DISAGGREGATION OF STRUCTURAL CHANGE IN THE AMERICAN ECONOMY: 1947–1966

BY ROGER H. BEZDEK AND ROBERT M. WENDLING

U.S. Energy Research and Development Administration, Washington, D.C., and Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C.

This paper utilizes input–output techniques to disaggregate and analyze structural change in the American economy between 1947 and 1966, focussing on the subperiods 1947–58, 1958–63, and 1963–66—periods determined by the availability of input–output tables for the terminal years. There was wide variability in the changes in output requirements among industries, but in all periods changes in final demand and in input–output coefficients tended to reinforce each other. Increases in final demand for an industry's output tended to be accompanied by increases in demand for its product as intermediate input, and vice versa. Plastics, utilities, drugs, and computing machines showed increases for both final consumption and intermediate consumption, whereas such industries as coal, wooden containers, and leather products were of declining importance for both consumption and production.

INTRODUCTION*

Here we examine changes in industry outputs in the United States between 1947 and 1966, specifically, for the subperiods 1947–58, 1958–63, and 1963–66. For each of these subperiods, we disaggregate output changes into those due to changes in input–output coefficients and those due to changes in final demand. We then compare our results to those obtained by Reiner Staglin and Hans Wessels for the West German economy for the period 1958–62. Section I describes the methodology and data base utilized here and discusses some conceptual problems dealing with base year prices and index numbers. Section II analyzes structural change in the U.S. for the periods 1947–58, 1958–63, and 1963–66. Section III compares our results with those obtained by Staglin and Wessels, and Section IV presents some general conclusions resulting from this study.

I. METHODOLOGY, DATA BASE AND SOME CONCEPTUAL PROBLEMS

In the static open interindustry model, which we utilize here, changes in final demand are exogenous to the system and arise from causes such as changes in the level and composition of personal consumption expenditures, changes in investment spending, shifts in government programs, etc. Changes in final demand induce changes in industry outputs, but changes in output requirements can also come about due to changes in input–output coefficients. These latter changes are often referred to as technological changes. However, while technological change is an important cause of changes in input–output coefficients, interindustry coefficients can change for many reasons having little or nothing to do with technological change. Coefficient change can result from, for example, changes in product mix, divergence of actual technical relationships from a linear–

*The authors are grateful to Constance Dunham for assistance with the computer programming involved in this study and to Beatrice N. Vaccara, Philip M. Ritz and an anonymous referee for helpful comments on a previous draft of this paper, but retain sole responsibility for the opinions expressed here and for any errors. This work was supported by the Federal Government's Interagency Economic Growth Project.

homogenous production function and the proportional relationship between changes in inputs and outputs which it assumes, the aggregation scheme employed in the input–output industry classification, statistical and methodological conventions used in preparing the input–output table, the methods used to handle secondary products and competitive imports, and changes in the relative prices of inputs and outputs.[1] Here we work with domestic base constant dollar data to minimize the effects on coefficient stability of the last two factors. Nevertheless, we do not identify coefficient change exclusively with technological change and instead refer to changes in interindustry relationships as structural change. This structural change may result from the factors mentioned above as well as from actual technological change.

We wish to factor the change in total industry outputs for the periods 1947–58, 1958–63, and 1963–66 into that caused by changes in input–output coefficients and that caused by changes in final demand. Because of the index number problems involved, our measures of change are averages of the Paasche and Laspeyres indexes. Using the following notation:

$(I-A_i)^{-1}$: the 80-order domestic base constant (1958) dollar input-output inverse matrix for year i.

Y_j: the 80-order domestic base constant dollar final demand vector for year j, where $j>i$.

X_i: the 80-order domestic base constant dollar gross output vector for year i.

X_j: the 80-order domestic base constant dollar gross output vector for year j,

we first derive the vector of differences between gross outputs for years i and j, X_d:

$$X_j - X_i = X_d. \tag{1}$$

We then derive the output requirements, X_1, which would have existed if the interindustry relationships of year i had been combined with the final demand of year j:

$$(I-A_i)^{-1} Y_j = X_1. \tag{2}$$

By subtracting X_i from X_1, we obtain a measure of the differences in output requirements between years i and j, X_{1df}, due solely to changes in final demand:

$$X_1 - X_i = X_{1df}. \tag{3}$$

By subtracting X_1 from X_j, we obtain a measure of differences in output requirements between years i and j, X_{1dc}, due to changes in input–output coefficients:

$$X_j - X_1 = X_{1dc}. \tag{4}$$

The estimates X_{1df} and X_{1dc} are essentially Paasche measures of the differences in industry outputs attributable to changes in final demand and to changes in

[1]See Vaccara [10], pp. 8–11.

coefficients, for they employ coefficients from an earlier year with final demand weights from a later year. The Laspeyres measure of output change induced by changes in final demand is derived by first computing the output requirements, X_2, which would have existed if the interindustry relationships of year j had been combined with the final demands of year i:

$$(I - A_j)^{-1} Y_i = X_2. \tag{5}$$

The Laspeyres measure of output changes between years i and j due solely to changes in final demand, X_{2df}, is derived by subtracting X_2 from X_j:

$$X_j - X_2 = X_{2df}. \tag{6}$$

The Laspeyres measure of output changes between years i and j due solely to changes in coefficients, X_{2dc}, is derived by subtracting X_i from X_2:

$$X_2 - X_i = X_{2dc}. \tag{7}$$

While the total change in output over the period would be identical according to either measure, the portions of that total attributed to changing final demand and to changing interindustry coefficients would not necessarily be the same in each case.[2] In our empirical work, we found that this was indeed the case for most industries in all three time periods, although the differences between the Paasche and the Laspeyres estimates were usually not significant.[3] In our study, we used the average indices of output change for each industry between years i and j due to changes in final demand, F, and to changes in input–output coefficients, C:

$$\frac{\frac{1}{2}(X_{a\,1df} + X_{a\,2df}) + X_{ai}}{X_{ai}} = F_a, \qquad a = 1, 2, 3, \ldots 79 \tag{8}$$

$$\frac{\frac{1}{2}(X_{a\,1dc} + X_{a\,2dc}) + X_{ai}}{X_{ai}} = C_a, \qquad a = 1, 2, 3, \ldots 79 \tag{9}$$

We factored the changes in industry gross output requirements for the periods 1947–58, 1958–63, and 1963–66 into those caused by changes in final demand and those caused by changes in interindustry coefficients. For our study, we required consistent constant (1958) dollar input–output inverse matrices, final demand vectors and gross output vectors for 1947, 1958, and 1966. For all years, we worked with domestic base data so as to eliminate any distortions which might have been caused by transferred imports.

The 1947 input–output study was conducted in the early 1950's by the Bureau of Labor Statistics, but the 1947 interindustry data were later extensively

[2]The reason for this discrepancy is the interaction effect which "... occurs whenever one attempts to factor out 'causes of change' when alternative weighting schemes are available." See Vaccara and Simon [11], p. 25 and Fromm [4], pp. 65–67.

[3]Another difficulty arises with respect to the base year prices which are used. Here we used 1958 base year prices because constant dollar data in 1958 prices were available for all the years in question. Theoretically, though, we could have just as well used 1947, 1963, or 1966 prices, had such data been available. The results derived here using 1958 price weights would not necessarily agree precisely with those which would be obtained using those of a different base year (see Fromm, *Ibid.*). However, the only results available on this topic suggest that a change in the base year prices used may not have a very significant effect on the specific results derived. Beatrice Vaccara examined structural change in the American economy between 1947 and 1958 and found that the results obtained using data in 1958 prices did not differ significantly from those derived using 1947 prices; see Vaccara [9] and [10].

reworked and converted to constant (1958) prices by Bureau of Economic Analysis staff to integrate them into the National Income and Product Accounts and to make them conceptually and statistically consistent with the later BEA interindustry studies.[4] The 1958 data utilized here were modified versions of the 1958 input–output data published in 1964.[5] The 1963 input–output study was published in current dollars and was deflated to 1958 prices by BEA staff in 1973–74. The 1966 interindustry update study was published in current dollars in 1972 and was deflated to 1958 prices by BEA staff in 1974.[6] The 1947 and 1958 data were modified to adhere to the concepts and conventions followed in the 1963 and 1966 interindustry studies.[7]

This study complements previous research on structural change in the American economy conducted by Beatrice Vaccara and Anne Carter. Vaccara has reported the results of several studies on postwar structural change in the American economy and has used techniques similar to those employed here to analyze structural change between 1947 and 1964.[8] However, in this latter study she used preliminary data at a higher level of aggregation and focused on changes in real product by industry. Although Carter has made an exhaustive analysis of many aspects of changes in input–output relationships, she has made no attempt to factor the changes into those due to changes in coefficients and those due to changes in final demand.[9]

II. Disaggregation of Changes in Gross Domestic Industry Output Requirements between 1947 and 1966

II.1. *Changes in Output Requirements, 1947 to 1958*

Table 1 shows the total changes in gross domestic output requirements by industry between 1947 and 1966.[10] Between 1947 and 1958, final demands for these industries increased 40 percent, by $114 billion from $288 billion to $402 billion. This represents an average annual rate of increase of 3.1 percent. Over this same period, gross domestic output requirements from these industries increased 42 percent, by $242 billion from $579 billion to $821 billion. There was a wide range among industries in the distribution of changes in output requirements, with output increasing in 64 industries and decreasing in 10 industries. The largest relative increases in output occurred in Aircraft and ordnance (60, 13), Communications and electronic equipment (56, 57), and Radio and TV broad-

[4]See [7].

[5]The original 1958 data are given in [5]. The modifications made in these data were confined to the final demand vector.

[6]See [8] and Bezdek, Frazier and Wendling [2].

[7]The differences in conventions between the 1958 and 1963 input–output studies related to the handling of research and development activities, warehousing margins, the Commodity Credit Corporation, scrap and byproducts and imported motor vehicles. The modifications made here were confined to the final demand vector.

[8]See Vaccara and Simon [11].

[9]Carter's research is detailed in [3].

[10]Because of differences in the 1947 and 1958 industry classification schemes, the following industries have been combined: 13 and 60; 16, 17 and 19; 24 and 25; 56 and 57. We have excluded from analysis here dummy industries as well as those industries representing only compensation.

casting (67), while the largest relative decreases in output occurred in Coal mining (7), Wooden containers (21), and Special industry machines (48).

Table 2 factors the industry output changes into those caused by changes in input–output coefficients and those caused by changes in final demand. This table indicates that the rising level of final demand between 1947 and 1958 did not affect all industries to the same extent, for there was a range of 142 points in the final demand indexes for individual industries.[11] This range is, however, considerably smaller than the range of 222 index points for total outputs in Table 1. Thus, if only final demand had changed between 1947 and 1958 while the input–output coefficients had remained constant, there would have been a substantial narrowing of the extent to which indexes of output change for individual industries differed from the average index. From columns 1 and 3 of Table 2, it is clear that gross domestic output within 36 industries would have increased more between 1947 and 1958 if only final demand had changed over this period and the coefficients had remained constant. The other 36 industries show lower final demand change than total change. There were only 6 industries where the change in output attributable to changes in coefficients exceeded the total change.

Columns 2 and 4 of Table 2 show the change in industry output requirements between 1947 and 1958 attributable solely to change in input–output coefficients. Within column 2, there is a wide range of variation in the individual entries, with the number of indexes greater than 100 being about two-thirds larger than the number of indexes less than 100. The indexes given in column 2 show what the 1958 indexes of industry output change (1947 = 100) would have been had there been no change in final demand during the period but only a change in interindustry relationships. An index of 100 indicates that there was a neutral effect of structural change, an index of under 100 indicates that there was a decline between 1947 and 1958 in the output of a given industry that would be required to produce a specified final demand bill of goods, and an index greater than 100 indicates an increase between 1947 and 1958 in the output requirements from the industry to produce a given vector of final demand.

Table 2 shows that the greatest positive impact of coefficient change occurred in Radio and TV broadcasting (67), Plastics and synthetic materials (28) and Machine shop products (50) where the increases in output over the period due to coefficient change were, respectively, 121 percent, 99 percent and 73 percent. The largest negative impacts on output requirements occurred in the Wooden container industry (21), Coal mining (7) and Agricultural services (4) where the declines in gross domestic output requirements due solely to changes in coefficients were, respectively, 44 percent, 34 percent and 33 percent.

Finally, it should be noted from Tables 1 and 2 that in most cases the individual industry indexes of output change which reflect changes in both final demand and input–output coefficients vary from the average index to a greater extent than do either of the corresponding indexes which reflect only changes in final demand or structural coefficients. This implies that, in general, the two elements of change in industry output requirements reinforced rather than offset one another between 1947 and 1958. This is especially true of the extremes in the array of indexes of total change in gross output. The industries with the largest increase in final demand are generally those with the largest increase in technical

[11]Ignoring Aircraft and ordnance.

TABLE 1

CHANGES IN U.S. DOMESTIC OUTPUT BY INDUSTRY, 1947–66

(dollar figures in millions)

Industry No. and Title	Domestic Output (1958 prices)				Index of Output Change		
	1947	1958	1963	1966	1947–58	1958–63	1963–66
1 Livestock and livestock products	21,406	26,291	30,324	31,707	122	116	105
2 Other agricultural products	19,143	23,787	26,001	25,911	120	113	100
3 Forestry and fishery products	833	1,150	1,069	1,301	138	93	122
4 Ag., forestry and fishery services	1,577	1,596	1,693	1,708	99	108	101
5 Iron and ferroalloy ores mining	924	799	939	1,175	86	118	125
6 Nonferrous metal ores mining	737	1,034	1,211	1,263	140	117	104
7 Coal mining	4,544	2,753	2,708	3,084	60	99	114
8 Crude petroleum and natural gas	6,635	9,704	10,806	12,237	146	112	113
9 Stone and clay mining and quarrying	708	1,512	1,835	2,102	213	122	115
10 Chemical and fertilizer mineral mining	314	486	584	761	154	121	130
11 New construction	29,591	52,418	60,211	64,730	177	115	108
12 Maintenance and repair construction	14,685	16,919	18,196	18,641	115	108	102
14 Food and kindred products	48,081	64,270	73,829	81,016	133	115	110
15 Tobacco manufactures	5,239	5,921	7,176	7,316	113	121	102
18 Apparel	10,166	14,264	17,702	20,322	140	124	115
16 Fabrics, yarn and thread mill 17 Misc. textiles and floor coverings 19 Misc. fabricated textile products	12,560	15,089	18,755	22,639	120	124	121
20 Lumber and wood prod., ex. containers	7,122	7,926	9,679	10,498	111	122	109
21 Wooden containers	715	449	417	501	62	94	120
22 Household furniture	2,427	3,300	3,864	4,665	136	117	121
23 Other furniture and fixtures	1,205	1,494	1,864	2,407	124	125	129
24 Paper and allied prod., ex. containers 25 Paperboard containers and boxes	8,798	13,108	16,838	20,200	149	128	120
26 Printing and publishing	9,758	12,593	14,723	16,985	128	118	115
27 Chemicals and selected chemical products	5,809	11,822	17,208	21,985	202	146	128
28 Plastics and synthetic materials	1,730	4,231	7,097	10,368	244	168	146
29 Drugs, cleaning and toilet preparations	3,020	6,592	9,206	11,668	218	140	127
30 Paints and allied products	1,649	1,877	2,416	2,804	114	129	116
31 Petroleum refining and related industries	10,538	17,403	20,860	23,505	165	120	113
32 Rubber and misc. plastic products	5,040	6,837	10,903	14,324	136	159	131
33 Leather tanning and ind. leather products	1,037	880	842	869	85	96	103
34 Footwear and other leather products	3,049	3,105	3,123	3,440	102	101	110
35 Glass and glass products	1,980	2,150	2,899	3,563	108	135	123

39 Metal containers	1,513	2,106	2,365	2,802	139	113	119
40 Heating, plumb. and struc. metal products	5,523	8,038	9,213	11,590	145	115	126
41 Stampings, screw mach. prod. and bolts	3,883	3,689	4,506	6,089	95	122	135
42 Other fabricated metal products	4,719	6,444	8,527	11,065	136	133	130
43 Engines and turbines	1,669	2,204	2,429	3,320	132	111	137
44 Farm machinery and equipment	2,366	2,449	2,703	3,883	103	111	144
45 Construc., mining and oil field machinery	3,092	3,086	3,746	5,098	100	121	136
46 Materials handling mach. and equipment	1,122	1,082	1,523	2,290	96	141	150
47 Metalworking machinery and equipment	3,404	3,635	4,577	6,744	107	126	147
48 Special industry machinery and equipment	3,317	2,510	3,334	4,736	76	133	142
49 General industrial mach. and equipment	3,413	3,749	5,129	7,118	110	137	139
50 Machine shop products	703	1,591	2,220	2,856	226	140	129
51 Office, computing and accounting machinery	917	2,225	3,718	6,736	242	168	181
52 Service industry machines	1,637	2,248	3,735	5,526	137	166	148
53 Electrical industrial equip. and apparatus	4,026	5,113	6,708	9,740	127	131	145
54 Household appliances	2,833	3,601	5,087	6,477	127	141	127
55 Electric lighting and wiring equipment	1,899	2,290	2,902	3,697	120	127	127
56 Radio, TV and comm. equipment 57 Electronic components and acc.	3,714	8,685	17,448	25,648	273	201	147
58 Misc. electrical machinery and equipment	1,413	1,536	2,152	2,713	108	140	126
59 Motor vehicles and equipment	19,035	22,781	39,800	49,110	120	175	123
60, 13 Aircraft and ordnance	2,748	17,455	19,826	24,200	631	114	122
61 Other transportation equipment	4,077	3,722	4,765	7,230	91	128	152
62 Scientific and controlling instruments	2,018	3,506	4,038	5,127	173	115	127
63 Optical, ophthalmic and photo. equipment	892	1,546	2,263	3,671	173	147	162
64 Miscellaneous manufacturing	3,959	5,278	6,552	7,856	133	124	120
65 Transportation and warehousing	34,187	33,594	36,095	42,927	98	108	119
66 Communications, ex. radio and TV broad.	4,383	9,313	12,881	16,629	212	139	129
67 Radio and television broadcasting	549	1,575	2,028	2,551	282	131	126
68 Electric, gas, water and sanitary service	8,465	20,281	27,483	32,643	239	136	119
69 Wholesale and retail trade	64,778	95,417	112,103	134,004	147	118	120
70 Finance and insurance	18,059	26,500	28,907	33,278	147	109	115
71 Real estate and rental	36,323	62,037	77,924	90,863	171	126	117
72 Hotels, pers. and repair ser., ex. auto	10,404	12,199	13,965	15,824	117	115	113
73 Business services	13,179	24,864	31,518	39,556	185	129	126
75 Automobile repair and services	5,924	7,929	9,980	11,221	134	126	112
76 Amusements	5,375	5,627	6,445	6,947	105	115	108
77 Medical, educ. serv. and nonprofit org.	13,142	22,723	28,689	33,497	173	126	117
78 Federal government enterprises	2,643	4,120	4,982	5,358	155	121	108
79 State and local government enterprises	2,797	4,796	6,558	8,034	171	137	123
Total	578,772	821,389	1,009,450	1,200,163	142	123	119

TABLE 2

CHANGES IN U.S. DOMESTIC OUTPUT BY INDUSTRY 1947–66, FACTORED BY CAUSE OF CHANGE

Industry Number	1947–58 Index of Output Changes		1947–58 Index Rank		1958–63 Index of Output Changes		1958–63 Index Rank		1963–66 Index of Output Changes		1963–66 Index Rank	
	Due to Final Demand Change	Due to Coeffi-cient Change	Final Demand Change	Coeffi-cient Change	Due to Final Demand Change	Due to Coeffi-cient Change	Final Demand Change	Coeffi-cient Change	Due to Final Demand Change	Due to Coeffi-cient Change	Final Demand Change	Coeffi-cient Change
1	134	88	34	60	112	103	68	23	110	95	77	65
2	130	90	38	58	111	99	69	42	104	96	73	61
3	115	122	56	13	121	72	45	72	126	96	29	57
4	133	67	35	71	113	94	67	63	106	95	71	63
5	91	95	72	51	137	81	10	70	119	106	49	9
6	155	85	16	66	145	72	4	73	111	93	65	68
7	94	66	69	72	113	85	65	69	115	99	55	49
8	149	97	22	46	115	96	59	53	121	92	38	70
9	182	131	5	11	118	104	54	20	113	101	61	30
10	128	126	41	12	119	101	50	29	128	103	20	23
11	177	100	7	37	115	100	60	37	108	100	69	41
12	146	69	26	70	117	91	56	65	115	88	60	73
14	129	104	40	30	115	100	61	35	112	98	64	54
15	121	92	50	55	114	107	62	15	104	98	72	53
18	122	110	48	23	122	102	42	25	115	100	59	39
16, 17, 19	108	112	61	21	95	129	73	2	122	99	36	48
20	126	86	46	65	118	104	53	19	120	88	43	71
21	107	56	63	73	120	73	49	71	119	101	50	32
22	138	98	31	42	121	96	44	55	123	98	34	51
23	132	92	36	56	131	94	16	62	129	101	17	36
24, 25	142	106	29	26	129	99	24	39	122	99	37	50
26	131	97	37	47	126	91	37	64	121	94	39	67
27	159	143	14	8	130	116	20	5	123	105	33	15
28	145	199	27	2	129	139	27	1	126	120	25	1
29	198	120	3	14	139	101	7	31	126	101	28	34
30	126	87	45	62	125	103	38	22	120	96	45	56
31	163	101	12	35	114	106	63	17	117	96	53	60
32	123	113	47	20	139	121	8	4	127	105	21	14
33	99	86	68	64	105	91	71	66	111	93	66	69

37	116	75	54	69	126	98	35	43	126	102	24	27
38	134	87	33	63	127	111	31	8	122	110	35	4
39	129	110	39	24	116	96	57	54	115	104	58	18
40	147	98	25	41	116	99	58	41	115	111	57	3
41	116	79	55	68	135	87	11	68	132	103	15	19
42	127	109	42	25	129	103	21	24	126	104	27	17
43	138	94	32	53	108	102	70	26	132	105	14	13
44	99	104	67	31	114	97	64	51	142	101	5	28
45	104	96	65	49	126	96	35	56	135	102	12	26
46	104	92	64	54	128	113	28	6	143	107	4	8
47	108	99	62	39	130	96	18	57	138	109	8	7
48	79	97	73	45	129	104	22	21	140	102	6	25
49	114	96	57	50	129	108	26	11	136	103	11	20
50	153	173	18	3	133	106	13	16	134	95	13	64
51	178	164	6	4	168	99	3	40	161	120	1	2
52	138	99	30	38	141	125	5	3	138	110	9	5
53	113	114	59	18	133	98	14	43	140	105	7	12
54	116	111	53	22	130	111	19	9	127	101	23	35
55	122	98	49	40	126	101	36	28	124	103	30	22
56, 57	221	152	2	5	191	109	1	10	137	110	10	6
58	118	90	52	59	140	101	6	32	132	95	16	66
59	119	101	51	36	174	100	2	34	128	96	19	62
60, 13	588	143	1	7	118	95	52	58	126	96	26	59
61	94	98	70	44	131	97	17	46	151	101	3	31
62	153	120	17	15	120	95	47	59	127	100	22	37
63	157	116	15	17	134	112	12	7	158	104	2	16
64	127	106	43	27	124	100	41	36	123	97	32	55
65	110	88	60	61	113	95	66	60	120	99	46	43
66	177	135	8	10	131	107	15	14	128	101	18	29
67	162	221	13	1	128	101	29	30	121	105	40	11
68	194	145	4	6	128	108	30	12	120	99	47	45
69	143	105	28	28	120	98	48	44	120	99	42	44
70	149	98	23	43	122	87	43	67	119	96	51	58
71	166	104	11	29	124	102	40	27	118	99	52	47
72	127	91	44	57	118	97	55	50	115	98	56	52
73	149	137	24	9	126	101	34	33	121	105	41	10
75	149	85	21	67	129	97	25	48	113	99	62	46
76	91	114	71	19	120	94	46	61	107	101	70	33
77	177	96	9	48	127	100	32	38	117	100	54	40
78	152	103	19	32	123	97	39	52	120	88	48	72
79	170	101	10	34	129	107	23	13	120	103	44	24
Total	141	100			123	100			119	100		

coefficients, and, similarly, those industries with the smallest increase in final demand are generally those which also show a negative influence of coefficient change.

II.2. *Changes in Output Requirements, 1958 to 1963*

Between 1958 and 1963, final demands for these industries rose 25 percent, by $102 billion from $402 billion to $504 billion, for an average annual rate of increase of 4.6 percent. Thus, the average annual rate of increase in final demand between 1958 and 1963 was somewhat above that between 1947 and 1958. Table 2 indicates that over this period gross output requirements rose 23 percent, by $188 billion from $821 billion to $1,009 billion. Once again, there was wide variation in the degree of output change among industries, with the largest percent increases in output occurring in Communications equipment and electronic components (56, 57), Motor vehicles and equipment (59) and Office and computing machines (51). Gross domestic output decreased in only four industries—Forestry and fishery products (3), Coal mining (7), Wooden containers (21) and Leather tanning (33)—and in each case decrease was relatively small.

The highly varied effects of the rising level of final demand between 1958 and 1963 are revealed by columns 5 and 7 of Table 2. The changes in the final demand indexes ranged from a high of 191 for Communications equipment and electronic components (56, 57) to a low of 95 for Textiles (16, 17, 19). This range of 96 index points is smaller than the range of 108 index points given in column 6 of Table 1, and for 1958–63 if only final demand had changed there would have been a narrowing of the extent to which indexes of output change for individual industries differed from the average index. Changing structural coefficients over this period thus tended to increase the variability of the industry indexes of output change.

Columns 6 and 8 of Table 2 indicate that the influence of coefficient change also varied widely among industries. The number of industries within which coefficient change tended to decrease output requirements was about equal to the number of industries where coefficient change tended to increase requirements. The largest negative impact of coefficient change on output requirements occurred in industry 6, Nonferrous metal ores mining (28 percent), industry 3, Forestry and fishery products (28 percent), and industry 21, Wooden containers (27 percent). The largest positive impacts of coefficient change on output requirements were experienced by industry 28, Plastics (39 percent), industry (16, 17, 19), Textiles (29 percent), and industry 52, Service industry machines (25 percent).

In most cases, the individual industry indexes of output change (reflecting changes in both final demand and input–output coefficients) varied from the average index to a greater extent than did either the final demand or the coefficient indexes (reflecting only changes in final demand or changes in input–output coefficients). This implies that between 1958 and 1963 the two elements of change in output reinforced rather than offset one another.

II.3. *Changes in Output Requirements, 1963 to 1966*

Between 1963 and 1966, final demand for these industries rose 20 percent, from $504 billion to $602 billion, for an average annual rate of increase of 6.1 percent. The average annual rate of increase in final demand between 1963 and 1966 was thus substantially above that which took place between either 1947 and 1958 or between 1958 and 1963. Gross domestic output requirements rose 19 percent, by $191 billion from $1,009 billion to $1,200 billion. As was true for the two earlier periods, between 1963 and 1966 there was wide divergence in the degree of output changes among industries. Between 1963 and 1966, gross output increased in every industry, with the largest percent increases occurring in industry 51, Office computing and accounting machines (81 percent), industry 63, Optical, ophthalmic and photographic equipment and supplies (62 percent), and industry 61, Other transportation equipment (52 percent).

The changes in the final demand indexes over this three year period varied from a high of 161 for Office computing and accounting machines (51) to a low of 105 for Tobacco manufactures (15) and for Miscellaneous agricultural products (2). This range of 36 index points was smaller than the range of 81 index points given in column 7 of Table 1, and if only final demand had changed between 1963 and 1966, there would again have been a narrowing of the extent to which indexes of output change for individual industries differed from the average index. The effect of changing input–output coefficients over this period tended to increase the variability of the actual industry indexes of gross output change.

Columns 10 and 12 of Table 2 indicate that the effect of coefficient change on industry output requirements differed appreciably among industries between 1963 and 1966, with coefficient changes tending to decrease output requirements in 31 industries and increase them in 35 industries. The largest negative impacts of coefficient change on output requirements took place in industry 78, Federal Government enterprises (12 percent), industry 12, Maintenance and repair construction (12 percent), and industry 20, Lumber and wood products (12 percent). The largest positive impacts of coefficient change on industry output requirements occurred in industry 28, Plastics and synthetic materials (20 percent), industry 51, Office, computing and accounting machines (20 percent), and industry 40, Heating and plumbing products (11 percent). As was the case for the two earlier periods, for most industries the individual indexes of output change varied from the average index to a larger degree than did either the final demand index or the coefficient index. Thus, during this period the two elements of output change again reinforced rather than offset one another.

II.4. *Analysis of Structural Change Between 1947 and 1966*

From the preceding discussion, it is clear that between 1947 and 1966 increases in final demand and in gross domestic output were dramatic, although all industries did not share equally in the expansion. During the subperiod 1947–58, the output of 12 industries declined, between 1958 and 1963 the output of 4 industries declined, while between 1963 and 1966 the output of every industry increased. The rate of output expansion clearly increased in the period 1963–66 and this was reflected in increases in the output of every industry.

The rapidly rising level of final demand between 1947 and 1966 did not affect all industries the same, and in each subperiod there was a wide range of variation in the final demand indexes for individual industries. Between 1947 and 1958, changes in final demand had the effect of reducing the output requirements for five industries, while in the two later subperiods final demand changes increased output requirements in every industry. In each subperiod, the range of final demand index points was smaller than the range of total output index points. Thus, if only final demand had changed while the structural coefficients remained constant, there would have been a considerable narrowing of the extent to which indexes of output change for individual industries differed from the average.

As was the case with final demand, in each subperiod there was a wide variation in the degree to which the outputs of individual industries were affected by changes in input–output coefficients. Between 1947 and 1958, changing interindustry coefficients increased output requirements in 36 industries and decreased them in 36 industries, between 1958 and 1963 coefficient change increased the output requirements in 33 industries and decreased them in 35 industries, while between 1963 and 1966 coefficient change increased the output requirements in 36 industries and decreased them in 31 industries.[12]

It is important to identify those industries experiencing the highest and the lowest overall rate of growth in output between 1947 and 1966 and to discuss the factors which may have caused these changes. We wish to determine if there are broad, easily discernible trends in structural change which have occurred throughout the postwar period, to analyze the role played by technological change and specialization, and to distinguish the influence of changes in intermediate output requirements from that of changes in final demand.

Table 3 lists the industries which experienced the highest and the lowest rates of growth in output between 1947 and 1966. We previously noted the tendency for changes in coefficients and changes in final demand to reinforce one another, and this is illustrated clearly in Table 3. For virtually every industry in which the output increased the most rapidly, the effect of both final demand changes and coefficient changes was to increase output requirements, while the opposite is true for the industries in which output decreased or increased the least.[13] While the relationship between increases in final demand and increases in gross output requirements is clear, it may initially appear surprising that the effect of coefficient changes in such high growth industries as Plastics and Communications equipment and electronic components would also be to increase output requirements. For to the extent that structural change represents technological change (progress), how can more inputs be required to produce the same deliveries to final demand with a more recent set of input–output coefficients? This phenomenon can be explained by both an increase in specialization, where establishments tend to use more intermediate inputs and fewer primary inputs as the economy develops, and the effect of substitution, where certain types of intermediate inputs are substituted for others.[14]

[12]For the period 1947–58 there was one industry with a coefficient index equal to 100; for the period 1958–63, there were 5 industries with coefficient indexes equal to 100; for the period 1963–66, there were 6 industries with coefficient indexes equal to 100.

[13]The only significant exceptions were the coefficient indexes for Aircraft and ordnance and for Amusements, both of which industries delivered most of their output to final demand.

[14]See the discussion in Carter [3], pp. 36–37.

TABLE 3

INDUSTRIES EXPERIENCING THE LARGEST AND SMALLEST CHANGES IN GROSS OUTPUTS BETWEEN 1947 AND 1966

Industry	Output Change (Percent)	Final Demand Index	Coefficient Index
Largest Output Increases			
28 Plastics and synthetic materials	+499.3	AA[a]	AA
29 Drugs, cleaning and toilet preparations	+286.4	AA	AA
50 Machine shop products	+306.3	AA	AA
51 Office, computing and accounting machines	+634.9	AA	AA
52 Service industry machines	+237.6	AA	AA
56, 57 Communications equipment and electronic components	+708.1	AA	AA
60, 13 Aircraft and ordnance	+780.9	AA	BA[b]
63 Optical, ophthalmic and photographic equipment	+312.4	AA	AA
67 Radio and television broadcasting	+365.2	AA	AA
68 Utilities	+285.7	AA	AA
Smallest Output Increases			
1 Livestock	+48.1	BA	BA
2 Other agricultural products	+35.4	BA	BA
4 Agricultural, forestry and fisheries services	+8.3	BA	BA
7 Coal mining	−32.1	BA	BA
12 Maintenance and repair construction	+26.9	BA	BA
21 Wooden containers	−29.9	BA	BA
33 Industrial leather products	−16.2	BA	BA
34 Footwear and other leather products	+12.8	BA	BA
65 Transportation and warehousing	+25.6	BA	BA
76 Amusements	+29.3	BA	AA

[a]AA: Industry index above overall average.
[b]BA: Industry index below overall average.

Of the industries experiencing the highest rates of growth, Drugs and cleaning preparations, Office and computing machines, and Aircraft and ordnance delivered between 70 and 80 percent of their output to final demand. The postwar increase in the Drug industry output was due primarily to rapidly rising consumer expenditures on these products, the increase in the gross outputs of the Office and computing machines industry was due to the rapid postwar increase in the use of computers and related machines, while the increase in the output of the Aircraft and ordnance industry (which experienced the highest rate of output growth in the economy) was due to the rapid increase in government purchases resulting from the cold war and the wars in Korea and Vietnam.

The Machine shop products industry and the Broadcasting industry deliver practically all of their output to intermediate demand, while the remaining industries in the upper portion of Table 3 deliver about half of their output to final demand and half to intermediate demand. The increase in the intermediate use of Machine shop products was due to the specialization and substitution factors mentioned above, while the increase in the output of the Broadcasting industry reflects primarily the growth of television advertising as an intermediate input in

the postwar period. The increase in the outputs of remaining industries in the upper portion of Table 3, Plastics, Service industry machines, Communications equipment and electronic components, Optical equipment, and Utilities, occurred as a result of both increased intermediate and final demand requirements. This latter point is especially significant to note for the Utilities industry, and indicates that the rapid postwar increase in energy consumption resulted from increased energy use in intermediate production as well as by consumers. Industries not listed in Table 3 because they did not experience exceptionally large increases in total output but which nevertheless had coefficient change indexes greater than 100 in each subperiod (and also delivered a substantial portion of their output to intermediate demand) include Chemical and fertilizer mining (10), Chemicals (27), Rubber and miscellaneous plastics products (32), Stone and clay products (36), Other fabricated metal products (42), Communications (66), and Business services (73). These industries should thus also be viewed as those which, due to the technological and structural changes which occurred between 1947 and 1966, came to be increasingly required as intermediate inputs.

It is also interesting to examine the industries listed in the lower portion of Table 3 in which gross output increased the least between 1947 and 1966. Except for Footwear and other leather products and Amusements, which sell primarily to final demand and whose slowly growing output is traceable largely to the slow rate of growth in consumer expenditures on these types of products, these industries deliver most of their output to intermediate demand. The consistent decline in the intermediate use of the outputs of these industries—coefficient indexes less than 100—can be ascribed to technological change represented by intermediate substitution away from the products of these industries in favor of the products produced by other industries. Thus, the decline in the intermediate use of Wooden containers resulted from the substitution of plastic and paper packaging materials for wooden ones, while the decrease in intermediate use of output from the agricultural and the leather products industries stems largely from the replacement of organic products by synthetic materials. The consistent decrease in the use of coal as an intermediate input reflects the postwar trend in declining use of coal as both an industrial and residential fuel. Industries not listed in Table 3 but which also consistently showed coefficient change indexes less than 100 include Nonferrous metal ores mining (6), Crude petroleum and natural gas (8), Printing and publishing (26), Finance and insurance (70), and Automobile repair services (75).

III. Comparison with the Staglin–Wessels Results

In 1972, Reiner Staglin and Hans Wessels utilized similar techniques to analyze structural change in the West German economy for the periods 1954–58 and 1958–62 within an interindustry scheme composed of 56 industries.[15] Although there are some difficulties involved in making an intercountry comparison of structural change, such as differences in industry definitions and in price deflation techniques, they made a preliminary comparison of their results with those obtained by Anne Carter for 1947–58 and 1958–61 for the U.S. economy.[16]

[15]Staglin and Wessels [6].

[16]Carter's results are discussed in [3].

They aggregated the U.S. and the West German industries to five industry groups and compared the intermediate output levels required to deliver 1962 final demand with 1954, 1958, and 1962 technology in Germany and the intermediate output requirements for delivering 1961 final demand with 1947, 1958, and 1961 technology in the U.S. Their comparison indicated a "... surprising correspondence in intermediate output requirements for Germany and the U.S."[17]

However, there are several problems with the Staglin–Wessels comparison. One difficulty is that the combination of some industries within such an aggregate sectoral breakdown is inherently subjective. Secondly, the five industry breakdown used by these authors in their comparison was probably too broad to be more than marginally useful. Finally, within any single industry the inputs delivered to different industries often serve different functions and it is impossible to classify most industries exclusively into any single category.[18]

Here we wished to test the hypothesis that structural change in the West German and American economies has been similar in the postwar period. We compared the results of our disaggregation of structural change for the period 1958–63 in the U.S. with the Staglin–Wessels results for Germany between 1958 and 1962 at a detailed industry level. Working with the published Staglin–Wessels findings for 1958–62 and with our results for 1958–63 given in Table 2, we aggregated the 56 West German industries and the 79 U.S. industries into 35 consistent industries. For these data, we computed the same measures of output changes given in Tables 1 and 2 and compared the final demand and the coefficient change indexes of the West German industries and the U.S. industries.[19] This comparison is shown in Table 4. In analyzing the data in Table 4, we found that there was a statistically significant rank order correlation between the final demand indexes but not between the coefficient indexes.[20] Thus, while the relative importance of changes in final demand in generating changes in gross output requirements was similar in the two economies, the relative impact of changes in input–output coefficients apparently was not.

The similarity of the effects of changes in final demand in generating changes in gross output requirements in the two economies is not surprising. First of all, many of the industries in the two countries sell to world markets and would thus be expected to show broadly similar industrial responses to worldwide demands. Of

[17]Staglin and Wessels [6], p. 391.

[18]For example, under the Staglin–Wessels classification, the output of the Coal mining industry is classified as a General industries (energy) input, which it is in most cases. However, practically all of the coal input into the Chemicals industry (27) goes into the production of Industrial organic and inorganic chemicals (SIC 281 except 28195) and this cell should more properly be regarded as a materials input rather than as a general input. Another example is that under their classification the output of the Glass industry (35) is classified under Materials inputs. However, in a number of industries the requirements from the Glass industry represent primarily requirements for Glass containers (SIC 3221) and for these industries glass serves more as a packaging input than as a basic materials input. These examples could be repeated for most industries and they illustrate the difficulty of classifying the entire output of any single industry into one exclusive broad category. This problem is discussed further in Bezdek and Dunham [2].

[19]These measures were computed according to the Laspeyres formula (6), as this was the technique used by Staglin and Wessels.

[20]The Spearman rank-order correlation coefficient of 0.312 for columns 1 and 2 of Table 3 was significant at $p = 0.05$; the coefficient of 0.113 for columns 3 and 4 of this table was not statistically significant.

TABLE 4

COMPARISON OF CAUSES OF CHANGE IN OUTPUTS IN U.S. AND WEST GERMAN ECONOMIES*

Reconciled Industry Number and Title	Rank of Final Demand Index		Rank of Coefficient Index	
	German	U.S.	German	U.S.
1 Agriculture, forestry and fishing	32	34	30	19
2 Electricity, gas and water	11	13	27	4
3 Coal mining	34	29	34	34
4 Iron ore mining	33	4	35	35
5 Petroleum and natural gas extraction	7	28	19	27
6 Mining, n.e.c.	5	11	4	31
7 Stone and clay products	13	24	7	10
8 Iron and steel manufacturing	20	15	26	25
9 Non-ferrous metals manufacturing	25	14	31	3
10 Chemicals	10	7	20	5
11 Petroleum refining	2	32	3	8
12 Rubber and asbestos manufacturing	8	6	8	2
13 Lumber and wood manufactures	24	25	22	12
14 Paper and paperboard manufactures	19	8	24	24
15 Machinery	9	10	21	11
16 Vehicles	4	1	14	14
17 Aerospace	1	26	2	28
18 Electrical engineering	6	2	9	9
19 Precision engineering and optics	21	20	32	15
20 Hardware and other metal goods	30	17	5	21
21 Glass	26	3	6	29
22 Musical instruments, toys, etc.	23	29	23	18
23 Printing and publishing	12	12	29	32
24 Plastics manufactures	3	5	1	1
25 Leather	35	35	10	26
26 Textiles	17	16	33	20
27 Clothing	28	22	16	13
28 Tobacco manufactures	22	31	25	6
29 Food and kindred products	27	30	18	16
30 Construction	18	27	28	22
31 Wholesaling and retailing	16	23	15	23
32 Transportation and warehousing	14	33	12	30
33 Communications	15	9	17	7
34 Banks and insurance	29	21	11	33
35 Real estate, hotel, auto repair, amusements, and other services n.e.c.	31	18	13	17

*Period involved for U.S. economy is 1958–63; period involved for West German economy is 1958–62.

course, such factors are considerably more significant for the West German economy than for the American economy due to the critical role of international trade in the West German economy.[21] More importantly, in both economies the postwar increases in final demand were concentrated among the same general types of durable and nondurable personal consumption items and industrial capital goods and tended to make the impact of changing final demand similar in both the United States and West Germany.

[21] In 1960, exports accounted for 20 percent of West German GNP and 5 percent of U.S. GNP. In this year, 35 percent of West German manufacturing output was exported, while only 6 percent of U.S. manufacturing output was exported.

On the other hand, the apparent lack of relationship between the coefficient change indexes is interesting, for it indicates that the pattern of technological change, specialization, and substitution of intermediate inputs in the late 1950's and early 1960's differed in the two economies. Of course, this finding may be due in part to the admittedly imperfect industry aggregation required for the inter-country comparison and to the quantitative techniques used to generate the data.[22] More fundamentally, to the degree that these findings are valid the results probably stem from the differing nature and stages of development of the West German and U.S. economies in the period 1958–63. At this time, West Germany was still in process of completing the reconstruction of industries devastated during the war. This implied that not only did the German economy possess more modern industrial plants with different technologies that their U.S. counterparts, but also that even as late as 1963 German economic development was still distorted by the uneven recovery of many industries during the preceding decade. This latter factor is mentioned by Staglin and Wessels as being responsible for some of their findings.[23] Finally, differences between the two economies in the substitution and use of intermediate inputs also resulted from the different prices and availability of raw materials and other inputs, i.e., one would expect U.S. technology to have been more energy intensive in the period 1958–63 than German technology because energy at that time was considerably less expensive in U.S. than in the Federal Republic of Germany.

IV. Conclusions

Here we utilized input–output techniques to dissaggregate and analyze structural change in the American economy between 1947 and 1966, focussing on the subperiods 1947–58, 1958–63, and 1963–66. We found that in each period there was a wide range in the distribution of changes in output requirements, but that changes in final demand and in input–output coefficients tended to reinforce rather than offset one another. We found a number of broad structural and technological trends which resulted both from changes in final demand as well as from changes in input–output coefficients. Thus, the large increase in the postwar output of industries such as plastics, utilities, drugs and cleaning preparations, and office and computing machines reflects the fact that the products produced by these industries were becoming increasingly attractive as intermediate inputs as well as for final consumption. Conversely, the decline or very slow rate of increase in the output of industries such as coal, wooden containers, and leather products reflects the declining importance of these products in most aspects of contemporary production and consumption.

We were able to identify a number of broad structural and technological trends which seem to be unaffected by cyclical phenomena, and were able to relate them to factors such as high levels of Federal Government defense spending, distinct shifts in consumer expenditure patterns, and the substitution of certain types of specialized and high technology intermediate inputs for other inputs. On the other hand, a close inspection of Table 1 will also reveal certain

[22]We used the Laspeyres measures of output change; see footnote 19.
[23]See Staglin and Wessels [6], pp. 389–90.

cyclical movements in the output changes. For example, the exceptionally large increases in output between 1958 and 1963 in the Household appliance and the Automobile industries was due in large part to the depressed conditions in these industries in 1958 due to the recession.

Of special importance is the finding that for those industries experiencing the largest relative increases or decreases in output the two factors, coefficient change and final demand change, in every instance influenced these output movements in the same direction. This consistent and mutually reinforcing pattern of change makes it likely that these trends have continued beyond 1966 and that, for many industries at least, they should be generally predictable. This finding can be useful in predicting technological change and changes in input–output structures.[24]

Finally, in comparing our results for the American economy for the period 1958–63 with the findings reported by Reiner Staglin and Hans Wessels for the West German economy for the period 1958–62, we found mixed evidence in support of the hypothesis that structural change tended to be similar in both economies. Despite the difficulties involved in making intercountry comparisons of structural change, this is an interesting issue deserving of further investigation. Future research in this area could be devoted to studying the patterns of change in intermediate input coefficients and, if the data permit, to analyzing changes in the composition of value added and real product.[25]

References

[1] Bezdek, Roger H., Jean Frazier, and Robert M. Wendling. "Documentation for the Deflation of the 1966 Input-Output Matrix to 1958 Dollars." U.S. Department of Commerce, Bureau of Economic Analysis, May 1974 (unpublished).

[2] ————, and Constance R. Dunham. "U.S. Postwar Structural Change by Broad Groups of Industries." U.S. Department of Commerce, Bureau of Economic Analysis, 1975 (unpublished).

[3] Carter, Anne P. *Structural Change in the American Economy.* Cambridge, Massachusetts: Harvard University Press, 1970.

[4] Fromm, Gary. "Comments to Beatrice N. Vaccara and Nancy Simon: Factors affecting the Postwar Industrial Composition of Real Product," in *The Industrial Composition of Income and Product,* Vol. 32 of Studies in Income and Wealth, New York: Columbia University Press, 1968, pp. 59–66.

[5] Goldman, Morris R., Martin L. Marimont, and Beatrice N. Vaccara "The Interindustry Structure of the United States: A Report on the 1958 Input–Output Study," *Survey of Current Business,* Vol. 44 (November 1964), pp. 10–17.

[6] Staglin, Reiner and Hans Wessels. "Intertemporal Analysis of Structural Change in the German Economy." in Anne P. Carter and Andros Brody, eds., *Input–Output Techniques,* Amsterdam: North-Holland, 1974, pp. 370–392.

[7] U.S. Department of Commerce, Bureau of Economic Analysis. "The Input–Output Structure of the United States Economy: 1947." 1970 (unpublished).

[8] ————, ————. *Input–Output Transactions: 1966,* Staff Paper in Economics and Statistics, No. 19, 1972.

[9] Vaccara, Beatrice N. "Changes Over Time in Input–Output Coefficients for the United States," in *Applications of Input–Output Analysis,* edited by Anne P. Carter and Andros Brody, Amsterdam: North-Holland Publishing Company, 1969, pp. 238–260.

[24] See the discussion in Vaccara and Simon [11], pp. 37–40.

[25] The authors are presently involved in a study utilizing similar techniques to analyze postwar changes in the composition of value added and real product for the U.S. economy.

[10] ————, "Changes Over Time in U.S. Input–Output Relationships," Paper Presented at the Seminar on Input–Output Analysis, Sponsored by the YMCA Center for International Management Studies and the State Planning Committee of Romania, Bucharest, Romania, September 4–18, 1969.

[11] ————, and Nancy W. Simon. "Factors Affecting the Postwar Industrial Composition of Real Product," in *The Industrial Composition of Income and Product.* Vol. 32 of Studies in Income and Wealth, New York: Columbia University Press, pp. 19–58.