 1975 input-output table. The definition by Clements [5] was used in Clements and Rossi [7] in an examination of the Brazilian economy using the 1980 input-output table. We make use of the latter definition for estimations made in this paper. In the next section, some comments about the Cella/Clements technique are provided, and a new approach is presented.

IV. THE PURE LINKAGE APPROACH

While, in essence, the idea behind the derivation of the Cella/Clements approach is correct, we think that the application can be improved according to the following suggestions. First of all, if one wants to isolate sector *j* from the rest of the economy, one should start with the following decomposition as an alternative to that provided in equation (4) above:

$$A = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix} = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & A_{rr} \end{bmatrix} = A_j + A_r , \tag{15}$$

where matrix A_j represents sector j isolated from the rest of the economy, and matrix A_r represents the rest of the economy. As before, define the Leontief inverse:

$$L = [I - A]^{-1}, \tag{16}$$

then we can show that each additive decomposition of the matrix of direct inputs (equation 15) can be converted into the two alternative multiplicative decompositions of the Leontief inverse as follows (see Sonis and Hewings [29]):

$$L = P_2 P_1, \tag{17}$$

or

$$L = P_1 P_3, \tag{18}$$

where

$$P_1 = [I - A_r]^{-1}, \tag{19}$$

$$P_2 = [I - P_1 A_j]^{-1}, \text{ and} \tag{20}$$

$$P_3 = [I - A_j P_1]^{-1}. \tag{21}$$

Equation (17) isolates the interaction within the rest of the economy (P_1) from the interaction of sector j with the rest of the economy (P_2). As can be seen in equation (20), P_2 shows the direct and indirect impacts that the demand for inputs from sector j will have over the whole economy ($P_1 A_j$).

Equation (18), on the other hand, isolates the interaction within the rest of the economy (P_1) from the interaction of the rest of the economy with sector j through (P_3). As can be seen in equation (21), P_3 reveals what the level of the impacts on sector j will be generated by the direct and indirect needs of the rest of the economy ($A_j P_1$).

Working with equations (17), (19), and (20), equation (17) can be expressed in the following form:

$$L = \underbrace{\begin{bmatrix} \tilde{\Delta}_j & \tilde{\Delta}_j A_{jr} \\ \Delta_r A_{rj} \tilde{\Delta}_j & I + \Delta_r A_{rj} \tilde{\Delta}_j A_{jr} \end{bmatrix}}_{P_2} \underbrace{\begin{bmatrix} I & 0 \\ 0 & \Delta_r \end{bmatrix}}_{P_1}, \tag{22}$$

where all the variables are as defined before, and the first term in the right hand side is P_2, while the second term is P_1.

From the first term in the right hand side of equation (22), we can present the following decomposition:

$$P_2 = \begin{bmatrix} I & 0 \\ \Delta_r A_{rj} & I \end{bmatrix} \begin{bmatrix} \tilde{\Delta}_j & 0 \\ 0 & I \end{bmatrix} \begin{bmatrix} I & A_{jr} \\ 0 & I \end{bmatrix}, \tag{23}$$

where

$$P_2 = [I - B_j]^{-1}, \tag{24}$$

and

$$B_j = P_1 A_j = \begin{bmatrix} A_{jj} & A_{jr} \\ \Delta_r A_{rj} & 0 \end{bmatrix}. \tag{25}$$

From equation (25) we can define a "pure backward linkage" (*PBL*) as:

$$PBL = i'_{rr} \Delta_r A_{rj} q_{jj}, \tag{26}$$

where q_{jj} is the value of total production in sector *j*, and the other variables are defined as before. If one wants to treat sector *j* as a sector isolated from the rest of the economy, we propose that it will be more appropriate to use the value of total production, instead of the value of final demand as used by Cella [4], given that the vector of total production will work like a vector of final demand in terms of the impact of sector *j* on the rest of the economy.

The *PBL* will give the pure impact on the economy of the value of the total production in sector *j:* i.e., the impact that is free from (a) the demand of inputs that sector *j* makes from sector *j*, and (b) the feedbacks from the economy to sector *j* and vice versa.

Using equations (18), (19), and (21), equation (18) can be expressed as:

$$L = \underbrace{\begin{bmatrix} I & 0 \\ 0 & \Delta_r \end{bmatrix}}_{P_1} \underbrace{\begin{bmatrix} \tilde{\Delta}_j & \tilde{\Delta}_j A_{jr} \Delta_r \\ \Delta_r A_{rj} \tilde{\Delta}_j & I + A_{rj} \tilde{\Delta}_j A_{jr} \Delta_r \end{bmatrix}}_{P_3}, \tag{27}$$

where all the variables are as defined before, and the first term in the right hand side is P_1, while the second term is P_3.

From the second term in the right hand side of equation (27), we can have the following decomposition:

$$P_3 = \begin{bmatrix} I & 0 \\ A_{rj} & I \end{bmatrix} \begin{bmatrix} \tilde{\Delta}_j & 0 \\ 0 & I \end{bmatrix} \begin{bmatrix} I & A_{jr} \Delta_r \\ 0 & I \end{bmatrix}, \tag{28}$$

where

$$P_3 = [I - F_j]^{-1}, \tag{29}$$

and

$$F_j = A_j P_1 = \begin{bmatrix} A_{jj} & A_{jr} \Delta_r \\ A_{rj} & 0 \end{bmatrix}. \tag{30}$$

From equation (30) we can derive a "pure forward linkage" (*PFL*) that is given by:

$$PFL = A_{jr} \Delta_r q_{rr}, \tag{31}$$

where q_{rr} is a column vector of total production in each sector in the rest of the economy. Again, the reason for using the value of total production instead of the value of final demand is the isolation of sector j from the rest of the economy, as stated above.

The *PFL* will give the pure impact on sector j of the total production in the rest of the economy. Again, this impact is freed from some of the confusion of definition in the earlier approaches of Cella and Clements/Rossi noted in the definition of *PBL*.

If one wants to know what the "pure total linkage" (*PTL*) of each sector in the economy is, for example, for the purpose of ranking them, it is possible to add the *PBL* and the *PFL*, given that these indices, as defined above, are expressed in currency values. Hence:

$$PTL = PBL + PFL. \tag{32}$$

The above derivation is an improvement over the method developed by Cella [4] and application by Clements and Rossi [6][7] to Brazil. However, there is another perspective, introduced by Hewings et al. [13] in an application to Brazil that will complement the definitions used in equation (32). The notion of a "field of influence" provides a more precise analytical procedure for evaluating a sector's (or some components of it) influence on the rest of the economy. The methodology is described in the next section and used to help interpret the several sets of key sector identification procedures described in section VI of this paper.

V. THE FIELD OF INFLUENCE APPROACH

In the development of the analytical form of the fields of influence, the ideas of Sherman and Morrison [25][26], Evans [9], Park [21], Simonovits [27], and Bullard and Sebald [2][3] should be acknowledged. The presentation of the material is inductive. First, the general formulation of concepts is given, followed by an exposition of the final results of the mathematical analysis. All of the proofs are provided in Sonis and Hewings [30].[1]

The condensed form of the solution of the coefficient change problem can be presented in the following manner: let $A = [a_{ij}]$ be an $n \times n$ matrix of direct input coefficients; let $E = [e_{ij}]$ be a matrix of incremental changes in the direct input coefficients; let $B = [I - A]^{-1} = \|b_{ij}\|$, $B(E) = [I - A - E]^{-1} = \|b(e)_{ij}\|$ be the Leontief inverses before and after changes; and let $\det B$, $\det B(E)$ be the determinants of the corresponding inverses. Then the following propositions hold:

PROPOSITION 1. The ratio of determinants of the Leontief inverses before and after changes is the polynomial of the incremental changes (e_{ij}) expressed in the following form:

$$Q(E) = \frac{\det B}{\det B(E)} = 1 - \sum_{j_1 i_1} b_{j_1 i_1} e_{i_1 j_1} + \sum_{k=2}^{n} (-1) \sum_{\substack{i_r \neq i_s \\ j_r \neq j_s}}' B_{or} \begin{pmatrix} j_1 & j_2 & \dots & j_k \\ i_1 & i_2 & \dots & i_k \end{pmatrix} e_{i_1 j_1} e_{i_2 j_2} \dots e_{i_k j_k}, \tag{33}$$

[1] This section draws on Sonis and Hewings [28][30].

where $B_{or}\begin{pmatrix} j_1\, j_2 \cdots j_k \\ i_1\, i_2 \ldots i_k \end{pmatrix}$ is a determinant of order k that includes the components of the Leontief inverse B from the ordered set of columns $i_1, i_2, \ldots, i_k$, and rows $j_1, j_2, \ldots, j_k$.[2] Further, in the sum $\sum'$, the products of the changes $e_{i_1 j_1}, e_{i_2 j_2}, \ldots, e_{i_k j_k}$, that differ only by the order of multiplication, are counted only once.

Proposition 2. This provides a fundamental formula between the Leontief matrices in matrix form:

$$B(E) = B + \frac{1}{Q(E)}\left[\sum_{k=1}^{n} \sum_{\substack{i_r \neq i_s \\ j_r \neq j_s}} F\begin{pmatrix} i_1 \cdots i_k \\ j_1 \ldots j_k \end{pmatrix} e_{j_1 i_1} \ldots e_{j_k i_k}\right], \tag{34}$$

where the matrix field of influence, $F\begin{pmatrix} i_1 \cdots i_k \\ j_1 \ldots j_k \end{pmatrix}$, of the incremental changes $e_{j_1 i_1} \ldots e_{j_k i_k}$ includes the components:

$$f_{ij}\begin{pmatrix} i_1 \cdots i_k \\ j_1 \ldots j_k \end{pmatrix} = (-1)^k\left[B_{or}\begin{pmatrix} i_1 \cdots & i_k & i \\ j_1 \ldots & j_k & j \end{pmatrix} - b_{ij} B_{or}\begin{pmatrix} i_1 \cdots i_k \\ j_1 \ldots j_k \end{pmatrix}\right], \; i, j = 1, \ldots, n. \tag{35}$$

Proposition 3. This proposition provides the fine structure of the fields of influence. Initially, two types may be identified, the first order being confined to changes in only one element in the matrix, and the second order examining the field of influence associated with changes in two elements.

(1) The first order field of influence, $F\begin{pmatrix} i_1 \\ j_1 \end{pmatrix}$, of the increment e_{ji} is the matrix generated by a multiplication of the jth column of the Leontief inverse B with its ith row:

$$F\begin{pmatrix} i \\ j \end{pmatrix} = \begin{bmatrix} b_{1j} \\ b_{2j} \\ \vdots \\ b_{nj} \end{bmatrix} [b_{i1} b_{i2} \ldots b_{in}]. \tag{36}$$

Moreover, the first order field of influence includes the components of the gradient of the function, $b_{i_1 j_1}$, considered as a scalar function of all components of the matrix, A:

$$F\begin{pmatrix} i_1 \\ j_1 \end{pmatrix} = \text{grad}\, b_{i_1 j_1}(A) \tag{37}$$

(here, the pqth component of the gradient is placed in the intersection of the qth row and pth column).

(2) The second order synergetic interaction between two incremental changes, $e_{j_1 i_1}$ and $e_{j_2 i_2}$, is reduced to the following linear combination of four first-order

[2] It should be emphasized that the order of columns and rows in B_{or} is essential.

fields of influence:

$$F\begin{pmatrix} i_1 & i_2 \\ j_1 & j_2 \end{pmatrix} = -\, b_{i_1 j_1} F\begin{pmatrix} i_2 \\ j_2 \end{pmatrix} + b_{i_1 j_2} F\begin{pmatrix} i_2 \\ j_1 \end{pmatrix} + b_{i_2 j_1} F\begin{pmatrix} i_1 \\ j_2 \end{pmatrix} - b_{i_2 j_2} F\begin{pmatrix} i_1 \\ j_1 \end{pmatrix}. \qquad (38)$$

Obviously, if $i_1 = i_2$ or $j_1 = j_2$, then $F\begin{pmatrix} i_1 & i_2 \\ j_1 & j_2 \end{pmatrix}$ is a null matrix.

(3) For each $k = 2, 3, ..., n - 1$, the following recurrent formula is true:

$$F\begin{pmatrix} i_1 \dots i_k \\ j_1 \dots j_k \end{pmatrix} = \frac{1}{k-1} \sum_{s=1}^{k} \sum_{r=1}^{k} (-1)^{s+r+1} b_{j_s i_r} F\begin{pmatrix} i_1 \dots i_{s-1}\ i_{s+1} \dots i_k \\ j_1 \dots j_{r-1}\ j_{r+1} \dots j_k \end{pmatrix}. \qquad (39)$$

This formula also provides for the possibility of presenting the field of influence of order k through the use of fields of influence of lesser order, 1, 2, ..., $k - 1$. Furthermore, the implication of the above theory provides the basis for the consideration of different, economic-based combinations of changes.

Sonis and Hewings provide more detailed presentations of the ways this concept can be applied to consider cases of changes in just one coefficient, a complete row or column, or the whole matrix [30]. This methodology is not limited to changes induced by technological change, improvements in efficiency, or changes in product lines. They could also arise as a result of changes in the competitive position of an economy, resulting in either increases or decreases in trade dependency that would decrease or increase purchases made from the domestic economy. Hence, the methodology is a general tool whose application in the context of linkage analysis is but one of many such applications that would be possible.

The main problem with the linkage methods to date is that even though they evaluate the importance of a sector in terms of its system-wide impacts, it is difficult to visualize the degree to which these impacts reflect the importance of one or two coefficients (or major flows) within the sector and the nature of the impact outside the sector. For example, is the impact concentrated on one or two other sectors or more broadly diffused throughout the economy? (See Van der Linden et al. [33] for a discussion of how this issue may be addressed in the field of influence approach.) From a policy analysis perspective, this is very important. In the next section, an attempt will be made to evaluate the different contributions that can be made by the alternative linkage approaches in combination with interpretation through the fields of influence.

VI. APPLICATION TO THE BRAZILIAN ECONOMY

In this section, comparative analysis of the approaches presented above will focus on (a) the Rasmussen/Hirschman backward and forward linkage indices, (b) the Cella/Clements backward, forward, and total linkage indices, (c) pure backward, forward, and total linkage indices, and (d) fields of influence.

To undertake the comparative analysis, use was made of the Brazilian input-output tables constructed for the years of 1959 (Rijckeghem [24]), 1970 (IBGE [15]), 1975 (IBGE [16]), and 1980 (IBGE [17]). All of these tables were aggregated to the level of twenty-seven sectors, following the tradition of the previous analysis for the Brazilian economy by Baer, Fonseca, and Guilhoto [1], Hewings et al. [13], and Guilhoto [11].

Appendix Tables I through VIII present the results of the various indices for each year, as well as the rank of the each sector for a given index in a given year. Appendix Figures 1 through 40 present in as clear a way as possible the data presented in Appendix Tables I through VIII and the results of the field of influence approach as presented in Hewings et al. [13] and in Guilhoto [11].

The analysis which follows will be divided in the following way: first, the data and the figures will be examined; then a comparison of the indices will be carried out; finally, an attempt will be made to use the alternative approaches to provide an interpretation of the evolution of the structure of the Brazilian economy.

A comparison of the backward linkage indices shows that the Rasmussen/Hirschman indices have a small variance in their values for any given year, with the values concentrated around the mean (1.0). The Cella/Clements and the pure linkage indices reveal, in a better way, the differences among sectors, taking into consideration the level of production and the internal structure of the indices as displayed by the Rasmussen/Hirschman indices. The value of the Cella/Clements indices are close to the pure linkage indices and, with two exceptions—sectors 6 and 4 in 1959 and sectors 25 and 19 in 1970—both indices provide the same ranking for each year. This confirms that the definition of backward linkage made by Cella/Clements are close to the definition presented in the pure backward linkage.

For the forward linkage indices, the Rasmussen/Hirschman indices show a much larger spectrum of variance than their backward linkage indices. The Cella/Clements and the pure linkage indices, in the same way as their backward indices, show greater differences among sectors, taking into consideration the level of production and the internal structure of the economy. The index of Cella/Clements has a lower value than the pure linkage index, and also the ranking of the sectors is different from the pure linkage. This difference may be ascribed to the fact that Cella/Clements underestimate the forward linkage.

Aggregation of the backward and forward linkage indices provides an alternative basis for comparison. The following procedure is used. For the Rasmussen/Hirschman indices, the backward linkage index is plotted on the X axis while the forward linkage index is plotted on the Y axis. Thus, sectors that have both forward and backward linkage indices greater than one are considered key sectors in the economy. For the Cella/Clements and the pure indices, the backward and forward linkage indices are summed to yield the total linkage indices, and sectors which have the greatest value of total linkage are considered key economic sectors. However, it should be noted that there is really no generally accepted criteria for the definition of key sectors using these approaches.

The field of influence approach is closely related to the aggregated results of the Rasmussen/Hirschman linkage indices. It turns out that the sectors that have backward and forward linkages greater than one are the ones that dominate the sectors with coefficients that have the greatest value in the field of influence.

A comparison of the results shows that in the Rasmussen/Hirschman linkage indices and in the field of influence approach, what is more important in defining which are the key sectors is the internal structure of the economy regardless of the value of the total production in the economy. For the Cella/Clements and for the pure linkage indices, not only is the internal structure important, but the level of production of each sector in the economy also needs to be considered. As a result, the definition and the determination of key sectors is quite different from the Rasmussen/Hirschman and field of influence approach. However, rather than engaging in debate about the efficacy of one method over the other, it is proposed that these alternative views be seen as complementary ways of identifying economic structure. In addition, the Cella/Clements linkage indices underestimate the forward linkage, and hence, the total linkage index is also underestimated, revealing a quite different ranking of key sectors than that given by the pure linkage indices. In summarizing the analysis, one might wish to make the following distinction: the Rasmussen/Hirschman and field of influence approaches identify what may be referred to as potential impacts from changes in any sector, while the other indices examine realized effects through their consideration of the volume of activity. However, none of the approaches fully addresses the issue raised by McGilvray [18] over ex ante and ex post distinctions. The application of the fields of influence in terms of volumetric changes over two time periods by Van der Linden et al. [33] represents an attempt to combine a number of desired attributes of all the techniques.

Finally, some comments will be made concerning the evolution of the structure of the Brazilian economy from 1960 to 1980, focusing on issues and interpretations not highlighted in earlier research (Baer, Fonseca, and Guilhoto [1], Hewings et al. [13], and Guilhoto [11]). For the Brazilian economy according to both the Rasmussen/Hirschman and the field of influence approaches, the key sectors from 1959 to 1980 are sectors 4 (metal products), 10 (paper), 13 (chemicals), 17 (textiles), and 19 (food). According to the pure linkage approach, the key sectors are 1 (agriculture), 4 (metal products), 13 (chemicals), 19 (food), 25 (construction), 26 (trade/transport), and 27 (services). The common sectors in both approaches are 4 (metal products), 13 (chemicals), and 19 (food). It is important to note that the pure linkage approach shows the importance of sectors like agriculture and services for the economy derived from the volume of production in those sectors. This effect is not totally captured by the Rasmussen/Hirschman and field of influence approaches. On the other hand, the importance of sectors like paper and textiles, that are crucial for the growth of the economy, is not captured by the pure linkage approach, given the low value of production in those sectors compared to the other sectors. Through the years 1959 to 1980 one can see an increase in the complexity of the Brazilian economy, in which the primary and secondary sectors are declining in importance relative to the tertiary sector, showing a trend that is common in more developed nations.

CONCLUSION

The concept and the determination of key sectors in any economy can be presented in different ways, but the basic need is to explore the insights provided by each kind of analysis, rather than focus on the real or apparent advantages any one technique might offer. It would be surprising if there was complete consistency. As Diamond [8] has noted, the multiplicity of objectives that characterize the growth and development strategies of most countries makes it unlikely that a small number of sectors would yield all the requisites for satisfying employment, income, output, foreign exchange, and other objectives.

The Rasmussen/Hirschman indices and the field of influence approach were used to see how the internal structure of the economy behaved, without taking into consideration the level of production in each sector. On the other hand, the pure linkage indices were used to look at the productive structure when the different levels of production in each sector were taken into consideration. The first kind of analysis is important, for when the internal structure of the economy is overlooked in defining key economic sectors, one can arrive at bottlenecks that will limit the growth of the economy. On the other hand, the level of production in each sector is also important, as it helps to determine which sectors will be the mainly responsible for changes in the levels of GNP and other macro-level measures of the economy. Hence, both kinds of analysis need to be combined, as has been the case in this presentation.

One improvement over the work completed would be to make a complementary analysis, in the tradition of the Leontief-Miyazawa approach, in which the structure of final household demand is incorporated into the analysis. Preliminary work done by Hewings et al. [13] using the concept of field of influence shows that this kind of analysis will add another important dimension to the determination of economic key sectors. The analysis can also be enhanced by addressing the temporal changes explicitly: for example, using the allocation of changes in outputs between two time periods that can be ascribed to changes in coefficients, changes in final demand, changes in their interactive effects, and distinguishing between changes originating within the sector and those originating elsewhere in the economy (see Sonis, Hewings, and Guo [31]).

REFERENCES

1. BAER, W.; FONSECA, M. A. R.; and GUILHOTO, J. J. M. “Structural Changes in Brazil’s Industrial Economy, 1960–80,” *World Development,* Vol.15, No.2 (February 1987).
2. BULLARD, C. W., III, and SEBALD, A. V. “Effects of Parametric Uncertainty and Technological Change on Input-Output Models,” *Review of Economics and Statistics*, Vol. 59, No. 1 (February 1977).
3. __________. “Monte Carlo Sensitivity Analysis of Input-Output Models,” *Review of Economics and Statistics*, Vol.70, No.4 (November 1988).
4. CELLA, G. “The Input-Output Measurement of Interindustry Linkages,” *Oxford Bulletin of Economics and Statistics*, Vol.46, No.1 (February 1984).

5. Clements, B. J. "On the Decomposition and Normalization of Interindustry Linkages," *Economic Letters*, Vol. 33, No. 4 (August 1990).
6. Clements, B. J., and Rossi, J. W. "Interindustry Linkages and Economic Development: The Case of Brazil Reconsidered," *Developing Economies*, Vol. 29, No. 2 (June 1991).
7. __________. "Ligações interindustriais e setores-chave na economia brasileira," *Pesquisa e planejamento econômico*, Vol.22, No.1 (April 1992).
8. Diamond, J. "Key Sectors in Some Underdeveloped Countries: A Comment," *Kyklos*, Vol. 29 (1976).
9. Evans, W. D. "The Effect of Structural Matrix Errors on Interindustry Relations Estimates," *Econometrica*, Vol. 22, No. 1 (January 1954).
10. Guccione, A. "The Input-Output Measurement of Interindustry Linkages: A Comment," *Oxford Bulletin of Economics and Statistics*, Vol. 48, No. 4 (November 1986).
11. Guilhoto, J. J. M. "Mudanças estruturais e setores chaves na economia brasileira, 1960–1990," *Anais do XIV encontro brasileiro de econometria*, Vol. 1 (December 1992).
12. Hewings, G. J. D. "The Empirical Identification of Key Sectors in an Economy: A Regional Perspective," *Developing Economies*, Vol. 20, No. 2 (June 1982).
13. Hewings, G. J. D.; Fonseca, M.; Guilhoto, J. J. M.; and Sonis, M. "Key Sectors and Structural Change in the Brazilian Economy: A Comparison of Alternative Approaches and Their Policy Implications," *Journal of Policy Modeling*, Vol. 11, No. 1 (Spring 1989).
14. Hirschman, A. O. *The Strategy of Economic Development* (New Haven, Conn.: Yale University Press, 1958).
15. Instituto Brasileiro de Geografia e Estatistica. *Matriz de relações intersetoriais, Brasil, 1970*, Final Version (Rio de Janeiro, 1979).
16. __________. *Matriz de relações intersetoriais, Brasil, 1975* (Rio de Janeiro, 1987).
17. __________. *Matriz de insumo-produto, Brasil, 1980*, Série Relatórios Metodológicos Vol. 7 (Rio de Janeiro, 1989).
18. McGilvray, J. "Linkages, Key Sectors and Development Strategy," in *Structure, System and Economic Policy*, ed. W. Leontief (Cambridge: Cambridge University Press, 1977).
19. Miyazawa, K. "Internal and External Matrix Multipliers in the Input-Output Model," *Hitotsubashi Journal of Economics*, Vol. 7, No. 1 (June 1966).
20. __________. *Input-Output Analysis and the Structure of Income Distribution* (New York: Springer-Verlag, 1976).
21. Park, S. "On Input-Output Multipliers with Errors in Input-Output Coefficients," *Journal of Economic Theory*, Vol.6 (August 1974).
22. Perroux, F. "Note sur la notion de 'pôle de croissance,'" *Economie applíqué* (1955).
23. Rasmussen, P. N. *Studies in Intersectoral Relations* (Amsterdam: North-Holland Publishing Co., 1958).
24. Rijckeghem, W. "An Intersectoral Consistency Model for Economic Planning in Brazil," in *The Economy of Brazil*, ed. H. S. Ellis (Berkeley, Calif.: University of California Press, 1969).
25. Sherman, J., and Morrison, W. "Adjustment of an Inverse Matrix to Changes in the Elements of a Given Column or a Given Row in the Original Matrix," *Annals of Mathematical Statistics*, Vol. 20, No. 4 (December 1949).
26. __________. "Adjustment of an Inverse Matrix Corresponding to a Change in One Element of a Given Matrix," *Annals of Mathematical Statistics*, Vol. 21, No. 1 (March 1950).
27. Simonovits, A. "A Note on the Underestimation and Overestimation of the Leontief Inverse," *Econometrica*, Vol. 43, No. 3 (May 1975).
28. Sonis, M., and Hewings, G. J. D. "Error and Sensitivity Input-Output Analysis: A New Approach," in *Frontiers of Input-Output Analysis*, ed. R. E. Miller, K. R. Polenske, and A. Z. Rose (New York: Oxford University Press, 1989).
29. __________. "Hierarchies of Regional Sub-Structures and Their Multipliers within Input-Output Systems: Miyazawa Revisited," *Hitotsubashi Journal of Economics*, Vol. 34, No. 1 (June 1993).
30. __________. "Fields of Influence in Input-Output Systems" (Urbana, Ill.: Regional Economics Applications Laboratory, University of Illinois, 1994).

31. Sonis, M.; Hewings, G. J. D.; and Guo, J. "Sources of Structural Change in Input-Output Systems: A Field of Influence Approach," Working Paper 93-T-12 (Urbana, Ill.: Regional Economics Applications Laboratory, University of Illinois, 1993).
32. Sonis, M.; Hewings, G. J. D.; and Lee, J. K. "Spatial Economic Structure and Spatial Multipliers: Three Perspectives," *Geographical Analysis*, Vol. 26, No. 2 (May 1994).
33. Van der Linden, J.; Oosterhaven, J.; Cuello, F.; Hewings, G. J. D.; and Sonis, M. "Fields of Influence of Technological Change in EC Intercountry Input-Output Tables 1970–1980," Working Paper 93-T-13 (Urbana, Ill.: Regional Economics Applications Laboratory, University of Illinois, 1993).

APPENDIX TABLE I

RASMUSSEN/HIRSCHMAN BACKWARD LINKAGES

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	0.6557	26	0.8200	22	0.8159	23	0.8116	23
2. Mining	0.6291	27	0.7790	24	0.8261	22	0.7941	25
3. Nonmetallic minerals	0.9129	22	0.9302	20	0.9105	20	0.9468	19
4. Metal products	0.9818	17	1.2176	2	1.1755	5	1.2270	1
5. Machinery	0.8592	24	1.0151	13	1.0188	12	1.0516	11
6. Electrical equipment	1.0302	13	1.0013	15	0.9854	16	0.9923	15
7. Transport equipment	0.9679	19	1.1630	6	1.3158	1	1.2226	2
8. Wood	0.9673	20	1.0548	12	0.9743	17	0.9959	14
9. Wood products	1.0486	12	1.0654	10	1.0292	11	1.0606	10
10. Paper	1.1675	3	1.1272	7	1.1462	7	1.1080	8
11. Rubber	1.0123	16	1.0136	14	1.1002	9	1.1419	6
12. Leather	1.0819	10	1.2154	3	1.1662	6	1.1995	4
13. Chemicals	1.1470	5	0.9844	17	0.9275	19	0.8133	22
14. Pharmaceuticals	1.0268	14	0.7828	23	0.7522	24	0.8456	21
15. Cosmetics	1.2078	1	1.0866	9	1.0055	14	1.0345	12
16. Plastics	1.0874	9	0.9718	18	1.0087	13	0.9806	17
17. Textiles	1.0913	8	1.1008	8	1.2623	2	1.1771	5
18. Clothing and footwear	1.1360	6	1.1797	4	1.1999	4	1.1207	7
19. Food	1.1021	7	1.2689	1	1.2558	3	1.2099	3
20. Beverages	1.0135	15	0.9916	16	0.9507	18	1.0826	9
21. Tobacco	0.9731	18	0.9544	19	0.9993	15	1.0089	13
22. Printing	1.0513	11	0.8927	21	0.8715	21	0.9151	20
23. Other industrial products	0.9207	21	1.1635	5	1.1400	8	0.9682	18
24. Public utilities	1.1590	4	0.6821	27	0.7125	25	0.7968	24
25. Construction	1.1760	2	1.0634	11	1.0815	10	0.9841	16
26. Trade/transport	0.8725	23	0.7359	26	0.7035	26	0.7462	27
27. Services	0.7210	25	0.7389	25	0.6649	27	0.7646	26

Source: [11].

APPENDIX TABLE II

RASMUSSEN/HIRSCHMAN FORWARD LINKAGES

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	2.1446	2	2.1988	1	1.9060	4	1.7041	4
2. Mining	0.9575	9	0.8000	17	0.7376	17	0.7410	15
3. Nonmetallic minerals	0.7873	11	0.8904	9	0.8409	13	0.7934	11
4. Metal products	1.9181	5	2.0456	2	2.1030	3	2.1514	3
5. Machinery	0.5705	22	1.0508	8	1.0107	8	0.9443	9
6. Electrical equipment	0.6218	19	0.8719	11	0.8545	11	0.6861	18
7. Transport equipment	0.6757	16	0.8635	12	0.9161	9	0.7761	12
8. Wood	0.8997	10	0.8521	13	0.8969	10	0.7732	13
9. Wood products	0.5478	25	0.6287	23	0.5729	25	0.4985	25
10. Paper	1.3305	6	1.1803	7	1.1911	6	1.0581	8
11. Rubber	0.7090	13	0.8010	16	0.8438	12	0.7708	14
12. Leather	0.7605	12	0.7010	18	0.7282	18	0.5987	19
13. Chemicals	2.9454	1	2.0188	3	2.4571	1	2.6945	1
14. Pharmaceuticals	0.5647	23	0.6783	20	0.6089	22	0.5398	23
15. Cosmetics	0.5460	26	0.6225	26	0.5702	26	0.4839	27
16. Plastics	0.5970	20	0.8119	15	0.8085	15	0.7220	16
17. Textiles	1.1620	7	1.3232	5	1.4488	5	1.2732	6
18. Clothing and footwear	0.5449	27	0.6253	24	0.5735	24	0.4962	26
19. Food	0.6993	14	1.2332	6	1.0175	7	1.1142	7
20. Beverages	0.5817	21	0.6583	22	0.6026	23	0.5269	24
21. Tobacco	0.6512	17	0.6230	25	0.6285	21	0.5834	21
22. Printing	0.6366	18	0.6849	19	0.6368	20	0.5791	22
23. Other industrial products	0.5587	24	0.8338	14	0.7743	16	0.7023	17
24. Public utilities	0.9592	8	0.8816	10	0.8092	14	0.9142	10
25. Construction	0.6854	15	0.6193	27	0.5560	27	0.5854	20
26. Trade/transport	1.9803	3	1.8433	4	2.2561	2	1.6059	5
27. Services	1.9648	4	0.6655	21	0.6505	19	2.6831	2

Source: [11].

APPENDIX TABLE III

Cella/Clements Backward Linkages

(Cr$ million)

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	68,108	7	4,860	6	42,432	6	827,456	5
2. Mining	3,843	27	492	27	3,838	24	156,070	19
3. Nonmetallic minerals	35,310	12	2,044	14	13,545	14	279,554	13
4. Metal products	48,416	10	4,240	8	31,657	9	620,063	7
5. Machinery	33,498	13	3,583	11	37,762	8	600,930	8
6. Electrical equipment	48,581	9	2,492	12	19,369	12	422,727	11
7. Transport equipment	64,271	8	5,685	4	47,286	4	707,857	6
8. Wood	17,311	21	1,421	16	8,927	17	153,501	20
9. Wood products	21,565	19	1,565	15	10,122	15	194,799	15
10. Paper	16,983	22	1,008	20	8,013	19	165,697	18
11. Rubber	20,765	20	1,032	19	7,034	21	115,743	23
12. Leather	9,388	24	692	23	2,811	27	57,942	26
13. Chemicals	93,344	5	5,573	5	43,195	5	556,608	9
14. Pharmaceuticals	25,136	17	573	26	3,235	26	75,095	25
15. Cosmetics	25,430	15	1,275	17	6,289	22	99,324	24
16. Plastics	8,485	25	963	22	10,063	16	180,918	17
17. Textiles	84,275	6	4,497	7	23,767	11	340,653	12
18. Clothing and footwear	46,120	11	3,707	10	27,682	10	539,790	10
19. Food	247,381	2	20,866	1	113,105	2	1,847,062	3
20. Beverages	24,284	18	1,003	21	6,139	23	125,277	22
21. Tobacco	6,735	26	614	25	3,770	25	46,441	27
22. Printing	27,739	14	1,226	18	8,758	18	149,244	21
23. Other industrial products	12,686	23	2,396	13	16,716	13	252,497	14
24. Public utilities	25,420	16	656	24	7,623	20	186,555	16
25. Construction	225,952	3	20,767	2	157,324	1	2,058,957	2
26. Trade/transport	278,129	1	8,282	3	54,466	3	1,386,543	4
27. Services	110,133	4	4,214	9	38,798	7	2,481,866	1

APPENDIX TABLE IV

Cella/Clements Forward Linkages

(Cr$ million)

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	213,192	1	16,741	1	81,717	3	1,069,236	5
2. Mining	31,047	9	1,298	17	6,675	18	152,995	17
3. Nonmetallic minerals	45,604	6	4,458	5	28,336	5	378,558	6
4. Metal products	133,920	4	11,325	2	87,636	2	1,157,108	2
5. Machinery	2,034	23	2,239	9	17,536	7	245,391	10
6. Electrical equipment	7,182	17	1,910	12	13,765	9	153,050	16
7. Transport equipment	15,106	14	1,447	13	11,563	12	194,642	12
8. Wood	29,404	10	1,992	10	15,631	8	176,016	14
9. Wood products	1,228	24	161	23	755	23	13,600	25
10. Paper	34,953	7	2,260	8	12,801	10	197,475	11
11. Rubber	16,056	13	1,307	16	8,752	16	137,860	19
12. Leather	8,676	16	394	21	2,446	21	32,847	23
13. Chemicals	193,991	2	9,095	4	78,957	4	1,449,320	1
14. Pharmaceuticals	4,887	19	507	20	2,216	22	41,123	22
15. Cosmetics	1,215	25	131	24	634	25	7,516	26
16. Plastics	2,509	22	1,359	15	10,160	14	175,259	15
17. Textiles	32,380	8	3,524	6	22,015	6	375,620	7
18. Clothing and footwear	1,070	26	113	25	645	24	17,961	24
19. Food	6,191	18	2,279	7	12,751	11	288,567	9
20. Beverages	2,726	20	106	26	2,717	20	45,809	21
21. Tobacco	0	27	2	27	29	26	758	27
22. Printing	11,271	15	511	19	2,780	19	124,280	20
23. Other industrial products	2,555	21	1,432	14	9,224	15	142,506	18
24. Public utilities	22,145	12	1,914	11	11,519	13	330,776	8
25. Construction	28,038	11	335	22	0	27	187,942	13
26. Trade/transport	118,118	5	10,654	3	93,805	1	1,136,668	4
27. Services	137,937	3	924	18	7,697	17	1,155,451	3

APPENDIX TABLE V

PURE BACKWARD LINKAGES

(Cr$ million)

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	65,886	7	4,641	6	40,515	6	791,010	5
2. Mining	3,974	27	489	27	3,824	24	155,333	19
3. Nonmetallic minerals	35,286	12	2,043	14	13,540	14	279,414	13
4. Metal products	48,604	9	4,201	8	31,418	9	613,809	7
5. Machinery	33,461	13	3,543	11	37,265	8	593,214	8
6. Electrical equipment	48,508	10	2,481	12	19,273	12	421,158	11
7. Transport equipment	64,161	8	5,653	4	46,877	4	704,142	6
8. Wood	17,308	21	1,420	16	8,925	17	153,462	20
9. Wood products	21,565	19	1,565	15	10,118	15	194,689	15
10. Paper	16,981	22	1,006	20	7,990	19	165,337	18
11. Rubber	20,742	20	1,031	19	7,023	21	115,715	23
12. Leather	9,386	24	692	23	2,810	27	57,934	26
13. Chemicals	93,865	5	5,496	5	42,078	5	551,063	9
14. Pharmaceuticals	25,095	17	573	26	3,234	26	75,003	25
15. Cosmetics	25,420	15	1,274	17	6,286	22	99,298	24
16. Plastics	8,484	25	962	22	10,051	16	180,840	17
17. Textiles	83,875	6	4,456	7	23,617	11	339,532	12
18. Clothing and footwear	46,107	11	3,704	10	27,658	10	539,249	10
19. Food	246,784	2	20,524	2	110,981	2	1,782,982	3
20. Beverages	24,260	18	1,002	21	6,138	23	125,180	22
21. Tobacco	6,735	26	614	25	3,770	25	46,439	27
22. Printing	27,683	14	1,222	18	8,722	18	148,905	21
23. Other industrial products	12,675	23	2,386	13	16,655	13	251,438	14
24. Public utilities	25,295	16	652	24	7,586	20	185,549	16
25. Construction	224,567	3	20,737	1	157,324	1	2,051,716	2
26. Trade/transport	267,071	1	7,969	3	52,059	3	1,352,345	4
27. Services	105,926	4	4,199	9	38,588	7	2,326,273	1

APPENDIX TABLE VI

Pure Forward Linkages

(Cr$ million)

Sector		1959		1970		1975		1980	
		Index	Rank	Index	Rank	Index	Rank	Index	Rank
1.	Agriculture	301,453	1	21,005	1	111,356	3	1,520,955	4
2.	Mining	88,890	6	2,701	10	14,238	13	398,542	10
3.	Nonmetallic minerals	56,057	7	4,669	5	27,554	6	437,314	9
4.	Metal products	127,830	5	9,800	4	76,647	4	1,060,538	5
5.	Machinery	2,791	23	3,615	7	28,314	5	458,211	8
6.	Electrical equipment	8,930	16	2,368	13	17,316	10	211,153	17
7.	Transport equipment	19,621	14	1,835	15	13,580	16	252,563	16
8.	Wood	33,146	12	2,050	14	16,865	11	208,718	18
9.	Wood products	1,559	26	259	23	1,130	24	23,131	25
10.	Paper	38,765	10	2,416	12	14,001	14	267,734	14
11.	Rubber	21,018	13	1,757	17	11,229	18	177,170	20
12.	Leather	8,248	18	425	22	2,369	22	34,781	23
13.	Chemicals	194,484	4	13,336	3	115,142	2	2,214,998	1
14.	Pharmaceuticals	8,233	19	858	19	3,014	20	65,719	22
15.	Cosmetics	1,991	24	208	24	989	25	13,651	26
16.	Plastics	3,157	22	1,771	16	13,790	15	264,347	15
17.	Textiles	36,233	11	4,028	6	19,410	8	327,916	11
18.	Clothing and footwear	1,795	25	190	25	1,153	23	34,272	24
19.	Food	8,806	17	3,163	9	17,889	9	472,188	7
20.	Beverages	4,963	20	130	26	2,980	21	68,556	21
21.	Tobacco	0	27	2	27	45	26	1,277	27
22.	Printing	19,005	15	674	20	4,431	19	198,298	19
23.	Other industrial products	4,243	21	2,463	11	16,399	12	300,174	12
24.	Public utilities	42,126	9	3,365	8	19,428	7	519,129	6
25.	Construction	47,474	8	477	21	0	27	288,379	13
26.	Trade/transport	207,232	3	16,053	2	152,711	1	1,878,264	3
27.	Services	224,610	2	1,231	18	12,841	17	2,085,822	2

APPENDIX TABLE VII

Cella/Clements Total Linkages

(Cr$ million)

Sector		1959		1970		1975		1980	
		Index	Rank	Index	Rank	Index	Rank	Index	Rank
1.	Agriculture	281,300	3	21,601	2	124,149	4	1,896,692	6
2.	Mining	34,890	19	1,789	20	10,513	22	309,064	19
3.	Nonmetallic minerals	80,914	9	6,502	9	41,882	11	658,112	11
4.	Metal products	182,336	7	15,565	5	119,293	6	1,777,171	7
5.	Machinery	35,532	18	5,822	10	55,298	8	846,321	9
6.	Electrical equipment	55,762	11	4,403	12	33,135	12	575,777	12
7.	Transport equipment	79,377	10	7,132	8	58,849	7	902,499	8
8.	Wood	46,714	15	3,413	15	24,558	15	329,518	18
9.	Wood products	22,794	23	1,726	22	10,877	21	208,399	22
10.	Paper	51,936	12	3,268	16	20,814	16	363,172	16
11.	Rubber	36,821	17	2,340	18	15,786	19	253,604	21
12.	Leather	18,063	24	1,086	25	5,257	26	90,789	26
13.	Chemicals	287,335	2	14,668	6	122,152	5	2,005,927	5
14.	Pharmaceuticals	30,023	20	1,080	26	5,451	25	116,218	24
15.	Cosmetics	26,645	22	1,406	23	6,923	24	106,841	25
16.	Plastics	10,994	26	2,322	19	20,223	17	356,177	17
17.	Textiles	116,656	8	8,020	7	45,782	10	716,272	10
18.	Clothing and footwear	47,191	14	3,820	14	28,328	13	557,751	13
19.	Food	253,572	5	23,145	1	125,856	3	2,135,629	4
20.	Beverages	27,010	21	1,109	24	8,856	23	171,086	23
21.	Tobacco	6,735	27	615	27	3,799	27	47,199	27
22.	Printing	39,010	16	1,737	21	11,537	20	273,524	20
23.	Other industrial products	15,242	25	3,828	13	25,940	14	395,004	15
24.	Public utilities	47,566	13	2,570	17	19,142	18	517,331	14
25.	Construction	253,990	4	21,102	3	157,324	1	2,246,900	3
26.	Trade/transport	396,247	1	18,936	4	148,271	2	2,523,211	2
27.	Services	248,070	6	5,138	11	46,495	9	3,637,316	1

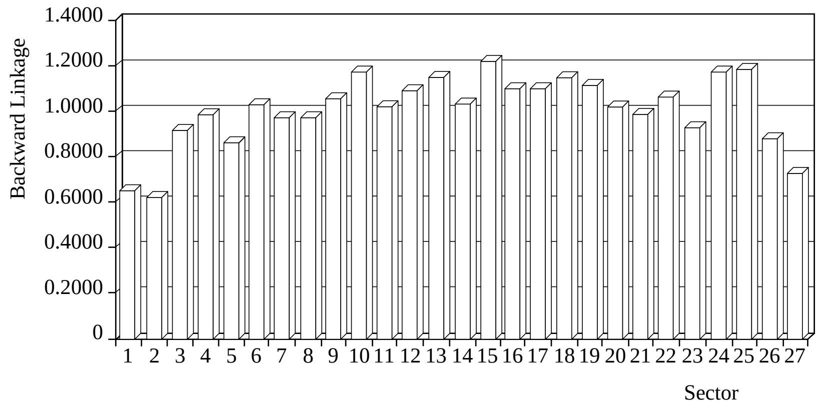
APPENDIX TABLE VIII

Pure Total Linkages

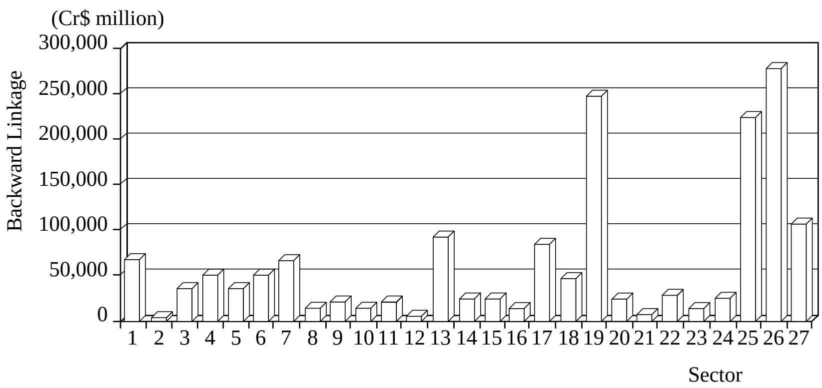
(Cr$ million)

Sector	1959		1970		1975		1980	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. Agriculture	367,340	2	25,646	1	151,871	4	2,311,965	5
2. Mining	92,865	9	3,190	18	18,063	20	553,875	15
3. Nonmetallic minerals	91,343	10	6,712	10	41,094	11	716,728	10
4. Metal products	176,434	7	14,001	6	108,065	6	1,674,347	7
5. Machinery	36,251	19	7,158	9	65,578	7	1,051,425	8
6. Electrical equipment	57,439	13	4,849	12	36,589	12	632,311	13
7. Transport equipment	83,782	11	7,488	8	60,456	8	956,705	9
8. Wood	50,454	15	3,471	16	25,790	16	362,180	19
9. Wood products	23,123	23	1,823	22	11,248	22	217,819	22
10. Paper	55,747	14	3,422	17	21,991	18	433,071	18
11. Rubber	41,761	18	2,788	19	18,252	19	292,885	21
12. Leather	17,634	24	1,117	26	5,179	26	92,716	26
13. Chemicals	288,349	4	18,833	5	157,219	3	2,766,060	3
14. Pharmaceuticals	33,329	20	1,431	24	6,248	25	140,722	24
15. Cosmetics	27,411	22	1,483	23	7,274	24	112,948	25
16. Plastics	11,640	26	2,733	20	23,840	17	445,187	17
17. Textiles	120,108	8	8,484	7	43,026	10	667,448	12
18. Clothing and footwear	47,901	16	3,894	15	28,811	14	573,521	14
19. Food	255,590	6	23,687	3	128,871	5	2,255,170	6
20. Beverages	29,223	21	1,133	25	9,118	23	193,736	23
21. Tobacco	6,735	27	616	27	3,815	27	47,717	27
22. Printing	46,688	17	1,896	21	13,153	21	347,204	20
23. Other industrial products	16,918	25	4,849	13	33,054	13	551,613	16
24. Public utilities	67,421	12	4,017	14	27,014	15	704,678	11
25. Construction	272,041	5	21,214	4	157,324	2	2,340,095	4
26. Trade/transport	474,303	1	24,023	2	204,770	1	3,230,609	2
27. Services	330,536	3	5,430	11	51,429	9	4,412,095	1

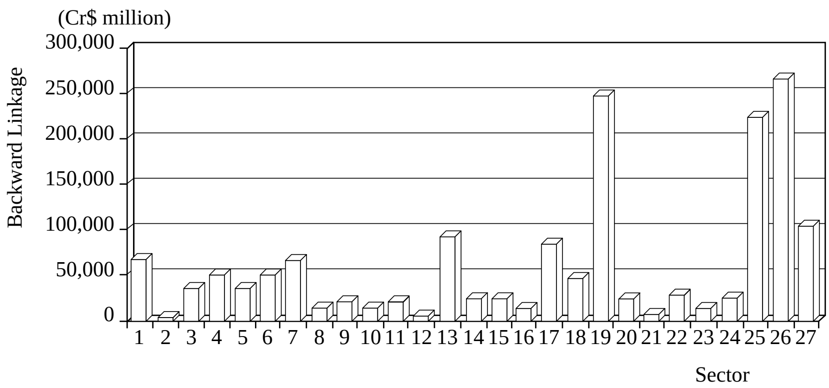
App. Fig. 1. Rasmussen / Hirschman, 1959



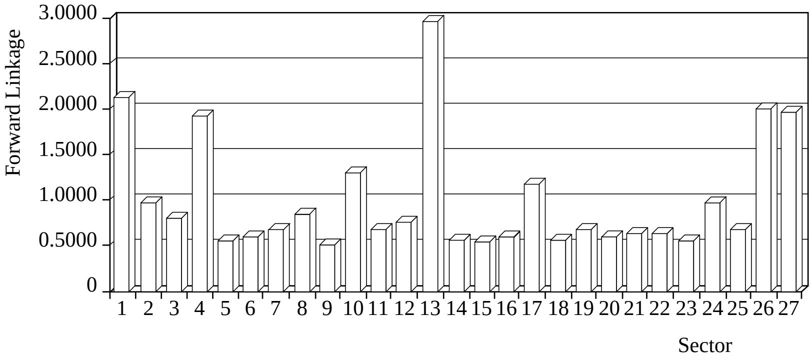
App. Fig. 2. Cella / Clements, 1959



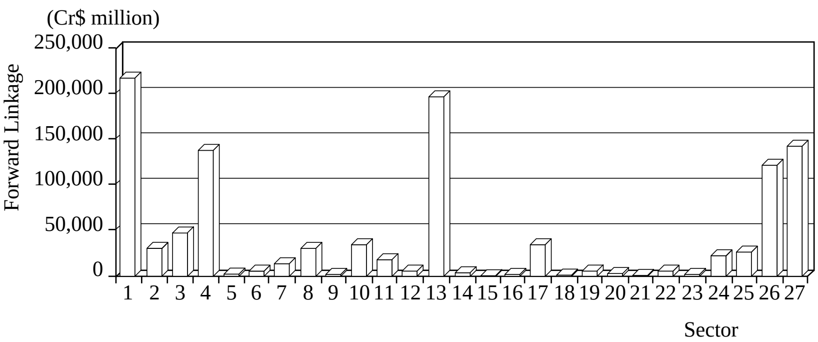
App. Fig. 3. Pure Linkage, 1959



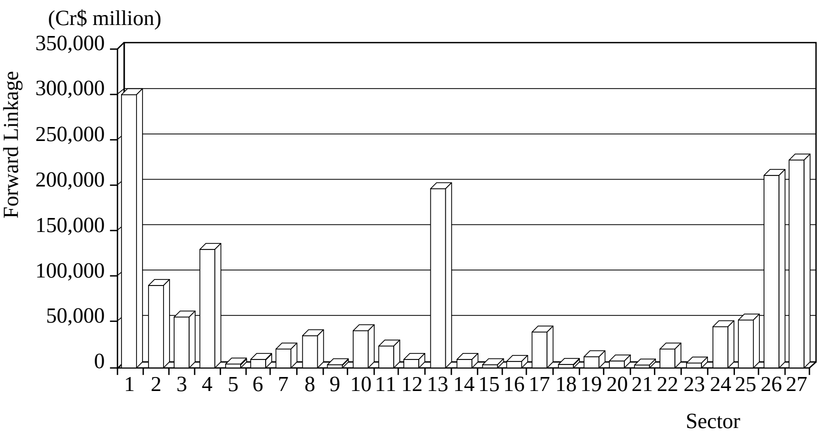
App. Fig. 4. Rasmussen / Hirschman, 1959



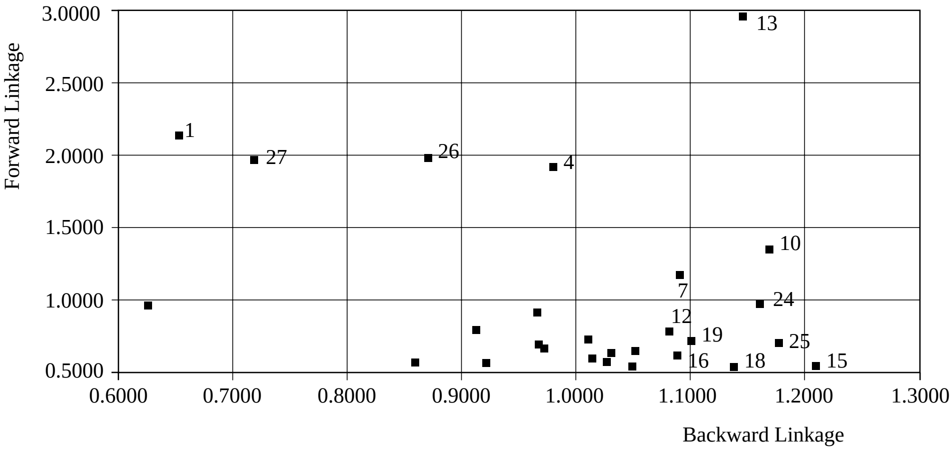
App. Fig. 5. Cella / Clements, 1959



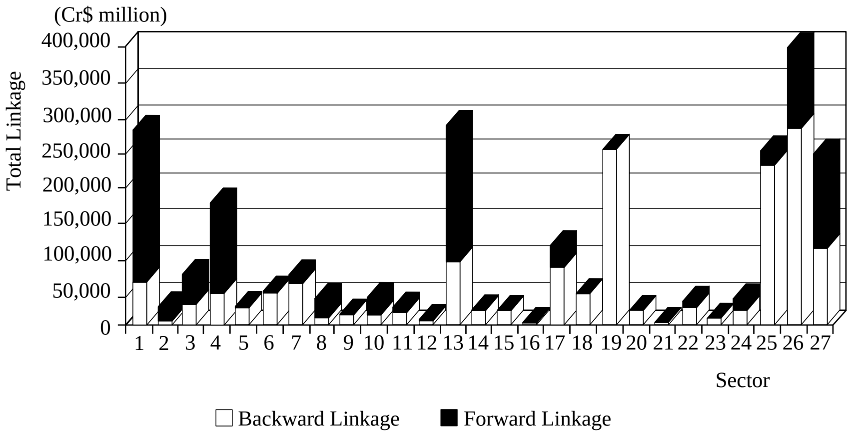
App. Fig. 6. Pure Linkage, 1959



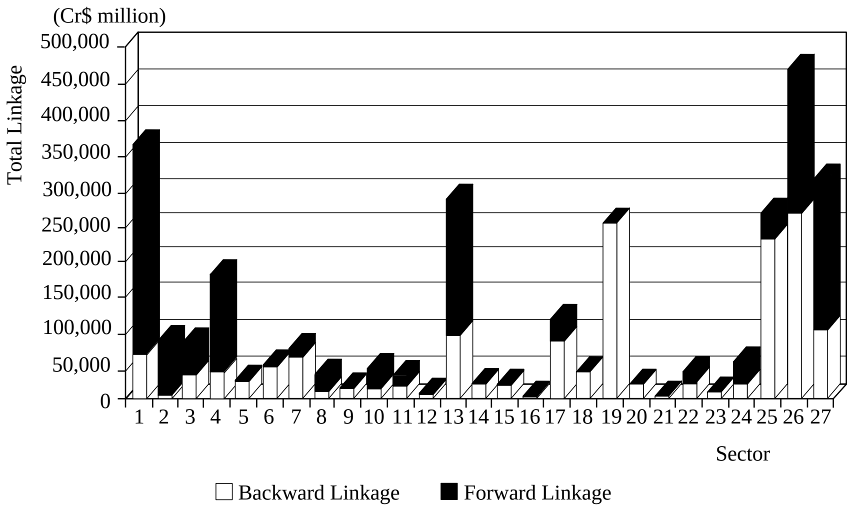
App. Fig. 7. Rasmussen / Hirschman, 1959



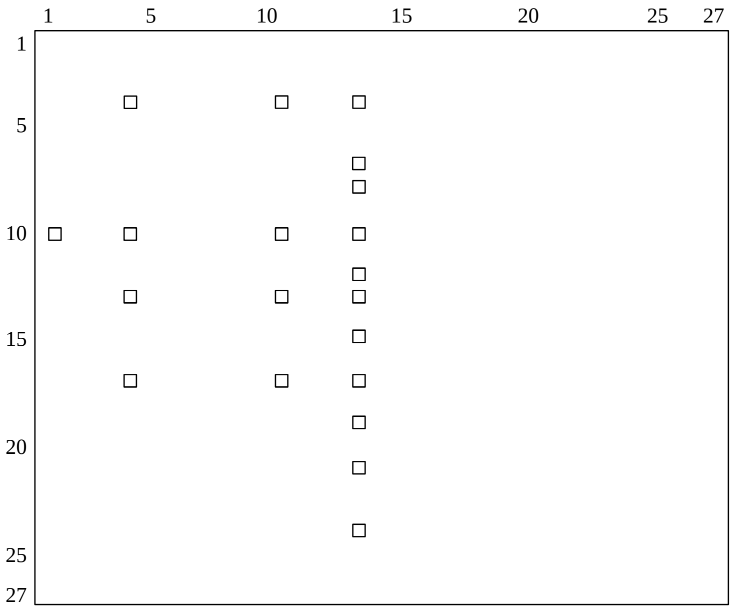
App. Fig. 8. Cella / Clements, 1959



App. Fig. 9. Pure Linkage, 1959

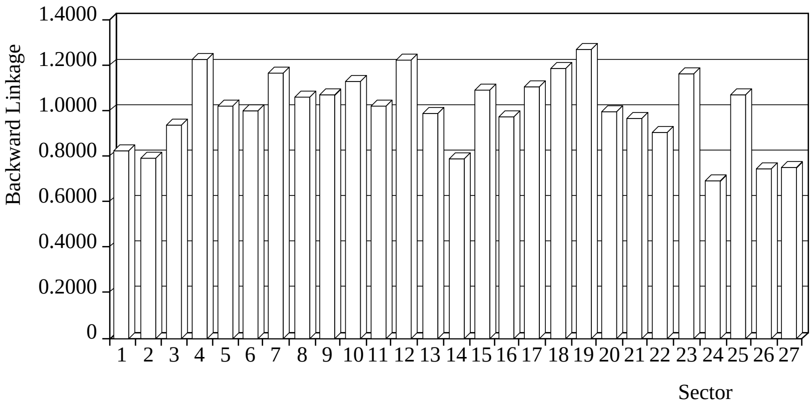


App. Fig. 10. Coefficients with the Largest Field of Influence, 1959

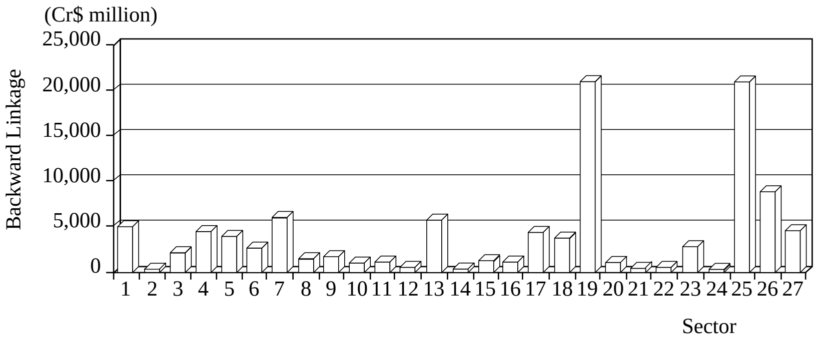


Source : [13]

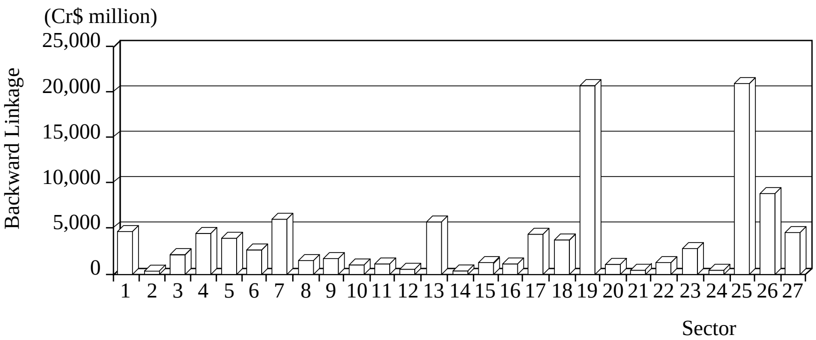
App. Fig. 11. Rasmussen / Hirschman, 1970



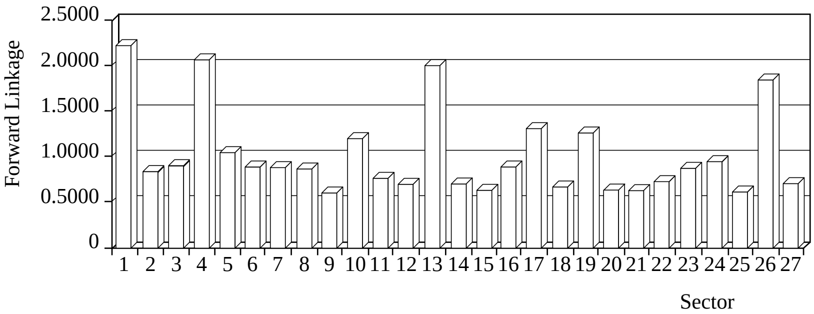
App. Fig. 12. Cella / Clements, 1970



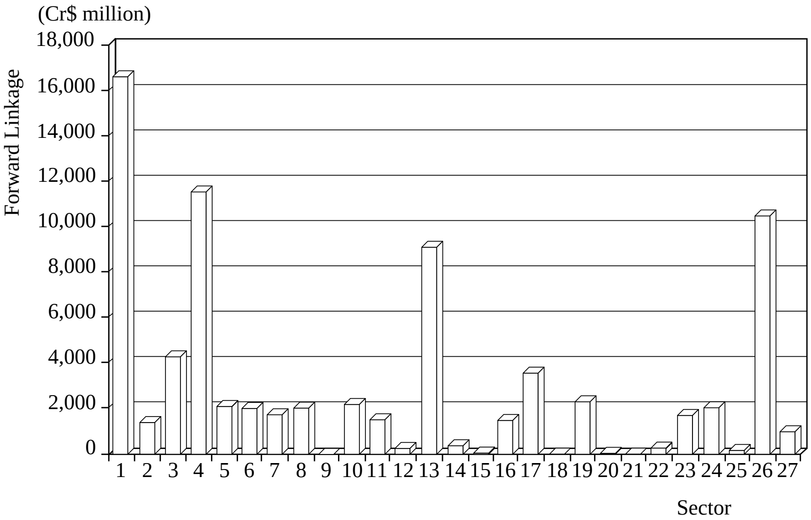
App. Fig. 13. Pure Linkage, 1970



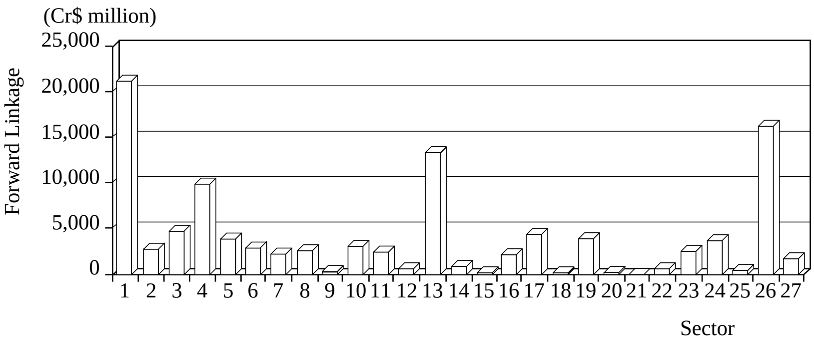
App. Fig. 14. Rasmussen / Hirschman, 1970



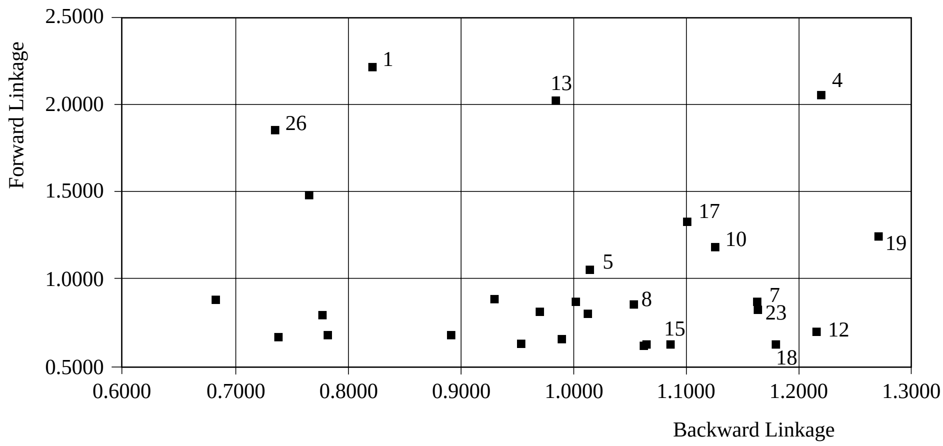
App. Fig. 15. Cella / Clements, 1970



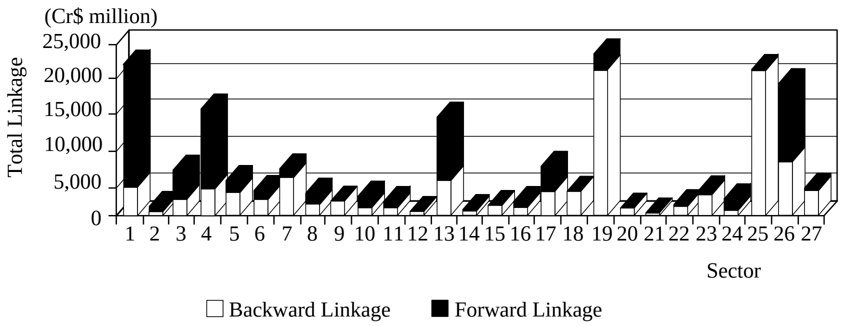
App. Fig. 16. Pure Linkage, 1970



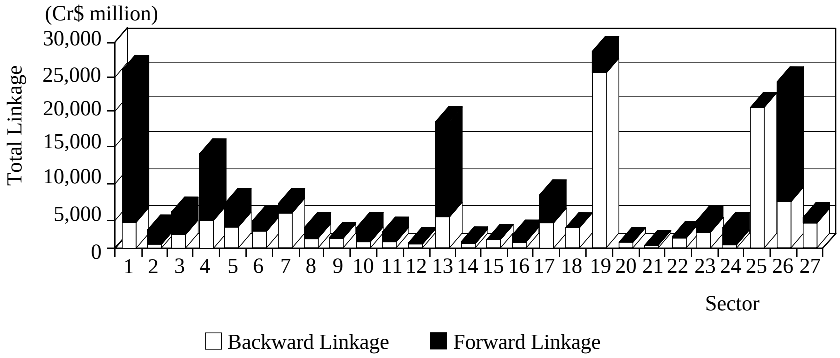
App. Fig. 17. Rasmussen / Hirschman, 1970



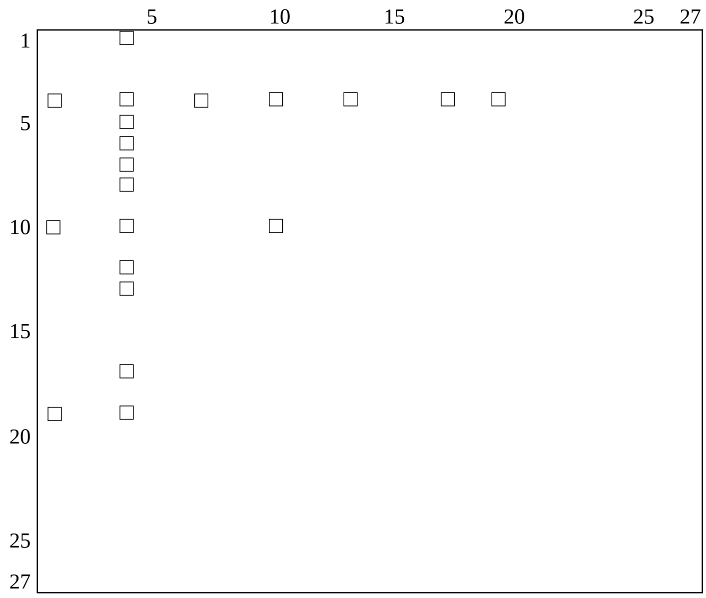
App. Fig. 18. Cella / Clements, 1970



App. Fig. 19. Pure Linkage, 1970

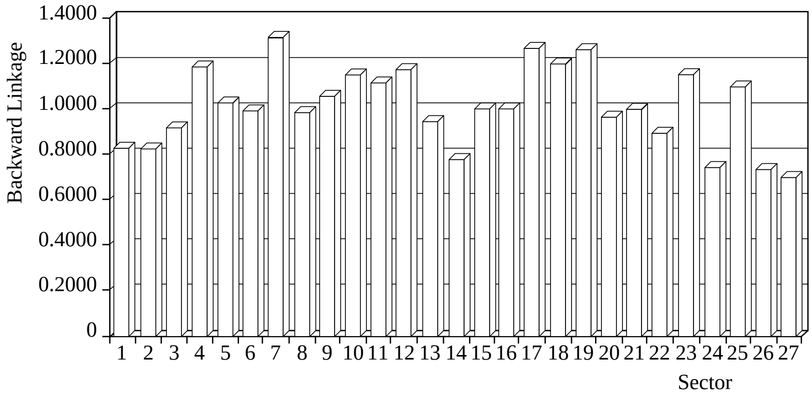


App. Fig. 20. Coefficients with the Largest Field of Influence, 1970

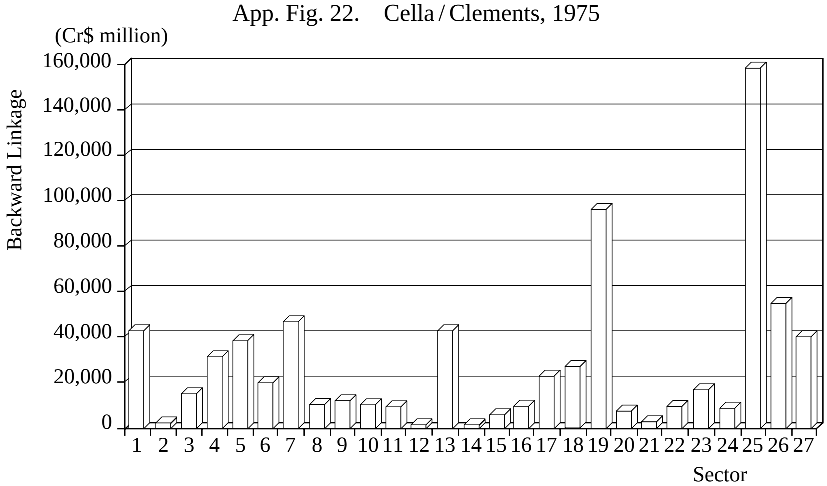


Source : [13].

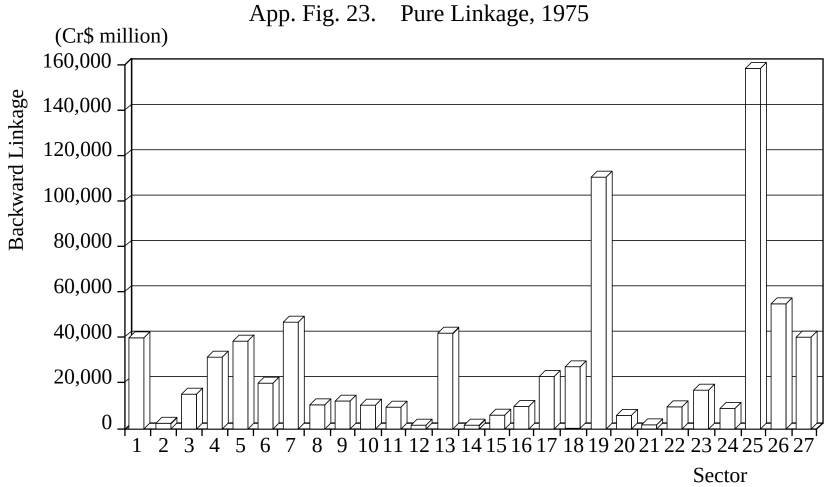
App. Fig. 21. Rasmussen / Hirschman, 1975



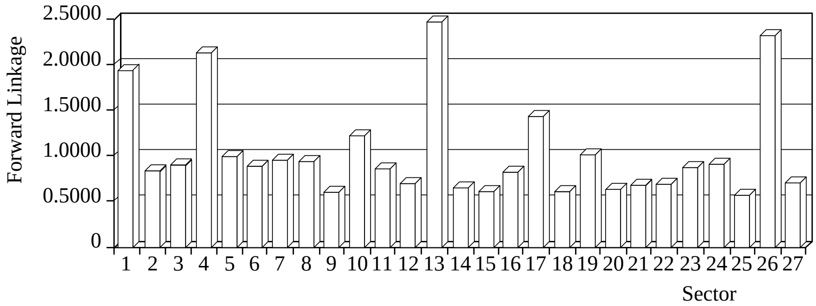
App. Fig. 22. Cella / Clements, 1975



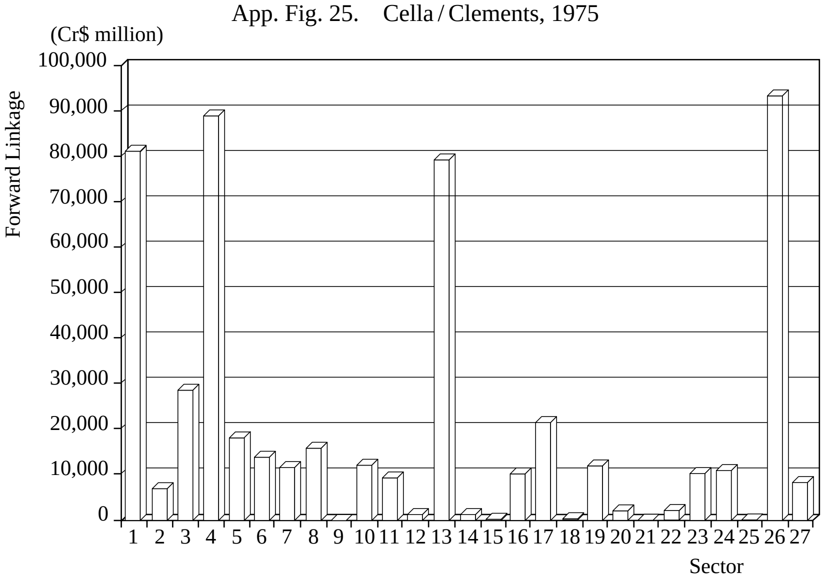
App. Fig. 23. Pure Linkage, 1975



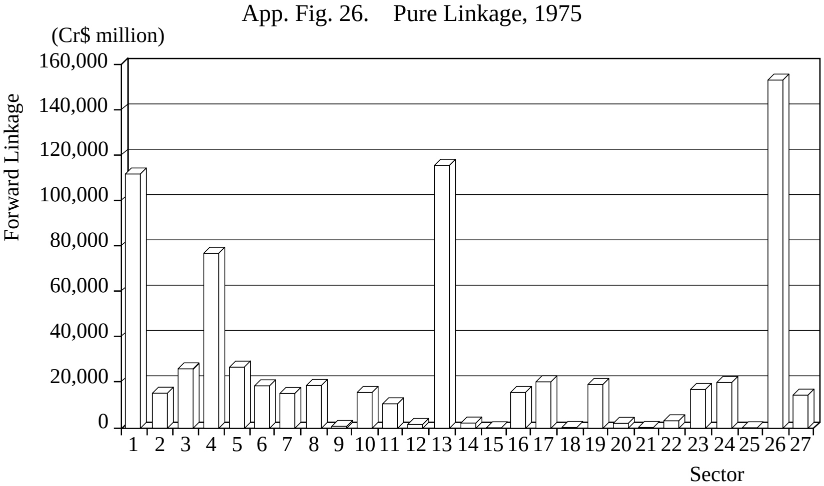
App. Fig. 24. Rasmussen / Hirschman, 1975



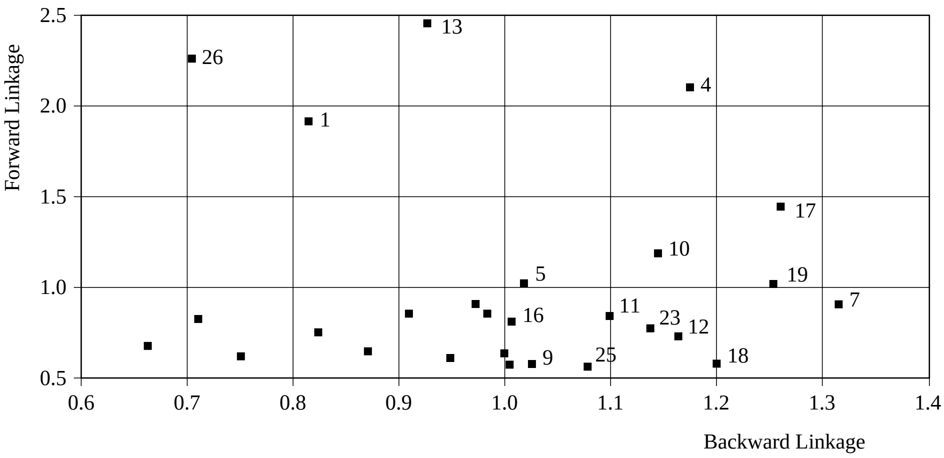
App. Fig. 25. Cella / Clements, 1975



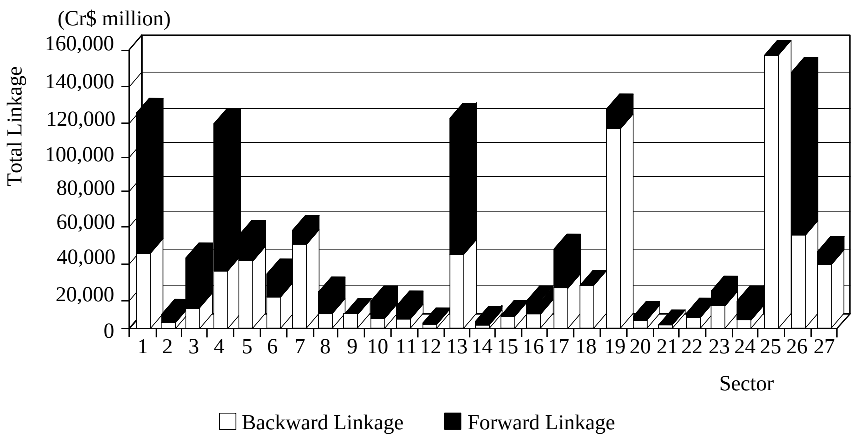
App. Fig. 26. Pure Linkage, 1975



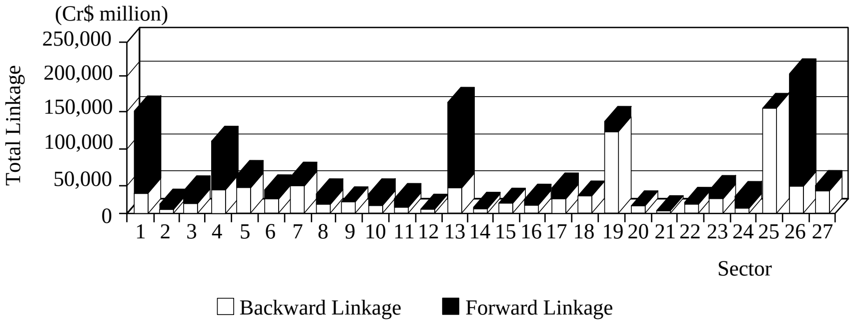
App. Fig. 27. Rasmussen / Hirschman, 1975



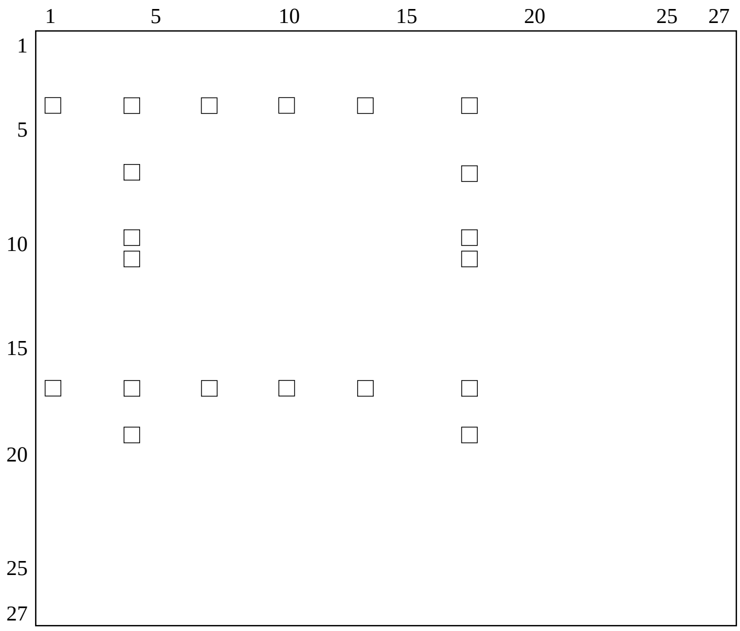
App. Fig. 28. Cella / Clements, 1975



App. Fig. 29. Pure Linkage, 1975

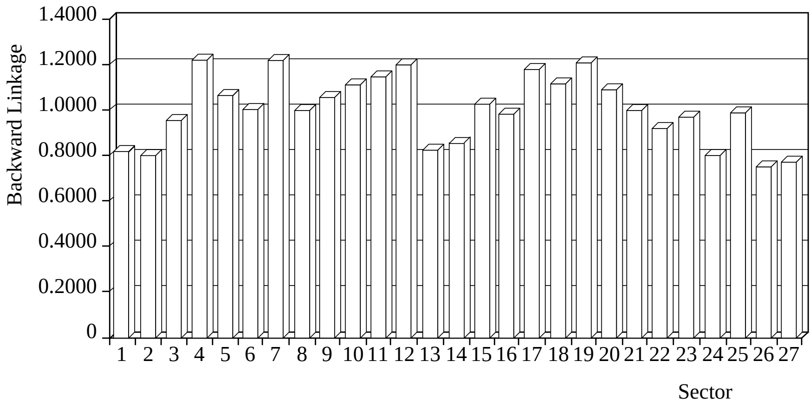


App. Fig. 30. Coefficients with the Largest Field of Influence, 1975

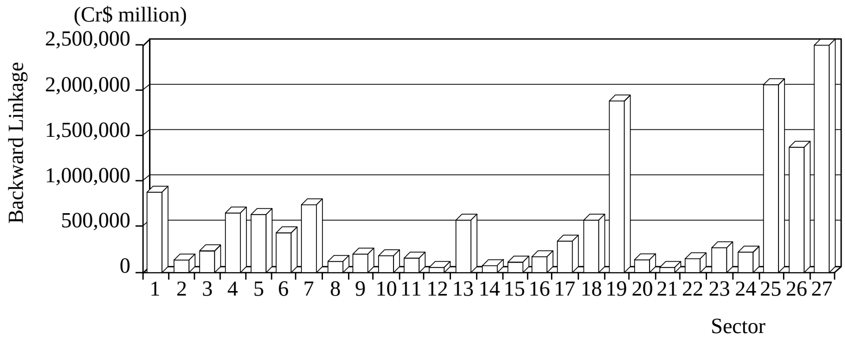


Source : [13].

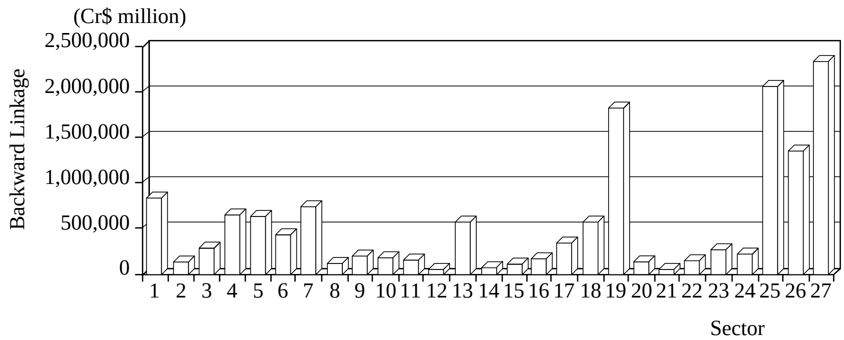
App. Fig. 31. Rasmussen / Hirschman, 1980



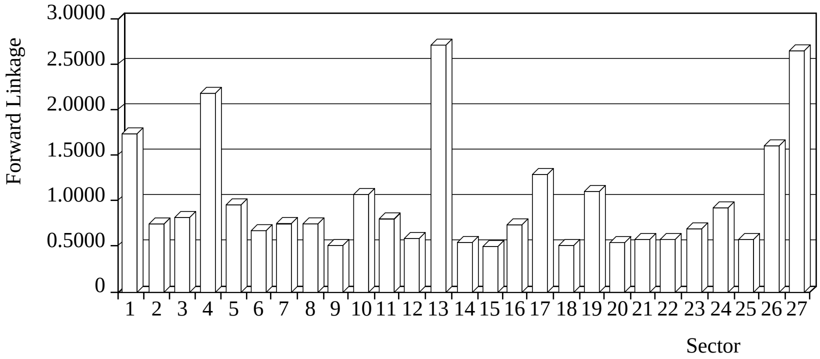
App. Fig. 32. Cella / Clements, 1980



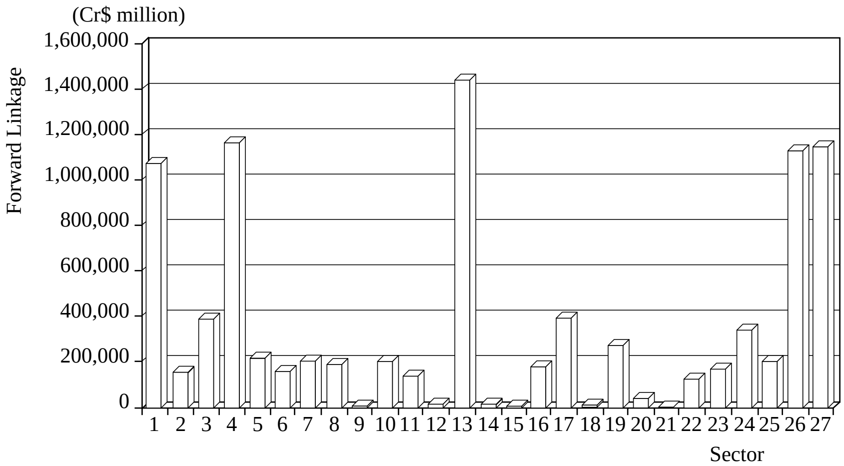
App. Fig. 33. Pure Linkage, 1980



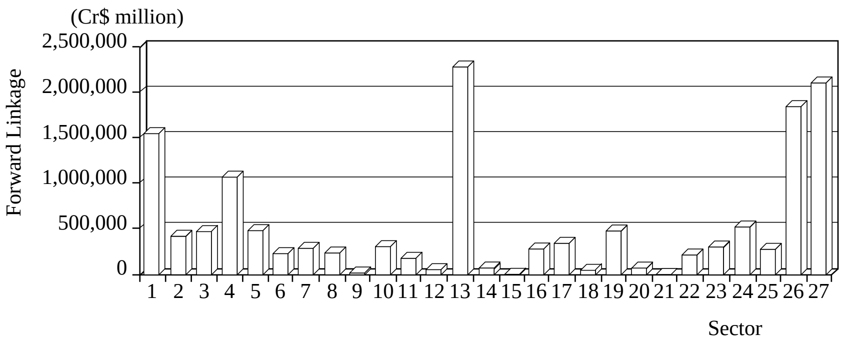
App. Fig. 34. Rasmussen / Hirschman, 1980



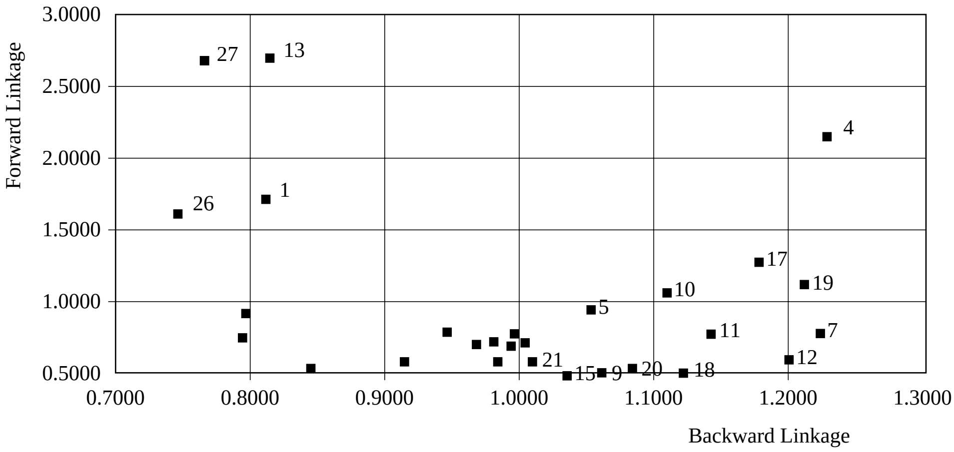
App. Fig. 35. Cella / Clements, 1980



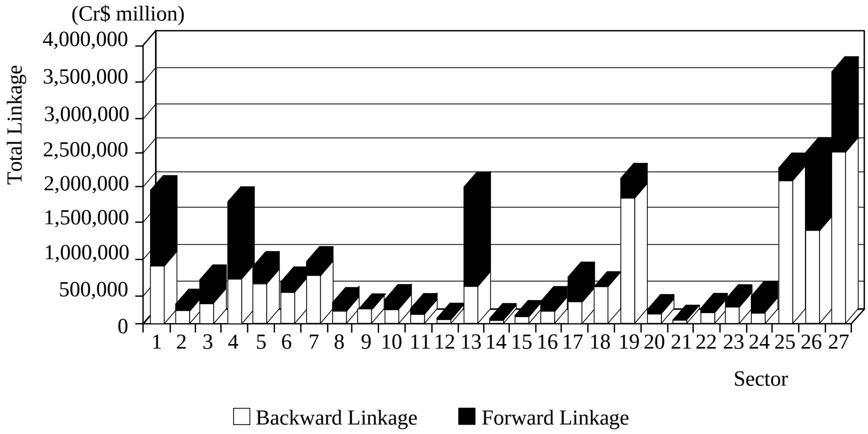
App. Fig. 36. Pure Linkage, 1980



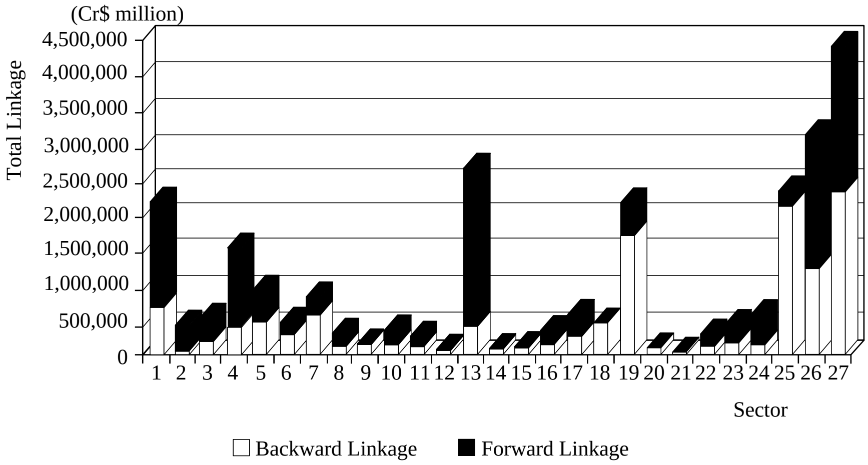
App. Fig. 37. Rasmussen / Hirschman, 1980



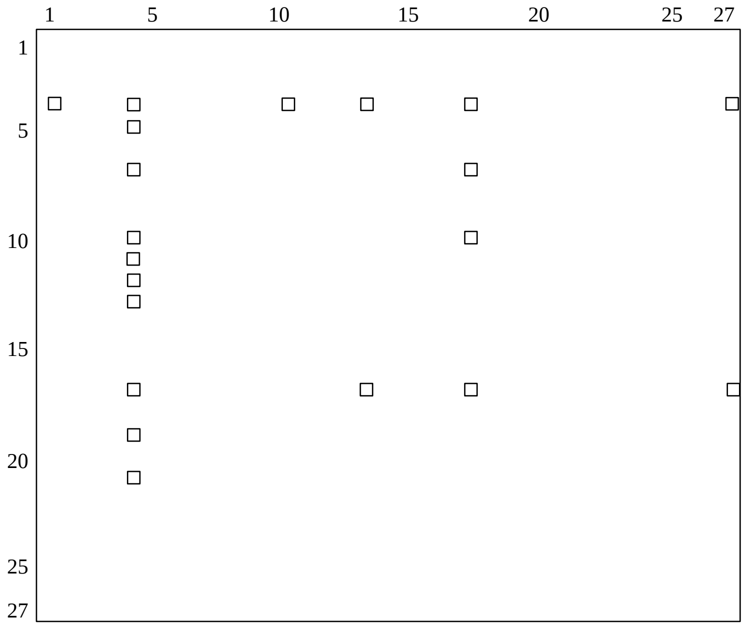
App. Fig. 38. Cella / Clements, 1980



App. Fig. 39. Pure Linkage, 1980



App. Fig. 40. Coefficients with the Largest Field of Influence, 1980



Source : [11]