U.S. government liabilities to rest of world, U.S. government credits and claims abroad, less monetary liabilities.[28] Private sector claims on state and local governments include state and local government total liabilities, less state and local

TABLE 20

PRIVATE NATIONAL WEALTH, 1929–1969 (CONSTANT PRICES OF 1958)

Year	Corporate Tangible Assets, Price Index	Corporate Tangible Assets, Quantity Index	Non-Corporate Tangible Assets, Price Index	Non-Corporate Tangible Assets, Quantity Index	Household and Institutional Tangible Assets, Price Index	Household and Institutional Tangible Assets, Quantity Index
1929	0.424	275.3	0.417	256.2	0.427	370.7
1930	0.399	276.4	0.382	256.0	0.410	366.1
1931	0.364	268.2	0.333	255.1	0.366	358.8
1932	0.332	253.5	0.293	250.4	0.312	346.7
1933	0.331	242.6	0.299	245.6	0.311	335.3
1934	0.350	237.5	0.318	240.3	0.335	327.5
1935	0.357	234.6	0.328	242.2	0.332	324.5
1936	0.363	238.6	0.341	242.5	0.345	325.9
1937	0.388	244.8	0.356	247.0	0.368	327.9
1938	0.384	240.2	0.348	246.2	0.375	325.6
1939	0.382	240.6	0.345	247.1	0.376	328.4
1940	0.390	247.7	0.355	249.7	0.387	334.3
1941	0.420	260.9	0.387	254.7	0.419	342.9
1942	0.465	260.3	0.425	255.3	0.461	336.5
1943	0.494	255.8	0.456	252.5	0.500	327.2
1944	0.518	251.6	0.482	251.6	0.547	317.7
1945	0.528	251.8	0.506	251.2	0.582	311.4
1946	0.587	271.7	0.582	255.0	0.633	326.7
1947	0.696	286.0	0.680	257.5	0.728	346.9
1948	0.746	300.8	0.722	266.2	0.793	368.1
1949	0.742	305.5	0.705	270.2	0.778	388.3
1950	0.773	321.2	0.764	278.6	0.816	418.9
1951	0.840	341.5	0.824	284.4	0.877	439.0
1952	0.857	353.4	0.827	287.2	0.897	455.4
1953	0.866	364.2	0.822	290.3	0.900	475.4
1954	0.873	370.0	0.835	292.7	0.894	495.4
1955	0.891	386.5	0.853	297.1	0.911	524.5
1956	0.942	405.2	0.901	299.2	0.952	545.0
1957	0.985	418.1	0.953	302.0	0.985	562.0
1958	1.000	422.2	1.000	303.9	1.000	574.0
1959	1.021	434.5	1.028	306.7	1.031	594.2
1960	1.033	447.4	1.069	309.2	1.049	611.0
1961	1.044	456.5	1.115	311.3	1.063	624.5
1962	1.062	470.8	1.164	315.2	1.086	643.6
1963	1.079	486.0	1.207	318.7	1.109	665.4
1964	1.101	505.3	1.255	322.4	1.140	688.7
1965	1.129	530.5	1.322	328.3	1.162	715.3
1966	1.167	565.4	1.393	333.2	1.190	739.9
1967	1.210	590.7	1.462	337.8	1.240	760.4
1968	1.255	614.5	1.545	342.7	1.300	786.9
1969	1.312	640.3	1.638	348.5	1.366	812.2

[28] *Survey of Current Business*, various issues.

government financial assets,[29] and assets of cash sickness compensation funds.[30] Net private claims on the rest of the world include private U.S. assets and investments abroad, less private U.S. liabilities to foreigners.[31] Private national wealth

TABLE 20—*continued*

Year	Net Claims on Governments and Rest of World, Price Index	Net Claims on Governments and Rest of World, Quantity Index	Private National Wealth, Price Index	Private National Wealth, Quantity Index
1929	0.943	35.0	0.572	725.3
1930	0.938	36.3	0.532	736.7
1931	0.881	40.0	0.475	736.3
1932	0.882	42.3	0.414	732.0
1933	0.891	44.2	0.417	714.0
1934	0.955	47.3	0.450	698.2
1935	0.956	49.5	0.460	691.9
1936	0.940	53.2	0.478	693.6
1937	0.947	54.6	0.504	705.4
1938	0.922	59.0	0.494	717.6
1939	0.905	63.8	0.498	720.6
1940	0.883	67.8	0.511	732.8
1941	0.938	75.1	0.562	752.2
1942	1.018	108.4	0.629	787.3
1943	1.010	153.7	0.653	857.8
1944	0.967	209.8	0.669	939.4
1945	0.935	255.8	0.660	1031.0
1946	0.944	259.0	0.693	1096.0
1947	0.934	257.2	0.763	1136.8
1948	0.931	253.7	0.806	1171.4
1949	0.932	260.5	0.794	1211.1
1950	0.951	250.9	0.835	1247.9
1951	0.956	249.2	0.885	1293.0
1952	0.956	257.3	0.893	1337.6
1953	0.966	265.9	0.899	1377.9
1954	0.971	275.5	0.899	1421.6
1955	0.976	275.5	0.920	1460.9
1956	0.984	276.0	0.954	1512.0
1957	0.989	282.3	0.986	1555.0
1958	1.000	294.7	1.000	1594.7
1959	1.014	296.6	1.029	1625.8
1960	1.028	298.4	1.046	1664.0
1961	1.032	307.0	1.062	1698.6
1962	1.042	315.3	1.093	1732.5
1963	1.045	321.4	1.115	1778.5
1964	1.039	333.8	1.146	1825.9
1965	1.044	340.9	1.178	1884.7
1966	1.043	353.0	1.217	1950.4
1967	1.028	378.6	1.254	2026.8
1968	1.023	395.4	1.299	2100.7
1969	1.028	399.2	1.350	2171.5

[29] *FFA* (1972), p. 56.

[30] We estimate these assets by cumulating the annual surplus in these funds from *NIP* (1966), Tables 3.8. and 3.9.

[31] *Survey of Current Business*, various issues.

in 1958 is presented in Table 18. Private national wealth and its components are presented annually in Table 19.

5.3. *Wealth in Constant Prices*

With geometric decline in efficiency the expression for the value of wealth is:

$$W_t = q_{A,t} K_t.$$

For several capital goods the acquisition price $q_{A,t}$ and quantity of capital K_t for each capital good can be combined into price and quantity indexes for wealth. Our wealth account for the U.S. private national economy includes tangible assets held by private households and institutions, and by corporate and non-corporate business, and net claims on the government and foreign sectors, including the claims of social insurance funds on general government. We estimate the price and quantity of assets for each of the five sectors by applying Divisia index number formulas to price and quantity data for each class of capital assets held by the sector. We construct price and quantity index numbers for the U.S. private national economy by applying these index number formulas to Divisia price and quantity indexes for the five sectors. Price and quantity indexes of wealth for 1929–1969 are given in Table 20.

References

Ando, A. and E. C. Brown (1963), "The Impacts of Fiscal Policy," in E. C. Brown *et al.*, *Stabilization Policies*, Englewood Cliffs, N.J., Prentice-Hall.

Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*, various monthly issues.

——— (1972), *Flow of Funds, Accounts, 1945–1971*, Washington, D.C.

Bowen, W. G. and T. A. Finegan (1969), *The Economics of Labor Force Participation*, Princeton, Princeton University Press.

Bureau of Economic Analysis, *Survey of Current Business*, various monthly issues.

Christensen, L. R. (1971), "Entrepreneurial Income: How Does it Measure Up?" *American Economic Review*, Vol. 61, September, pp. 575–585.

Christensen, L. R. and D. W. Jorgenson (1969), "The Measurement of U.S. Real Capital Input, 1929–1967," *Review of Income and Wealth*, Series 15, December, pp. 293–320.

——— and ——— (1970), "U.S. Real Product and Real Factor Input, 1929–1967," *Review of Income and Wealth*, Series 16, March, pp. 19–50.

Council of Economic Advisers (1972), *Economic Report of the President*, Washington, D.C.

Frane, L. and L. R. Klein (1953), "The Estimation of Disposable Income by Distributive Shares," *Review of Economics and Statistics*, Vol. 35, November, pp. 333–337.

Goldsmith, R. W. (1951), "A Perpetual Inventory of National Wealth," *Studies in Income and Wealth*, Vol. 14, New York, National Bureau of Economic Research, pp. 5–61.

——— (1955), *A Study of Saving in the United States*, Princeton, Princeton University Press.

——— (1962), *The National Wealth of the United States in the Postwar Period*, New York, National Bureau of Economic Research.

——— (1965), *The Flow of Capital Funds in the Postwar Economy*, New York, National Bureau of Economic Research.

Goldsmith, R. W., R. E. Lipsey, and M. Mendelson (1963), *Studies in the National Balance Sheet of the United States*, Princeton, Princeton University Press.

Grose, L., T. Rottenberg, and R. Wasson (1969), "New Estimates of Fixed Business Capital in the United States," *Survey of Current Business*, Vol. 49, February, pp. 46–52.

Internal Revenue Service, *Statistics of Income: Individual Returns*, various annual issues.

Kendrick, J. W. (1972), *Postwar Productivity Trends in the United States*, New York, National Bureau of Economic Research.

Office of Business Economics (1966), *The National Income and Product Accounts of the United States, 1929–1965, A Supplement to the Survey of Current Business*, Washington, D.C., U.S. Department of Commerce.
U.S. Department of the Treasury, *Treasury Bulletin*, various issues.

REPRINTS

260. Arthur S. Goldberger, "Maximum-Likelihood Estimation of Regressions Containing Unobservable Independent Variables," *International Economic Review*, Vol. 13, No. 1, Februry, 1972

261. Donald J. Harris, "On Marx's Scheme of Reproduction and Accumulation," *The Journal of Political Economy*, Vol. 80, No. 3, Part 1, May June 1972
and
Wilhelm Krelle, "Marx as a Growth Theorist," *The German Economic Review*, Separate Print, Vol. 9, 1971, No. 2, pp 122-133.

262. Dennis J. Aigner, "A Note on Verification of Computer Simulation Models," *Management Science*, Vol. 18, No. 11, July, 1972.

263. Theodore Groves and Roy Radner, "Allocation of Resources in a Team," *Journal of Economic Theory*, Vol. 4, No. 3, June 1972.

264. Kenneth J. White, "Estimation of Liquidity Trap with a Generalized Functional Form," *Econometrica*, Vol. 40, No. 1 (January, 1972).

265. Karl G. Jöreskog and Arthur S. Goldberger, Factor Analysis by Generalized Least Squares," *Psychometrika*, Vol. 37, No. 3, (September, 1972).

266. Edgar L. Feige and Harold W. Watts, "An Investigation of the Consequences of Partial Aggregation of Micro-Economic Data," *Econometrica*, Vol. 40, No. 2 (March, 1972).

267. Mark Menchik, "Residential Environmental Preferences and Choice: Empirically Validating Preference Measures," *Environment and Planning*, 1972, Volume 4, pages 445-458.

268. Ernst R. Berndt and Laurits R. Christensen, "The Translog Function and the Substitution of Equipment, Structures, and Labor in U.S. Manufacturing 1929-68," *Journal of Econometrics* 1 (1973).

269. Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Transcendental Logarithmic Production Frontiers," *The Review of Economics and Statistics*, Vol. LV, No. 1, February 1973.

270. Ernst R. Berndt and Laurits R. Christensen, "The Internal Structure of Functional Relationships: Separability, Substitution, and Aggregation," *The Review of Economic Studies*, Vol. XL (3), July, 1973.

272. Laurits R. Christensen and Dale W. Jorgenson, "U.S. Income, Saving, and Wealth, 1929-1969," *The Review of Income and Wealth*, Series 19, No. 4, December 1973.

273. Laurits R. Christensen, "Simultaneous Statistical Inference in the Normal Multiple Linear Regression Model," *Journal of the American Statistical Association*, June 1973, Volume 68, Number 342.

275. Richard H. Day and Jon P. Nelson, "A Class of Dynamic Models for Describing and Projecting Industrial Development," *Journal of Econometrics*, Vol. 1, issue 2 (June 1973).

277. Arthur S. Goldberger, "Structural Equation Methods in the Social Sciences," *Econometrica*, Volume 40, November, 1972, Number 6

278 Dale J. Poirier, "Piecewise Regression Using Cubic Splines," *Journal of the American Statistical Association*, September 1973, Volume 68, Number 343, pp. 515-524.

279. Dennis J. Aigner, "On Estimation of an Econometric Model of Short-Run Bank Behaviour," *Journal of Econometrics 1* (1973) 201-228.

280. Mark D. Menchik, "Optimal Allocation of Outdoor Recreation Use in the Presence of Ecological Carrying Capacity Limitations and Congestion Effects," *Papers of the Regional Science Association, Volume Thirty.*

281. Richard H. Day, Samuel Morley, and Kenneth R. Smith, "Myopic Optimizing and Rules of Thumb in a Micro-Model of Industrial Growth," *The American Economic Review*, March 1974, Vol. 64, No. 1.

282. Stephen M. Robinson and Richard H. Day, "A Sufficient Condition for Continuity of Optimal Sets in Mathematical Programming," *Journal of Mathematical Analysis and Applications*, Vol. 45, No. 2, February 1974.

This series includes selected publications of members of the SSRI staff and others working in close association with the institute. Inquiries concerning publications should be addressed to Ms. Linda Bielski, SSRI, University of Wisconsin-Madison, 1180 Observatory Drive, Madison, Wisconsin 53706.

RECEIVED

MAR = 6 1995

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

U.S. REAL PRODUCT AND REAL FACTOR INPUT, 1929–1967

LAURITS R. CHRISTENSEN AND DALE W. JORGENSON

University of Wisconsin and Harvard University

The objective of this paper is to provide a conceptual basis for separating social product and social factor input accounts into price and quantity components. Despite the essential similarity between concepts of real product and real factor input, the measurement of social factor outlay in constant prices is not well established in social accounting practice.

Production accounts are constructed for the United States in current and constant prices, including social product and social factor outlay, for the period 1929–1967. The resulting estimates are applied to the measurement of total factor productivity and the study of the responsiveness of product and factor intensities to price changes.

1. INTRODUCTION

Within the framework of social accounting the production account includes an allocation of the total social product among final uses such as private and public consumption, capital formation, and net exports. The factor outlay account includes a similar allocation of factor outlay among productive factors—labor services and various types of capital services. As an accounting identity the value of the social product is equal to the value of outlays on factor services required for production. The objective of this paper is to provide a conceptual basis for separating social product and social factor input into price and quantity components.[1]

The measurement of social product in current and constant prices is well established in accounting practice. For most countries with production accounts a separation of the social product into price and quantity components is available. Each delivery of social product to final demand involves a commodity or service flow that may be separated into price and quantity components. Quantities and prices of individual commodities and services are combined into indexes of real product and its price or implicit deflator.

An analysis of the sources of economic growth requires the measurement of social factor outlay in current and constant prices. The conceptual basis for separation of factor outlay into price and quantity components is identical to that for social product. Each outlay on factor services must be separated into price and quantity components. Price and quantities of the individual factor services are combined into indexes of real factor input and its price. As an illustration, the value of labor services may be divided between wage rate and quantity of labor time. The product of the two is the outlay on labor services or labor compensation.

[1]The measurement of social factor input in constant prices was proposed by Copeland [6] and has been discussed from the viewpoint of social accounting by Stone [33], Kendrick [24], and Jorgenson and Griliches [23]. Social factor input in constant prices is not included in the United Nations system of standard national accounts [37] or in the United States national income and product accounts [28, 29, 30].

Despite the essential similarity between concepts of real product and real factor input, the measurement of social factor outlay in constant prices is not well established in social accounting practice. The chief remaining problem is the measurement of capital input in real terms. We have attempted to provide a conceptual basis for measuring real capital input in a previous paper.[2] An accounting imputation is required for separation of outlay on capital services into price and quantity components. Our method for imputation is based on the correspondence between asset prices and service prices implied by the equality between the value of an asset and the discounted value of its services. This method for imputation requires the same data as the perpetual inventory method for measurement of capital stock, together with data on property compensation by legal form of organization.

In this paper we present production accounts for the United States in current and constant prices, including social product and social factor outlay, for the period 1929–1967. Deconsolidation by commodities or by industrial sectors may be carried out along conventional lines, resulting in product and factor outlay accounts for each sector and incorporating inter-industry transactions in current and constant prices. Income, expenditure, and capital finance accounts may also be separated into price and quantity components. The uses of capital finance correspond to changes in the quantity of national wealth, while revaluations correspond to changes in its price.[3] In this paper we discuss price and quantity measurement only for the production account.

The principal applications of measures of real product and real factor input are to the study of production. We apply our estimates to the measurement of total factor productivity in the United States. We also measure the elasticity of substitution between labor and capital input and the elasticity of transformation between investment and consumption goods output. Our study of total factor productivity extends that of Jorgenson and Griliches [23], providing measurements for a considerably longer period of time and analyzing the growth of real factor input in more detail. Our estimates of the elasticities of substitution and transformation provide an alternative characterization of production possibilities to that given by Arrow, Chenery, Minhas, and Solow [2].

2. The Production Account in Current Prices

The fundamental accounting identity for the production account is that the value of output is equal to the value of input. Letting q_i represent the price of the ith output and Y_i its quantity and letting p_j represent the price of the jth input and X_j its quantity, this accounting identity may be written:

$$q_1 Y_1 + q_2 Y_2 + \ldots + q_m Y_m = p_1 X_1 + p_2 X_2 + \ldots + p_n X_n.$$

The first accounting problem is to define appropriate concepts of output and input. We define the value of output as gross value added from the point of view of the producer. For each sector we measure revenue as net proceeds to

[2]Christensen and Jorgenson [5].

[3]The compilation of national accounts in constant prices has been discussed by Stone [33] and more recently by Broderick [3], Burge [4], Courbis [7], Fabricant [12], and Geary [15].

the sector and outlay as gross expenses of the sector. Our concept of gross value added is intermediate between gross product at market prices and at factor cost, as these terms are conventionally employed. The value of output is net of taxes on output while the value of input is gross of taxes on input. The justification for this definition is that the main analytical use of the production account is in the study of producer behaviour. Revenue and outlay must be measured from the producer's point of view.

In implementing the production account for the United States we confine our attention to the private domestic economy. We exclude government since government product is equal to labor compensation in the government sector by definition. The services of capital in the government sector are ignored, so that production accounts for private and government sectors are not comparable. Our concept of private domestic output treats direct taxes in the same way as in the U.S. national income and product accounts. However, rather than include or exclude all indirect taxes from the value of output, we exclude indirect business taxes charged against revenue, such as excise or sale taxes, and include indirect business taxes charged to the producer as part of outlay on productive factors, such as property taxes. Taxes on output reduce the net proceeds of the business sector and subsidies increase these proceeds; accordingly, we add production subsidies in arriving at the value of output from the producer's point of view.[4]

In measuring gross private domestic product for the United States our treatment of excise and sales taxes, business nontax payments, and customs duties is symmetric in that each is excluded from the value of output. Excise and sales taxes and nontaxes[5] are deducted from revenue in arriving at net proceeds to the producer. Customs duties are part of the outlay on imports of commodities and services of the foreign sector and must be excluded from value added in the private domestic sector.

In the U.S. national income and product accounts the services of owner-occupied housing and structures utilized by non-profit institutions are included in the product of the private sector. The flows of capital services resulting from investment in housing by owner-occupiers and investment in structures by non-profit institutions are not recorded in market transactions. The value of the service flow must be imputed from data on rental values. The treatment of capital services from consumers' durables and producers' durables used by non-profit institutions is not symmetrical with that of housing and structures. Purchases of consumers' durables are treated as part of personal consumption expenditures and purchases of producers' durables by non-profit institutions are treated as part of private investment, but the service flow from these durables is not included in private product.

We treat the services of owner-utilized consumers' durables and producers' durables utilized by non-profit institutions symmetrically with the services of owner-occupied housing and the structures of non-profit institutions. Purchases

[4]The evaluation of output from the producer's point of view is equivalent to incorporating indirect taxes included in outlay on productive factors in factor cost. As Stone [33] points out, output must be evaluated at market prices in order for value added to be equal to deliveries to final demand.

[5]See [29] for a description of nontax payments included in the U.S. national accounts.

of new consumers' durables and purchases of producers' durables by institutions are included in private investment. This change from the conventions of the U.S. national income and product accounts leaves the value of the total product unaltered. We then impute the value of services of consumers' durables and producers' durables owned by institutions from rental values implied by the imputed service flow for owner-occupied housing and institutional structures. We add the resulting service flow to the product of the private sector. This change increases the value of the total product and requires data for the imputation of the rental value of these capital services.

Given our definitions of output and input, we may describe more explicitly the measurement of gross private domestic product and gross private domestic factor outlay. The value of gross product is defined as private gross national product less rest of the world product,[6] less income orginating in government enterprises,[7] plus the value of the services of consumers' durables and producers' durables utilized by institutions,[8] less federal indirect business tax and nontax accruals, except for capital stock tax,[9] less state and local indirect business tax and nontax accruals, except for motor vehicle licences, property taxes, and other taxes,[10] plus subsidies and less current surplus of federal and state and local government enterprises.[11] The resulting value of gross private domestic product for the year 1958 is presented in Table 1.

The value of gross private domestic factor outlay is equal to the value of gross private domestic product by definition. The value of factor outlay is the sum of income originating in private enterprises and in private households and institutions,[12] plus the imputed value of the services of consumers' durables and durables utilized by institutions,[13] plus indirect business taxes charged to the producer as part of factor outlay, as described in the definition of gross product. The value of factor outlay also includes capital consumption allowances, business transfer payments, and the statistical discrepancy[14] arising from differences between the product side and the factor outlay side of the production account. Capital consumption allowances are part of the outlay on capital services and are included in the rental value of capital services. Business transfer payments and the statistical discrepancy are taken as part of income from capital. The resulting value of gross private domestic factor outlay for the year 1958 is given in Table 1.

In separating the values of gross product and gross factor outlay into price and quantity components, we find it useful to divide total product between consumption and investment goods and total factor outlay between capital and

[6]All references to data from the U.S. national income and product accounts will be to *The National Income and Product Accounts of the United States*, 1929–1965, *Statistical Tables, A Supplement to the Survey of Current Business*, August 1966, henceforward *NIP* [28], and subsequent national income issues of the *Survey of Current Business*, unless otherwise indicated. *NIP* [28], Table 1.7.

[7]*NIP* [28], Table 1.13.

[8]These values are imputed by methods discussed in detail in our previous paper, [5], Section 5.

[9]*NIP* [28], Table 3.1.

[10]*NIP* [28], Table 3.3.

[11]*NIP* [28], Tables 3.1 and 3.3.

[12]*NIP* [28], Table 1.13.

[13]See footnote 8, above.

[14]*NIP* [28], Table 1.9.

TABLE 1

PRODUCTION ACCOUNT, GROSS PRIVATE DOMESTIC PRODUCT AND FACTOR OUTLAY, UNITED STATES, 1958 (CURRENT PRICES)[a]

	PRODUCT	
1.	Private gross national product (Table 1.7)	405.2
2.	− Income originating in government enterprises (Table 1.13)	4.8
3.	− Rest of the world gross national product (Table 1.7)	2.0
4.	+ Services of consumers' durables (our imputation)	39.8
5.	+ Services of durables held by institutions (our imputation)	.3
6.	− Federal indirect business tax and nontax accruals (Table 3.1)	11.5
7.	+ Capital stock tax (Table 3.1, footnote 2)	——
8.	− State and local indirect business tax and nontax accruals (Table 3.3)	27.0
9.	+ Business motor vehicle licences (Table 3.3)	.8
10.	+ Business property taxes (Table 3.3)	13.8
11.	+ Business other taxes (Table 3.3)	2.9
12.	+ Subsidies less current surplus of federal government enterprises (Table 3.1)	2.7
13.	− Current surplus of state and local government enterprises (Table 3.3)	1.8
14.	= Gross private domestic product	418.4
	FACTOR OUTLAY	
1.	Capital consumption allowances (Table 1.9)	38.9
2.	+ Business transfer payments (Table 1.9)	1.6
3.	+ Statistical discrepancy (Table 1.9)	1.6
4.	+ Services of consumers' durables (our imputation)	39.8
5.	+ Services of durables held by institutions (our imputation)	.3
6.	+ Certain indirect business taxes (product account above, 7 + 9 + 10 + 11)	17.4
7.	+ Income originating in business (Table 1.13)	312.2
8.	− Income originating in government enterprises (Table 1.13)	4.8
9.	+ Income originating in households and institutions (Table 1.13)	11.4
10.	= Gross private domestic factor outlay	418.4

[a]All table references are to *The National Income and Product Accounts of the United States, 1929–1965, Statistical Tables, A Supplement to the Survey of Current Business*, August, 1966.

labor services. In the U.S. national income and product accounts total output is divided among durables and structures output (which we denote investment goods output) and nondurables and services output (which we denote consumption goods output).[15] Our definition of durables output includes consumers' durables, as in the U.S. national accounts. Our definition of services output includes the services of consumers' durables and institutional durables along with services output included in the U.S. accounts. The output of the foreign and government sectors consists entirely of services, so that we define the output of services by the private sector as services included in gross national product,[16] less the product of foreign and government sectors (including government enterprises),[17] plus the services of consumers' durables and durables utilized by non-profit institutions.

The value of factor outlay in the private domestic sector includes the labor compensation of employees in private enterprises and in private households and non-profit institutions,[18] plus the labor compensation of self-employed persons.[19]

[15]*NIP* [28], Table 1.3.

[16]*NIP* [28], Table 1.5.

[17]*NIP* [28], Tables 1.7, 1.13.

[18]*NIP* [28], Table 1.13.

[19]Self-employed persons include proprietors and unpaid family workers. Alternative methods for imputation of the labor compensation of the self-employed are reviewed by Kravis [27].

We estimate labor compensation of the self-employed by multiplying the compensation of employees by the ratio of proprietors and unpaid family workers to full-time equivalent employees in each sector. Our estimates of non-farm proprietors and employees are those of the Office of Business Economics. Our estimates of non-farm unpaid family workers are those of Kendrick, allocated among sectors in proportion to the number of proprietors in each sector, as Kendrick suggests. Our estimates of persons engaged in the farm sector are from Kendrick.[20] In effect we assume that for each sector the average labor compensation of proprietors and unpaid family workers is equal to average labour compensation of full-time equivalent employees in the same sector. The sectors utilized in carrying out this imputation are: (1) The farm sector—agriculture, forestry, and fisheries, (2) mining, (3) contract construction, (4) nondurable manufacturing, (5) durable manufacturing, (6) transportation, (7) communication, (8) electric, gas, and sanitary services, (9) wholesale and retail trade, (10) finance, insurance, and real estate, (11) services. This method of imputation is only one of many that have been proposed; Denison has suggested that the results are likely to be biased in the direction of allocating too large a portion of proprietors' income to labor compensation.[21]

All factor outlay not allocated to labor is allocated to capital.[22] Specifically, the value of outlay on capital services includes the following: property income of self-employed persons, the portion of proprietor's income not allocated to labor compensation; profits, rentals, and interest; capital consumption allowances; business transfer payments; the statistical discrepancy; indirect business taxes that are part of the outlay on productive factors, such as motor vehicle licenses, property taxes, and other taxes; and the imputed value of the services of consumers' durables and producers' durables utilized by institutions.[23] Gross private domestic product and factor outlay in current prices for 1929–1967 are given in Table 2. Total product is divided between gross private domestic investment and gross private domestic consumption. Total factor outlay is divided between labor compensation and property compensation.

3. Price and Quantity Index Numbers

To separate flows of product and factor outlay into prices and quantities, we introduce price and quantity index numbers. As an example, we consider the value of output, say qY, introduced in the production accounts. Suppose that there are m components to the value of output,

$$qY = q_1 Y_1 + q_2 Y_2 + \ldots + q_m Y_m.$$

[20]These data have been compiled for John W. Kendrick's forthcoming study, *Postwar Productivity Trends in the United States*, for the National Bureau of Economic Research [25]. We are indebted to Kendrick for providing us with these data in advance of publication. The conceptual basis for compilation of the data is the same as in Kendrick's *Productivity Trends in the United States* [26]. The Office of Business Economics data on non-farm proprietors and employees are from *NIP* [28], Tables 6.4 and 6.6.

[21]Denison [9], page 4.

[22]This is a consequence of the accounting identity between the value of output and the value of input.

[23]Of these components of gross factor outlay, the statistical discrepancy is the only component that might be partly assigned to labor compensation. We assume that any discrepancy reflects errors in reporting property income rather than labor income.

TABLE 2

GROSS PRIVATE DOMESTIC PRODUCT AND FACTOR OUTLAY, 1929–1967 (CURRENT PRICE)

Year	1. Gross Private Domestic Product	2. Investment Goods Product	3. Consumption Goods Product	4. Labor Compensation	5. Property Compensation
1929	103.0	28.4	74.5	56.2	46.8
1930	89.8	20.2	69.5	51.4	38.4
1931	77.0	14.1	62.9	43.2	33.8
1932	57.9	7.1	50.7	33.4	24.5
1933	55.5	7.5	48.0	31.0	24.4
1934	60.0	10.4	49.6	35.2	24.9
1935	69.1	12.7	56.4	38.3	30.8
1936	76.4	17.0	59.3	42.9	33.5
1937	84.9	19.7	65.2	49.1	35.8
1938	77.4	15.3	62.1	45.4	32.0
1939	84.9	19.3	65.6	48.9	36.0
1940	93.4	23.8	69.5	52.9	40.5
1941	115.7	37.0	78.7	64.9	50.8
1942	143.2	47.6	95.6	81.5	61.7
1943	168.7	60.6	108.2	96.5	72.2
1944	177.2	61.3	116.0	103.1	74.1
1945	175.2	52.6	122.5	103.3	71.8
1946	190.5	49.9	140.6	115.2	75.3
1947	218.2	64.2	154.0	132.9	85.3
1948	239.6	72.7	166.9	145.9	93.7
1949	236.1	72.2	164.0	143.5	92.6
1950	269.1	91.2	177.9	156.3	112.8
1951	307.3	106.2	201.0	177.4	129.9
1952	323.1	108.2	214.9	188.9	134.2
1953	340.2	115.3	225.1	202.7	137.5
1954	343.1	110.9	232.1	200.8	142.2
1955	374.7	128.6	246.1	216.5	158.2
1956	396.4	135.3	261.1	234.0	162.5
1957	415.1	140.0	275.1	245.9	169.2
1958	418.4	130.4	288.0	245.1	173.3
1959	453.4	146.8	306.6	265.5	187.8
1960	472.5	148.8	323.7	278.7	193.8
1961	487.2	147.4	339.7	284.7	202.5
1962	423.5	163.5	360.0	302.6	220.9
1963	550.9	173.2	377.7	316.8	234.1
1964	588.5	186.7	410.8	338.4	250.1
1965	640.7	204.7	436.0	362.7	278.0
1966	700.8	223.6	477.2	397.1	303.7
1967	732.0	226.9	505.0	423.1	308.9

We must introduce index numbers for the price of output q and the quantity of output Y, defined in terms of the prices $\{q_i\}$ and quantities $\{Y_i\}$ of the m components. Differentiating totally with respect to time and dividing both sides by the corresponding total value of output, we obtain:

$$\frac{\dot{q}}{q} + \frac{\dot{Y}}{Y} = \Sigma w_i \left[\frac{\dot{q}_i}{q_i} + \frac{\dot{Y}_i}{Y_i}\right],$$

with weights $\{w_i\}$ given by the relative shares of the value of the ith output in

the value of total output:

$$w_i = \frac{q_i Y_i}{\Sigma q_i Y_i}.$$

We define the price and quantity indexes of output in terms of rates of growth of the prices and quantities of individual components; the rates of growth of the price index q and the quantity index Y are

$$\frac{\dot{q}}{q} = \Sigma w_i \frac{\dot{q}_i}{q_i}, \qquad \frac{\dot{Y}}{Y} = \Sigma w_i \frac{\dot{Y}_i}{Y_i},$$

respectively. These index numbers are Divisia price and quantity indexes.[24] Rates of growth of the Divisia indexes of prices and quantities add up to the rate of growth of the value of output (factor reversal test) and are symmetric in different directions of time (time reversal test). They also have the reproductive property that a Divisia index of Divisia indexes is a Divisia index of the components.

For application to data for discrete points of time an approximation to the Divisia indexes for continuous time is required. Price and quantity index numbers originally discussed by Fisher [13] may be used for this purpose:

$$\log q_t - \log q_{t-1} = \Sigma \bar{w}_{it}[\log q_{it} - \log q_{i,t-1}],$$
$$\log Y_t - \log Y_{t-1} = \Sigma \bar{w}_{it}[\log Y_{it} - \log Y_{i,t-1}],$$

where the weights w_{it} are arithmetic averages of the relative shares in the two periods,

$$\bar{w}_{it} = \tfrac{1}{2} w_{it} + \tfrac{1}{2} w_{i,t-1}.$$

These index numbers have been suggested as a discrete approximation to the Divisia index by Tornquist [36]. Obviously, the discrete and continuous index numbers are equal if relative shares are constant. If shares are not constant, the discrete approximation involves an error that depends on the variability of the relative shares and the length of the time period.

Divisia index numbers for discrete time are symmetric in data of different time periods (time reversal). They have the basic reproductive property that a discrete Divisia index of discrete Divisia indexes is a discrete Divisia index of the components. Theil [34] has demonstrated that the sum of changes in logarithms of discrete Divisia indexes of price and quantity is approximately equal to the change in the logarithm of the value (factor reversal). The factor reversal test is satisfied exactly if relative shares are constant; the accuracy of the approximation depends on the change in relative shares. As a practical matter this approximation is extremely accurate for annual time series of national accounting aggregates such as consumption; Theil shows that the error averages only 0.01 per cent of the annual rate of growth in the value of consumption in The Netherlands for the period 1921–1963.

It is convenient to have the product of price and quantity indexes equal to the value of transactions so that standard accounting identities hold for variables

[24]The economic interpretation of Divisia indexes of total factor productivity has been discussed by Solow [32], Richter [31], and Jorgenson and Griliches [23].

defined as price and quantity index numbers. Accordingly, we construct discrete Divisia price indexes as the value in current prices divided by the discrete Divisia quantity index. The resulting price indexes are approximately equal to the Divisia price indexes.

In defining the price and quantity of output we distinguish between the price representing proceeds to the producer and the price paid by the ultimate consumer. The difference between the two prices includes excise and sales taxes. Just as price and quantity index numbers may be defined in terms of the prices and quantities of the components of output, we may define a tax index, incorporating the effective tax rate, in terms of prices, quantities, and tax rates of the components of output. Let the market price of output q^+ equal the product of the producers' price q and unity plus the effective tax rate $1+t$. The value of output at market prices is

$$q^+ Y = (1 + t)q Y.$$

We now define the value of output at market prices in terms of prices, quantities and tax rates of the components of output:

$$\begin{aligned} q^+ Y &= \Sigma q_i^+ Y_i, \\ &= \Sigma (1 + t_i) q_i Y_i. \end{aligned}$$

Proceeding as before, we differentiate totally with respect to time, obtaining:

$$\frac{(1 \dot{+} t)}{1 + t} + \frac{\dot{q}}{q} + \frac{\dot{Y}}{Y} = \Sigma w_i \left[\frac{(1 \dot{+} t_i)}{1 + t_i} + \frac{\dot{q}_i}{q_i} + \frac{\dot{Y}_i}{Y_i}\right].$$

The rate of growth of the tax index $1+t$ is

$$\frac{(1 \dot{+} t)}{1 + t} = \Sigma w_i \frac{(1 \dot{+} t_i)}{1 + t_i};$$

rates of growth of the price and quantity indexes are the same as before. The effective tax rate is the tax index less unity.

Again, it is convenient to preserve equality between the product of price, quantity, and tax indexes and the value of transactions. Accordingly, we construct an index of taxes $1+t$ by dividing the value of transactions at market prices by the value of transactions at producers' prices. The resulting tax index is approximately equal to the Divisia tax index defined for discrete points of time.

4. Total Product in Constant Prices

We now turn to separation of gross product and gross factor outlay from the production account into price and quantity indexes of product and factor input. Product is allocated between consumption and investment goods and factor input is allocated between capital and labor services. Consumption goods include nondurable goods and services; investment goods include durable goods and structures. We construct quantity index numbers of output and of final sales for these two types of output from data for the corresponding components of gross national product in constant prices.[25] Change in business inventories

[25] *NIP* [28], Tables 1.5 and 1.6, except for structures—see Section 5 below.

in constant prices is defined as the difference between index numbers of output and of final sales in constant prices. The product of the rest of the world and government sectors is composed entirely of services. The price index for the product of each of these sectors is assumed to be the same as for services as a whole. Quantity index numbers for the services of consumers' durables and institutional durables are constructed as part of our imputation of the value of these services and will be described below.

The value of output from the point of view of the producing sector excludes certain indirect business taxes less subsidies. The price of output is implicit in the value of output and the quantity index of output described above. The market price of final sales is the price index implicit in the quantity index of final sales described above and the value of final sales at market prices as calculated from the U.S. national accounts. The tax index is implicit in the value of final sales from the point of view of the producing sector and the value of final sales at market prices. Price and quantity index numbers for gross private domestic product and final sales from the point of view of the producing sector are given for 1929–1967 in Table 3.

We require a division of output between consumption and investment goods. Sales and excise taxes must be allocated between these two categories of output. If taxes were assessed only on the basis of deliveries to final demand, we could allocate them directly between investment and consumption goods deliveries. In fact a substantial portion of sales and excise taxes falls on deliveries to intermediate demand; examples would include taxes on airline tickets, automobiles, gasoline, telephone services, and business machines. A completely satisfactory allocation of these taxes would require a detailed input-output analysis. The data required to carry out this analysis on an annual basis are unavailable. We have allocated the taxes in proportion to the value of consumption and investment goods output in the value of final sales. This is equivalent to assuming that the effective tax rate is the same for consumption and investment goods. Price and quantity index numbers for consumption and investment goods output are given in Table 3, together with the relative share of investment goods output in the value of total output.

5. Total Factor Input in Constant Prices

The input of the producing sector is divided between labor and capital services. We present quantity indexes for input of each type. The construction of a quantity index of labor input begins with private domestic persons engaged; our estimates of persons engaged are described above.[26] Our estimates for the non-farm sector are identical to those of the Office of Business Economics for full-time equivalent employees and proprietors; we add Kendrick's estimates of unpaid family workers to obtain total persons engaged. For the farm sector we employ Kendrick's estimates.[27] Persons engaged is essentially the stock of labor and must be adjusted for hours utilized per person to obtain a measure of

[26]Persons engaged includes full-time equivalent employees, proprietors, and unpaid family workers.

[27]See footnote 20, above.

the quantity of labor input. Man-hours are also estimated by Kendrick and we employ his estimates for the private domestic sector.[28]

The assumption that effective labor services are proportional to the stock of labor is obviously incorrect. On the other hand the assumption that effective labor services can be measured directly from data on man-hours is equally incorrect, as Denison [8] has pointed out. The intensity of effort varies with the number of hours worked per week, so that effective labor input can be measured accurately only if data on man-hours are corrected for the effects of variations in the number of hours per man on effective labor input. Denison [10] suggests that the stock of labor provides an upper bound for effective labor services while the number of man-hours provides a lower bound. He estimates effective labor input by correcting man-hours for variations in labor intensity. We employ Denison's correction for intensity, but we apply this correction to actual hours per man rather than potential hours per man.

It is desirable to distinguish among outputs of different types and to deflate each type of output separately; similarly, it would be desirable to distinguish among different categories of labor, classified by sex, race, number of years of schooling, occupation, age, and so on. Labor input is defined as a quantity index of labor inputs of each type; corresponding to the quantity index of labor input there is a price index for labor representing the aggregate wage rate. Denoting the quantity index by L and the price index by p^L the value of labor input is the sum of the values of labor inputs:

$$p^L L = \Sigma\, p_j{}^L L_j,$$

where labor input of each type is measured in effective man-hours and the prices are corresponding hourly wage rates. Proceeding as before, we obtain indexes of the wage rate and quantity of labor,

$$\frac{\dot{p}^L}{p^L} = \Sigma\, v_j \frac{\dot{p}_j{}^L}{p_j{}^L}, \qquad \frac{\dot{L}}{L} = \Sigma\, v_j \frac{\dot{L}_j}{L_j},$$

where the weights $\{v_j\}$ are the relative shares of each type of labor in the value of total labor input.

For each category of labor, man-hours are the product of persons engaged, say n_j, and effective hours per person, say h_j. The index of total labor input may be rewritten:

$$\frac{\dot{L}}{L} = \Sigma\, v_j \frac{\dot{n}_j}{n_j} + \Sigma\, v_j \frac{\dot{h}_j}{h_j}.$$

Where N is person engaged and H is effective hours per man, the index may be finally rewritten in the form:

$$\frac{\dot{L}}{L} = \Sigma\, v_j\left(\frac{\dot{n}_j}{n_j} - \frac{\dot{N}}{N}\right) + \Sigma\, v_j\left(\frac{\dot{h}_j}{h_j} - \frac{\dot{H}}{H}\right) + \frac{\dot{N}}{N} + \frac{\dot{H}}{H};$$

the first term is the change in labor input per person due to shifts in the composition of the labor force, the second is the change in labor input per hour due to

[28]See footnote 20, above.

TABLE 3

GROSS PRIVATE DOMESTIC PRODUCT AND FINAL SALES, 1929–1967 (CONSTANT PRICES OF 1958)

Year	1. Gross Private Domestic Product, Quantity Index	2. Gross Private Domestic Product, Price Index	3. Gross Private Domestic Final Sales, Quantity Index	4. Gross Private Domestic Final Sales, Price Index	5. Effective Tax Rate, Final Sales	6. Consumption Goods Product, Quantity Index	7. Consumption Goods Product, Price Index	8. Investment Goods Product, Quantity Index	9. Investment Goods Product, Price Index	10. Relative Share of Investment Goods Product
1929	189.8	0.543	185.9	0.544	0.018	136.275	0.547	55.781	0.509	0.276
1930	172.1	0.522	172.2	0.523	0.019	132.291	0.525	41.253	0.489	0.225
1931	159.1	0.484	160.9	0.486	0.021	128.840	0.488	31.097	0.453	0.183
1932	135.6	0.427	141.2	0.428	0.027	118.260	0.429	17.642	0.405	0.123
1933	132.0	0.420	135.7	0.420	0.040	113.791	0.422	18.548	0.403	0.135
1934	141.8	0.423	143.7	0.422	0.050	117.234	0.432	25.064	0.414	0.173
1935	153.9	0.449	150.9	0.450	0.047	124.285	0.454	30.325	0.418	0.184
1936	171.5	0.445	167.8	0.447	0.046	131.804	0.450	41.077	0.415	0.223
1937	183.0	0.464	176.9	0.465	0.045	139.840	0.467	44.620	0.442	0.232
1938	173.2	0.447	174.7	0.448	0.046	140.153	0.443	34.272	0.447	0.198
1939	188.5	0.450	186.5	0.453	0.044	146.147	0.449	43.755	0.442	0.228
1940	205.5	0.454	199.6	0.457	0.046	153.778	0.452	53.265	0.447	0.255
1941	236.0	0.491	225.4	0.494	0.046	164.364	0.479	73.076	0.506	0.319
1942	257.8	0.555	253.1	0.551	0.039	178.567	0.535	80.802	0.589	0.332
1643	277.5	0.608	277.4	0.610	0.037	180.380	0.600	98.066	0.618	0.359
1944	291.1	0.609	292.5	0.610	0.042	188.830	0.614	103.207	0.594	0.346
1945	284.5	0.616	286.9	0.614	0.049	192.278	0.637	92.600	0.568	0.300
1946	274.0	0.695	264.8	0.695	0.054	195.802	0.718	77.297	0.646	0.262

1947	279.9	0.780	280.3	0.780	0.049	193.836	0.794	85.665	0.749	0.294
1948	297.6	0.805	293.2	0.801	0.049	203.862	0.819	93.524	0.777	0.303
1949	297.7	0.793	301.8	0.793	0.050	206.087	0.796	91.290	0.791	0.306
1950	328.9	0.818	321.0	0.817	0.050	214.858	0.828	113.906	0.801	0.339
1951	351.4	0.874	341.0	0.871	0.048	228.406	0.880	122.928	0.864	0.346
1952	360.4	0.896	357.4	0.896	0.048	237.323	0.905	122.964	0.880	0.335
1953	378.9	0.898	378.1	0.899	0.049	247.628	0.909	131.165	0.879	0.339
1954	375.8	0.913	377.6	0.913	0.045	250.337	0.927	125.156	0.886	0.323
1955	406.7	0.921	400.6	0.920	0.047	262.884	0.936	143.864	0.894	0.343
1956	416.3	0.952	411.8	0.951	0.047	272.994	0.956	143.264	0.945	0.341
1957	422.8	0.982	421.7	0.981	0.046	281.133	0.978	141.574	0.989	0.337
1958	418.4	1.000	419.9	1.000	0.045	287.953	1.000	130.421	1.000	0.312
1959	445.7	1.017	441.1	1.017	0.047	300.725	1.020	144.979	1.013	0.324
1960	457.3	1.033	454.1	1.032	0.049	310.005	1.044	147.263	1.010	0.315
1961	466.3	1.045	464.4	1.045	0.047	320.353	1.061	145.736	1.012	0.303
1962	495.3	1.057	489.8	1.057	0.048	334.981	1.075	160.431	1.019	0.312
1963	515.5	1.069	510.0	1.069	0.048	346.273	1.091	169.410	1.022	0.314
1964	544.1	1.082	538.5	1.082	0.048	363.320	1.106	181.165	1.030	0.317
1965	579.2	1.106	570.9	1.106	0.047	383.562	1.137	196.323	1.043	0.320
1966	615.6	1.138	603.0	1.138	0.044	406.587	1.174	209.890	1.065	0.319
1967	631.1	1.160	625.4	1.161	0.044	424.326	1.190	206.903	1.097	0.310

TABLE 4

PRIVATE DOMESTIC LABOR INPUT, 1929–1967 (CONSTANT PRICES OF 1958)

Year	1. Private Domestic Persons Engaged (Millions)	2. Educational Attainment Per Person (Index)	3. Private Domestic Hours Per Person (Thousands Per Year)	4. Effective Labor Input Per Hour (Index)	5. Private Domestic Labor Input, Quantity Index	6. Private Domestic Labor Input, Price Index
1929	44.151	0.836	2.579	0.858	173.3	0.324
1930	41.898	0.840	2.530	0.875	165.4	0.311
1931	36.948	0.844	2.494	0.910	158.2	0.273
1932	35.686	0.848	2.409	0.916	141.7	0.236
1933	35.533	0.852	2.395	0.921	141.6	0.219
1934	37.854	0.855	2.210	0.974	148.0	0.238
1935	39.014	0.859	2.260	0.960	154.4	0.248
1936	40.765	0.863	2.326	0.941	163.5	0.263
1937	42.484	0.867	2.372	0.927	172.0	0.285
1938	40.039	0.871	2.297	0.950	161.5	0.281
1939	41.443	0.875	2.334	0.939	168.6	0.290
1940	43.149	0.879	2.340	0.937	176.5	0.300
1941	46.576	0.886	2.361	0.931	192.4	0.337
1942	49.010	0.893	2.416	0.914	205.1	0.398
1943	49.695	0.900	2.465	0.898	210.1	0.459
1944	48.668	0.907	2.489	0.896	208.8	0.494
1945	47.136	0.914	2.427	0.911	202.1	0.511
1946	49.950	0.922	2.308	0.946	213.4	0.540
1947	52.350	0.929	2.252	0.962	223.6	0.594

1948	53.336	0.936	2.228	0.969	228.2	0.639
1949	51.469	0.942	2.223	0.970	221.3	0.647
1950	52.972	0.948	2.197	0.978	228.8	0.683
1951	55.101	0.954	2.185	0.981	239.0	0.742
1952	55.385	0.960	2.187	0.980	241.7	0.782
1953	56.226	0.965	2.159	0.986	245.2	0.827
1954	54.387	0.971	2.139	0.990	237.4	0.846
1955	55.718	0.977	2.161	0.986	245.9	0.880
1956	56.770	0.982	2.151	0.988	251.6	0.930
1957	56.809	0.988	2.121	0.995	251.5	0.978
1958	55.023	1.000	2.099	1.000	245.1	1.000
1959	56.215	1.012	2.122	0.995	254.9	1.042
1960	56.743	1.020	2.126	0.994	259.6	1.074
1961	56.211	1.028	2.110	0.998	258.1	1.103
1962	57.078	1.036	2.117	0.996	264.6	1.144
1963	57.540	1.043	2.117	0.996	268.5	1.180
1964	58.508	1.051	2.122	0.995	275.4	1.229
1965	60.055	1.058	2.134	0.992	285.3	1.271
1966	62.130	1.067	2.126	0.994	297.4	1.335
1967	63.162	1.077	2.126	0.994	305.0	1.387

shifts in relative hours per man among components of the labor force, and the sum of the last two terms is the change in total effective man-hours. Two types of "quality" adjustments are required to convert total man-hours to an index of aggregate labor input—one based on shifts in composition of the labor force and the other based on changes in relative hours worked.

Quality adjustments of effective man-hours required to obtain an index of labor input are not available in the detail that would be desirable. Kendrick distinguishes different categories of labor by industry; Jorgenson and Griliches distinguish labor by years of schooling completed.[29] Both adjustments account for changes in quality associated with changes in the composition of the labor force. We have used the quality adjustment provided by Jorgenson and Griliches and extended by Griliches[30] to adjust for changes in the quality of labor due to changes in the educational composition of the labor force. Our measure of labor services is based on the stock of labor as measured by persons engaged, adjusted for effective hours per person and for changes in the composition of the labor force by educational attainment. The cost of labor services index is calculated by dividing total labor compensation by the quantity index of labor services. The number of persons engaged, the index of quality change, actual hours per worker, effective labor input per man-hour, and the quantity of labor input for 1929–1967 are given in Table 4. The price of labor services implicit in private domestic labor compensation is also given in Table 4. It would obviously be desirable to incorporate additional aspects of labor force composition in adjusting the stock of labor for quality change. It would also be desirable to adjust the number of hours per man for changes in the relative number of hours worked by persons differing in educational attainment.

In a previous paper [31] we have constructed a quantity index of capital input. The starting point for such an index is the measurement of capital stock corresponding to each type of capital services. We have used the perpetual inventory method[32] to estimate the level of capital stock for seven types of assets—land, residential structures, non-residential structures, producers' durable equipment, nonfarm business inventories, farm inventories, and consumers' durable equipment. We have allocated each class of assets among four sectors of the private domestic economy—corporations, non-corporate business, households, and institutions.

The second step in the construction of a quantity index of capital input is to separate price and quantity components of the value of property compensation for each sector of the economy. Our method of imputation is based on the equality of the value of an asset and the discontinued value of its services. Total property compensation or the value of all capital services is equal to the

[29]See Kendrick [26] and Jorgenson and Griliches [23].

[30]See Jorgenson and Griliches [23] and Griliches [21]. We have extended Griliches' estimates back to 1929, using relative earnings for 1939 and estimates of the educational attainment of the labor force for 1930 and 1940 by Folger and Nam [14].

[31]Christensen and Jorgenson [5].

[32]The perpetual inventory method is discussed by Goldsmith [18] and employed extensively in his *Study of Saving* [20] and more recent studies of U.S. national wealth [16, 17, 19]. This method is used in the OBE *Capital Goods Study* [22] and in the study of capital stock for the United States, 1900–1962, by Tice [35].

sum of the values of the individual capital services. Each capital service flow may be expressed as the sum of four terms, depending on the rate of return, the rate of replacement, the rate of capital losses accrued, and the tax structure. The rate of return for each sector is imputed from total property compensation.

The final step in construction of a quantity index of capital input is the measurement of actual quantities of each type of capital service utilized. For land, inventories, residential structures, and consumers' durables we assume that actual capital services are equal to potential services. For non-residential structures and producers' durables we adjust the potential quantities of capital services on the corporate and non-corporate sectors to reflect changes in relative utilization. Our estimates of relative utilization are based on the consumption of electricity relative to installed horsepower of electric motors.

Our measure of capital services is based on capital stock for each asset, weighted by potential service prices, and adjusted for relative utilization of capital. The quantity index of capital input for 1929–1967 is given in Table 5. The price of capital services implicit in private domestic property compensation is also given in Table 5. To provide the basis for comparison of sources of growth of capital input with those for labor input we present data on capital stock, potential service flow per unit of capital stock, and the relative utilization of capital in Table 5. Capital stock is a Divisia index of capital stock for each class of asset—consumers' durables, non-residential structures, producers' durables, residential structures, non-farm inventories, farm inventories, and land. The potential service flow per unit of capital stock is the ratio of the quantity of potential gross private domestic capital input to the index of capital stock. The relative utilization of capital is the ratio of the quantity of actual to potential gross private domestic capital input.

We can combine estimates of labor and capital services into an estimate of real factor input for the U.S. private domestic economy. The basic data on labor input—number of persons engaged, educational attainment per person, and hours per person—are presented in Table 4. The corresponding data on capital input—capital stock, potential service flow per unit of stock, and the relative utilization of capital—are presented in Table 5. Persons engaged is an unweighted stock of labor. The index of educational attainment per person provides an adjustment for the aggregation bias that results from combining different types of labor into an unweighted aggregate. Persons engaged, adjusted for educational attainment, must be multiplied by hours per person to obtain the flow of labor services. Similarly, capital stock is an unweighted aggregate; the index of potential capital services per unit of the capital stock provides an adjustment for the aggregation bias that results from combining different types of capital by adding together capital services weighted by asset prices rather than service prices. Potential capital services must be adjusted for relative utilization to obtain the actual flow of capital services.

We construct price and quantity index numbers of factor input by combining Divisia indexes of labor and capital input into a Divisia index of total factor input. The weights for labor and capital are the relative shares of labor and property compensation in the value of total factor outlay. Price and quantity

TABLE 5

GROSS PRIVATE DOMESTIC CAPITAL INPUT, 1929–1967 (CONSTANT PRICES OF 1958)

Year	1. Private Domestic Capital Stock	2. Potential Capital Input per unit of Capital Stock	3. Relative Utilization of Capital	4. Private Domestic Capital Input, Quantity Index	5. Private Domestic Capital Input, Price Index
1929	888.9	0.116	0.880	87.8	0.533
1930	904.0	0.116	0.848	87.8	0.437
1931	900.2	0.116	0.818	84.0	0.402
1932	883.6	0.116	0.780	78.3	0.312
1933	851.4	0.114	0.804	76.6	0.318
1934	823.7	0.112	0.836	76.0	0.326
1935	805.3	0.112	0.870	77.7	0.396
1936	800.4	0.112	0.896	79.1	0.423
1937	805.5	0.113	0.888	80.0	0.447
1938	817.6	0.114	0,840	77.6	0.411
1939	809.8	0.114	0.892	81.4	0.442
1940	814.1	0.114	0.944	87.0	0.465
1941	830.3	0.115	1.013	96.2	0.528
1942	857.9	0.117	1.053	104.4	0.589
1943	851.4	0.116	1.118	110.0	0.656
1944	834.6	0.116	1.123	107.8	0.686
1945	819.3	0.116	1.081	102.1	0.702
1946	812.3	0.117	1.031	97.2	0.774
1947	851.3	0.119	1.050	105.9	0.805
1948	888.3	0.122	1.042	113.0	0.828
1949	934.6	0.124	0.995	114.9	0.805
1950	964.6	0.126	1.028	124.1	0.908
1951	1021.4	0.127	1.036	134.5	0.965
1952	1068.5	0.129	1.019	139.7	0.959
1953	1100.3	0.129	1.037	147.4	0.932
1954	1134.6	0.130	1.007	148.9	0.955
1955	1163.2	0.131	1.040	158.6	0.996
1956	1213.9	0.132	1.042	167.1	0.971
1957	1255.5	0.134	1.026	171.9	0.983
1958	1287.9	0.135	1.000	173.1	1.000
1959	1305.8	0.135	1.038	182.5	1.028
1960	1341.4	0.136	1.042	189.0	1.024
1961	1373.9	0.137	1.034	194.1	1.043
1962	1399.1	0.137	1.056	202.3	1.091
1963	1436.7	0.138	1.062	205.4	1.139
1964	1477.8	0.140	1.086	215.9	1.158
1965	1524.4	0.141	1.091	225.0	1.235
1966	1582.2	0.144	1.096	236.2	1.285
1967	1645.3	0.146	1.096	247.9	1.245

index numbers for gross private domestic input may be represented in the form:

$$\log p_t - \log p_{t-1} = \bar{v}_L[\log p_t^L - \log p_{t-1}^L] + \bar{v}_K[\log p_t^K - \log p_{t-1}^K],$$

$$\log X_t - \log X_{t-1} = \bar{v}_L[\log L_t - \log L_{t-1}] + \bar{v}_K[\log K_t - \log K_{t-1}]$$

where p is the price index and X the quantity index, $\bar{v}_L$ and $\bar{v}_K = 1 - \bar{v}_L$ are arithmetic averages of the relative shares of labor and property compensation in total factor outlay in the two periods, p^L and p^K are the price indexes of labor and capital input, and L and K are the corresponding quantity indexes. Price

and quantity indexes for 1929–1967 are given in Table 6. The relative share of property compensation for the same period is also given in Table 6.

To provide a detailed accounting for the sources of growth in real factor input, we can separate the growth of quantity indexes of labor and capital input into the growth of the stock, growth in the quantity of input due to shifts in composition of such unweighted aggregates as persons engaged and capital stock or "quality change,"[33] and growth in relative utilization. The growth in labor input is the sum of growth in the number of persons engaged, the quality of the labor force, and the effective number of hours per person. The growth in capital input is the sum of growth in capital stock, the quality of capital, and relative utilization. Geometric average annual rates of growth for 1929–1967 and for the sub-periods 1929–1948 and 1948–1967 are given for each component of the growth of labor and capital input in Table 7.

The sources of growth in factor input may be seen from a different perspective through a similar decomposition of growth in factor prices. Considering factor price indexes that result from dividing total labor and property compensation by stocks of capital and labor, we obtain "stock" factor prices. These prices do not represent the cost of factor services since they fail to take into account the aggregation biases and variations in relative utilization that must be eliminated in order to measure the actual cost of factor services. We may adjust labor and capital stock for quality change; dividing total labor and property compensation by the resulting potential flows of factor services, we obtain "potential" service prices. Finally, adjusting labor and capital for relative utilization we obtain the actual service prices. All three sets of factor prices are given in Table 8. The actual prices are, of course, the price indexes of labor and capital services from Tables 4 and 5, respectively.

From these data it is apparent that estimates of the growth in labor and capital costs and the change in relative factor prices depend critically on the method of measurement. Consider, for example, the growth in labor cost. If we measure labor cost as labor compensation per person engaged, the stock price of labor from Table 8, we obtain rates of growth of 4.03 per cent from 1929–1948, 4.72 per cent from 1948–1967, and 4.37 per cent from 1929–1967; these rates of growth are given in Table 9 along with the growth of labor costs taking into account changes in the quality of the labor force, the labor cost for potential labor services and costs taking into account relative utilization of the labor force, the cost for actual labor services.

Estimates of the growth of capital cost or the rental price per unit of capital input may be analyzed in a similar way. The rental price per unit of capital stock grows at the average annual rate of 3.66 per cent from 1929–1948, 3.03 per cent from 1948–1967, and 3.34 per cent for 1929–1967. Capital costs taking into account changes in the quality of capital, the potential flow rental price, grows

[33] "Quality change" in this sense is equivalent to aggregation bias. Aggregation bias may be removed by treating the components of aggregate factor input separately, weighting each component in proportion to its relative price. This is not to imply that any proposed adjustment for quality change is legitimate. The appropriateness of each adjustment must be judged on the basis of evidence on the movement of separate components of aggregate factor input and the relative prices of the components. For further discussion, see Jorgenson and Griliches [23], especially pages 259–260.