Changing Input-Output Coefficients: The Case of West Virginia

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This study analyzes changes in input-output coefficients for the West Virginia economy. The study uses the 1965 and 1975 survey-based West Virginia input-output tables.[1] First, changes are reported on demand (input) and supply (output) sides, using direct coefficient and Leontief inverse matrices. Second, pictorial representations of input-output change are analyzed using graph-theoretic techniques.

Carter [4] has emphasized the reason for using both direct coefficient and Leontief inverse matrices in analyzing changing input-output structures:

> Measures of structural change based on inverse coefficients have some important advantages over direct coefficient comparisons. Steel for refrigerator doors, for example, may be purchased directly from iron and steel in one year and indirectly, through the stampings sector, the next. Measures based on the inverse matrix, however, have their own disadvantages. In particular, they tend to obscure the primary locus of change.[2]

The scope of this paper is not with causes of coefficient change, but with the direction and degree of coefficient change—a necessary first step in analyzing such change. Determining the many causes of coefficient change is beyond the scope of this paper.

PRICE DEFLATION

Each transactions table reflects producers' prices as follows:

$$(1)\quad a_{ij} = q_{ij}\left(\frac{P_i}{P_j}\right),$$

where

a_{ij} = a direct purchase from sector i by sector j in value terms,

q_{ij} = a direct purchase from sector i by sector j in physical terms, and

P_i, P_j = output prices for sectors i and j.

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Deflating the 1975 table is a necessary first step for analyzing changes in physical coefficients. This is because input and output prices usually move in the same direction after an appropriate lag. Inputs with relatively declining prices may be substituted for those with relatively rising prices, especially when the base years are a decade apart. The use of constant prices shows how substitution has contributed to structural change.[3]

Deflating the 1975 prices was a difficult process. There were qualitative changes in some industries' outputs, although we implicitly assume homogeneity of output. Another problem is raised by possible errors in price deflators. If the 1975 deflator for the chemicals sector—one of West Virginia's major industries—was too small, for example, the output of this industry is overstated when compared with 1965 transactions. The chemical sector's row coefficients would be overstated by a fixed proportion. On the other hand, its column coefficients would be understated by the same fixed proportion. The only consolation is that such distortions, if they exist, affect only the sectors in which the errors occur. Finally, and unfortunately, some differences in the coefficients reflect random factors. Different methods were used to estimate interindustry relationships in the two years, and there are differences in the quality and accuracy of the data in the two sets of tables.[4]

DEMAND SIDE COMPUTATIONS

Leontief [8] and Carter [4] used inverse matrices for different time periods with vectors of final demand for a given time period to analyze changes in intermediate and gross output levels over time. The same approach was applied to the West Virginia data as follows:

$$(2)\quad {}_t a_{ij} = {}_t x_{ij} / {}_t X_j,$$

where

${}_t a_{ij}$ = a direct purchase from sector i by sector j in year t per dollar of j's output,

${}_t x_{ij}$ = a transactions flow from sector i to sector j in year t, and

${}_t X_j$ = gross outlay of sector j in year t.

The calculations from equation (1) for both years yield the familiar "A" matrices. Multiplying the interindustry coefficients for each year by 1975 sectoral gross output yields intermediate output (${}_t W_i$) required from each sector to produce 1975 output with 1965 and 1975 technologies. The results of these calculations are shown in Table 1.

The Leontief inverse matrix is formed in the usual manner from equation (1) to solve for gross output in year t as a function of final use in year t, or

TABLE 1

(Thousands of dollars)

Sectors	Intermediate Outputs 65^{W_i}	75^{W_i}	% Change	Intermediate and Gross Outputs $75^{\hat{Z}_i}$	% Change[7]*	$75^{\hat{X}_i}$	75^{X_i}	% Change (X_i)
1. Agriculture	30192	30320	0.42	31197	− 2.81	91793	90916	0.96
2. Coal min.—under.	109781	72114	−34.31	113415	−36.42	670667	629367	− 6.16
3. Coal min.—strip	53725	48845	− 9.08	56433	−13.45	104134	96547	− 7.29
4. Petroleum & natur. gas	32319	25209	−22.00	31859	−20.87	49042	42393	−13.56
5. All other mining	44039	40301	− 8.49	45324	−11.08	75843	70820	− 6.62
6. Gen. contr.—bldg.	44622	18469	−58.6	43875	−57.90	147905	122499	−17.18
7. Gen. contr.—nonbldg.	31312	26300	−16.0	32209	−18.34	191734	185826	− 3.08
8. Spec. trade contr's	76519	67295	−12.1	83888	−19.78	143640	127047	−11.55
9. Food-meats	18708	13724	−26.6	19054	−27.97	57732	52402	− 9.23
10. Food-dairies	6370	6015	− 5.6	6323	− 4.86	34479	34172	− 0.89
11. Food-bakeries	4632	5553	19.9	4594	20.89	44300	45260	2.17
12. Food-bev's	2282	4466	95.75	2227	100.55	33647	35886	6.66
13. Apparel	1581	1756	11.09	1560	12.61	49803	50000	0.40
14. Log & sawmills	19726	24552	24.47	19985	22.85	37408	41975	12.21
15. Furniture	5741	3009	−47.59	6082	−50.52	43011	39938	− 7.14
16. Print. & publish.	61594	61592	-0-	60203	2.31	84715	86106	1.64
17. Chemicals	214629	176568	−17.73	221912	−20.43	1328850	1283506	− 3.41
18. Petroleum	44721	33978	−24.02	46154	−26.38	71070	58894	−17.13
19. Glass	11703	14031	19.89	11529	21.71	208705	211208	1.20
20. Stone & clay	34230	52018	51.97	36908	40.94	139708	154818	10.82
21. Primary metals	77668	66007	−15.01	76138	−13.31	832161	822031	− 1.23
22. Fabric. metals	35841	46403	29.47	37933	22.33	182831	191302	4.63
23. Machinery	7883	12432	57.71	8215	51.33	118977	123194	3.54
24. Elect. mach.	4615	11778	155.21	4632	154.30	156840	163987	4.56
25. Transp. equipm.	2446	3812	55.86	2603	46.44	130994	132202	0.92

26. Instruments	4054	6347	56.54	4161	52.53	44803	46989	4.88
27. All other manf.	40015	43142	7.81	40865	5.57	168918	171195	1.35
28. Eat. & drink. est.	5010	5338	6.56	4933	8.23	128928	129334	0.31
29. Wholesale trade	104870	115491	10.13	104987	10.01	304407	314911	3.45
30. Retail food	1153	4574	296.84	1148	298.51	195551	198978	1.75
31. Retail gas stat's	9793	8946	− 8.65	9584	− 6.67	54853	54214	− 1.16
32. All other retail	31571	51244	62.32	31433	63.03	503594	523405	3.93
33. Banking	30227	33103	9.52	30163	97.47	113752	116692	2.59
34. Other finance	6074	8079	33.01	6045	33.65	81680	83714	2.49
35. Insurance	77536	79401	2.40	77234	2.81	224856	227024	0.96
36. Real estate	41550	47908	15.30	40623	17.93	118754	126039	6.13
37. All other FIRE	28736	27680	− 3.68	28532	− 2.99	54124	53272	− 1.57
38. Hotels	5162	4250	−17.66	5093	−16.54	45420	44578	− 1.85
39. Medical & legal	47157	52956	12.30	47547	11.38	288335	293743	1.88
40. Educat. serv.	1964	17347	783.11	1927	800.42	405505	420926	3.80
41. All other serv.	129195	158410	22.61	127903	23.85	481064	511570	6.34
42. Railroads	64492	41423	−35.77	65380	−36.64	338973	315016	− 7.07
43. Truck. & wareh.	68020	85072	25.07	67990	25.12	224848	241930	7.60
44. All other transp.	31841	38837	21.97	31022	25.19	73842	81658	10.58
45. Communications	52165	73229	40.38	52050	40.69	166741	187920	12.70
46. Elect. companies	111134	101917	− 8.29	112232	− 9.19	434551	424237	− 2.37
47. Gas companies	63428	78724	24.12	62897	25.16	120640	136467	13.12
48. Water & sanitary	15984	12387	−22.50	16846	−26.47	31600	27141	−14.11
Total	1,948,010	1,962,343	0.74%	1,905,347	2.99%	9,635,728	9,665,224	0.31%

* between ${}_{75}\hat{Z}_i$ and ${}_{75}W_i$

(3) ${}_tX_i = \Sigma_j\ {}_tQ_{ij}^{-1}\ {}_tY_i,$

where

${}_tQ_{ij}^{-1}$ = the Leontief inverse showing direct and indirect purchases from sector i by sector j in year t per dollar of delivery to final demand by sector j, and

${}_tY_i$ = final demand for sector i in year t.

Finding the amount of inputs necessary for satisfying final demand for 1975 using 1965 technology requires the following:

(4) ${}_{75}\hat{X}_i = \Sigma_j\ {}_{65}Q_{ij}^{-1}\ {}_{75}Y_i$

Using 1975 technology in equation (3) requires use of the 1975 Leontief inverse (${}_{75}Q_{ij}^{-1}\ {}_{75}Y_i$).

Intermediate output levels for both years are determined as follows:

(5) ${}_{75}Z_i = \Sigma_j\ {}_{75}Q_{ij}^{-1}\ {}_{75}Y_i - {}_{75}Y_i$, and

(6) ${}_{75}\hat{Z}_i = \Sigma_j\ {}_{65}Q_{ij}^{-1}\ {}_{75}Y_i - {}_{75}Y_i,$

where

${}_{75}Z_i$ = intermediate output for industry i for 1975.

The results of the above computations are shown in Table 1.

SUPPLY SIDE COMPUTATIONS

Conventional input-output analysis, like much of economics, has underemphasized the supply side. Giarratani [6], however, has emphasized, "the input-output table is a neutral image of an economy, emphasizing neither supply nor demand forces but rather recording equilibrium values at one point in time."[5]

To get an accurate picture, therefore, of changing interindustry relationships, an examination is also needed of changes in output coefficients. Production relationships underlying these coefficients are determined by the availability of inputs rather than by technical factors. The coefficients are determined as follows:

(7) ${}_t\vec{a}_{ij} = {}_tx_{ij}/{}_tX_i,$

where

$_{t}\vec{a}_{ij}$ = the direct sales of sector i to sector j in time period to per unit of sector i's output.

Gross outlay (=output) in year t is solved for as a function of primary inputs as follows:

$$(8)\ {}_{t}\vec{X}_{j} = \Sigma_{i}\ {}_{t}V_{j}\ {}_{t}\vec{Q}_{ij}^{-1},$$

where

$_{t}V_{j}$ is a purchase of primary inputs by sector j in year t.

The years 1965 and 1975 are substituted for t in equations (6) and (7) in the same manner as in the demand side computations. Intermediate inputs determined from equation (6) are given in Table 2. Intermediate inputs ($_{75}\hat{\vec{Z}}_{j}$ and $_{75}\vec{W}_{j}$)—given in Table 2 with gross outlays—are determined by subtracting value added (V_j) from gross outlay (X_j) in equation (7) for both years.

RESULTS

Table 1 shows that the percent change in total intermediate requirements between the two years is only 0.74%. Some sectors, however, show considerably greater changes. The sector displaying the largest change is educational services (40) at 783.11%. This reflects the emphasis placed on upgrading West Virginia's educational facilities and programs. The metal-manufacturing bloc underwent significant change as shown by electrical machinery and apparatus (24), machinery—except electrical (23), transportation equipment (25), and instruments and related products (26) at 155.21%, 57.71%, 55.86%, and 56.54%.

Percent increases in intermediate requirements may appear paradoxical. One usually expects that technological change should lead to less, not more, inputs required to produce the same levels of output at a later date. An increased supply of inputs, however, could result from import substitution. Such increases could also result from an increase in the degree of specialization. Sectors using 1975 technologies may have used more intermediate inputs but less capital and labor than they did in 1965. Nonetheless, substantiation of the reasons for the increases requires thorough analysis of sectoral production functions.

Some sectors show significant decreases. General contractors—building (6) has the largest at -58.61%. Railroads (42) shows a decline of 35.77%. Finally, coal mining—underground (2) and petroleum (18) changed by -34.31% and -24.02%. This might be due to sectors substituting away from coal and petroleum usage because of rising energy prices.

TABLE 2

(Thousands of dollars)

	Intermediate Outlays			Intermediate and Gross Outlays				
Sectors	$_{65}\vec{W}_j$	$_{75}\vec{W}_j$	% Change	$_{75}\hat{\vec{Z}}_j$	% Change*	$_{75}\hat{\vec{X}}_j$	$_{75}\vec{X}_j$	% Change ($\vec{X}_j$)
1. Agriculture	34205	34198	-0-	33547	1.94	90265	90916	0.72
2. Cola min.—under.	105921	146416	38.23	97054	50.86	580005	629366	8.51
3. Coal min.—strip	37000	74694	101.89	24863	200.42	46715	96546	106.67
4. Petroleum & natur. gas	13953	16444	17.86	13088	25.64	39037	42393	8.60
5. All other mining	11785	14152	20.08	11621	21.78	68289	70820	3.71
6. Gen. Contr.—bldg.	116044	69139	40.42	115666	−40.23	169026	122499	−27.53
7. Gen. contr.—nonbldg.	84587	77735	− 8.10	80529	− 3.47	188620	185826	− 1.48
8. Spec. trade contr's	38892	39776	2.27	37976	4.74	125246	127046	1.44
9. Food—meats	19032	18786	− 1.29	18861	− 0.40	52477	52402	− 0.14
10. Food—dairies	21613	11893	−44.98	21553	−44.82	43833	34172	−22.04
11. Food-bakeries	10138	9340	− 7.88	10070	− 7.25	45989	45260	− 1.59
12. Food-bev's	4445	5126	15.31	4460	14.93	35220	35886	1.89
13. Apparel	2023	4603	127.56	1989	131.36	47387	50000	5.52
14. Log & sawmills	18547	17039	− 8.13	18669	− 8.73	43606	41976	− 3.74
15. Furniture	5701	7135	25.16	5741	24.29	38544	39938	3.62
16. Print. & publish.	31193	33290	6.72	30206	10.21	83021	86105	3.72
17. Chemicals	401414	281642	−29.84	421421	−33.17	1423285	1283506	− 9.82
18. Petroleum	24096	33495	39.10	23448	42.85	48847	58894	20.57
19. Glass	55176	40756	−26.13	55598	−26.70	226050	211207	− 6.57
20. Stone & clay	36918	43505	17.84	35831	21.42	147144	154817	5.22
21. Primary metals	117729	65609	−44.27	116143	−43.51	872565	822030	− 5.79
22. Fabric. metals	20474	32951	60.94	20973	57.11	179324	191302	6.68
23. Machinery	21086	15435	−26.80	21225	−27.28	128984	123194	− 4.49
24. Elect. mach.	42164	34135	−19.04	43177	−20.94	173028	163986	− 5.23
25. Transp. equipm.	25790	15728	−39.02	26504	−40.66	142979	132202	− 7.54

26. Instruments	780	1381	77.13	821	68.34	46428	46989	1.21
27. All other manf.	20577	20309	− 1.30	20026	1.41	170913	171195	0.17
28. Eat. & drink. est.	25341	35784	41.21	25952	37.89	119502	129334	8.23
29. Wholesale trade	57223	41199	−28.00	56581	−27.19	330293	314910	− 4.66
30. Retail food	39798	49814	25.17	37533	32.72	186697	198978	6.59
31. Retail gas stat's	10778	12605	16.95	10352	21.76	51961	54214	4.34
32. All other retail	102059	101406	− 0.64	98019	3.46	520018	523405	0.65
33. Banking	12049	18946	57.24	11850	59.88	109596	116692	6.47
34. Other finance	10100	21135	109.27	9587	120.47	72165	83714	16.00
35. Insurance	32502	15791	−20.65	36294	−28.94	237525	227023	− 4.42
36. Real estate	20828	37723	81.12	20787	81.48	109102	126039	15.52
37. All other FIRE	37817	27102	−28.33	35679	−24.04	61849	53273	−13.87
38. Hotels	20586	16270	−20.96	19373	−16.02	47681	44578	− 6.51
39. Medical & legal	38422	51289	33.49	37740	35.90	280195	293743	4.84
40. Educat. serv.	44803	80247	79.11	48754	64.59	389434	420926	8.09
41. All other serv.	63823	84832	32.92	63172	34.29	489909	511569	4.42
42. Railroads	34531	22534	−34.74	34879	−35.40	327362	315017	− 3.77
43. Truck. & wareh.	25370	31102	22.59	25788	20.61	236616	241930	2.25
44. All other transp.	14197	15143	6.66	13817	9.60	80332	81658	1.65
45. Communications	13762	16391	19.10	13654	20.05	185182	187919	1.48
46. Elect. companies	78111	83894	7.40	67734	23.86	408076	424236	3.96
47. Gas companies	46898	14840	−68.36	44339	−66.53	165966	136467	− 1.78
48. Water & sanitary	12919	9600	−25.69	12852	−25.30	30393	27141	−10.70
Total	2,063,200	1,962,359	− 4.89%	2,022,142	− 2.96%	9,696,681	9,623,239	− 0.76

* between $_{75}\hat{Z}_i$ and $_{75}\vec{W}_i$

The other results in Table 1 were derived from Leontief inverses. The changes for total intermediate and gross outputs are 2.99% and 0.31%, not much different than those in Table 1. Percent changes in intermediate flows calculated from the inverse are generally greater than those calculated from the "A" matrix because of the addition of indirect effects picked up by the inverse. Notable exceptions to this, by as much as 11%, are stone and clay products (20), fabricated metal products (22), machinery—except electrical (23), transportation equipment (25), and instruments and related products (26). The percent decreases mean that secondary output requirements (indirect effects) needed to satisfy final demand requirements have partially offset primary output requirements (direct effects).

Percent changes in gross outputs are relatively small. General contractors—building (6) and petroleum and natural gas (4) have the largest changes. Visual observation shows that intermediate outputs have changed considerably more than gross outputs. This suggests that the regional interindustry structure may be relatively unstable due to import shifts, while the underlying technical relations may be relatively stable.[6] Testing this assertion, however, requires additional information on import shares and production relationships.

Table 2 shows supply side results. The change for total intermediate requirements is -4.89%. Energy sectors (2, 3, 4, and 18), however, display much more change than this. For example, coal mining—strip and auger (3) shows an increase of over 100%. Its demand side change, however, is -9.08%, and is in the opposite direction. This implies that this sector's production function has not changed nearly as much as has its output distribution.

The above sectors show negative percent changes on the demand side, but positive percent changes on the supply side. Some manufacturing sectors (23, 24, and 25), however, show the opposite. On the demand side, this might be due to import substitution. On the supply side, it might be due to technological change or to shifts in output distribution from intermediate stages to final demand. Regardless, substantiation of such causes depends on full information about production functions and sectoral output distribution.

Changes for intermediate and gross output sums are -2.96% and 0.76%, not much different from those in Table 3. This suggests that indirect effects had a relatively small impact on structural change. The exception to this is coal mining—strip and auger (3), showing a percent jump of almost 100%.

There are few large percent changes in gross outputs. Once again, coal mining—strip and auger (3) displays the greatest change, followed by general contractors—building (6), food and kindred products—dairies (10), and petroleum (18). As in the demand side results, greater change is shown in intermediate inputs than is shown in total outlays. This suggests that regional interindustry relationships might be unstable compared to technical relationships.

TABLE 3

Clusters

1965	1975
1. Petroleum & natural gas (4) Gas companies & systems (47) L = 0.39	1. All other FIRE (37) Medical & legal services (39) Insurance agents (35) L = 0.17 (35,37); L = 0.26 (37,39)
2. Chemicals (17) Instruments & related products (26) L = 0.19	2. General contractors—building (6) Special trade contractors (8) L = 0.21
3. General contractors—nonbuilding (7) Petroleum (18) L = 0.23	3. Petroleum & natural gas (4) Gas companies & systems (47) L = 0.14
4. General contractors—building (6) Special trade contractors (8) L = 0.29	4. General contractors—nonbuilding (7) Petroleum (18) All other mining (5) L = 0.21 (7,18); L = 0.12 (5,18)
5. Logging & sawmills (14) Furniture & other wood fabrication (15) L = 0.09	5. Agriculture (1) Food & kindred products—dairies (10) Food & kindred products—meats (9) L = 0.13 (1,9); L = 0.15 (1,10)
6. Insurance agents & brokers (35) All other FIRE (37) Medical & legal services (39) L = 0.28 (35,37); L = 0.27 (37,39)	6. Coal mining—underground (2) Logging & sawmills (14) Coal mining—strip (3) Furniture & wood fabrication (15) L = 0.14 (2,14); L = 0.12 (2,3); L = 0.09 (14,15)
7. Agriculture (1) Food & kindred products—meats (9) Food & kindred products—dairies (10) L = 0.14 (1,9); L = 0.18 (1,10)	

APPLICATION OF GRAPH THEORY

As applied to input-output analysis, graph theory represents an application of cluster analysis. Cluster analysis is a tool of scientific inquiry used for making inductive generalizations—that is, bringing order to data. Yet it can be used in a deductive sense. For instance, the Hirschman linkage hypothesis suggests that sectors with the strongest interindustry linkages have dominant influence on growth and decline.[8] If true, this means that identification of such sectors and those linked to them are important for regional and urban policy. Identifying such sectors might be accomplished easily and efficiently by applying a graph-theoretic clustering algorithm to input-output data.

Campbell [3] has recommended the application of graph theory to input-output tables for identifying sectors for growth pole strategy. Siebert [12] has suggested using graph theory for representing the interdependence of spatial points to determine regional centers of economic activity. Slater [13] has used graph theory to expose salient and subtle structural features of input-output flows.

The approach used here is a variant of that used by Slater.[9] It generates a hierarchical representation of an economy's set of interindustry linkages at a given point in time. The hierarchical representation is provided pictorially by a dendrogram—a diagram showing how sectors are linked by the range of values of the interindustry linkages. Changes over time in interindustry relationships will change the dendrogram's hierarchical representation.

The dendrograms for 1965 and 1975 were generated from a matrix (B) of backward and forward linkages calculated as follows:

$$(9)\quad {}_tb_{ij} = 0.5\,({}_ta_{ij} + {}_t\vec{a}_{ij}),$$

where

${}_ta_{ij}$ = a direct input coefficient defined in equation (1), and

${}_t\vec{a}_{ij}$ = a direct output coefficient defined in equation (6).

To construct a dendrogram, each West Virginia sector is represented by a vertex without any linkages between sectors. The largest linkage is found, and an arrow is drawn between the corresponding sectors. This procedure is followed sequentially for the second, third, and nth largest linkage until all sectors are linked. Any two sectors are considered linked as long as a linkage exists between sector i and sector j, without regarding which sector is purchasing from the other.[10]

Unfortunately, an adequate statistical procedure for determing clusters from dendrograms does not exist at present. An analyst, therefore, must visually scan the dendrogram to determine clusters. This is accomplished by using the threshold scale at the top of the dendrogram.[11] Two sectors are said to be joined if the linkage joining them exceeds a threshold level (read from right to left at the top of a dendrogram). For example, if the threshold is set at 27 in Figure 1, only three clusters exist: petroleum and natural gas (4) and gas companies and systems (47); general contractors—building (6) and special trade contractors (8); and insurance (35), "all other" FIRE (37), and medical and legal services (39). As the threshold is lowered to 14, however, other clusters [e.g., chemicals (17) and instruments and related products (26)] appear. Finally, when the threshold is lowered to approximately 2, all 48 sectors are linked hierarchically. Those clusters that exist at a relatively high threshold can be said to be salient because the linkages joining the sectors comprising the clusters are the strongest in the economy. In some cases, salient clusters "can be regarded as relatively integrated self-propulsive groups of industries. Increases in the production of one member industry will place added demands on every other constituent."[12]

Visual examination of Figure 1 suggests that seven clusters exist; while that of Figure 2 suggests that six exist. These clusters are represented in Table 3 with a linkage index (L) representing the degree of strength of the linkages

FIGURE 1

Dendrogram, 1965

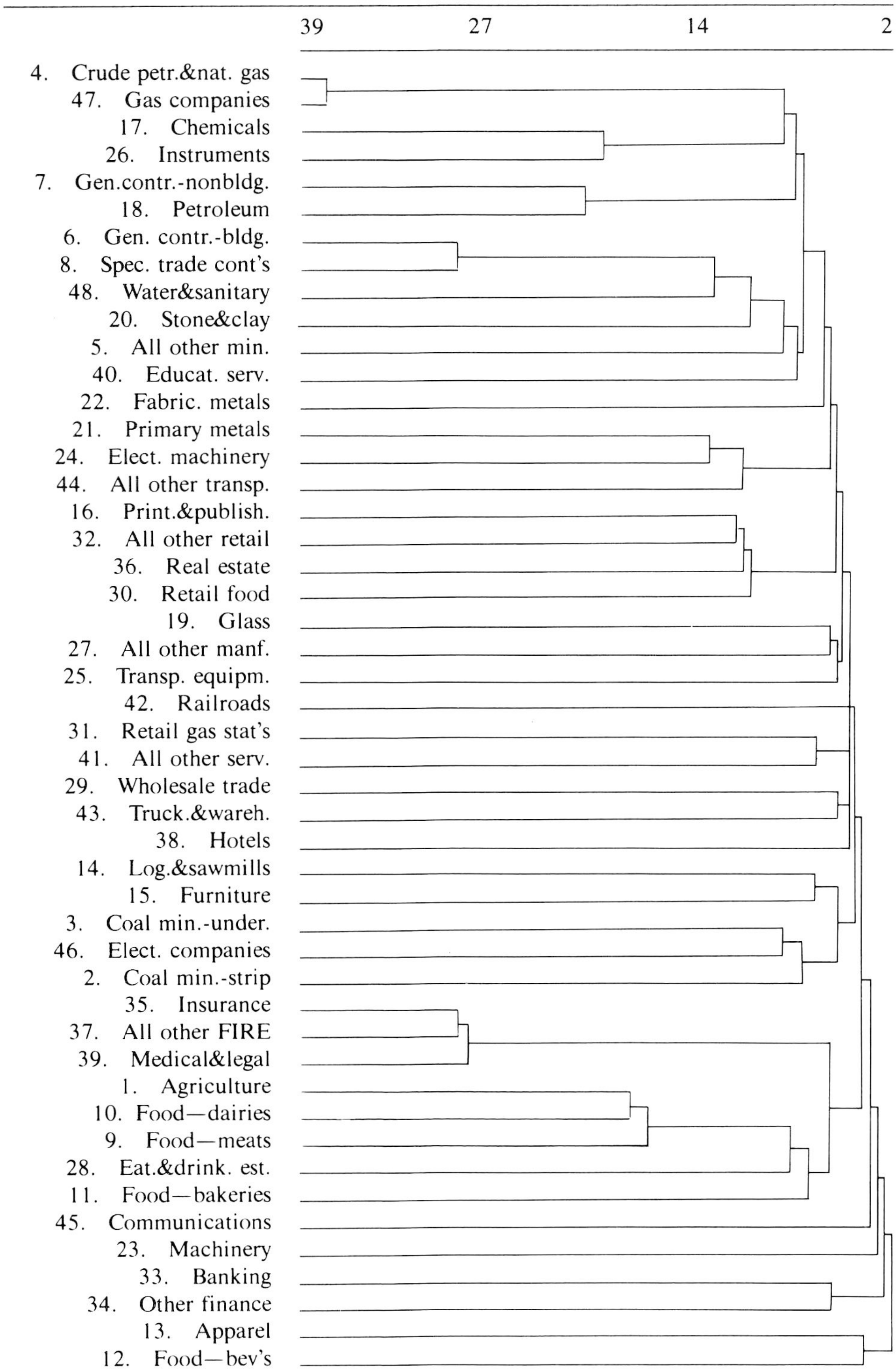
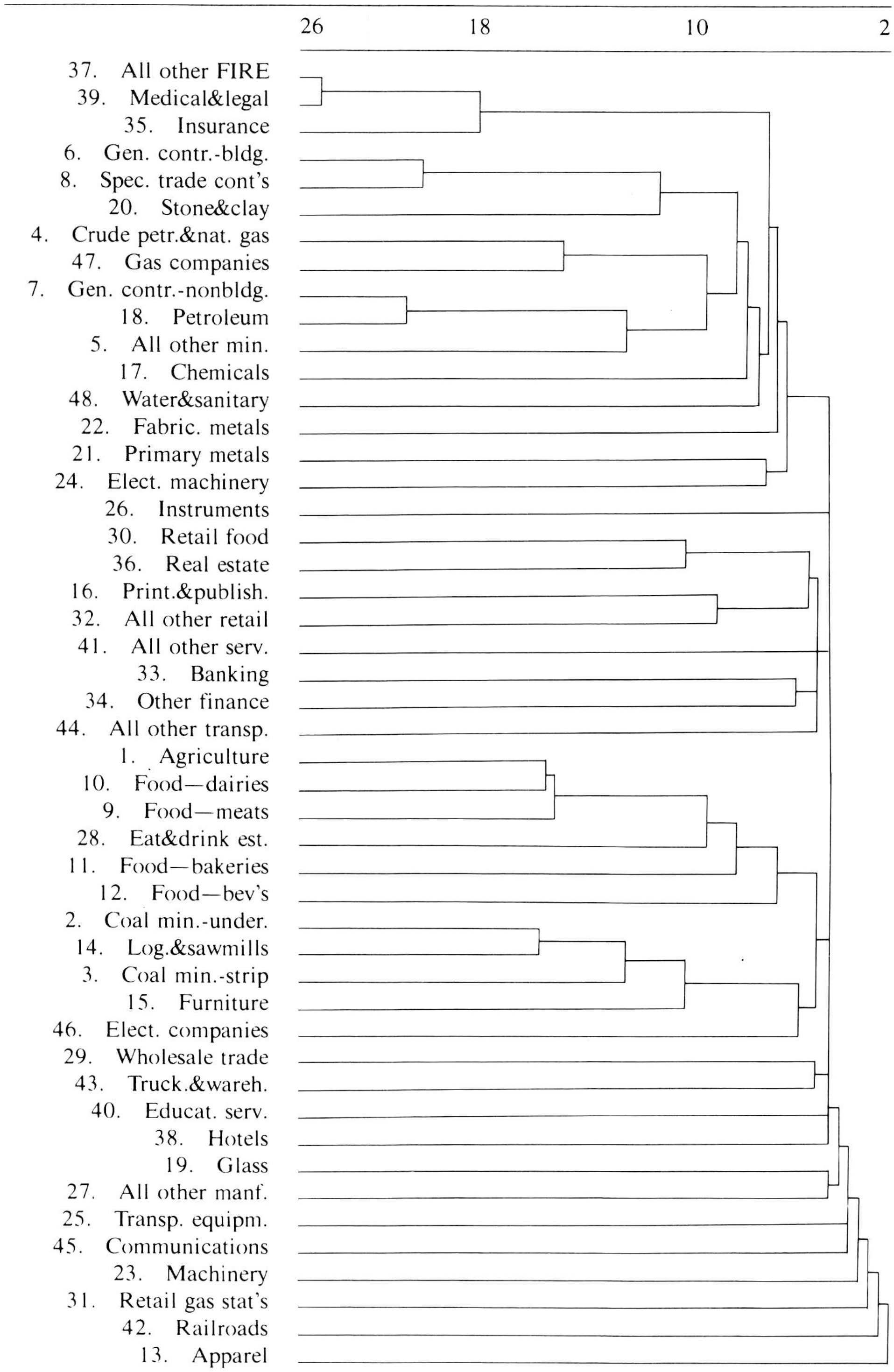


FIGURE 2

Dendrogram, 1975



binding together the sectors in each cluster. The index (L) is the threshold associated with a particular cluster divided by 100. Changes in L and in the composition of clusters indicate structural change.

One noticeable change that occurred among the 1965 clusters as compared to those for 1975 is the general decline in L. The decline in linkage strength between petroleum and natural gas (4) and gas companies and systems (47) is from 0.39 to 0.14. Secondly, the cluster comprising chemicals (17) and instruments and related products (26) disappeared. The strength of the linkage for this group declined from 0.19 in 1965 to 0.05 in 1975. Another noteworthy change is that "all other" mining (5) is not in any of the 1965 clusters, but in 1975 it joined with general contractors—nonbuilding (17) and petroleum (18). Finally, the two coal mining sectors (2, 3) are members of the 1975 clusters, but not of the 1965 clusters.

CONCLUSION

The results indicate that significant structural change occurred in the West Virginia economy from 1965 to 1975 on both demand and supply sides. Noticeable changes on the demand side occurred in some manufacturing sectors. Significant changes occurred on the supply side in energy sectors. The next step is to determine the major causes of structural change in all sectors.

FOOTNOTES

1. Anthony L. Loviscek *et. al.* [9] and Miernyk *et. al.* [10].
2. Carter [4], p. 26.
3. Changing trade patterns also affect regional input coefficients. For more on this, see Beyers [2] and Conway [5].
4. In particular, the data for the 1965 tables were obtained by personal interview. The data for 1975, however, were obtained from a mail questionnaire supplemented by telephone interviews. This difference alone could lead to changes in coefficients.
5. Giarratani [6], p. 447. Others emphasizing the use of supply coefficients are Augustinovics [1] and Hoover [6], pp. 235-237.
6. For more on this, see Beyers [2].
7. The values for $_{75}W_i$ and $_{75}Z_i$ are equal. The same is true for the values of $_{75}W_j$ and $_{75}\bar{X}_j$.
8. For more on this, see McGilvray [10].
9. Slater's method involves biproportionally standardizing transactions flows with diagonal entries removed. The algorithm then applies graph theory to the standardized flows.
10. This is an application of weak components of a directed graph. The existence of strong components, however, requires that a linkage not only exist from i to j, but also from j to i.
11. Visual observation shows that the threshold in Figure 1 differs from that of Figure 2. This is because a threshold is unique to its data base. As shown in Table 5, even if two dendrograms have identical clusters, the interindustry linkages of one cluster are likely to be different from that of the same cluster in the other dendrogram.
12. Slater [13], p. 3.

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