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Hewings, Geoffrey J.D. and Fonseca, Miguel A. and Guilhoto, Joaquim José Martins and Sonis, Michael

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Key Sectors and Structural Change in the Brazilian Economy: A Comparison of Alternative Approaches and Their Policy Implications

Geoffrey J.D. Hewings, *University of Illinois at Urbana-Champaign, USA*

Manuel Fonseca and Joaquim Guilhoto, *University of Sao Paulo, Brazil*

Michael Sonis, *Bar Ilan University, Israel and University of Illinois at Urbana-Champaign, USA*

Attempts to identify key sectors in an economy with input–output models have been a source of considerable debate. In this paper, several old and new approaches to the problem are evaluated with reference to the Brazilian economy using the input–output models for 1959, 1970 and 1975. Two alternative approaches are suggested in this paper. The first of these focuses on key coefficients through the identification of fields of influence associated with changes in these coefficients, including the effects of simultaneous changes in more than one coefficient. The second approach decomposes the interindustry transactions into a set (hierarchy) of flows. It is claimed that the flows associated with the higher levels of the hierarchy can be considered as the key flows or most important transactions. These new approaches are compared to earlier techniques to examine the degree to which important changes in the economy could be detected.

1. INTRODUCTION

In this paper, some of the more traditional approaches to key sector identification are compared with two newer methods. The comparison is made with reference to the Brazilian economy using the input–output tables for the periods 1959, 1970 and 1975. Essentially, the questions

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Address correspondence to Geoffrey J.D. Hewings, Department of Geography, University of Illinois, Urbana, IL 61801-3671.

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to be asked concern the role of key sectors and the degree to which the input–output tables can be manipulated to help uncover important components associated with structural change.

In the next section of the paper, a brief review of developments in the Brazilian economy is provided to establish the necessary context for evaluation of methods. Thereafter, the set of methods is presented. In the fourth section, the applications to the Brazilian economy are compared. Finally, some summary statements are made about the analysis and future needs.

2. The Brazilian Economy: A Brief Overview

In the 1950s, the Brazilian economy experienced an intense import substitution industrialization (ISI) program accompanied by relatively high rates of growth. This period of expansion ended in the first half of the 1960s and was followed by several years of economic stagnation. The crisis of the latter period coincided with the end of the earlier ISI experience, an experience characterized by import substitution of durable and nondurable consumer goods for the most part. Extremely high rapid economic growth returned in the late 1960s and early 1970s (in the period 1968–74), the average annual rate of real growth was above 10%). During this period, also associated with ISI, the focus of attention was on the sectors producing capital goods (Baer, Guilhoto and Fonseca 1986).

During the two ISI cycles of the 1950–75 period, major structural changes took place in the Brazilian economy. Traditionally, attention has been focused on the structural changes in the production sector of the economy i.e., changes in production processes, types of commodities produced, changing capital-output ratios, etc. However, of equal importance were the changes which took place in the structure of consumption and the distribution of income. On the production side, there was a shift from agricultural products and textiles to consumer durable goods and capital goods and to a general increase in the intermediation of production (i.e., increasing complexity in the structure of production and exchange among sectors in the economy). Also, there was an increase in the concentration of income after the first half of the 1960s. Associated with the income changes were differences in the patterns of consumption, again with more emphasis on consumer durables.

The increase in the production of intermediate goods resulted, in large part, from the vast investments in infrastructure projects initiated by the Brazilian government. These investments were focused in the metal products and chemical sectors. On the other hand, multinational corporations had a dominant role in the expansion of output levels in the machinery, electrical and transp . equipment sectors (Fonseca 1986). On the consumption side, the major increases were in the nondurable sectors, mainly textiles, and in sectors such as machinery (refrigerators, washing machine and business machines), transport equipment (automobiles and parts), and chemicals (gasoline and oil). Our attention will be directed towards uncovering the associated structural changes in the economy which took place over this period.

3. ANALYTICAL TECHNIQUES

A. The Focus on Input–Output Tables

In the previous section, it was noted that changes in the structure of the Brazilian economy were not concentrated in the production sectors alone. Associated changes in the patterns of consumption and the distribution of income were of equal importance. The interconnections between changes in production, consumption and income distribution provide a major challenge in terms of the identification of an appropriate framework of analysis. In recent years, there has been a great deal of renewed interest in extending the input–output framework to accommodate some of these concerns. For example, the links between income distribution and production have been explored in models of the kind developed by Miyazawa (1976); these models are still linear in the variables and assume a fixed-price environment. The social accounting structure (SAM) provides for a more complex set of interrelationships, involving production, institution and factor accounts. The model for Sri Lanka developed by Pyatt and Roe (1977) has established a useful standard for these types of models. In particular, the SAM provides a convenient framework for establishing the impacts of production changes on income distribution and back to production through changes in consumption patterns. Thus, the symbiotic nature of changes in an economy can be captured within the SAM environment. The spirit of the Walrasian general equilibrium framework has been captured in the set of models now referred to generically as computable general equilibrium models (CGE). The movement towards a flexible-price model provides for new insights into the functioning of economies.

However, none of these models—input–output alone, SAM and CGE—is without problems. The problems are of two major types: data problems and analytical issues. The former are often severe enough to preclude the implementation of more sophisticated techniques, especially if some form of analysis of changes over time is required. The analytical issues have been discussed extensively in the literature (McGilvray 1977; Taylor and Lysy 1979; Bell and Srinivasan 1986) and will not be repeated here. The major focus of this paper is on changes over time. Since a consistent set of models had to be employed, attention is limited to a set of input–output tables for the three years 1959, 1970 and 1975. A Miyazawa-type model has been developed for 1975 (Fonseca 1986) and this will be used to illustrate some of the problems with the interconnections between production and consumption.[1]

B. The Traditional Approaches

The presence of input–output tables provided analysts with an opportunity to examine the structure and functioning of an economy. In particular, a major concern arose about the degree to which some sectors created a "greater than average" impact upon an economy. The initial conceptual developments may be traced to the work of Rasmussen (1952) and Hirschman (1958). Rasmussen suggested the use of two indices, the power of dispersion and the sensitivity of dispersion. These indices have now become part of the generally accepted procedures for identifying key sectors. 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 $B_{.j}$ and $B_{i.}$ are the associated typical row and column sums, then the indices may be developed as follows:

Power of Dispersion $\quad U_j = [B_{.j}/n]/B^* \quad$ (1)

Sensitivity of Dispersion $\quad U_i = [B_{i.}/n]/B^* \quad$ (2)

where n is the number of sectors in the economy. A key sector is defined as one with either U_j or $U_i > 1$, i.e., a key sector is one in which the average value in the column or row of the inverse matrix is greater than the average value in the matrix as a whole. From a policy perspective, the sector is key by these definitions because a unit change in final demand in a sector in which $U_j > 1$ will generate an above increase in activity in the economy. The other criterion, $U_i > 1$, implies that a change in the final demand in all sectors will generate an above average increase in the output of sector i.

There has been an extensive literature on this topic; some authors

[1] While the framework for a CGE model was prepared (Guilhoto 1986) in the spirit of the ORANI model of Australia (Dixon) et al. 1980), the model has yet to be implemented empirically.

have attempted to modify the indices, while others have been very critical of the whole approach (see Hewings 1982 for a review). Ultimately, the issues dissolve to consideration of the way any such index can provide important insights into what has happened in an economy and the degree to which they may be of use in the development of a planning strategy, especially one centering around the allocation of governmental resources with high opportunity costs.

C. Two New Approaches: The Field of Influence

In this section, we provide an alternative to the large number of ways of approaching these problems. Unlike the Rasmussen indices, the focus of attention is on what may be referred to as inverse important coefficients and on the set of flows (e.g., interindustry flows in the input–output table) that may be regarded as contributing most to the functioning of the economy. The approaches are complementary, and, as will be suggested below, they could be combined to yield still a different vision of the economy.

In the last two years, a significant step has been made in the analysis of the structure of transmissions of influence in the context of error and sensitivity analysis of input–output and social accounting systems (Defourny and Thorbecke 1974; Sonis and Hewings 1988a; Hewings, Sonis and Jensen 1988). The transmission of influence has been specified in the form of the influence of changes in all the direct coefficients on the components of the Leontief Inverse. The compact formula which has been proposed provides the structure of change in the global influence, b_{ij}, inflicted by the changes in all direct influences, a_{ij}. The new approach (Sonis and Hewings 1988a; 1988b) has the capability of addressing the problem of transfer of influence of changes in a more general way than was the case with some of the earlier attempts (Bullard and Sebald 1977; Byron 1978; Jensen and West 1980; Hewings and Romanos 1981; and Hewings 1984a, 1984b). The field of influence is the matrix of changes in the inverse associated with a change in one or more elements of the direct coefficient matrix. The method is general enough to handle changes in one coefficient, in all entries in a row or column, or in all coefficients simultaneously. Given the structure of the existing system, changes in some elements are likely to have far more impact on the rest of the system. This field of influence will probably change as the economy becomes more interconnected over time. Hence, the method can assist in identifying changes in the structure and complexity of an economy over time.

The approach can be presented in the following form. Let A =

$| a_{ij} |$ be a matrix of direct input coefficients, $E = | \epsilon_{ij} |$ a matrix of incremental changes in the direct input coefficients. The associated Leontief inverse matrices will be: $B = [I - A]^{-1} = | b_{ij} |$ and $B(\epsilon) = [I - A - \epsilon]^{-1} = | b_{ij}(\epsilon) |$. The following formula for the global influence of change may be presented as:

$$b_{ji}(\epsilon) = \frac{b_{ji} + \frac{1}{\Delta}\sum_{k=1}^{n-1}(-1)^k \sum_{\substack{i_r \neq i_s, i \\ j_r \neq j_s, j}} \mathrm{Sign}\begin{pmatrix} j_1 & \ldots & j_k j \\ i_1 & \ldots & i_k i \end{pmatrix} M \begin{pmatrix} j_1 & \ldots & j_k j \\ i_1 & \ldots & i_k i \end{pmatrix} \epsilon_{i_1 j_1} \ldots \epsilon_{i_k j_k}}{1 - \sum_{i_1 j_1} b_{j_1 i_1}\epsilon_{i_1 j_1} + \frac{1}{\Delta}\sum_{k=2}^{n-1}(-1)^k \sum_{\substack{i_r \neq i_s \\ j_r \neq j_s}} \mathrm{Sign}\begin{pmatrix} j_1 & \ldots & j_k \\ i_1 & \ldots & i_k \end{pmatrix} M \begin{pmatrix} j_1 & \ldots & j_k \\ i_1 & \ldots & i_k \end{pmatrix} \epsilon_{i_1 j_1} \ldots \epsilon_{i_k j_k}} \quad (3)$$

where $\Delta = \det(I - A)$.

$M\begin{pmatrix} j_1 & \ldots & j_k \\ i_1 & \ldots & i_k \end{pmatrix}$ is a minor derived from $\det(I-A)$ by removal of rows $i_1, \ldots, i_k$ and of columns $j_1, \ldots, j_k$:

$$\mathrm{Sign}\begin{pmatrix} j_1 & \ldots & j_k \\ i_1 & \ldots & i_k \end{pmatrix} = (-1)^{i_1 + \ldots + i_k + j_1 + \ldots + j_k + \delta(i_1, \ldots, i_k) + \delta(j_1, \ldots, j_k)}$$

and $\delta(i_1, \ldots, i_k)$ is the (odd or even) index of the permutation $i_1, \ldots, i_k$.

Should the change take place in only one direct coefficient:

$$\epsilon_{ij} = \begin{cases} \epsilon & i = i_1, j = j_1 \\ 0 & i \neq i_1, \text{ or } j \neq j_1 \end{cases}$$

then the associated field of influence in the matrix may be approximated by the expression:

$$F(\epsilon) = [B(\epsilon) - B]/\epsilon \quad (4)$$

Furthermore, an approximate formula may be derived for consideration of the change in two direct coefficients:

$$\epsilon_{ij} = \begin{cases} \epsilon_1 = \epsilon_{i_1 j_1} & i = i_1, j = j_1 \\ \epsilon_2 = \epsilon_{i_2 j_2} & i = i_2, j = j_2 \\ 0 & \text{otherwise} \end{cases}$$

This equation may be seen to be derived as a composition of the changes in the sum of the individual influences of each error $F(\epsilon_1)$ and $F(\epsilon_2)$, the field of crossinteractions between errors:

$$b_{j_1 i_1} F(\epsilon_2) + b_{j_2 i_2} F(\epsilon_1)$$

and the field of synergetic interactions which may be obtained from:

$$F(\epsilon_1)\,[(1+b_{j_1i_1})/\epsilon_2+b_{j_2i_2}]+F(\epsilon_2)\,[(1+b_{j_2i_2})/\epsilon_1+b_{j_1i_1}]-[B(\epsilon_1\epsilon_2-B]/\epsilon_1\epsilon_2$$

An example of the application of this technique is provided in Section 4.

D. A Superposition Principle for the Derivation of the Structure of Socio-Economic Systems

The field of influence approach is associated with change in the Leontief inverse. We now provide a different approach which focuses attention on the matrices of intermediate flows rather than the inverse matrix, although the relationship between the two matrices in the form of the input–output model provides the necessary linkage. The new approach examines the flows in terms of their hierarchical structure drawing upon the superposition principle (Sonis 1980; 1982; 1985; 1986).

The superposition principle considers the socioeconomic accounting system as one comprised of a decentralized set of sub-systems (industrial sectors, components of final demand, etc.) which are acting according to different, often conflicting and non-commensurable, extreme tendencies or trends. In a sense, these tendencies may be regarded analogously as objectives in a multi-objective framework. The intersectoral flows matrix in the input–output model may therefore be regarded as the resultant or the "weighted" sum of these tendencies. As Sonis (1982) has demonstrated, the decomposition of flows viewed in this fashion may be regarded as an inverted problem of multi-objective programming in which the overall challenge is to find the weights associated with various sets of flows in the system. These sets of flows are extracted hierarchically (the most important first), and thus provide a way of decomposing the interactions which differs from the Pyatt and Round (1979) and Defourny and Thorbecke (1984) approaches.

In developing the hierarchical decomposition, consider first a very simple economy with limited interaction between sectors, such that each sector makes only one sale to and one purchase from another sector. The structure of this economy would not be very difficult to discern. However, as the economy becomes more complex and each sector interacts with more than one other sector, purchases from sector i by sector j will only provide a partial contribution to sector j's total needs. Hence, the total intersectoral flows may be decomposed into a set of subflows, X_1, X_2, X_3, . . . , X_k with associated weights p_1, p_2, p_3, . . . , p_k, such that

$$X = p_1X_1 + p_2X_2 + \ldots + p_kX_k, \tag{5}$$

where

$$0 \le p_i \le 1; \qquad \text{and } p_1 + p_2 + \ldots + p_k = 1$$

It is possible to prove that in the input–output case, the vertices are the accounting matrices ($X_1, X_2 \ldots$) of a specific form—in each column of such matrix there is only one non-zero coefficient. The choice of this vertex corresponds to the "everything or nothing" principle of the economic transactions. Of course, such an extreme tendency can only enter with some partial weight (given the multiple objectives in the system), although, as will be noted, the simpler the system, the larger the initial weights and the smaller the number of hierarchies.

As with the other decompositions, the one shown in equation (5) is not unique. The choice usually made is a hierarchical viewpoint that is close to the "principal" component statistical analysis technique. The vertex X will be decomposed into the extreme tendencies, X_1, $X_2, \ldots$ such that the weight p_1 will be the largest one and:

$$1 > p_1 \ge p_2 \ge \ldots \ge p_k > 0$$

This hierarchical rule provides the possibility for using the sequential sums:

$$p_1, p_1 + p_2, p_1 + p_2 + p_3, \ldots, p_1 + p_2 + \ldots + p_s$$

as measures of the appropriateness of partial decompositions:

$$\begin{aligned} X &= p_1X_1 + p_2X_2 + \ldots + p_sX_s + p_{s+1}Y_s \\ &= X_s + p_{s+1}Y_s \end{aligned} \tag{6}$$

where $p_{s+1} = 1 - p_1 - p_2 - \ldots - p_s$, and Y_s is a negligible residual Thus, one can now interpret the approximate decomposition:

$$X \approx p_1X_1 + p_2X_2 + \ldots + p_sX_s \tag{7}$$

as a reflection of the hierarchical structure of the system under consideration. Clearly, X could reflect the intersectoral flows in an input–output table or the broader set of social accounts within a social accounting system. In either case, the system may be specified at the single economy (region or nation) or multi-economy level.

E. Discussion

Although all the methods presented here are with reference to an input–output table alone, there should be no a priori reason why they could not be applied to a broader set of social accounts. In addition, it should be noted that all the techniques are applied ex post, whereas the notion of key sectors or components suggests consideration of future investment planning strategy (McGilvray 1977). The hierarchical decomposition and the field of influence may prove of greater value in this regard as the focus of attention is on a small set of coefficients or flows. In Sonis and Hewings (1988c), a suggestion is made about the way these two approaches might be combined to yield a more powerful tool of interpretation of the structure of an economy. Essentially, the approach would first place the flows associated with the coefficients having the largest fields of influence in the first level of the hierarchy, and then proceed to identify fields from the remaining residual (Y_s of equation (6)). The algorithm would continue in this fashion; and the final reduced form would therefore contain the flows which were associated with the coefficients that were analytically the most important.

4. APPLICATIONS TO THE BRAZILIAN ECONOMY

Tables 1 and 2 provide the Rasmussen (1958) indices of forward and backward linkages for the Brazilian economy in 1959, 1970 and 1975. The earliest data reveal that three sectors (paper, textiles and chemicals) had high backward and forward linkages. In fact, these sectors accounted for about 14 percent of the economy's total output. In the latter two time periods, five sectors (metal products, machinery, paper, textiles, and food products) dominated production, accounting for 24 percent and then 23 percent of it. As Baer, Guilhoto and Fonseca (1986) note, the metal products, machinery and food sectors were relatively unimportant in the early ISI era but assumed far greater importance in the later ISI periods. A further suggestion may be inferred from these data—that the Brazilian economy was becoming more complex in terms of the degree of intermediation in production. As a result of the influences of the key sectors themselves, they created additional demands on other sectors of the economy, thereby generating the need for additional, local capacity and further enhancing growth prospects.

However, these data provide little assistance in identifying the nature of the linkages among the sectors. The field of influence approach provides an alternative perspective focusing on individual coefficients. Figures 1, 2 and 3 show the elements with the largest field of influence in the Brazilian economy. The dominance of the chemical industry is revealed in Figure 1. While the key sector identification process suggested the sector to be a "key" one, as Hazari (1970) noted, the index provided little information on the distribution of that influence. In 1959,

Table 1. Backward Linkage Indices for Brazil

	1959	1970	1975
1. Agriculture	.6557	.8200	.8159
2. Mining	.6291	.7790	.8261
3. Nonmetallic minerais	.9129	.9302	.9105
4. Metal products	.9818	1.2176	1.1755
5. Machinery	.8592	1.0151	1.0188
6. Electrical equipment	1.0302	1.0013	.9854
7. Transport equipment	.9679	1.1630	1.3158
8. Wood	.9673	1.0548	.9743
9. Wood products	1.0486	1.0654	1.0292
10. Paper	1.1675	1.1272	1.1462
11. Rubber	[illegible]	1.0136	1.1002
12. Leather	1.0819	1.2154	1.1562
13. Chemicals	1.1470	.9844	.9275
14. Pharmaceuticals	1.0268	.7828	.7522
15. Cosmetics	1.2078	1.0866	1.0055
16. Plastics	1.0874	.97[illegible]	1.0087
17. Textiles	1.0913	1.1008	1.2623
18. Clothing and footwear	1.1360	1.1797	1.1999
19. Food	1.1021	1.2689	1.2558
20. Beverages	1.0135	.9916	.9507
21. Tobacco	.9731	.9544	.9993
22. Printing	1.0513	.8927	.8715
23. Other industrial products	.9207	1.1635	1.1400
24. Public utilities	1.1590	.6821	.7125
25. Construction	1.1760	1.0634	1.0815
26. Trade/transport	.8725	.7359	.7035
27. Services	.7210	.7389	.6649

Source: Baer, Guilhoto and Fonseca (1986).

over 50 percent (11) of the top 20 coefficients with the most important field of influence were located in the chemical sector. The paper sector contained four of these coefficients. The textile sector was not represented in terms of backward links, but three coefficients involved purchases from the textile industry.

The pattern in 1970 was very different. The dominant industry now appeared to be metal products. A similar proportion of the top 20 coefficients was located in this sector in 1970 as had been located in the chemical sector in 1959. The domination was not restricted to backward linkages alone, as seven coefficients involved purchases from metal products. By 1975, the pattern had changed again. While the metal products industry was still dominant (six coefficients in both the row and column), its domination was matched by the textiles industry. These two sectors had fields of influence that overshadowed all other

Table 2. Forward Linkage Indices for Brazil

	1959	1970	1975
1. Agriculture	2.1446	2.1988	1.9060
2. Mining	.9575	.8000	.7376
3. Nonmetallic minerals	.7873	.8904	.8409
4. Metal products	1.9181	2.0456	2.1030
5. Machinery	.5705	1.0508	1.0107
6. Electrical equipment	.6218	.8719	.8545
7. Transport equipment	.6757	.8635	.9161
8. Wood	.8997	.8521	.8969
9. Wood products	.5478	.6287	.5729
10. Paper	1.3305	1.1803	1.1911
11. Rubber	.7090	.8010	.8438
12. Leather	.7605	.7010	.7282
13. Chemicals	2.9454	2.0118	2.4571
14. Pharmaceuticals	.5647	.6783	.6089
15. Cosmetics	.5460	.6225	.5702
16. Plastics	.5970	.8119	.8085
17. Textiles	1.1620	1.3232	1.4488
18. Clothing and footwear	.5449	.6253	.5735
19. Food	.6993	1.2332	1.0175
20. Beverages	.5817	.6583	.6026
21. Tobacco	.6512	.6230	.6285
22. Printing	.6366	.6849	.6368
23. Other industrial products	.5587	.8338	.7743
24. Public utilities	.9592	.8816	.8092
25. Construction	.6854	.6193	.5560
26. Trade/transport	1.9303	1.8433	2.2561
27. Services	1.9648	.6655	.6505

Source: Bauer, Guilhoto and Fonseca (1986).

sectors. The data in Tables 1 and 2 provide little suggestion of this domination. Recall that the field of influence notion provides a statement about the degree to which minor changes in the value of a coefficient are likely to impact on the rest of the system. Therefore, it may be inferred that trading relationships involving textiles and metal products in 1975 had a profound effect on the rest of the economy.

Figures 4, 5 and 6 examine the synergistic effects—the major fields of influence generated by simultaneous change in two coefficients. The patterns revealed in these Figures indicate even more strongly the domination by a small number of transactions, especially in the earlier years. The synergistic effects are dominated by interactions between pairs of elements which are, singly, ranked in the top 20. However, the set of synergistic interactions often involves a smaller set; in Figure

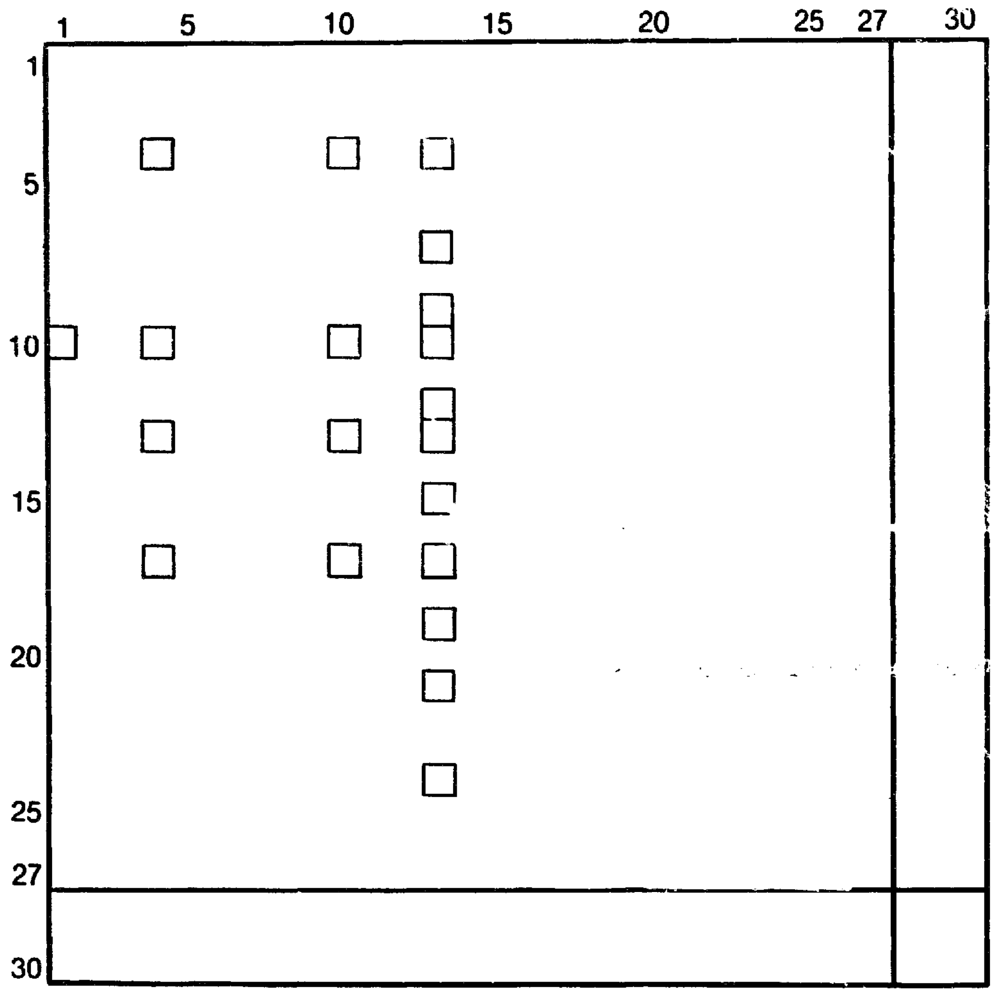

Figure 1. Coefficients with largest field of influence, 1959.

4, the 20 most important interactions involve only 12 coefficients.[2] Some coefficients appear to occupy a central position. For example, the intra-paper sector coefficient is involved with eight other coefficients, while the public utilities–chemical coefficient has only one major interactive effect. The changes between the years in the single effects are further reinforced in Figures 5 and 6. In 1970, the agriculture-metal products coefficient would appear to have played a dominant role, but there are also several other coefficients with important synergistic links with other coefficients. In particular, the links between the row and column coefficients in the metal products sector should

[2]While one could continue the synergistic analysis to evaluate interactions among three or more coefficients, the size of the marginal increments to the synergistic effects begins to decline rapidly after two-way pairs are considered.

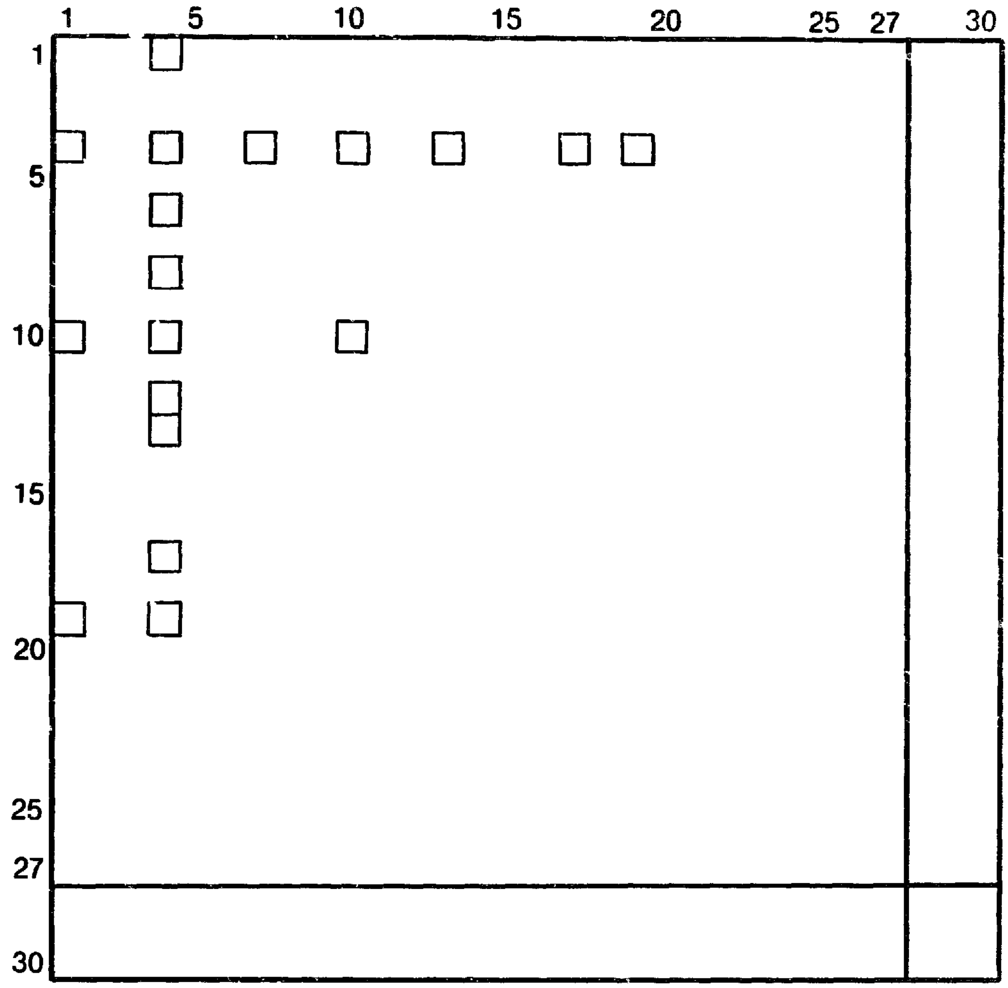

Figure 2. Coefficients with largest field of influence, 1970.

be noted. The pattern in 1975 appears more diffused and dominance appears less evident, and the link between the intra metals coefficient and elements in the textiles industry would seem to be the most important. Since these relationships are derived from the Leontief inverse matrices, care should be taken not to confuse these links with a notion of direct impacts. The synergistic effects often involve a complex chain of actions.

Finally, Figure 7 and 8 show comparable data for the Miyazawa framework developed for 1975 by Fonseca (1986). These data confirm similar findings for the State of Washington (Hewings 1985) and Sri Lanka (Hewings 1984a). Once households are introduced into the system of accounts, they tend to dominate the transactions. In Figure 7, only three of the most important coefficients are located outside the middle income consumption vector, and these are located in the trade

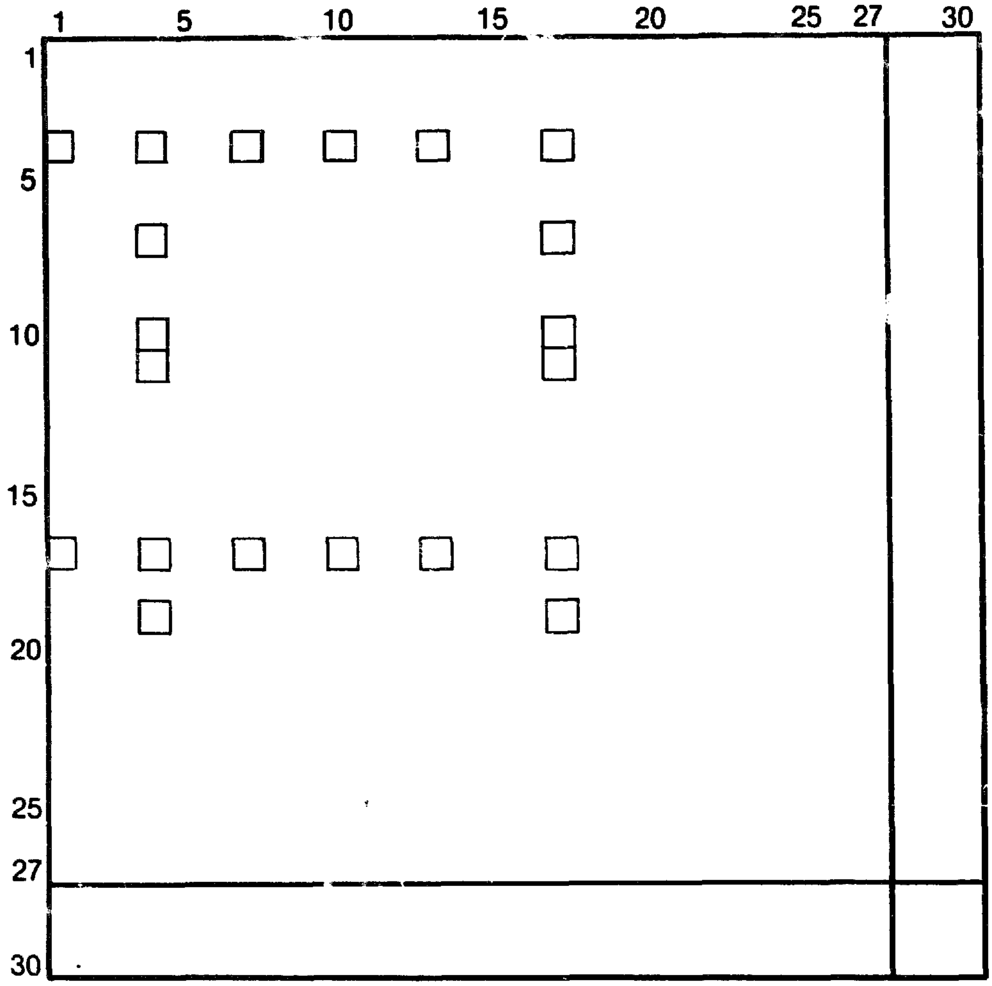

Figure 3. Coefficients with largest field of influence, 1975.

sector. The synergistic patterns (Figure 8) reveal a similar dominance. The conclusion to draw from these Figures is *not* that all development funds should be poured into consumption! The analysis reveals only that the consumption induced linkages often provide a greater *potential* for change than those in the interindustry transactions. This would be especially true during periods of rapid development and associated structural change, since rapid rises in income are likely to be associated with pronounced changes in the consumption patterns.

In applying the hierarchical decomposition, it was anticipated that the increasing complexity of flows in the Brazilian economy would be reflected in (1) a decrease in the value of the first weight and (2) a smaller percentage of the total interindustry transactions accounted for by the first k levels in the hierarchy. These expectations are summarized in Figure 9. Table 3 provides information on the value of the weights

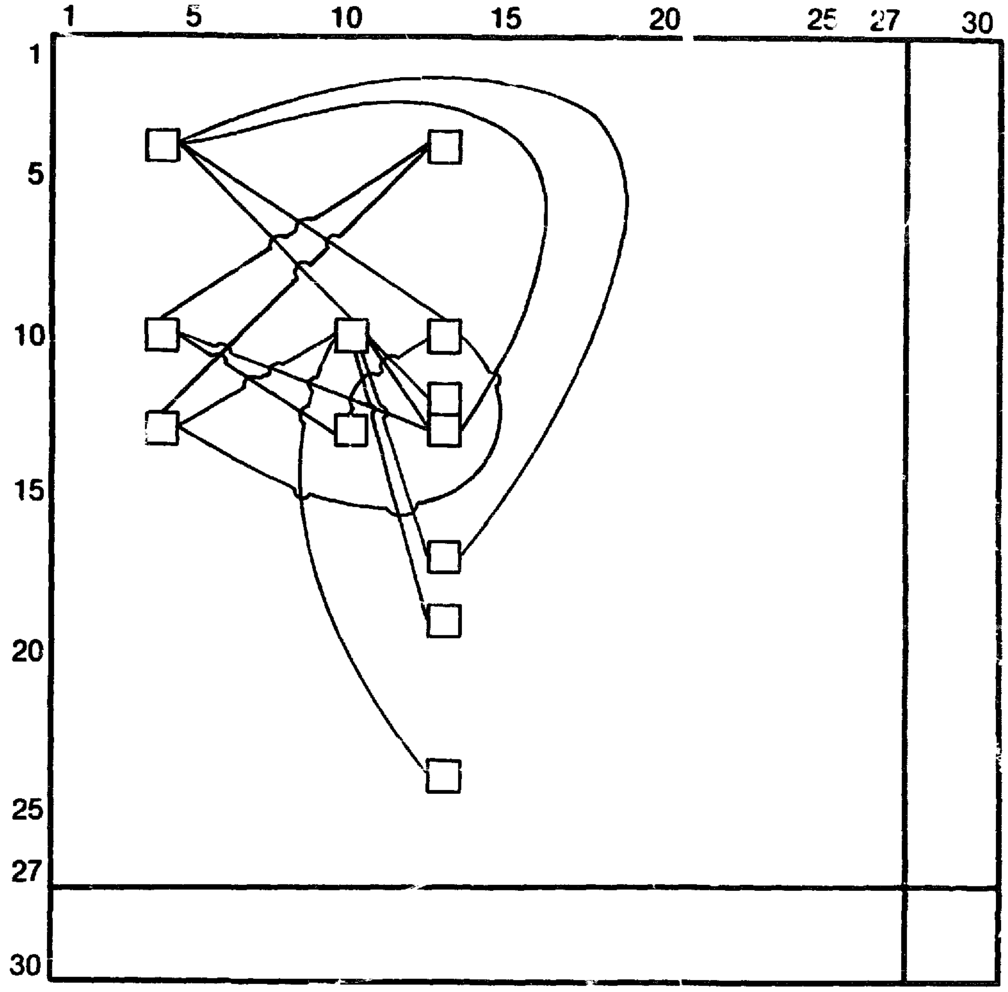

Figure 4. Most important synergistic fields of influence, 1959.

for the first 10 levels for the hierarchical decomposition of the Brazilian economy for each time period. The results would appear to confirm the a priori expectations and the earlier analysis conducted on the fields influence. Over the three time periods, the Brazilian economy has indeed become more complex, since more "levels" in the hierarchy are required in 1975 to account for the same proportion of flows in 1959. Furthermore, the value of the weight of the first tendency tended to decline over time, reinforcing the notion that the complexity of interactions among the sectors had increased thereby precluding a simple representation by only n flows.

Table 4 shows the sectors which appeared most frequently in the top five. The entries in parentheses are the number of times an entry in the column of that sector appeared as part of the matrices $X_1, \ldots X_{10}$, i.e., the first 10 tendencies. While the rankings reveal some sta-

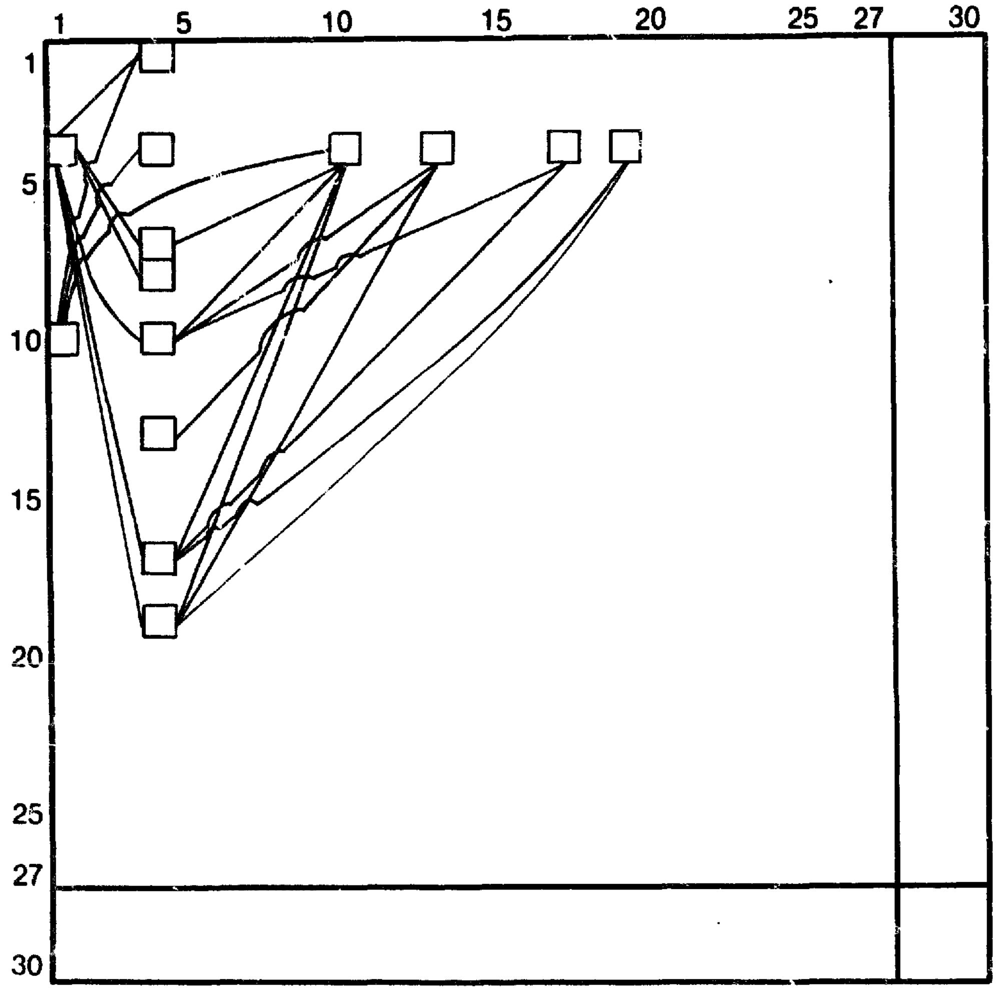

Figure 5. Most important synergistic fields of influence, 1970.

bility, with the exception of sectors 26 and 13 (trade/transport and chemicals), the economy revealed a tendency to be less dependent upon a small number of sectors. This increased dispersion of flows would appear consistent with the notion that economic development is associated with increased complexity in the structure of intermediation of production.

5. CONCLUSIONS

The research reported here provides some insights in changes in the Brazilian economy over the period 1959 to 1975 using three input–output tables. A comparison of some traditional methods of key sector identification with some newer approaches revealed that the earlier methods provided few insights into the nature of the changes which took place in the economy, since they were focused at the aggregate

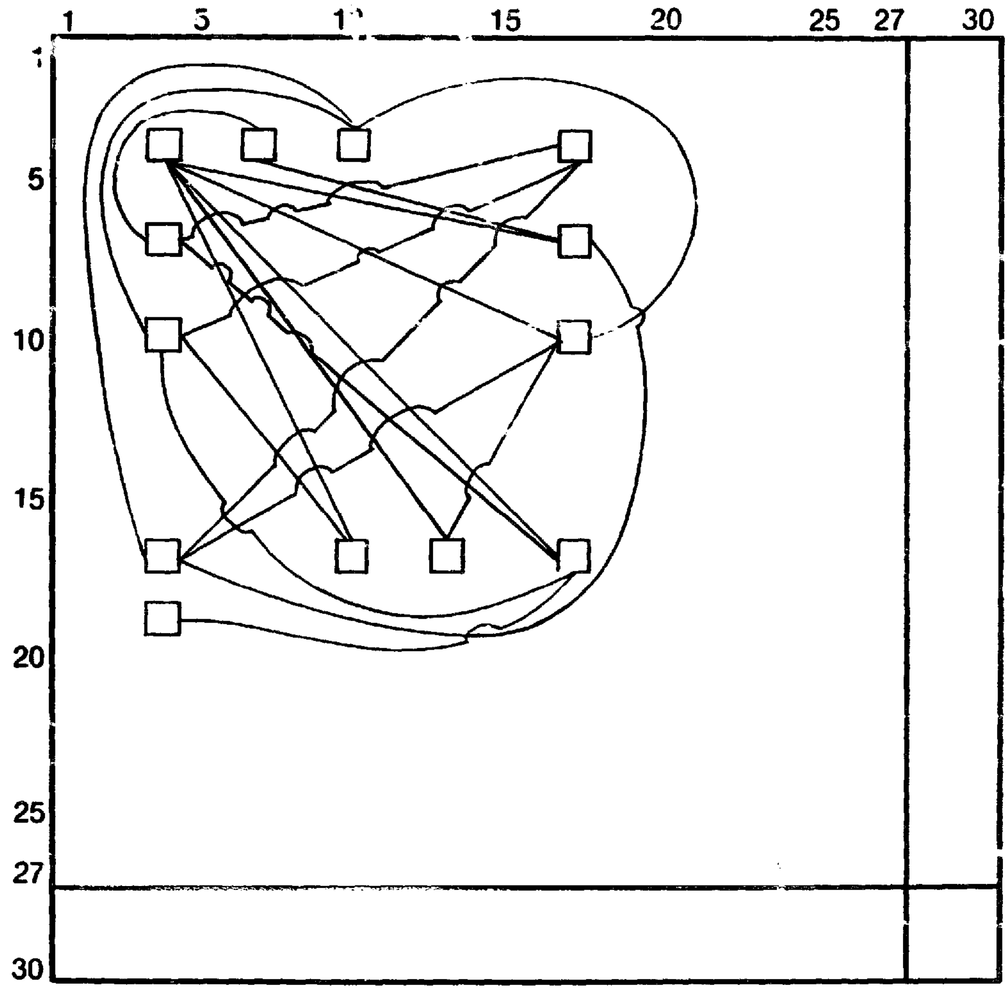

Figure 6. Most important synergistic fields of influence, 1975.

sector level. The newer approaches tended to concentrate on individual entries in the input–output table and show their relationship to other elements. In this way, a much richer pattern of change can be detected.

The analysis was only able to offer some suggestions about the role of change generated outside the transactions matrix. The Miyazawa model developed for 1975 provided important clues about the role changes in the composition of final demand might play in generating change. In this regard, the empirical evidence provided by Feldman, McClain and Palmer (1987) for the United States might provide some relevance. They found that for nearly 80 percent of 400 industries in the period 1963–78, final demand changes account for the majority of output change. However, in the Brazilian economy, there is some suggestion, that the process of structural change was still important, especially in the earlier years and as a direct result of the ISI policy.

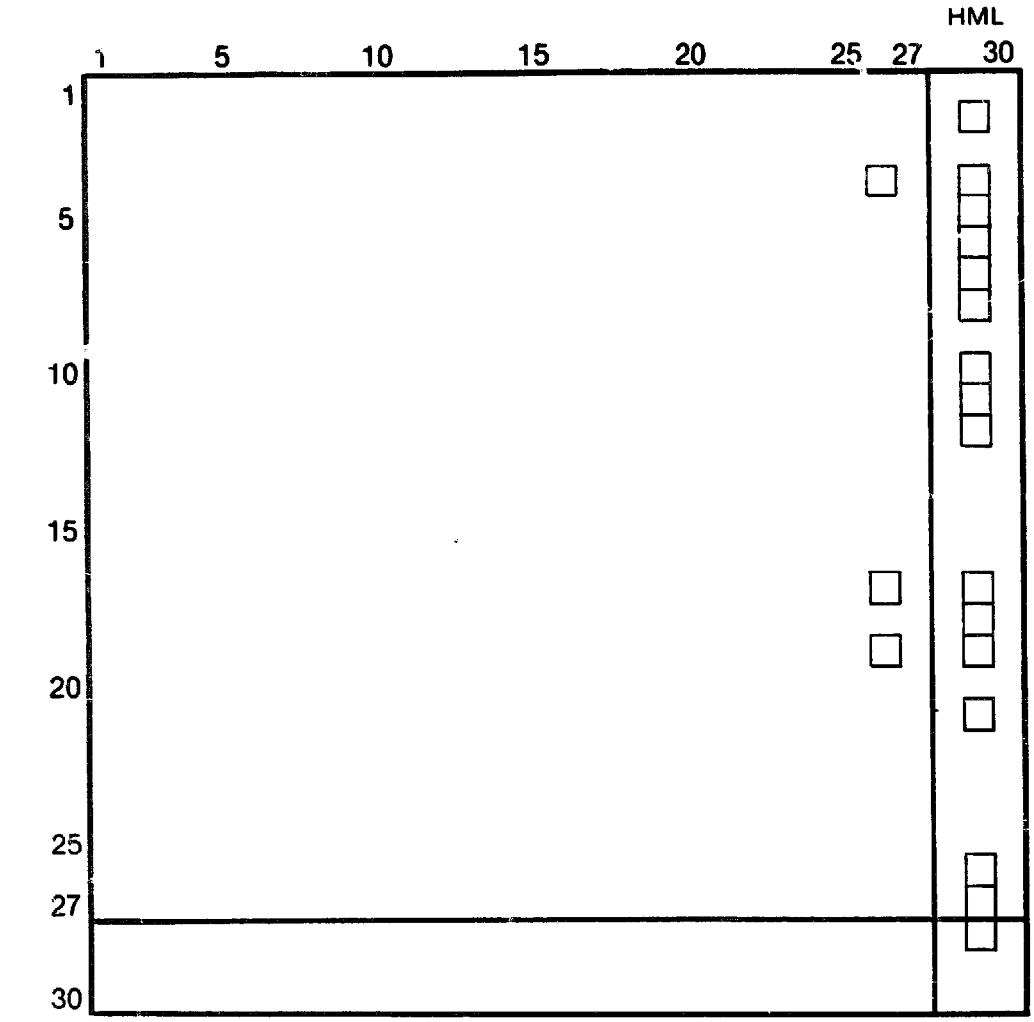

Figure 7. Coefficients with largest field of influence, 1975 SAM.

As an economy matures, one would expect that the results found for the United States would tend to be applicable.

Notwithstanding the evidence accumulated for Brazil, the input–output model alone provides only some partial insights into the role of production changes. It would be difficult, without recourse to a more general equilibrium model, to infer the degree to which changes in income distribution and consumption patterns provided further major impulses for change in the economy. Also missing from this analysis is any attention addressed to important regional and spatial issues—the problems of gaps in growth rates between regions and the role of urban/rural income differentials in changing the aggregate composition of demand.

The methods employed show some promise of more general applications across a wider spectrum of models. In particular, the notion

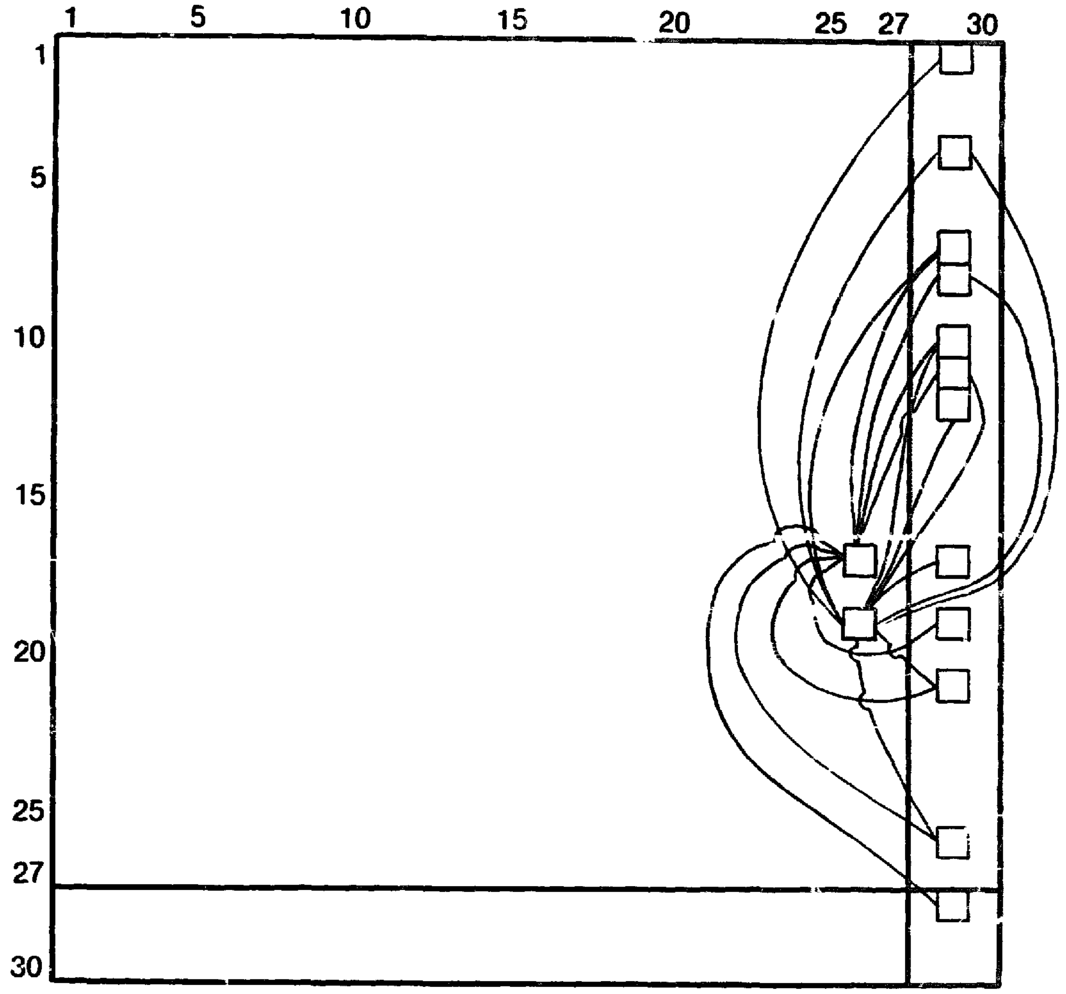

Figure 8. Most important synergistic fields of influence, 1975 SAM.

of a field of influence and an associated reduced form structure of the most important flows suggests a strong relationship with the work being conducted in transportation systems (Nagurney 1987). The hierarchical procedure would probably be enhanced if the link with the notion of analytical importance was made in the choice of elements entering the first levels of the hierarchy.

Finally, Robinson and Roland-Holst (1987) have expressed important concerns about model structure and interpretation. It is unlikely that research and policy formulations will be able to continue to rely on input–output models alone. On the other hand, the input–output framework will continue to play an important role in the more general modeling frameworks now being developed. The need to consider the complex interrelationships between a broader set of markets than the interindustry system requires the development of integrated modeling

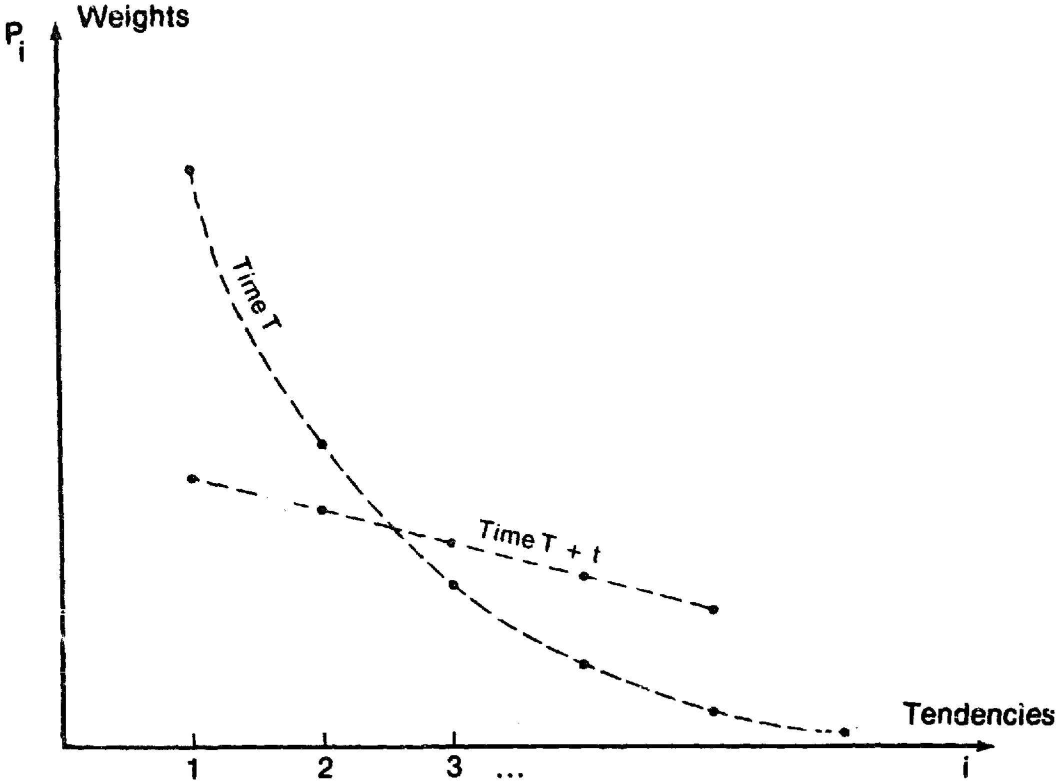

Figure 9. Expectations for extreme tendency weights over time.

ventures. The main research challenge will be to explore alternative ways in which these models of the various markets can be linked to provide some of the important, tractable policy evaluations considered when the concept of key sectors was first raised.

Table 3. Value of the Weights for the First Ten Hierarchical Levels in Brazil, 1959, 1970, 1975

	1959	
Decomposition Number	**Value of Weight for this Level**	**Cumulative Value of Weights**
1	.196	.196
2	.135	.332
3	.112	.444
4	.103	.548
5	.068	.617
6	.062	.680
7	.049	.729
8	.038	.768
9	.036	.804
10	.026	.831

Table 3. *(continued)*

	1970	
Decomposition Number	**Value of Weight for this Level**	**Cumulative Value of Weights**
1	.182	.182
2	.134	.317
3	.118	.435
4	.064	.500
5	.063	.564
6	.056	.620
7	.041	.662
8	.040	.702
9	.031	.734
10	.025	.759

	1975	
Decomposition Nubmer	**Value of Weight for this Level**	**Cumulative Value of Weights**
1	.179	.179
2	.150	.329
3	.083	.412
4	.083	.496
5	.067	.563
6	.053	.616
7	.044	.661
8	.040	.702
9	.036	.739
10	.026	.765

Table 4. Ranking of the Top Five Sectors in Terms of their Appearance in the First Ten Levels of the Hierarchical Decomposition

Rank	Sector	1959 (appearances)	Sector	1970 (appearances)	Sector	1975 (appearances)
1	27	(45)	26	(45)	26	(49)
2	13	(41)	13	(39)	13	(39)
3	26	(38)	1	(30)	1	(22)
4	1	(30)	4	(26)	4	(21)
5	4	(28)	19	(17)	11	(15)

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