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Estimates of Real Product in the United States by Industrial Sector, 1947–55

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THE output of the economy can, in theory, be measured as the total value of final goods and services (gross national product in constant prices) or as the sum of the unduplicated output (real gross product) by industry of origin. The first approach is based on expenditure by major categories of final demand, e.g., household purchases of consumer goods and services and business investment in plant, equipment, and change in inventories. The second approach reflects the difference between deflated values of production and purchased intermediate products, calculated on an industry basis. Only the former method is currently used to develop the official estimates of United States GNP.[1]

This paper presents the results of some exploratory work on annual indexes of national production for the 1947 to 1955 period based on the latter method, i.e., the development of real product measures for major industrial sectors. These estimates were the outcome of a special study undertaken at the request of and in cooperation with the Interagency Subcommittee on Production and Productivity, Office of Statistical Standards, Bureau of the Budget.[2] The paper also includes a general analysis of sector trends in output per man-hour, based on the results of the interagency project but representing the views of the authors.

There has long been a need for sector real product measures that would be consistent with an aggregate measure for the total economy. Such data would provide information on the growth or decline of individual sectors, relative to each other and to the trend of total

[1] A description of the methods and sources used to develop both the current and constant dollar estimates of gross national product is given in the *National Income Supplement, 1954, Survey of Current Business.*

[2] The following agencies were represented on the Subcommittee: Bureau of Labor Statistics, Department of Labor; Office of Statistical Standards, Bureau of the Budget; Office of Business Economics, Department of Commerce; Bureau of the Census, Department of Commerce; Federal Reserve Board. The chairman was John Kendrick of the Office of Statistical Standards. Along with the Subcommittee, a member of the staff of the Council of Economic Advisers participated in the development of the sector real product estimates.

activity. In conjunction with matching man-hour data, sector estimates could yield output per man-hour measures which would indicate the net effect of differential movements in sector productivity and shifts between low and high output per man-hour. Sector productivity estimates might also be usefully correlated with related variables. Finally, if sufficient data were available, the aggregation of sector real product measures would provide an independent check on the published GNP estimates derived from deflated expenditures.[3] This was not a purpose of the present study, but to the extent that independent sources were used, a check is provided.

Since the project aim was to explore the feasibility of estimating sector production and productivity on the basis of readily available data, there was no intensive consideration of alternative methods or data sources. Further work is needed to improve the estimating methods and to clarify the theoretical problems involved in defining output and output per man-hour in areas such as finance, insurance, real estate, business and personal services, and communications. Therefore, the estimates derived should be regarded as tentative.

The limitations of the individual sector estimates are not considered in this paper. Many of the data limitations for specific sectors are covered in Leon Greenberg's paper prepared for this conference, "Data Available for the Measurement of Output per Man-Hour."

Concept of Real GNP by Industrial Origin

Real GNP is implicitly the sum of the real gross products of the component industries, each industry product thus encompassed representing gross output minus purchased intermediate goods and services. Since the output values involved are net, in that the contribution of other industries is excluded, aggregation provides an unduplicated measure of the value added at each stage of the productive process.

Industry gross product can theoretically be obtained by either a product or an income approach. In the national income accounts, income by industrial origin is estimated by an appropriate allocation of labor and property shares. GNP originating could be estimated by adding to the factor payments, the nonfactor charges (capital consumption allowances, indirect business taxes, and miscellaneous items). However, such estimates are not regularly prepared because of

[3] John W. Kendrick in "Measurement of Real Product," *A Critique of the United States Income and Product Accounts*, Studies in Income and Wealth, Volume Twenty-Two (Princeton University Press for National Bureau of Economic Research, 1958), used industry output estimates primarily for purposes of checking aggregate real product estimates.

special problems involved in the distribution of the latter, particularly indirect business taxes and, in any event, estimates thus derived cannot be readily deflated.

Gross product originating does not measure the total output of an industry but only the portion attributable to the activity in question. Since the usual type of price indexes are not directly applicable to the deflation of value added, industry real gross product must be obtained by deflating gross output and intermediate purchases separately and then subtracting deflated inputs from deflated output.[4]

Derivation of Real Product Estimates

Only for agriculture and manufacturing have estimates been developed by methods which are technically consistent with the concept of "double deflation," and data are not readily available for the development of similar real product measures for other sectors. Therefore, the estimates prepared for this paper were based on the more conventional gross output concept. This approach assumes that there was relatively little change in input-output relationships within each of the sectors from 1947 through 1955 and that, therefore, changes in gross output approximate changes in net output.

The sector indexes were combined with value added or net output weights to provide an approximation at the national level of the conceptually correct measure. The output measures entering into the sector indexes were similarly weighted wherever possible. 1947 was selected as the base year because, when the study was started, the published real GNP figures were in 1947 dollars.[5]

SECTOR WEIGHTS

The weights used in this study are 1947 gross national income weights derived by estimating capital consumption allowances and indirect business taxes by sector and adding these items to the published figures of sectoral national income. It was not possible to distribute the other components of GNP consisting of subsidies, less the current surplus of government enterprises, business transfer payments,

[4] Almarin Phillips, in his paper "Industry Net Output Estimates in the United States," this volume, develops Kuznets' suggestion that value added can be directly deflated by an index formed by taking a weighted average of the difference between a gross output price index and an input price index

[5] Since completion of this study, the constant dollar GNP figures have been modified due to revisions in the data and shifting of the price weights from 1947 to 1954. (See *Survey of Current Business*, July 1958.) However, no attempt has been made to revise the estimates shown here since the original purpose of the project was to explore the feasibility of constructing sector real product estimates.

and the statistical discrepancy. These items represented about 1 per cent of GNP in 1947.

The total capital consumption allowance for each sector was obtained as the sum of separate estimates of (1) depreciation, (2) capital outlays charged to current account, and (3) accidental damage to fixed capital. Similarly, the estimate of sector indirect taxes was based on separate estimates of (1) federal excise taxes, (2) state and local sales taxes, (3) state and local property taxes, and (4) miscellaneous indirect taxes and nontax liabilities. The distribution of the various categories of capital consumption allowances and indirect business taxes was based on various data including Internal Revenue tax returns and data from the Office of Business Economics, Department of Commerce.

One major adjustment was made to the distribution of gross national income as originally derived. In certain branches of manufacturing, particularly petroleum and steel, the activities of parent companies frequently include the operation of captive mining operations, e.g., petroleum drilling and extraction, iron ore and coal mining. In order to be consistent with manufacturing and mining output data which reflect activity on an establishment or product basis, the estimated part of manufacturing gross income derived from captive mining activities was transferred to the mining sector. This modification primarily affected nonlabor charges because the estimates of wages and salaries used in the national income accounts were already on an establishment basis. The same statistical problem (captive operations in sectors other than that where the parent company is located) exists elsewhere but not so seriously as to require modification of the gross national income weights.

There is an additional problem of relating output to gross national product which occurs in almost all sectors but is particularly important in utilities, communications, and railroads industries. The problem is that sector output data usually do not include the output of new construction workers on payroll of utility, etc., whereas the gross national product originating weight for each sector does reflect these activities. No adjustment has been made for this factor in the estimates prepared for this paper.

The procedure employed in deriving sector weights is described in greater detail in Section I of the appendix. The weights themselves are presented in Table A-1.

SECTOR INDEXES

The sector real product estimates were prepared in approximately the same industry group detail as that shown in Table 13, National

Income by Industrial Origin, *National Income Supplement, 1954, Survey of Current Business*. However, the following modifications were made in order to achieve consistency with the available output and man-hours data:

1. Separate estimates were made for general government and government enterprises. This change was made because the real gross output measure for government, based on the National Income concept and methodology, is limited to the output of general government employees. The output of government enterprises, e.g., Post Office and TVA, is considered part of the private economy. Productivity measurement considerations were another reason for showing general government product separately.

2. "Agriculture" was separated from "agriculture, forestry, and fisheries" and shown separately as farming to be consistent with the coverage of the net output index for agriculture. "Agricultural services, forestry, and fisheries" were added to the services sector to be consistent with the BLS man-hour estimates.

3. "Radio broadcasting and television" was separated from "communications and public utilities" and added to the services sector to be consistent with man-hour estimates.

4. "Real estate" was removed from "finance, insurance, and real estate" and shown separately because of statistical and conceptual problems in relating output and man-hours.

5. "Private households" was removed from "services" and shown separately for the same reasons as in the case of real estate.

Sector real product indexes are shown in Table A-2. Net output indexes derived by the separate deflation of output and intermediate inputs were available for agriculture and manufacturing. The former series was developed by the OBE; the latter by the Division of Productivity and Technological Developments of the BLS. For the remaining sectors industry gross output indexes were combined with national income originating weights or value added weights to obtain approximate net output measures. National income weights were obtained from the national income accounts; industry value added data were obtained from unpublished detailed charges against final product prepared in connection with the BLS interindustry relations study, which also referred to a 1947 base year. The industry output indexes were derived either by deflating current output values or by measurement of physical quantities, such as ton miles and kilowatt hours. Where current output data were not available, substitute measures were employed.

A wide variety of sources and methods were of necessity involved in the derivation of the sector real product estimates and these are described in Section II of the appendix. In general, the data differed from those used in the development of the official constant dollar GNP measures but the detail of the Commerce Department estimates provided the basis for estimates of general government, finance and insurance, real estate, households, services, and rest of the world.

Comparison of Sector Real Product Aggregate with Published GNP

Data other than that used by the Commerce Department for estimating gross national product were used to measure the change in output, wherever such data were readily available. However, overlap is inevitable where the output of an industry consists almost entirely of a product that becomes a component of personal consumption expenditures, such as local transportation. In such cases the project estimates may be independent and still identical with the Commerce figures. Duplication is also present because limited resources for investigating the possibilities of alternative methods of estimation or deficiencies in primary data made it necessary to substitute the movement of appropriate components of personal consumption expenditures for industry output. In all, about 25 to 30 per cent of the total weight of the combined index represents industries for which the output estimates were not independent.

With this limitation in mind, the index derived by aggregating the sector real product estimates can be compared with that based on the published GNP in constant dollars for 1947–55. These indexes are given in Table A-2. The average difference between the two is less than 1.5 per cent, and the largest difference between them in any one year is less than 3 per cent. Although the derived index is consistently lower than the published index, the difference does not increase over the period; if anything, it decreases in the latter years.

The two indexes can also be compared in terms of average annual change over the period. The average annual change of the published private GNP index was slightly higher than that of the derived GNP, 4.2 per cent as compared to 4.1 per cent. The closeness of the results of both comparisons may have been due to offsetting movements of net-gross ratios in various industries.

On the basis of this comparison, the Subcommittee concluded that it was feasible to use existing data, to construct a largely independent sector output aggregate that coincided closely with the published deflated GNP. This conclusion does not imply endorsement of the

particular methods and sources used. Much work remains to be done and the estimates must be considered as primarily exploratory.

Derivation of Estimates of Real Product per Man-Hour

One of the major uses of the sector real product measures is in the development of sector real product per man-hour measures. The remainder of this paper is devoted to a brief description of some of the problems involved in the development of such estimates and an indication of how they may be used to analyze trends for the economy as a whole and major components of the total.

"Productivity" can be defined as the ratio of output to any related input or combination of inputs. However, most existing measures relate output to labor input. As we all know, such measures do not represent the unique contribution of labor to production but the interaction of many factors, such as changes in technology, capital per worker, scale of output, utilization of capacity, etc. Within the general concept of productivity, defined as output per unit of labor input, there are several alternative measures which can be developed. First, there are gross physical productivity measures which show the change in labor time required to produce a fixed composite of goods and services. Second, there are the measures which reflect shifts in the relative importance of industries with different levels of value of output per man-hour, in addition to changes in physical productivity. These measures can record an increase in productivity for a sector even if there is no change in the productivity of component industries. Third, there are the net measures which reflect not only physical productivity changes and interindustry shifts but also changes in labor requirements due to changes in materials consumed per unit of output, e.g., less coke per ton of steel.

RELATIONSHIP TO BLS MEASURES OF PRODUCTIVITY

Most of the work of the BLS in the field of productivity measurement has been based on the concept of physical productivity but more recently two sets of estimates have been developed based on the net output concept. The two sets of net output productivity estimates cover the man-hours of all persons, including the self-employed, unpaid family workers, and wage and salary workers, but are distinguished by the fact that they are based on different man-hour data sources.

One set was based primarily on Census Bureau figures which attempt to measure hours worked. The other set was based primarily on BLS employment and hours data which refer to hours paid for,

including hours paid for but not worked, such as vacations, holidays, and sick leave. The latter cover the total private economy with breakdowns between agriculture and nonagriculture, and manufacturing and nonmanufacturing for 1947 to 1957.

The BLS-based man-hour data were used in conjunction with the sector output indexes derived for this paper to develop measures of sector real product per man-hour. In concept these measures are net but because the real product estimates for most sectors were developed by combining industry gross output measures with fixed net output weights, they do not adequately reflect changes in labor requirements due to changes in materials consumed per unit of output. In most cases they were not developed in as much detail or with quite the same intensive statistical analysis as the productivity measures previously published by the BLS. Therefore, they must be regarded as exploratory and not official.[6]

SPECIAL PROBLEMS

Certain areas of the economy involve special problems from the viewpoint of productivity measurement.

1. *Government.* In the national income accounts, the output of general government is approximated by employee compensation, implying no change in productivity. Although there are other areas where output is measured by labor input, this is, from the viewpoint of employment, by far the most significant. Since the concept of productivity in government is without meaning, most estimates of national productivity such as those developed by John Kendrick, and by the staff of the Joint Economic Committee, have excluded general government. In this paper, as in the *1958 Economic Report of the President*, the estimate of productivity is limited to the private economy.

2. *Rest of the World.* GNP includes income from abroad accruing to U.S. residents. Since this income is not related to domestic labor input, it should be subtracted so that domestic employment is related to gross domestic product. The detail shown in Table A-2 provides the basis for such an adjustment.

3. *Households.* In the national income system, this classification includes the output of domestic employees and net interest received by

[6] The BLS estimates of net output in 1947 dollars per man-hour for the years 1947 to 1957 are published in the *January 1958 Economic Report of the President* (Appendix E, Productivity Statistics). These estimates, revised to be consistent with constant dollar GNP in 1954 dollars and extended to 1958, are published in *Trends in Output per Man-hour in the Private Economy, 1909–58*, BLS Bulletin 1249, December 1959. A detailed analysis of these estimates and a description of the methods and sources employed is presented in this Bulletin.

individuals. Since the former is measured by labor compensation and the latter has no labor input, it was felt that no meaningful measure of productivity could be derived for this area.

4. *Real Estate.* In the national income accounts, the real estate industry includes the imputed rental of owner-occupied homes as well as income from commercial operations. For homes that are rented through real estate agencies employment involved in managing and maintaining the property is reflected in the industry total. However, the time thus spent by owner-occupiers cannot be calculated. Consequently no productivity estimates were prepared for this sector.

5. *Services.* This sector also includes a number of business and personal service industries where output is measured by payrolls. Since it is difficult to separate these industries from those where the data are more adequate, the effect of this limitation cannot be quantitatively evaluated. The effect is probably a downward bias since some productivity increase has probably taken place and the measurement of output through employment assumes no change in productivity.

Analysis of Changes in Real Product per Man-Hour

SECTOR TRENDS

Estimates of the average annual change in real product per man-hour between 1947 and 1955 for the total private economy and major sectors are presented in Table 1. Whether or not these percentages represent trends that can reasonably be expected to continue or whether the period is a "normal" one that can be compared, without further analysis, with prior periods or some "long-run" average is not at issue here. These estimates, however, may not be indicative of secular rates, since 1947 was below trend and represented a decline in total private output per man-hour from the peak level reached in the last year of the war, 1945.

The average annual increase of 3.6 per cent shown for the total private economy compares with a rate of 3.7 per cent derived from the productivity indexes (based primarily on BLS man-hour data) published in the *1958 Economic Report of the President.* This is not surprising since the aggregate of the sector real product measures is quite close to the constant dollar GNP estimated from the expenditure side and the man-hours are consistent with those used in the published estimates. Excluding the "Rest of the World, Real Estate, and Households" from the private economy has no effect upon the estimate because the excluded sectors account for less than 10 per cent of total private output, and their implied change in productivity,

TABLE 1

Average Annual Change in Real Product, Man-Hours, and Real Product per Man-Hour, by Sectors, 1947–55
(per cent)

	Real Product	Man-Hours	Real Product per Man-Hour
Total private	4.1	0.6	3.6
Total private, excluding rest of the world, real estate, households	4.2	0.6	3.6
Total goods	4.2	−0.2	4.4
Farm	1.8	−4.2	6.3
Mining	2.1	−2.7	5.0
Construction	5.6	3.0	2.5
Manufacturing	5.0	1.6	3.3
Total services	4.1	1.2	2.8
Trade	3.9	1.3	2.6
Finance and insurance	6.8	4.4	2.3
Transportation	2.8	−1.5	4.3
Communication and public utilities	8.7	1.9	6.7
Business and personal services	2.6	1.6	1.0
Government enterprises	3.9	2.8	1.1
Addendum			
Private nonfarm (goods and services)	4.4	1.4	3.0
Private nonfarm (goods)	4.8	1.6	3.1

Source: The underlying real product estimates are presented in Table A-2 and described in Section II of the appendix. The man-hour data, mostly from the BLS, are described in the Appendix, Section III. The average annual per cent change is based on the least squares trend of the logarithms of the three sets of indexes.

which has little meaning in itself, is little lower than the average for all other sectors combined.

The sectors producing "goods" showed a considerably higher rate of increase than the "service" sectors, 4.4 versus 2.8 per cent. Much of this difference, however, was due to the 6.3 per cent gain in the farm sector. The increase for nonfarm goods sectors combined was about 3.1 per cent, which is not much higher than the average gain for services, and about the same as the increase for the total private nonfarm economy. This indicates that the popular belief that increases in output per man-hour in services have been lagging behind goods producing sectors must be qualified and, in fact, services such as transportation, communications, and public utilities showed better than average increases.

There seems to have been more variation within the goods and services groups than between these groups. Within the goods group, the increases ranged from 2.5 per cent for construction to 6.7 per cent for farm, with manufacturing at 3.3 per cent. The increase within services ranged from about 1 per cent for business and personal services to 6.7 per cent for communication and public utilities. It is

difficult to estimate how much of the relatively modest increase indicated for business and personal services is due to the conceptual and statistical problem of measurement and how much to the inherent nature of the industries involved. In either case, the small gain here tended to dampen the rate of increase for the private economy as a whole.

INTERSECTORAL SHIFTS

Besides providing information on the differential movement in productivity for individual sectors, the sector estimates can be used to determine how much of the over-all increase in output per man-hour was due to increases in physical productivity and how much to shifts in the relative importance of sectors. Methods of accomplishing such a breakdown are described in section IV of the appendix.

The estimates indicate that changes in the relative importance of all private sectors accounted for only about 4 per cent of the total increase in output per man-hour between 1947 and 1955. (The result is about the same whether relative importance is considered in terms of output or man-hours.) Conversely, 96 per cent of the total increase is accounted for by productivity advances within the sectors.

When the farm and nonfarm sectors are considered as units the effect of internal shifts are eliminated and the effect of the shift between these two groups can be isolated. The preliminary estimates indicate that about 8 per cent of the total increase in output per man-hour of the private economy was accounted for by a shift in man-hours from farm to nonfarm activities. This positive effect arises because the farm sector, with a relatively lower level of productivity, constituted a declining proportion of total man-hours.

Since the farm-nonfarm effect was higher than the "all sector" effect, shifts within the nonfarm segment must have had a dampening effect on the change in total output per man-hour because the only difference between the two analyses was the treatment of shift among nonfarm activities. Actually, the effect of shifts within the nonfarm group was minus 5 per cent. Thus, as a result of the increasing importance within the nonfarm group of sectors with lower than average productivity, the total change in output per man-hour of the nonfarm group was 5 per cent lower than the average of the increases within the sectors.

These results led to an attempt to relate the data to the belief that the relatively faster growth in man-hours of the service industries has had and may continue to have a depressing influence on productivity in general.

The data show that the service industries as a whole comprise a steadily increasing proportion of total man-hours, but that this shift

in man-hours has not been the factor responsible for the dampening effect of the nonfarm total. The shift in man-hours from all goods to all services has had practically no influence on the change in output per man-hour of the nonfarm economy, but the shift within each group has been to lower output per man-hour industries. This analysis can be summarized as follows:

1. For the period 1947–55, increases in output per man-hour within sectors were responsible for almost all of the increases in real product per man-hour of the total private economy.

2. The effect of changes in relative importance of sectors with differing levels of real product per man-hour was positive but minor.

3. A shift from the less productive farm segment to the more productive nonfarm segment accounted for all of the positive effect. The latter was somewhat offset by the negative effect of shifts within nonfarm goods and services.

These conclusions must be qualified because the analysis of shifts is limited to the sector level. More work is required at the industry level to determine the full effect of changing resource allocation.

Another major qualification to the estimated effect of shifts on the change in output per man-hour is the price level underlying the real product estimates, i.e., whether the real product is stated in 1947 dollars or the dollars of some other period. Some exploratory work done based on the revised GNP in 1954 constant dollars indicates that the effect of farm-nonfarm shift is higher because the difference in the relative productivity levels of the farm and nonfarm sectors was greater in 1954 prices than in 1947 prices.

APPENDIX

Derivation of Sector Weights

The weights for combining the sector indexes are 1947 gross national income weights, as shown in Table A-1. National income originating by sector and total capital consumption allowances and indirect business tax are from the *National Income Supplement, 1954, Survey of Current Business*. Estimates of sector capital consumption allowances and indirect business taxes were derived by distributing the totals for these items as follows:

FARM

Capital consumption allowances for this sector were computed from data compiled by the Agricultural Marketing Service (AMS) of the Department of Agriculture. Depreciation was built up from the

TABLE A-1
Gross National Income by Sectors, 1947
(millions of dollars)

	National Income Originating	Capital Consumption Allowance	Indirect Business Tax	Total
Gross national product				232,228
+Subsidies less current surplus				−227
−Statistical discrepancy				1,383
−Business transfer payments				674
Gross national income	197,168	14,118	18,658	229,944
General government	16,663	—	—	16,663
Gross private national income	180,505	14,118	18,658	213,281
Farm	17,777	2,444	610	20,831
Mining[a]	5,445	1,119	384	6,912
Contract construction	8,401	301	187	8,889
Manufacturing[a]	57,463	2,723	6,543	66,729
Trade	37,341	1,562	4,595	43,498
Wholesale	11,651	365	567	12,583
Retail	25,690	1,197	4,028	30,915
Finance and insurance	4,949	133	258	5,340
Real estate	10,301	2,795	2,691	15,787
Transportation	11,498	984	1,355	13,837
Railroad	6,294	362	901	7,557
Other	5,204	622	454	6,280
Communication—tel. and tel.	2,077	304	490	2,871
Utilities	2,811	544	461	3,816
Electric and gas	2,709	544	461	3,714
Local utilities	102	—	—	102
Households	3,272	—	—	3,272
Services[b]	16,340	1,209	1,120	18,669
Government enterprises	1,956	—	—	1,956
Rest of the world	874	—	—	874

[a] After "Establishment-company" adjustments. See notes.
[b] Excludes households; includes agricultural services, forestry and fisheries, and radio broadcasting and television.

annual charges to the replacement value of durable goods adjusted to exclude the amount allocable to nonfarm landlords. Capital outlays charged to current expense were selected from appropriate items included in the AMS farm production expenses. Indirect business taxes were also derived from AMS expense data.

The gross national income of the farm sector equals national income originating plus these two items. It is less than published farm GNP by the amount of government payments to farm landlords. However, the difference is insignificant and has no effect on the weighted output measure.

NONFARM

Capital Consumption Allowances. For each sector, separate estimates of depreciation, capital outlays charged to current account, and

accidental damage to fixed capital were added to arrive at the total capital consumption allowance. Much of the basic data were obtained from the Office of Business Economics (OBE).

Depreciation, which accounts for 85 to 95 per cent of capital consumption allowances, was distributed by industry largely on the basis of tax returns data. Within each sector, corporate and noncorporate segments were estimated separately.

The components of capital outlays charged to current account for which separate estimates are available are oil and gas well drilling, and "producers' durable equipment." The former was allocated entirely to mining. The latter was distributed mainly on the basis of the sector proportions of total corporate and noncorporate nonfarm depreciation after the exclusion of real estate, where this item appeared insignificant. Accidental damage to fixed capital was similarly distributed, with real estate included.

Indirect Business Taxes. "Indirect business tax and nontax liabilities" were classified into four main categories and allocated as follows:

1. *Excise taxes.* Federal excises on manufactures of liquor and tobacco were obtained from the published National Income tables, which in turn are based on Internal Revenue Service (IRS) data adjusted to an accrual basis. Federal exercises paid by manufacturing excluding liquor, tobacco, communications, and retailing firms were taken from Federal budget documents with fiscal year estimates averaged to derive calendar year estimates. Taxes on transportation of persons and property from IRS collections were allocated between railroads and other transportation on the basis of corporate sales.

2. *Sales taxes.* The published total was distributed largely on the basis of 1947 sales by sector after assigning those known to be paid by specific industries such as tobacco and liquor.

3. *Property taxes.* The nonfarm total was distributed in general on the basis of relative industry capital assets from IRS data.

4. *Miscellaneous indirect taxes and nontax receipts* were allocated in general on the basis of sector sales.

Mining-Manufacturing Adjustment. The above estimates of capital consumption allowances and indirect taxes were derived on a basis consistent with national income classification structure. The resulting gross national income estimates for mining and manufacturing were then adjusted to put both sectors on an establishment basis.

1. Gross national income of the mining sector on an establishment basis was estimated through the use of data from the BLS 1947 Interindustry Relations study. Table 1 of the 192 order matrix of that study

provided for each mining industry the items that generally cover the income and other charges contained in the concept of gross national income.

2. It was assumed that the difference between mining GNI on an establishment basis (interindustry derivation) and on a company basis (national income derivation) was solely the result of mining activities classified under manufacturing in the national income accounts. The difference was therefore subtracted from manufacturing gross national income as originally estimated to derive estimated gross national income on an establishment basis.

3. National income originating and the intervening items were then adjusted to conform to the adjusted GNI.

The sources and methods employed in arriving at the various output indexes presented in Table A-2 are described below.

TABLE A-2

Sector Indexes of Production, 1947–55
(1947 = 100)

	1948	1949	1950	1951	1952	1953	1954	1955
Total GNP—published	105.0	104.0	114.0	121.8	126.5	131.5	129.8	139.0
Total GNP—derived from weighted sector output indexes	104.4	101.4	112.9	120.4	124.2	129.7	128.3	138.2
Private GNP—published	105.4	103.9	114.4	120.5	124.7	130.2	128.6	138.7
Private GNP—derived	104.7	101.2	113.3	119.0	122.3	128.3	127.1	137.8
Farm	118.9	109.7	117.0	109.7	112.1	115.5	122.3	126.7
Mining	105.0	92.2	103.5	113.4	111.5	113.0	108.4	118.6
Contract construction	108.9	109.2	125.1	138.0	139.7	139.1	145.6	155.9
Manufacturing	102.0	94.8	110.9	121.2	124.8	135.6	127.4	142.3
Trade	101.8	101.2	114.8	116.7	121.4	125.8	125.0	135.2
Finance and insurance	106.1	111.9	125.0	131.9	140.6	150.2	156.8	167.9
Real estate	104.5	106.1	111.5	117.4	119.5	119.9	122.4	126.2
Transportation	100.1	91.0	103.8	113.8	112.3	115.5	110.5	121.4
Communication and public utilities	111.0	117.0	129.6	143.9	154.2	165.7	176.5	197.3
Households	104.9	112.0	129.1	131.0	132.1	143.6	144.1	166.3
Services	103.5	104.5	107.5	109.5	113.3	116.4	119.3	124.0
Government enterprises	107.8	112.9	117.0	123.9	128.6	130.4	133.6	138.3
Rest of the world	112.2	117.2	127.5	124.8	124.4	132.7	163.6	180.4

Derivation of Sector Indexes

FARM

This is an index of net output derived by deflating gross output and subtracting deflated intermediate inputs. The estimates are from the *Survey of Current Business*, June 1957 and November 1957. The procedure is described in the August 1954 issue.

MINING

The index on an establishment basis was estimated by combining Federal Reserve Board indexes of production for coal, crude oil and natural gas, metal mining, and stone and earth minerals with estimated gross national income weights derived from BLS interindustry data.

CONTRACT CONSTRUCTION

The production index was derived by deflating estimated GNP originating in current dollars. The implicit deflator was derived by dividing the value of new construction minus the value of building materials used, both in current dollars by the value of construction minus building materials, both in constant dollars. The estimates of building materials used in new construction are from an unpublished study of the Commerce Department's National Income Division which was benchmarked on BLS Report No. 2, *Construction in the 1947 Interindustry Relation Study*, and *Census of Manufactures* product detail for 1947 and 1954.

MANUFACTURING

1947, 1949–53. Estimates for these years were based on the previous work of the BLS on net output indexes for manufacturing industries.[1] They were obtained by subtracting the cost of materials, parts, components, etc., in constant dollars, from the constant dollar value of output (sales adjusted for changes in inventories). The data on dollar value of shipments, inventories, and cost of materials were obtained from the *1947 Census of Manufactures* and the *Annual Survey of Manufactures*, 1949–53. These data were supplemented by unpublished tabulations and special estimates. Totals for manufacturing cover virtually all of the approximately 450 Census industries. The deflators were specially constructed by arranging the BLS wholesale price series for commodities into industry groups.

1948, 1954–55. The detailed value data required for calculating the desired net output index for 1948 were not available since there was no Annual Survey that year. Detailed data for 1954 and 1955 have become available only recently. Therefore, a gross measure based on the deflation of manufacturers' sales, adjusted for change in inventories of finished products and goods in process was substituted for these years. The data on sales and inventories are from the published estimates of the OBE. The adjusted sales at the total manufacturing level were deflated separately for total durables and nondurables and then

[1] For a detailed description see BLS Report No. 100, "Trends in Output Per Man-Hour and Man-Hours Per Unit of Output-Manufacturing, 1939–53," 1955.

combined with value added weights. The deflators were special unpublished BLS price indexes for durable and nondurable manufactures.

TRADE

1947–52. The same procedure was followed for both wholesale and retail trade for this period. Indexes for the wholesale and retail components of the trade sector are shown in Table A-3. Base year margin

TABLE A-3

Trade Sector—Industry Production Indexes
(1947 = 100)

Year	Wholesale Trade	Retail Trade
1948	100.7	102.2
1949	98.8	102.2
1950	114.1	115.1
1951	119.9	115.4
1952	124.0	120.3
1953	125.2	126.0
1954	122.1	126.2
1955	130.8	137.0

ratios were computed from the Interindustry input-output table as the ratio of the value of wholesale and retail margins to manufacturers' shipments for each industry. These ratios were then applied to the deflated value of manufacturers' shipments in each year. The shipments were obtained as one stage in the process of computing net output for the manufacturing sector. The constant dollar value of margins were then summed and an index derived.

1953–55. The retail trade index was extended by an index obtained by deflating total retail sales by a retail price index, both furnished by the OBE. The wholesale trade index was extended by a series derived by deflating total wholesale sales from the OBE by the total BLS Wholesale Price Index.

FINANCE AND INSURANCE

Industry indexes were combined with national income originating weights. Indexes for banking, security brokers, etc., and insurance are shown separately in Table A-4. The index for banking was imputed to "finance, n.e.c." and the index for insurance carriers was imputed to "insurance agents."

Banking. National income originating in current dollars was deflated. The deflator was derived by dividing the current value by the constant dollar value of the personal consumption expenditures (p.c.e.) for

TABLE A-4

Finance and Insurance—Industry Production Indexes
(1947 = 100)

Year	Banking	Security Brokers, etc.	Insurance
1948	103.5	103.3	109.2
1949	110.6	93.9	114.4
1950	131.5	145.1	127.8
1951	131.0	127.0	133.3
1952	140.0	105.3	143.4
1953	148.4	108.2	154.6
1954	156.8	138.1	158.0
1955	168.4	155.7	168.1

(1) bank service charges, (2) imputed bank services, and (3) interest on personal debt.

Security Brokers, etc. This is the index of deflated p.c.e. for brokerage charges.

Insurance. Separate indexes were derived for life and nonlife insurance and these were combined with estimated national income weights from the Interindustry study.

The life insurance index was derived from the sum of p.c.e. for life insurance (expenses) and hospital and health insurance. (According to the BLS interindustry report, life insurance companies are large sellers of health and accident insurance.)

The nonlife index was constructed by combining auto, casualty, and health and accident (sold by nonlife companies) indexes with output weights derived from the interindustry reports. The indexes for auto and health and accident insurance represent deflated p.c.e. for these items. The index for casualty insurance (other than auto) is derived from premiums earned data from Best's insurance volumes. Indications are that there were no rate changes in this area and the value was not deflated.

REAL ESTATE

This index was derived by deflating estimated GNP originating in current dollars by the NID deflator for nonfarm residential space rent adjusted to exclude repair and maintenance. For this purpose repair and maintenance expenditures included in space rental values were deflated by the cost price index for new residential construction.

TRANSPORTATION

A separate index was derived for each industry as shown in Table A-5. The index for transportation other than railroads was computed

TABLE A-5
Transportation Sector—Industry Production Indexes
(1947 = 100)

	1948	1949	1950	1951	1952	1953	1954	1955
Railroads	96.5	79.9	87.4	95.9	91.5	89.7	81.5	91.1
Other transportation	104.4	104.4	123.6	135.3	137.3	146.6	145.3	157.8
Highway and local passenger	98.7	87.2	80.9	77.1	73.8	71.0	64.6	61.7
Highway freight	113.7	124.0	169.3	184.2	190.6	212.7	210.2	221.5
Water	93.6	85.8	91.5	108.5	100.7	96.8	94.2	116.5
Air	106.1	120.5	137.7	169.5	195.7	223.9	255.1	294.0
Pipelines (oil)	111.0	108.7	126.1	151.0	157.4	167.7	175.4	198.9
Services	99.3	96.7	108.1	128.0	128.2	133.5	137.3	159.8

by combining the component industry indexes with national income originating weights from National Income Table 13. "Other transportation" was combined with railroads with estimated gross national income as weights to obtain the sector index.

Railroads. Ton miles and passenger miles were weighted by 1947 revenue per ton mile and passenger mile. Data from Interstate Commerce Commission (ICC), *Statistics of Railways*, and Statement M-220.

Local and Highway Passenger Transportation. Indexes of deflated p.c.e. for intercity bus, taxi, and local transportation were combined with estimated national income weights derived from the Interindustry Division tabulation of charges against final product.

Highway Freight. Index of vehicle ton miles of intercity freight traffic as estimated in ICC, Statement No. 568 and seventieth annual report, p. 43.

Water. The index for U.S. water transportation companies for 1947 to 1953 was built on estimates presented in Harold Barger, *The Transportation Industries, 1889–1946* (NBER, 1951). Separate indexes were prepared for freight and passenger traffic.

The freight series was extended to 1953 by using essentially the the same sources and methods described by Barger. The sources are various reports of the Maritime Commission, Army Engineers, and the Census Bureau. Except in the case of inland and Great Lakes traffic, the series are derived from separate tonnage and average haul estimates.

In the case of passenger traffic, the Barger series for international trade from 1939 was extrapolated by the numbers of arrivals and departures from and to foreign countries on American flag vessels reported in the annual reports of the Immigration and Naturalization Service, Department of Justice. Estimates of other passenger travel were made from the gross tonnage of vessels engaged in the coastwise and internal trade of the United States.

The 1947–53 series was extrapolated to 1954–55 by a weighted index of inland waterway and ocean transportation. Weights are estimated national income as derived from interindustry data.

The estimate for ocean transportation is an index of freight and passenger traffic weighted by 1947 revenue. Freight traffic consists of tons of dry and tanker cargo, exports and imports, carried by American operated vessels. Tons of each type and 1947 revenue are from the *Survey of Current Business*, March 1956, pp. 19 and 20.

Passenger Traffic for 1953 and 1954 is index of arrivals on U.S. flag carriers. The 1955 index was derived by applying the change 1955/1954 in total arrivals in the United States. Passenger revenue is from the interindustry report.

The estimate for inland waterways is an index of ton miles of freight traffic on inland waterways as estimated in ICC Statement 568.

Air. Index of ton miles of passenger, excess baggage, mail, express and freight of domestic and international scheduled air carriers, weighted by 1947 revenue per ton mile. Data from Civil Aeronautics Administration, *Statistics of Aviation.*

Pipelines (Oil). For 1947 through 1954, barrel miles of crude and refined oil were weighted by 1947 revenue per barrel mile, on the basis of data from ICC, *Statistics of Oil Pipeline Companies.* The index was extended to 1955 by the change 1955/1954 in intercity ton miles carried by oil pipelines from the ICC annual report, 1956.

Services Allied to Transportation. This industry consists of numerous miscellaneous activities. Indexes for the major ones were imputed as follows: (1) Services incidental to water transportation, i.e., docks, piers, stevedoring and other terminal operations—production index for water transportation; (2) Forwarding and arranging of transportation—weighted average of trucking and railroad freight; (3) Flying, except common carriers, and operation of airports and flying fields—production index for air transportation.

Output weights for each activity, obtained from the interindustry reports, were used to combine the indexes.

COMMUNICATIONS AND PUBLIC UTILITIES

Communications. Separate indexes were computed for the Telephone and Telegraph industries as shown in Table A-6 and these were combined with estimated national income weights derived from the interindustry table of charges against final product.

Estimates for the Telephone industry were based on deflated revenues rather than the number of calls, as has sometimes been used.

TABLE A-6
Communications—Industry Production Indexes
(1947 = 100)

Year	Telephone	Telegraph
1948	112.7	90.0
1949	119.4	83.0
1950	128.4	85.5
1951	139.9	87.1
1952	148.5	76.1
1953	156.6	80.0
1954	163.6	76.9
1955	188.0	78.3

It was felt that the latter understated industry output because of the change in the classification of calls since 1948.

Revenue data were obtained from the Federal Communications Commission (FCC). Local service revenues were deflated by the unrevised BLS Consumer Price Index for telephone service (1939 =100). Toll message revenues (excluding private line service) include intrastate and interstate revenues. Intrastate revenues were deflated by the Consumer Price Index. Interstate revenues were not deflated through 1952 because there were no rate changes. In 1953 and 1954 they were deflated by the estimated effective rate increases determined in consultation with the FCC. A similar procedure was followed for 1955 but certain estimates were made because all the necessary FCC data were not then available.

For the telegraph segment the number of messages, domestic, ocean cable, and radio telegraph were weighted by 1947 revenue per message. Data was from the FCC, *Statistics of the Communication Industry of the U.S.*, 1956.

Utilities. Separate indexes from the Federal Reserve Board, as shown in Table A-7, were combined with FRB value added weights. The

TABLE A-7
Utilities—Industry Production Indexes
(1947 = 100)

Year	Electricity	Gas	Total Electricity and Gas
1948	111.3	112.1	111.5
1949	118.1	118.7	118.2
1950	132.6	138.5	134.2
1951	148.7	159.3	151.6
1952	162.0	172.5	164.9
1953	178.8	181.3	179.5
1954	192.4	198.9	194.2
1955	213.5	216.5	214.4

published weight for electricity was reduced to reflect the private sector alone.

The index for electricity (private) is a weighted combination of seven series, including six series on energy sales by Class A and B utilities by type of customer for residential, general industrial, Atomic Energy Commission, commercial and other; and one series for energy sales of cooperatively owned utilities.

Gas is a component of the Federal Reserve Index of Electricity and Gas Output, as described in the *Federal Reserve Bulletin*, October 1956. The gas index is a weighted combination of four series by class of customer for residential, industrial, commercial, and other. Separate indexes are not available for private and public (municipal) utilities. In 1955, it is estimated that the latter accounted for 4 per cent of total therms sold to ultimate consumers. This percentage is somewhat higher than in 1947.

For local utilities the index represents deflated p.c.e. for water.

HOUSEHOLDS

Deflated domestic service payrolls and net interest on consumer debt from NID estimates of GNP in constant dollars. Other interest, such as that on brokers' loans, equals less than one-third of one per cent of total income (and product) originating in households and was not deflated.

SERVICES

Indexes were derived for each industry (excluding private households) in the services sector as shown in National Income Table 13 and combined with national income originating weights from the same table. The industry indexes are presented in Table A-8. Many of them were derived by combining appropriate items of constant dollar p.c.e. The detailed unpublished expenditures were obtained from the OBE. The assignment of the expenditures to the various industries was made on the basis of an examination of the content of each industry in terms of the Standard Industrial Classification, 1942 edition. The reconciliation of the national income and SIC classification is shown on p. 66 of the *National Income Supplement*, 1954. The notes accompanying Table 30 of the same publication were also helpful in making industry assignments.

Hotels and Lodging Places. Constant dollar p.c.e. for housing in hotels and clubs were combined with estimated expenditures by business for hotels. The latter 1947 weight was estimated on the basis of data in the interindustry report. The index imputed to it was the index for clubs because it was lower than the hotel index. The latter

TABLE A-8

Services Sector—Industry Production Indexes
(1947 = 100)

	1948	1949	1950	1951	1952	1953	1954	1955
Services	103.5	104.5	107.5	109.5	113.3	116.4	119.3	124.0
Hotels and lodging places	103.6	101.8	102.9	106.0	109.1	112.4	116.1	120.9
Personal services	99.5	97.4	97.5	96.1	97.3	100.1	102.2	105.4
Commercial and trade schools	103.7	106.8	118.6	121.1	123.0	109.3	108.1	109.9
Business services n.e.c.	106.7	104.8	111.8	122.5	132.0	139.4	146.0	157.8
Miscellaneous	109.7	118.0	134.0	138.0	145.1	148.8	153.3	163.5
Motion pictures	93.5	88.9	84.8	80.2	76.3	69.5	67.9	65.2
Amusements, excluding motion pictures	98.1	97.4	94.5	95.0	97.5	98.1	98.9	102.1
Medical and other health services	104.1	108.6	113.5	114.8	118.7	123.1	125.9	129.7
Legal services	112.6	114.1	114.1	112.9	109.3	113.3	111.1	112.1
Engineering and other professional services	111.1	107.6	109.0	127.1	144.4	151.4	152.8	167.4
Educational services n.e.c.	106.0	112.6	119.8	124.3	131.6	133.3	142.3	149.1
Nonprofit membership organizations n.e.c.	100.6	102.5	103.3	100.0	105.6	109.0	113.9	115.7

includes motels, the index for which is known to be increasing faster than that for hotels. The industry index was computed from the sum of the deflated expenditures.

Personal Services. An index was derived from the sum of constant dollar p.c.e. for shoe cleaning and repair, cleaning, dyeing and pressing, laundry, barber and beauty parlor, other personal services, and funeral services.

Commercial and Trade Schools and Employment Agencies. An index was derived from the sum of constant dollar p.c.e. for commercial business schools, correspondence schools, and employment agency fees.

Business Services, n.e.c. This industry includes advertising and miscellaneous activities such as credit bureaus, duplicating services, and building services. An index was derived by deflating national income originating in this industry by the implicit deflator for services (National Income Supplement, Table 41).

Miscellaneous Repair Services. Constant dollar p.c.e. for these services were combined with an estimate for business expenditures for repair services. An estimate of the 1947 value of business use of repair services was derived from the interindustry report. The index imputed to this segment was the deflated p.c.e. for care of electrical equipment. The items represented by p.c.e. include upholstery repair,

rug repair, care of electrical equipment, radio and TV repair, and watch and jewelry repair.

Motion Pictures. Included are motion picture production and distribution as well as theaters. The index of constant dollar p.c.e. for motion picture theater admissions was imputed to the entire industry.

Amusements, except Motion Pictures. An index was derived from the sum of constant dollar p.c.e. for legitimate theaters, spectator sports, commercial participant amusements, and pari-mutuel net receipts.

Medical and Other Health Services. An index was derived from the sum of constant dollar p.c.e. for physicians, dentists, other professional services, and hospitals.

Legal Services. The index of deflated p.c.e. was imputed to this industry.

Engineering and Other Professional Services. This is the index of persons engaged in this industry from National Income Table 28.

Educational Services, n.e.c. An index was derived from the sum of constant dollar p.c.e. for higher education, elementary and secondary schools, other instructions, foundations' expenditures for education and research, and museums, libraries, etc.

Nonprofit Membership Organizations. An index was derived from the sum of constant dollar p.c.e. for clubs and fraternal organizations, labor union net payments, religious bodies, and social welfare.

GOVERNMENT ENTERPRISES

Production indexes were estimated for Post Office and public power operations as shown in Table A-9. The Post Office index was

TABLE A-9

Government Enterprises—Production Indexes
(1947 = 100)

Year	Post Office	Public Power
1948	107.3	117
1949	112.0	130
1950	115.2	151
1951	120.7	184
1952	124.6	203
1953	125.7	217
1954	128.5	229
1955	130.7	279

imputed to all government enterprises except public power. The two indexes were combined with estimated national income originating (employee compensation) weights. Data from OBE on wages and

salaries for the Post Office and TVA provided a basis for making a crude allocation of total government enterprise compensation.

Public Power. The index was obtained by subtracting the output of privately owned utilities from that total utility output of electricity. This index approximates a directly computed index weighted by class of customer. Unweighted total kilowatt hours sold by publicly owned utilities are available from the Federal Power Commission.

Post Office. The index represents a weighted aggregate of the number of pieces of mail handled or number of transactions performed by the Post Office, by type. The weights are based on the estimated amount of labor involved in performing a unit of each of the various services.

REST OF THE WORLD

These estimates represent investment income received from abroad deflated by an index of the value of U.S. imports of goods and services, and investment income paid to foreigners deflated by an index of U.S. exports. The deflators were based mainly upon the published indexes of unit values of merchandise compiled by the Bureau of Foreign Commerce. Wages and salaries, which represent a fractional part of the total, were not deflated.

Man-Hour Data Underlying "BLS Based" Productivity Estimates

BLS DATA

Estimates of nonagricultural employees by industry, and hours of workers were taken from the BLS "Employment and Earnings" monthly reports. The BLS statistics are based on payroll records from a sample of establishments. Changes from one month to the next in the employment reported by the sample respondents are applied to benchmark totals based primarily on unemployment compensation returns made by employers.

Average hours data are available only for production workers in manufacturing and nonsupervisory workers in certain nonmanufacturing industries. In computing the total hours for industries except for manufacturing, the hours of supervisory employees were assumed to be the same as for nonsupervisory workers. Thus, estimates of employees were multiplied by the average hours of nonsupervisory workers. For manufacturing, production workers were multiplied by production worker weekly hours (estimates of both being readily available) while nonproduction workers were assumed to work a forty-hour week. The average hours data refer to hours paid for.

SUPPLEMENTARY DATA

Since the BLS data are limited to nonfarm employees (excluding domestics), estimates for farm employment, nonfarm self-employed, unpaid family workers, and domestics were obtained elsewhere. Data from other sources were also used to supplement BLS average hours data in certain areas. The Census *Monthly Report of the Labor Force* provided estimates of agricultural employment and hours. In computing total hours, average hours data were applied to estimates of all employees instead of just those "at work," for comparability with the BLS concept of hours paid. This procedure implies that persons who held farm jobs but were absent from work were paid. The same procedure was used for other areas, e.g., finance, insurance, and real estate, where average hours from Census labor force data were used.

Although the BLS statistics cover government employment, separate data are not shown for government enterprises which sell their "product" (Post Office, TVA) and are therefore considered in the National Income framework to be part of the private economy. For this series, estimated employees of government enterprises as shown in the *National Income Supplement* and the average hours of public administration workers from the *Monthly Report of the Labor Force* were used.

Active proprietors in unincorporated enterprises were derived from the National Income Supplement by subtracting the full-time equivalent employees from the total number of persons engaged in production, by industry. The number of domestics were obtained from the same source. The average hours for these groups were obtained from unpublished Census data on hours worked. Unpaid family workers included in this measure, are persons working without pay in family businesses for at least fifteen hours a week. The number of such workers and the average hours worked were taken from the Census *Monthly Report of the Labor Force.*

In evaluating the estimates, it must be remembered, that assumptions and imputations have been made, and that the data come from different sources and reflect different concepts. For 1955, one-fourth of the total employment figure was taken from non-BLS sources, and the hours of one-half of the employees were either obtained from other sources or imputed from other BLS data. Of the nonfarm total (i.e., excluding farm, self-employed, and unpaid family workers), only 7 per cent of the employment estimate was derived from other sources, and the hours of only one-third of the employees were either imputed from other BLS data or derived from other sources.

Methods of Determining the Effect of Intersectoral Shifts on the Movement of Total Real Product per Man-Hour

In analyzing the change in total private real product per man-hour it is useful to determine the respective rates of (1) changes in the productivity of individual sectors and (2) changes in the relative importance of sectors with different levels of productivity. In this context, relative importance can be measured in terms of either sector output or man-hours, depending on the purpose in view.

An accepted analytical procedure involves holding each contributory factor constant in turn while the direct effect of the other is measured.[2] The sum of the effects so measured will not generally equal the total change in real product per man-hour because the two factors do not in fact remain constant over time and the interaction between them also affects the result. Also, the effect of each factor on the total change will vary depending on the weight base period, that is whether the factors are held constant at the beginning or the end of the period being measured.

One method of eliminating the differences in results due to differences in weight base period and at the same time allocating the effect of the interaction to the two directly measured factors is to average the alternative measures of change for each direct factor. The average change in sector productivity plus the average change due to shifts, obtained by this method, will equal the total change in real product per man-hour, the effects of the interaction being distributed equally between the two factors.

Another approach, suggested by Frederick C. Mills,[3] is to allocate the effect of the interaction equally to each of the two direct factors as measured by either the beginning or end year base weighted alternatives. This procedure will yield the same result as the previous method, the difference being that in this case the effect of the interaction is allocated explicitly.

The results of a productivity analysis of this type may be affected to some extent by the particular set of price weights used in constructing the sector output measures because the relative levels of sector output and consequently sector output per man-hour may be affected differently by the price weights of different years. The output

[2] See the Technical Appendix to article by Harlow D. Osborne and Joseph B. Epstein, "Corporate Profits since World War II," *Survey of Current Business*, January 1956. For a more detailed and technical discussion of the alternative methods and problems of decomposing total change into the additive contributions of various input factors, see Irving H. Siegel, "Concepts and Measurement of Production and Productivity," Working Paper of the National Conference on Productivity, 1952, pp. 86–92.

[3] *Productivity and Economic Progress*, National Bureau of Economic Research, Occasional Paper 38, 1952, pp. 31–6.

measures used in this report to compute real product per man-hour are based on 1947 price weights.

COMMENT

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Instead of attempting a critique of the concepts and methodology of the Jack Alterman's and Eva Jacobs' sector output measurements, I have combined them with current income data to indicate how they might be used to construct an integrated set of price, output, and unit cost measures.

Concepts

PRICE INDEXES

From the standpoint of income distribution, a price is the sum of all charges against output calculated per unit of product. In the case of sector value added, which is Alterman's concern, the relevant price deflator is the sum of income and other charges per unit of "real" value added. Since real value added is defined in terms of constant base period prices, the division of total income paid out by real value added automatically yields a Paasche price index with the constant dollar base year (1947) as 100.

In each sector the index of value added price can be converted into unit cost components—labor, property, and indirect tax.

Let L_i = Compensation of employees in sector i
R_i = Sum of gross property income—net rent, interest, profits, and capital consumption allowances
I_i = Indirect taxes
P_i = Price deflator
Z_i = Value of output, expressed in constant 1947 dollars
Y_i = Total gross income (charges against product) originating in sector i.

Then $$\left[\frac{L_i}{Z_i}\right]_t + \left[\frac{R_i}{Z_i}\right]_t + \left[\frac{I_i}{Z_i}\right]_t = \left[\frac{Y_i}{Z_i}\right]_t = P_i\,(t).$$

The ratios L_i/Z_i, R_i/Z_i, etc., can be considered as "points" in the price index. Hence a given price increase may be allocated to the cost elements which benefited therefrom as follows:

$$\Delta P_i = \Delta L_i/Z_i + \Delta R_i/Z_i + \Delta I_i/Z_i$$

(where the Δ's are expressed in percentage points). The meaning of the $\Delta L_i/Z_i$, etc., is somewhat ambiguous since the individual sectors are themselves aggregates of industries, encompassing many different products. This does not, however, affect the character of the P_i as

standard indexes of the Paasche form, since we have defined them as

$$P_i = Y_i/Z_i = \Sigma p_1 q_1 / \Sigma p_0 q_1.$$

The change in the price index between the base year and a given year does not incorporate the effect of "mix" changes since the weights are constant. The indexes of output and price are also internally consistent since the price index is Paasche and the output index, Laspeyre: multiplying the price index by the output index yields a value index identical to that derived by dividing given year aggregate value by base year aggregate value.[1]

UNIT COST INDEXES

Movements in the sector unit cost indexes, however, even between the base year and a given year are not pure measures of changes in unit costs. A unit labor cost index, U, in sector i, with given year quantity weights (quantity equaling constant dollar output in base period prices), would equal:

$$U_i = \frac{\sum\left[\frac{L_1}{p_0 q_1} \cdot p_0 q_1\right]}{\sum\left[\frac{L_0}{p_0 q_0} \cdot p_0 q_1\right]} = \frac{\Sigma L_1}{\sum\left[\frac{L_0}{p_0 q_0} \cdot p_0 q_1\right]}$$

where the L, p, and q are the wage bill, price, and quantity of the commodities produced in sector i. This unit labor cost index is thus the given year total wage bill divided by the wage bill which would have existed had given year quantities been produced at base year unit labor costs.

The unit labor cost index, derived from L_i/Z_i which we shall use as a component of the sector price deflator, is however:

$$U_i = \frac{\Sigma L_1}{\Sigma p_0 q_1} \Big/ \frac{\Sigma L_0}{\Sigma p_0 q_0} = \frac{\Sigma L_1}{\Sigma L_0} \Big/ \frac{\Sigma p_0 q_1}{\Sigma p_0 q_0}.$$

This is simply the index of the aggregate sector wage bill divided by the index of the aggregate sector output. The $\Delta L_i/Z_i$, $\Delta R_i/Z_i$, etc., consequently reflect not only changes in the unit costs of producing each product, but changes in product mix as well. Comparing changes in unit costs by this method is somewhat analogous to comparing Paasche indexes between years other than the given year and the

[1] Cf. Richard Stone, *Quantity and Price Indexes in National Accounts*, Organization for European Economic Cooperation, December 1956, pp. 37–8.

base year, although here one cannot strictly compare the given year even with the base year.[2]

The sensitivity of the cost indexes to intrasectoral shifts probably does not invalidate these measures since changes in product mix seldom seem to be so large in the short run as to make a substantial difference in the results. For example, a comparison of Paasche and Laspeyres GNP price indexes, using sector quantity weights showed that from 1947 to 1955, the two indexes were never more than ½ of 1 per cent apart, and that the differential change in any one year was even smaller. While not conclusive proof of the minor impact of intrasectoral shifts on "true" unit labor cost measures, this finding is indicative of the usually narrow range of variation imparted by changes in product mix to indexes incorporating quantity weights.

The equation allocating a given price change to the cost elements involved reveals "ex post" relationships only. If money wages rise more than productivity, unit labor costs increase. The latter development is often associated with a price rise, but whether the wage advance or the price increase is the causal factor can never be discovered from ex post price and cost data alone. Usually, changes in costs and prices are mutually determined by interacting changes in supply and demand schedules, a fact which is generally recognized when profits per unit of output are at issue but often neglected when unit labor or material costs are discussed.

SECTOR PRICE INDEXES

Just as the price index of sector value added can be separated into cost components, the price index for total GNP can be decomposed into the "points" contributed by each sector. In this case, however, the appropriate price index is not the GNP deflator, which incorporates given year quantity weights, but a base year weighted index. If $P_{g(t)}$ is the base year weighted price index for GNP in year t, then

$$P_{g(t)} = \sum_{i=1}^{n} \frac{Y_{i(t)}}{Z_{i(t)}} \cdot \frac{Z_{i(0)}}{\sum_{i=1}^{n} Z_{i(0)}},$$

remembering that the $Z_{i(t)}$ are sector outputs valued in constant base period prices. Thus a change in the GNP price between any two periods can be allocated to the sectors responsible, as follows:

$$\Delta P_g = \Delta Y_i/Z_i \cdot W_i + \Delta Y_j/Z_j \cdot W_j, \text{ etc.},$$

[2] See the Appendix to this comment for an exposition of this point.

where $$W_i = \frac{Z_{i(0)}}{\sum_{i=1}^{n} Z_{i(0)}}.$$

Despite its ex post nature, such an analysis can be a useful research tool.

While the measures described above suffer from the shortcomings inherent in defining changes in real economic output as changes in physical production, and from the further difficulties presented by product heterogeneity, they do provide internally consistent data on incomes, output, prices, and unit costs. Unit costs equal unit price and the latter rises as incomes per unit increase. Also, the movement of the "price" of GNP can be specifically related to price movements in each sector, and within sectors to changes in specific incomes per unit of output.

Construction of Estimates

Construction of price and unit cost indexes requires, in addition to the measures of real sector output provided by Alterman, corresponding measures of current dollar *gross* charges against product, by major components. The Department of Commerce publishes series on income originating by sector. To these data must be added estimates of capital consumption allowances and indirect taxes. The Alterman-Jacobs paper describes the method of estimating the latter in the base year, 1947. Essentially the same methodology was followed in deriving estimates for succeeding years.[3] In the mining and manufacturing sectors, the nonwage components of gross income were changed from the company basis used in the Commerce data to an establishment basis.[4]

With this information and the Alterman-Jacobs estimates of "real" gross product, consistent price and unit cost indexes for the total private nonfarm economy (less real estate) and for some of the major sectors were constructed. These are not presented here because (1) they represent a first attempt at quantifying the concepts discussed above and require additional refinement, and (2) they do not as yet incorporate the important recent revisions in the income accounts.[5]

[3] I wish to acknowledge the cooperation of the National Income Division of the Dept. of Commerce, in making available certain unpublished estimates. Harlow Osborne of the Division also furnished some of the calculations behind the article, written in conjunction with Epstein, "Corporate Profits Since World War II," *Survey of Current Business*, January 1956. The division bears, of course, no responsibility for the particular results obtained from the use of their data.

[4] The procedure for this redistribution is described in the Alterman-Jacobs paper.

[5] Since this paper was written, some of the sector price, cost, and output indexes have been published. See, Charles L. Schultze, *Prices, Costs and Output*, Committee for Economic Development (Washington, 1960); and Charles L. Schultze and Joseph L. Tryon, *Prices and Costs in Manufacturing Industries*, Study Paper No. 17, Joint Economic Committee, U.S. Congress, 86th Cong., 2nd Sess. (Washington, Govt. Printing Office, 1960).

However, some derivative calculations of changes in prices and unit costs are presented in order to illustrate the possible uses of the data.

Illustrative Analysis

1951–55 PRICE STABILITY

One interesting application of the data is in the interpretation of postwar cost-price behavior. Table 1 shows the percentage change in

TABLE 1

Percentage Changes in Selected Deflators and Price Indexes, Intervals, 1947–55

Deflator or Index	*Percentage Change* 1947–55	1947–51	1951–55
All industries: deflator: given year weights	22.2	16.2	5.2
deflator: base year weights	22.8	16.7	5.2
Manufacturing: deflator: given year weights	26.1	23.1	3.3
wholesale price index, manufactured products[a]	18.2	18.9	−.6
Retail trade: deflator: given year weights	10.4	11.3	−.8
Farm products: wholesale price index[b]	−10.4	13.4	−21.0
Crude industrial raw materials: wholesale price index[c]	22.1	30.0	−6.1

[a] Table 39, *Productivity Prices and Incomes*, Joint Economic Committee, 85th Congress, 1957.

[b] Bureau of Labor Statistics, Wholesale Price Index.

[c] January 1958, *Economic Report of the President*, Table F-37.

Source: With the exceptions noted above, developed from data described in the text.

selected deflators for intervals from 1947 to 1955. The deflator for private nonfarm GNP (less real estate) rose at a rate of about 1 per cent per year from 1951 to 1955.[6] It appears from Table 2, which shows the points attributable to movements in sector indexes, that about one-half of this increase was contributed by the steady upward trend in "all other industries," consisting mainly of services, finance, and insurance. The deflator for value added in manufacturing increased only 3.3 per cent over the same four years, while that for retail trade declined slightly.[7]

[6] Whether one uses a standard deflator with implicit given year weights, or weights the individual sector deflators by base period values makes little difference in the results, as can be seen from the first two rows of Table 1.

[7] Since the changes in "real" retail trade value added are essentially measured as the change in the physical throughput of commodities, this implies a decline in retail sector charges per unit of commodities sold. Such a measurement ignores changes in the volume of "services" rendered per unit of retail sales. This omission is also generally implicit in the currently used measures of real GNP (except where such changes take place through a shift from one kind of store to another, e.g., from department stores to discount houses). Hence these indexes are at least consistent with the underlying GNP data.

TABLE 2

Relation between Changes in the All Industries and Sector Deflators, Intervals 1947–55

Sector	Per cent Change			Sector Point Contribution			Base Period Weight[a]
	1947–55	1947–51	1951–55	1947–55	1947–51	1951–55	
All industries[b]	22.8	16.7	5.2	22.8	16.7	6.1	100
Mining	21.0	21.7	−.6	.8	.8	0	3.9
Construction	28.6	20.8	6.5	1.4	1.0	.4	5.0
Manufacturing	27.1	23.1	3.3	10.2	8.7	1.5	37.5
Wholesale trade	24.5	16.1	7.2	1.7	1.1	.6	7.1
Retail trade	10.3	11.3	−.8	1.8	2.0	−.2	17.4
Railroads	40.3	33.2	5.3	1.7	1.4	.3	4.1
Highway freight	3.0	−12.6	17.9	.1	−.1	.2	1.4
Telephone and telegraph	29.0	15.4	11.8	.4	.2	.2	1.6
Electric and gas utilities	3.3	4.2	−.9	.1	.1	0	2.1
All other industries	23.4	7.5	14.8	4.7	1.5	3.2	20.0

[a] Sector gross charges against product as a per cent of total gross charges for all industries during 1947.

[b] Excludes farm, government, and real estate sectors.

Source: Developed from data described in the text.

Table 3 provides information on the behavior of various elements of cost. In contrast to prices, unit labor costs and indirect taxes increased substantially from 1951 to 1955. In manufacturing, the movement of these two items alone represented a rise of about seven points in the deflator, other things being equal, while in retail trade, they represented over two points of increase. Had not "property" costs (net rent, interest, profit, and capital consumption allowances) declined in some areas, and increased far less than labor costs in others, the impact on the value added deflators would have been much more significant. In manufacturing, the small rise in the deflator of value added that did occur was offset by sharp declines in the price of raw materials, so that the index of product prices remained stable.

A review of earlier developments clearly indicates that from 1951 to 1955 the economy was living off the "fat" of the immediate post-Korean inflation. In 1950 and 1951 rapid increases in demand led to price advances far in excess of increases in unit labor and indirect tax costs so that gross property charges against product were lifted well above normal in most sectors. Between 1947 and 1951 the latter absorbed about one-half of the increase in unit prices (in the all industry average and in manufacturing), although they constituted only between a quarter and a third of total charges in the base period. Aggregate data on functional income distribution reveal the same phenomenon. By 1951, for example, corporate profits before taxes

TABLE 3

Relation between Changes in Price and Unit Cost, Indexes, Selected Industry Sectors, Intervals, 1947–55

Sector	Per cent Change			Factor Point Contribution			Base Period Weight[a]
	1947–55	1947–51	1951–55	1947–55	1947–51	1951–55	
All industries[b]							
Total charges per unit (=deflator)	22.3	16.2	5.2	22.3	16.2	6.1	100
Labor	22.1	13.3	7.8	13.3	8.0	5.3	60.3
Property	24.3	23.9	.3	7.5	7.4	.1	30.9
Depreciation	78.0	42.0	25.3	3.9	2.1	1.8	5.0
Other	13.9	20.5	−5.4	3.6	5.3	−1.7	25.9
Indirect taxes	17.0	9.1	7.3	1.5	.8	.7	8.8
Manufacturing							
Total charges per unit (=deflator)	27.1	23.1	3.2	27.1	23.1	4.0	100
Labor	24.1	15.6	7.4	16.1	10.4	5.7	66.7
Property	39.1	51.5	−8.7	9.2	12.1	−2.9	23.5
Depreciation	90.2	39.0	36.8	3.7	1.6	2.1	4.1
Other	28.4	54.1	−16.7	5.5	10.5	−5.0	19.4
Indirect taxes	18.4	6.1	11.5	1.8	.6	1.2	9.8
Retail trade							
Total charges per unit (=deflator)	10.3	11.3	−.9	10.3	11.3	−1.0	100
Labor	15.5	13.1	2.1	6.7	6.5	1.2	49.7
Property	−4.3	4.6	−8.5	−1.6	1.7	−3.3	37.3
Depreciation	69.2	43.6	17.9	2.7	1.7	1.0	3.9
Other	−12.9	0	−12.9	−4.3	0	−4.3	33.4
Indirect taxes	32.3	23.8	6.8	4.2	3.1	1.1	13.0

[a] Factor charges against product as a per cent of total charges against product during 1947.
[b] Excludes farm, government, and real estate sectors.

Source: Developed from data described in the text.

were 22 per cent of corporate gross product as compared to 18.5 per cent in 1947 and a post war average of 19.5 per cent.[8]

For several years after 1951, the cushion of abnormally high gross profit margins permitted sizeable increases in unit labor costs and indirect taxes, without either a full pass-through of such costs or a decline of profit margins to subnormal levels. This is brought into even sharper relief when net property margins are examined. While gross property costs per unit declined from 1951 to 1955, capital consumption allowances per unit increased rapidly. Part of the increase reflected the post-Korean accelerated amortization program, and should be reallocated to profits but even after such an adjustment,

[8] Profits were adjusted to reflect straight line nonaccelerated depreciation in order to make the postwar years comparable with each other. I am indebted to Alterman for his permission to use some unpublished estimates as the basis for this comparison.

the decline in net property margins was substantial, although not excessive.

The behavior of raw materials prices also contributed to price stability. The prices of farm and industrial products in this category rose rapidly during the Korean inflation only to decline sharply from 1951 to 1955, thereby providing an offset to rises in labor costs indirect taxes and depreciation charges.

Demands for goods and services were not generally excessive during the period. The rate of increase in aggregate demand slackened significantly after 1951, as declining inventory investment and consumer durable purchases offset the rise in defense spending.[9] The handsome profit margins enjoyed by most industries gave rise, however, to an excess demand for factors of production. The result was an exceedingly low rate of unemployment and a continued advance in unit labor costs. This "factor demand" inflation is the inevitable aftermath of a sharp increase in profit margins in an economy characterized by substantial downward rigidity in prices. Even when aggregate excess demand in the commodity markets has been eliminated, the combination of high profit margins and downward rigidities in the prices of finished goods practically guarantees a further inflation in factor prices. A new floor is erected beneath the price level reached in each burst of inflation. Paradoxically, then, an analysis of the period between 1951 and 1953, when commodity prices were generally stable, provides a good insight into the process by which a secular upward bias is imparted to the general price level.

1947–55: SHIFTS IN DISTRIBUTION OF UNIT COSTS

By 1953 price-income relationships had returned to a more normal pattern. Although a typical cyclical shift in functional income distribution occurred in 1954 normality was restored by the middle of the 1955 recovery. Considering 1947 to 1955 as a whole, Table 3 shows that for all industries, unit labor costs accounted for 13.3 points or 60 per cent of the total 22.3 point rise in the price index. This is the same proportion which labor costs were of total costs in the 1947 base period. Thus the increase in price relative to labor costs in the first subperiod was exactly offset by the increase in labor costs

[9] In "The Lull that Came to Stay," *Journal of Political Economy*, February 1955, John P. Lewis, examines the major demand factors in the 1951–55 period, and comes to much the same conclusion reached here. Lewis' major objective is to point to the special features which make it impossible to generalize the possibility of the coexistence of full employment and price stability solely from the experience of these years. Somewhat similar conclusions may also be found in Bert Hickman's *The Korean War and United States Economic Activity*, National Bureau of Economic Research, Occasional Paper 49, 1955.

relative to price in the second period. Gross property costs accounted for 7.5 points, or 34 per cent of the change in price, compared to a base period weight of 30 per cent. Again the sharp rise in property costs relative to total costs in the first subperiod was offset by their subsequent decline.

Manufacturing presents a similar picture. Between 1947 and 1955, labor costs accounted for 60 per cent of the rise in total charges per unit compared to a 67 per cent base period weight. The less than average contribution of labor costs before 1951 (10.4 points, or 45 per cent of the total 23.1 point rise) was not quite offset by their more than proportional rise thereafter (5.7 points compared to a 4.0 point rise in total charges). Property costs accounted for 52 per cent of the rise in total unit charges in the first interval and declined absolutely in the second.

Retail trade does not appear to have shared the experience of "all industries" and manufacturing. From 1947 through 1955 labor and indirect tax costs per unit rose by 10.9 points, while the over-all price increase was 10.3 points. Gross property charges actually declined during these years. In the first subperiod the latter contributed only 1.7 points out of a total 11.3 point price increase. During the second subperiod, while price declined 1.0 points, unit gross property charges fell 3.3 points, and net property charges 4.3 points.

Gross property margins may have failed to rise more than proportionately during the 1947–51 period because they were initially quite high. In 1947 net property margins were approximately 33 per cent, while depreciation charges were only 4 per cent of unit value added. The corresponding ratios for the all industry average were 26 and 5, and for manufacturing, 19 and 4. Net margins were 5 times depreciation in the latter two areas and 8 times depreciation per unit in retail trade. If depreciation per unit is used as a crude measure of capital investment per unit, then profits in retail trade appear to have been relatively high. While retail net property charges had fallen to 4.5 times depreciation by 1955, the ratio for both the all industry average and for manufacturing had declined to 3.2. However, because the meaning of book depreciation is so vague, particularly in a transition period like 1947, such comparisons can only be suggestive.

POST 1955: INFLATION

The increase in aggregate demand after the end of 1955 was not substantially greater than that between 1951 and 1955, but it was accompanied by a significant rise in prices. This is not surprising in view of certain contrasts between the two periods. The price stability

between 1951 and 1955 was in part the result of a distorted income distribution built up in the prior inflation. Although the rapid upsurge of demand which occurred during 1955 lifted profit margins somewhat above the postwar average,[10] the abnormality was substantially smaller than in 1950 and 1951 and the "cushion" of a distorted set of price-income relations much less. Also, raw materials prices appeared to have reached a lower turning point in 1955. Hence increases in labor and raw material costs—whether of an autonomous nature or stemming from excess demands in particular sectors—had their main impact on prices rather than on profit margins.

Conclusion

This analysis illustrates one potential use of an extension of the concepts in the Alterman-Jacobs paper. While this particular analysis might have been based on aggregate income distribution data alone, the use of sector unit cost data provides a direct link between price behavior and income distribution changes. It also illuminates the relationship between price movements in general and trends in individual sectors. So long as the analyst remembers that he is dealing with ex post facto data, and does not try to impute simple causality between associated developments, this type of data can be a significant aid to aggregate price analysis.

The particular body of data used in this paper requires substantial further refinement. In particular the segmentation of the manufacturing area would provide much needed information. Further, matching man-hour data with the unit labor cost and output data would shed some light on the determinants of unit labor costs.

This type of analysis shares with all attempts to deal with price-output relationships to the problem of suitable definitions of terms. Unequivocal measures of the magnitude or interrelationship of prices, costs, and output cannot be achieved; the necessary information on utility functions (or preference fields) and on production functions will never be available. Recourse must be had to "a basis of comparison in pragmatic terms which can be given an operational significance."[11] It is because the measures developed by Alterman and Jacobs and elaborated here may provide insights into certain important economic problems, that they promise to be of operational significance when further refined and developed.

[10] This tendency appears in sharper relief in the recently revised GNP data, which raise the 1955 estimates of corporate profits about $2 billion above the earlier estimates incorporated in our data.

[11] Richard Stone, *op. cit.*, p. 12.

APPENDIX

The sector unit cost measures used, assuming for the purpose of exposition only two components of costs—labor (L) and property (R) —are:

$$\frac{\Sigma L_1}{\Sigma p_0 q_1}+\frac{\Sigma R_1}{\Sigma p_0 q_1}=\frac{Y_1}{\Sigma p_0 q_1}=\frac{\Sigma p_1 q_1}{\Sigma p_0 q_1}=P_1 \tag{1}$$

With appropriate weighting, "true" unit cost indexes can be also made to add up to a Paasche price index:

$$\frac{\Sigma L_1}{\sum \frac{L_0}{p_0 q_0}\cdot p_0 q_1}=\text{"true" unit labor cost index}=\bar{L}_1 \text{ in period 1} \tag{2}$$

$$\frac{\Sigma R_1}{\sum \frac{R_0}{p_0 q_0}\cdot p_0 q_1}=\text{"true" unit property cost index}=\bar{R}_1 \text{ in period 1} \tag{3}$$

$$\frac{\Sigma L_1}{\sum \frac{L_0}{p_0 q_0}\cdot p_0 q_1}\cdot\frac{\sum \frac{L_0}{p_0 q_0}\cdot p_0 q_1}{\Sigma p_0 q_1}+\frac{\Sigma R_1}{\sum \frac{R_0}{p_0 q_0}\cdot p_0 q_1}\cdot\frac{\sum \frac{R_0}{p_0 q_0}\cdot p_0 q_1}{\Sigma p_0 q_1}$$

$$=\frac{\Sigma L_1}{\Sigma p_0 q_1}+\frac{\Sigma R_1}{\Sigma p_0 q_1}=\bar{P}_1 \text{ (by equation 1).} \tag{4}$$

Hence by weighting our "true" unit cost indexes (which themselves have given year quantity weights) with the base year unit cost of producing given year quantities we can sum to a Paasche price index. The sum of the changes in the aggregates derived by weighting our "true" unit cost indexes thus equals the change (in terms of per cent points) of the price index. But these changes in the unit cost aggregates are a combination of changes in the index of unit costs and in the product mix, $p_0 q_1/\Sigma p_0 q_1$ which enters into the weights.

The per cent point difference between a Paasche price index in a given year and its value in the base year (=1.00) does not, of course, involve the problem of changing product mix. The point difference in the unit cost aggregates as used in this paper—which sum to the price index—does, however, involve a change in product mix, even when taken against the base year. For the difference in points is:

$$\Delta\frac{\Sigma L}{\Sigma Z}=\frac{\Sigma L_1}{\Sigma p_0 q_1}-\frac{\Sigma L_0}{\Sigma p_0 q_0}; \qquad \Delta\frac{\Sigma R}{\Sigma Z}=\frac{\Sigma R_1}{\Sigma p_0 q_1}-\frac{\Sigma R_0}{\Sigma p_0 q_0}. \tag{5}$$

In both the base year and the given year these aggregates add to the price index, which is of course 1.00 in the base year. On the other

hand, the unit cost aggregates in the base year which have the same weights as in the given year are:

$$\bar{L}_0 \cdot \frac{\sum\left[\frac{L_0}{p_0q_0} \cdot p_0q_1\right]}{\Sigma p_0q_1} + R_0 \frac{\sum\left[\frac{R_0}{p_1q_0} \cdot p_0q_1\right]}{\Sigma p_0q_1}. \tag{6}$$

Since both $\bar{L}_0$ and $\bar{R}_0$ equal 1, the expression is:

$$\frac{\sum\left[\frac{\bar{L}_0}{p_0q_0} \cdot p_0q_1\right] + \sum\left[\frac{\bar{R}_0}{p_1q_0} \cdot p_0q_1\right]}{\Sigma(p_0q_1)}. \tag{7}$$

which *does not* equal $\Sigma(p_0q_1)/\Sigma(p_0q_1) = 1.00$, the Paasche index in the base period. Only if the $p_0q_1/\Sigma(p_0q_1)$ in equation (6) are replaced by $(p_0q_0/\Sigma(p_0q_1)$ will equation (6) reduce to

$$\frac{\Sigma L_0}{\Sigma(p_0q_0)} + \frac{\Sigma R_0}{\Sigma(p_0q_0)} = \frac{\Sigma Y_0}{\Sigma(p_0q_0)} = 1.00.$$

Hence the aggregates of unit costs, which can be made to add to the price index in all periods, are not free from the effects of changing product mix, even when we are comparing a given year with a base year.