THE MEASUREMENT OF U.S. REAL CAPITAL INPUT, 1929–1967

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The purpose of this paper is to develop methods for the measurement of real capital input. These methods are based on perpetual inventory estimates of capital stock and corresponding estimates of capital service prices. Stocks and service prices are adjusted for relative utilization of capital. The resulting estimates represent a separation of income from capital into price and quantity components. Estimates of capital input in current and constant prices are constructed for corporate business, non-corporate business, and households and non-profit institutions in the United States for the period 1929–1967. These estimates are prepared in a form suitable for integration into the U.S. National Income and Product Accounts.

1. INTRODUCTION

The measurement of social factor outlay in constant prices is not well established in social accounting practice. The chief problem is the measurement of capital input in real terms.[1] A flow of capital services may be divided between price and quantity with price as the rental rate and quantity as the amount of capital service time utilized. Accounting problems arise from the fact that the supplier of the capital service and its ultimate user are typically within the same economic unit. An accounting imputation is required for separation of outlay on capital services or property compensation into price and quantity components.

For property with an active rental market the price of capital services may be observed directly as the rental price for the use of a capital asset. The product of the rental price and the quantity of the asset used is the outlay on capital services or property compensation. This method for measuring capital services may be extended from rental property to property utilized by its owners if market rental values reflect the implicit rentals paid by owners for the use of their property.[2] The main obstacle to application of this method of imputation is the paucity of data on market rental values.

An alternative method for separation of price and quantity components of outlay on capital services or property compensation is based on the correspondence between asset prices and service or rental prices implied by the equality between the value of an asset and the discounted value of its services. The service price depends on the asset price, the rate of return, the rate of replacement, and the tax structure. Given the quantity of assets held by each sector, the prices of

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[1]The measurement of capital input in real terms has been discussed by Griliches and Jorgenson [15] and by Johansen and Sørsveen [22].

[2]This method is used for imputation of the value of services on owner-occupied dwellings and structures held by non-profit institutions in the U.S. national accounts. See [26] for a discussion of this imputation.

the assets, rates of replacement, and data on the tax structure, the rate of return for all assets used in the sector may be determined from total property compensation. Combining the rate of return with other components of the service price, factor outlay on capital may be separated into price and quantity components.

Data on asset prices and rates of replacement together with data on investment are required for perpetual inventory estimates of capital stock. Our method for measurement of capital services requires the same data as the perpetual inventory method for measurement of capital stock, together with data on total property compensation and the tax structure;[3] data on property compensation by legal form of organization are required for incorporation of the effects of the tax structure.

In this paper we present capital outlay accounts for the United States in current and constant prices for the period 1929–1967. We construct estimates of real capital input for corporate business, non-corporate business, and households and non-profit institutions. In a subsequent paper[4] we incorporate these estimates into production accounts for the United States, including social product and social factor outlay. We apply the resulting measures of real product and real factor input to the study of total factor productivity and the estimation of the responsiveness of factor and product intensities to changes in relative factor and product prices.

2. The Measurement of Capital Stock

The starting point for construction of a quantity index of capital input is the measurement of the capital stock corresponding to each type of capital service. A perpetual inventory method is employed to estimate the level of capital stock for each investment good. In discrete time our method may be represented in the form:

$$K_{it} = I_{it} + (1 - \mu_i) K_{i,t-1},$$

where K_{it} is end-of-period capital stock, I_{it} the quantity of investment occurring in the period, and μ_i the rate of replacement, all for the ith stock. The data required for implementation of this perpetual inventory method are investment in constant prices, a capital benchmark, and a rate of replacement for each capital stock. All of our investment data in current prices are from the U.S. national accounts. We now describe the selection of price indexes, capital stock benchmarks, and rates of replacement for seven capital stocks that generate inputs of capital services for the producing sector—land, residential structures, non-residential structures, producers' durable equipment, non-farm business inventories, farm inventories, and consumers' durable equipment.

For producers' durables and non-residential structures, we employ data

[3]The perpetual inventory method is discussed by Goldsmith [12] and employed extensively in his *Study of Saving* [14] and more recent studies of U.S. national wealth [10, 11, 13]. This method is used in the OBE *Capital Stock Study* [16] and in the study of capital stock for the United States, 1900–1962, by Tice [27].

[4]Christensen and Jorgenson [5].

from the *Capital Stock Study* of the Office of Business Economics.[5] Investment in non-residential structures is divided into twenty categories; investment in producers' durables is divided into fifty-two categories. We assume that economic depreciation can be approximated by the double declining balance method; the appropriate rate of replacement for each capital good is $\mu_i = 2/n_i$, where n_i is the mean service life for the *Capital Stock Study*. The replacement rate for each group is a weighted average of replacement rates for the individual components, using relative shares of the value of each capital stock in the value of all capital stock as weights.

Data on investment in current prices for producers' durables and non-residential structures in the *Capital Stock Study* are the same as those from the U.S. national accounts for the period since 1929. We use the "constant cost 2" price index for non-residential structures from the *Capital Stock Study* and the U.S. national income and product account price index for producers' durables. As benchmarks for capital stock of each type we take the 1929 values of capital stock in constant prices for double declining balance depreciation. We weight the rates of replacement of the individual components in proportion to the relative value of the 1929 capital stock in current prices for double declining balance depreciation. Investment goods output at market prices includes the output of non-residential structures. We take the "constant cost 2" price index for output of non-residential structures in place of the price index from the U.S. national accounts.

Residential structures may be divided into farm and non-farm components. Benchmarks for 1929 are taken to be the same proportion to the 1929 benchmark for non-residential structures as in Goldsmith.[6] Goldsmith obtains 1.191 as the ratio of farm residential structures and 1.466 for the ratio of non-farm residential structures to non-residential structures in 1929. We take the mean service life to be fifty years for non-farm and one hundred years for farm residential structures. The replacement rate is a weighted average of the double declining balance replacement rates for the two types of structures with weights equal to the relative shares of the value of each stock in the value of all residential capital stock in 1929. The service lives correspond to those of Bulletin F, published by the U.S. Treasury Department.[7] We use the "constant cost 2" price index for non-residential and for residential structures.

The consumers' durables benchmark is taken from Goldsmith.[8] The value of the stock of consumers' durables in 1929 is $42.23 billions in current prices. We increase this figure, raising it to constant dollars of 1958, using the consumers' durables price index from the U.S. national accounts. We assume that the rate of replacement for consumers' durables is .200. This rate of replacement is employed in estimates of the stock of consumers' durables in the FRB-MIT model by

[5]The Office of Business Economics *Capital Stock Study* is reported in a series of articles. See Grose, Rottenberg and Wasson [16] and the references given there. We are indebted to Robert Wasson for permission to use the underlying data on investment in current and constant prices.

[6]See Goldsmith [11], Tables A-35 and A-36, pages 177–180.

[7]These lifetimes have been compiled for the Office of Business Economics *Capital Stock Study*; we are indebted to Robert Wasson for providing us with data on service lives. Bulletin F [3] lives have been compared with alternative lifetimes by Wasson [29].

[8]See Goldsmith [11], Table A-38, page 183.

deLeeuw.[9] Data on investment in consumers' durables are the U.S. national accounts[10] figures for personal consumption expenditures on durables. The corresponding price index is also taken from the U.S. national accounts.

To establish a benchmark for land we assume that land is 39 per cent of the value of all private real estate in 1956. This is based on a study of the value of real estate and land by Manvel.[11] Taking the value of residential and non-residential structures in 1956 to be 61 per cent of the value of all private real estate, we obtain a benchmark for the value of land in 1956. The quantity of land is constant. We take the price index of land to be the same as Goldsmith's through 1958.[12] We estimate the rate of growth of land prices between 1956 and 1966 to be 6.9 per cent; we use this rate of growth to extrapolate Goldsmith's price index from 1958 to 1967. The rate of replacement for land is, of course, zero. There is no investment series for land.

Inventories are divided between farm and non-farm inventories. An appropriate benchmark for inventories is provided by an estimate of the replacement cost of the entire stock. The replacement cost of inventories for 1958 is estimated as $27.6 billions for farm and $101.4 billions for non-farm in constant prices of 1958 by the Office of Business Economics.[13] Following Goldsmith we deflate the stock of non-farm business inventories by the Bureau of Labor Statistics' wholesale price index for goods other than farm products and processed food.[14] Goldsmith used a very detailed procedure in deflating farm inventories.[15] We have found that for the years that Goldsmith's and our data overlap the wholesale price index for farm products behaved very much like the implicit deflator resulting from Goldsmith's disaggregated procedure. Accordingly, we employ the price index for farm products as our farm inventory deflator. We should note that we use the wholesale price indexes as asset deflators only.[16] For the deflation of inventory investment we employ the price indexes implicit in the U.S. national accounts; we employ data from the national accounts for inventory investment in current and constant prices. Inventories have zero rates of replacement.

In summary, for each type of capital good we follow these steps: (1) a benchmark is obtained, (2) the investment series in current prices from the U.S. national accounts is deflated to obtain a real investment series, (3) a rate of replacement is chosen, and (4) the stock series is computed using the perpetual

[9]See deLeeuw [7].

[10]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* [25], and subsequent national income issues of the *Survey of Current Business*, unless otherwise indicated. *NIP* [25], Table 1.2.

[11]See Manvel [24].

[12]See Goldsmith [11], Tables A-40 and A-41, pages 186–189.

[13]These data were provided to us by Shirley Loftus of the Office of Business Economics; we are indebted to her for permission to use these data.

[14]See Goldsmith [11], Tables B-130 and B-131, pages 359–360; the price index is from the Bureau of Labor Statistics [4].

[15]See Goldsmith [11], Tables B-87 to B-97, pages 308–322.

[16]Asset deflators are weighted by the relative proportion of assets of each type in total assets; investment deflators are weighted by the relative proportion of investment goods of each type in total investment. See Denison [8], page 12. Asset deflators are appropriate for deflating asset values and for estimating rental values of capital services; see below, Section 4, for further discussion of capital service prices.

TABLE 1

BENCHMARKS, RATES OF REPLACEMENT, AND PRICE INDEXES EMPLOYED IN ESTIMATING CAPITAL

Asset Class	1929 Benchmark (billions of 1958 dollars)	Replacement Rate	Deflator
1. Consumers' durables	74.9	0.200	Implicit deflator, national product accounts[a]
2. Non-residential structures	148.2	0.056	Constant cost 2 deflator[b]
3. Producers' durables	77.5	0.138	Implicit deflator, national product accounts[a]
4. Residential structures	214.2	0.039	Constant cost 2 deflator[b]
5. Non-farm inventories	57.1	—	Investment: Implicit deflator, national product accounts[c] Assets: BLS wholesale price index, goods other than farm products and food[d]
6. Farm inventories	21.9	—	Investment: Implicit deflator, national product accounts[c] Assets: BLS wholesale price index, farm products[d]
7. Land	322.2	—	Goldsmith[e]

[a]NIP [25], Table 8.1.
[b]*Capital Stock Study* [16].
[c]NIP [25], Tables 1.1 and 1.2.
[d]BLS [4].
[e]Goldsmith [11], Tables A-5 and A-6.

inventory method. Benchmarks, rates of replacement, and price indexes for each capital good are listed for reference in Table 1. All of the price indexes for investment are from the U.S. national income and product accounts except for the price index for residential and non-residential structures. In measuring the price and quantity of investment goods output for the producing sector, we replace the structures deflator from the national accounts by the "constant cost 2" price index from the *Capital Stock Study*. Price indexes for each asset class for 1929–1967 are given in Table 2.

3. THE ALLOCATION OF CAPITAL STOCK

For tax purposes the private sector may be divided into corporate business, non-corporate business, and households and non-profit institutions. Households and institutions utilize the services of consumers' and institutional durables, owner-occupied dwellings, institutional structures, and the associated land with no direct tax on the corresponding income flow. Non-corporate business is subject to personal income taxes on income generated by its capital services while corporate business is subject to both corporate and personal income taxes on income generated by its capital services.

TABLE 2

PRICE INDEXES BY CLASS OF ASSET, 1929–1967 (1958 = 1.000)

Year	1. Consumers' Durables	2. Structures, Non-residential and Residential	3. Producers' Durables	4. Investment, Non-farm Inventories	5. Assets, Non-farm Inventories	6. Investment, Farm Inventories	7. Assets, Farm Inventories	8. Land
1929	0.564	0.388	0.446	0.500	0.520	—*	0.617	0.381
1930	0.553	0.367	0.430	0.250	0.483	1.500	0.521	0.349
1931	0.491	0.340	0.411	0.410	0.426	0.333	0.382	0.305
1932	0.432	0.304	0.391	3.714	0.399	0.125	0.284	0.271
1933	0.419	0.318	0.345	0.368	0.404	0.400	0.302	0.280
1934	0.447	0.322	0.388	0.667	0.444	0.300	0.385	0.288
1935	0.437	0.340	0.387	0.400	0.442	0.500	0.463	0.290
1936	0.436	0.340	0.385	0.447	0.451	0.500	0.477	0.307
1937	0.458	0.370	0.414	0.459	0.483	0.444	0.509	0.314
1938	0.467	0.358	0.430	0.385	0.463	0.500	0.404	0.315
1939	0.460	0.353	0.422	0.429	0.462	0.200	0.385	0.321
1940	0.465	0.357	0.434	0.452	0.470	0.429	0.399	0.331
1941	0.504	0.389	0.463	0.465	0.506	0.364	0.484	0.354
1942	0.593	0.453	0.515	0.333	0.542	0.550	0.624	0.375
1943	0.642	0.509	0.511	1.500	0.550	0.500	0.722	0.406
1944	0.715	0.544	0.519	0.429	0.559	0.800	0.727	0.436
1945	0.759	0.544	0.517	0.286	0.566	0.444	0.756	0.467
1946	0.768	0.594	0.575	0.627	0.620	0.000	0.875	0.544
1947	0.827	0.721	0.646	0.929	0.757	1.125	1.053	0.617
1948	0.863	0.749	0.703	0.833	0.821	1.700	1.130	0.661

*Investment in constant prices is zero.

TABLE 2—*continued*

Year	1. Consumers' Durables	2. Structures, Non-residential and Residential	3. Producers' Durables	4. Investment, Non-farm Inventories	5. Assets Non-farm Inventories	6. Investment, Farm Inventories	7. Assets, Farm Inventories	8. Land
1949	0.868	0.743	0.736	0.688	0.804	1.125	0.978	0.642
1950	0.878	0.763	0.752	0.800	0.833	1.000	1.027	0.706
1951	0.942	0.836	0.809	0.919	0.920	1.200	1.195	0.760
1952	0.954	0.881	0.822	0.840	0.899	1.429	1.127	0.785
1953	0.943	0.895	0.835	0.786	0.906	1.500	1.022	0.786
1954	0.929	0.897	0.840	0.808	0.909	1.200	1.008	0.811
1955	0.919	0.902	0.859	0.917	0.929	1.250	0.945	0.850
1956	0.949	0.959	0.918	0.944	0.970	0.667	0.932	0.897
1957	0.984	1.001	0.975	1.143	0.997	1.000	0.958	0.951
1958	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1959	1.014	1.006	1.020	1.000	1.018	—*	0.938	1.069
1960	1.009	1.005	1.022	1.031	1.018	1.000	0.935	1.143
1961	1.006	1.008	1.021	0.944	1.013	1.500	0.924	1.222
1962	1.008	1.024	1.023	1.019	1.013	1.000	0.943	1.306
1963	1.004	1.037	1.023	1.000	1.012	1.000	0.924	1.396
1964	1.004	1.053	1.030	1.000	1.017	1.000	0.910	1.492
1965	0.996	1.078	1.039	1.062	1.030	1.111	0.950	1.595
1966	0.988	1.115	1.060	1.057	1.052	1.000	1.019	1.705
1967	1.004	1.161	1.091	1.057	1.068	0.833	0.962	1.823

*Investment in constant prices is zero.

We divide each class of assets among four sectors of the private domestic economy—corporations, non-corporate business, households, and institutions. The stock of non-residential structures for 1929 is allocated among three sectors in proportion to Goldsmith's data on stocks for that year.[17] Goldsmith's current values for 1929 are $5.86 billions for farm structures, $47.87 billions for corporate structures, $11.24 billions for the structures of non-farm, non-corporate business, and $5.57 billions for institutional structures. The stock of non-residential structures for the farm sector is allocated to non-corporate business. The relative proportions of investment in current prices allocated to corporations, non-corporate business, and institutions by Goldsmith are applied to data on investment from the U.S. national accounts.[18] The "constant cost 2" price index and the rate of replacement for non-residential structures are employed in calculating the stock for each sector by the perpetual inventory method.

Residential structures are assigned to corporations, non-corporate business, and households in a similar manner. All of farm housing is assigned to the household sector. Non-farm residential housing is allocated among the three sectors by the same method used for non-farm non-residential structures. First, the stock of residential structures for 1929 is allocated among the three sectors in proportion to Goldsmith's data on stocks—$4.63 billions for corporations, $5.48 billions for non-corporate business, and $85.79 billions for households. Goldsmith's relative proportions of investment in each sector are applied to data on investment from the U.S. national accounts.[19] The "constant cost 2" price index and the replacement rate given in Table 1 are used for non-farm residential housing investment assigned to each sector in deriving perpetual inventory estimates of stock for each year.

All consumers' durables are assigned to the household sector. Producers' durables are assigned among three sectors in the same way as non-residential structures. The stock of producers' durables for 1929 is allocated among corporations, non-corporate business, and non-profit institutions in proportion to Goldsmith's current values for that year—$29.01 billions for corporations, $8.43 billions for non-corporate business, and $0.37 billions for institutions. The relative proportions of investment in current prices from Goldsmith are applied to data on investment from the U.S. national accounts.[20] The implicit deflator from the U.S. national accounts and the rate of replacement given in Table 1 are used to derive perpetual inventory estimates of the stock of producers' durables in each sector.

All farm inventories are assigned to the non-corporate sector. Non-farm inventories for 1929 are allocated among corporate and non-corporate business in proportion to Goldsmith's current values for that year—$22.00 billions for corporations and $6.43 billions for non-corporate business. Data on inventory investment in constant prices from the U.S. national accounts are allocated between the sectors in proportion to inventory investment in current prices.[21] For each sector perpetual inventory estimates of stock for each year are derived by cumulating inventory investment in constant prices and adding the result to the 1929 benchmark.

[17]See Goldsmith [11], Table A-36, pages 179–180.
[18]See Goldsmith [11], Table A-36, pages 179–180, and the references given there.
[19]See Goldsmith [11], Table A-35, pages 177–178, and the references given there.
[20]See Goldsmith [11], Table A-37, pages 181–182, and the references given there.
[21]NIP [25], Table 5.6.

The allocation of land among the three sectors is based on data from Manvel and Goldsmith.[22] First, the relative proportions of the current value of land in 1956 allocated to farm land, residential land, and non-farm non-residential land by Manvel are used to allocate land in that year. Manvel's estimates are $112 billions for farm land, $86 billions for residential land, and $71 billions for non-farm non-residential land.[23] We assign farm land to the non-corporate business sector. Residential land is allocated among three sectors in proportion to current values from Goldsmith for 1956, $47.17 billions for households, $4.37 billions for corporations, and $3.86 billions for non-corporate business.[24] Non-farm non-residential land is allocated in the same way, employing Goldsmith's current values for 1956 of $29.14 billions for corporations, $11.44 billions for non-corporate business, and $6.37 billions for non-profit institutions.[25] The relative proportions of capital stock by asset class and sector for 1958 are given in Table 3.

TABLE 3

RELATIVE PROPORTIONS OF CAPITAL STOCK BY ASSET CLASS AND SECTOR, 1958

Asset Class	Sector			
	1. Corporate Business	2. Non-corporate Business	3. Households and Institutions	Total
1. Consumers' durables	—	—	0.1374	0.1374
2. Non-residential structures	0.1021	0.0261	0.0136	0.1418
3. Producers' durables	0.0894	0.0412	0.0016	0.1322
4. Residential structures	0.0184	0.0173	0.2016	0.2373
5. Non-farm inventories	0.0662	0.0143	—	0.0805
6. Farm inventories	—	0.0207	—	0.0207
7. Land	0.0475	0.1251	0.0775	0.2501
Total	0.3236	0.2447	0.4317	1.0000

4. CAPITAL SERVICE PRICES

The second step in the construction of price and quantity indexes of capital input is to define appropriate prices for capital services. For property with an active rental market the price of capital services may be observed directly as the rental price for the use of a capital asset. The product of the rental price and the quantity of the asset used is the capital service flow in current prices. This method for measuring capital services may be extended from rental property to property

[22]See Manvel [24] and Goldsmith [11].
[23]See Manvel [24].
[24]See Goldsmith [11], Table A-40, pages 186–187.
[25]See Goldsmith [11], Table A-41, pages 188–189.

utilized by its owners if market rental values reflect the implicit rentals paid by owners for the use of their property. The assumption that market and implicit rentals are equal is used to impute the capital service flow from owner-occupied dwellings and institutional buildings in the U.S. national income and product accounts.[26] The main obstacle to broader application of this method of imputation is the scarcity of data on market rental values.

An alternative method for imputation of the value of capital services from owner-utilized assets is based on the equality of income from property and the current value of capital services for each sector of the economy. The problem for imputation is to separate the flow of services for each asset from total property income. This separation may be carried out on the basis of the correspondence between asset prices and service or rental prices implied by the equality between the value of an asset and the discounted value of its services. Given the quantity of assets held by each sector, the price of each asset, and the rate of replacement for each asset, only the rate of return for all assets used in a given sector remains to be determined. Griliches and Jorgenson [15] have proposed to measure the rate of return as the rate implicit in the total flow of property income. In measuring the rate of return, differences in tax treatment of income from different classes of assets must be taken into account. Our method for measuring the rate of return is conceptually similar to that of Griliches and Jorgenson; however, we employ a breakdown of sectors by legal form of organization in order to provide a better representation of the tax structure for property income.

Our imputation of rental prices for capital services from data on income from property is based on the correspondence between asset prices and service prices. To make this correspondence explicit, we must specify the relationship between the quantity of an asset acquired at one date and the quantity of the service flow of the asset at future dates. In our perpetual inventory estimates of the stock of assets, we have assumed that the service flow from a given asset declines geometrically over time. Where q_t^A is the price of the asset at time t and p_t^S its service price,

$$q_t^A = \sum_{r=t}^{\infty} \prod_{s=t+1}^{r+1} \frac{1}{1+r_s} p_{r+1}^S (1-\mu)^{r-t},$$

where r_s is the rate of return at time s and μ is the rate of replacement. The quantity of capital services at time $r+1$ from one unit of investment at time t is $(1-\mu)^{r-t}$. The sequence of capital services declines geometrically,

$$1, (1-\mu), (1-\mu)^2 \ldots .$$

To infer the capital service price p_t^S from the sequence of asset prices, we rewrite the asset price q_t^A in the form:

$$q_t^A = \frac{1}{1+r_{t+1}} \left[p_{t+1}^S + (1-\mu) q_{t+1}^A \right].$$

Solving for the service price, we obtain:

$$p_t^S = q_{t-1}^A r_t + q_t^A \mu - (q_t^A - q_{t-1}^A).$$

[26]See footnote 2, above.

The service price is the sum of the cost of capital $q^A_{t-1}r_t$, the current cost of replacement $q_t{}^A\mu$, and the cost of capital loss on the value of the asset, $-(q_t{}^A - q^A_{t-1})$. Given the sequence of asset prices $\{q^A_t\}$, the rate of replacement μ and the rate of return r_t, we obtain a measure of the service price $p_t{}^S$.

Data on asset prices and rates of replacement for all assets are required for the perpetual inventory estimates of capital stock described in preceding sections. We have assumed that capital services decline geometrically so that replacement may be estimated by the declining balance method. The correspondence between asset prices and service prices may be generalized to alternative assumptions about the service flow of an asset over time. The formula developed by Haavelmo [17] for one-hoss shay replacement, that is, a constant service flow over the lifetime of the asset, has been suggested as a means of aggregating capital services by Johansen and Sørsveen [22]. Arrow [1] has provided formulas for the service price for an arbitrary sequence of replacements. We conclude that a method for imputation of the flow of captial services is implicit in any perpetual inventory estimate of capital stock. Inferring the capital service price from the assumed distribution of replacements over time, the value of all capital services for a given sector may be set equal to the total flow of property income. Solving for the rate of return, capital service prices for each class of assets may be imputed from the sequence of asset prices, the distribution of replacements, and the rate of return.

As we have already indicated, the correspondence between asset prices and service prices depends not only on the distribution of replacements over time, but also on the tax structure for property income generated by that asset. We have divided the stock of each class of assets among sectors that differ in the tax treatment of property income. For convenience in notation we denote each asset class by a two-digit subscript. The first refers to the sector—(1) corporations, (2) non-corporate business, (3) private households, (4) non-profit institutions; the second refers to the class of assets—(1) consumers' durables, (2) non-residential structures, (3) producers' durables, (4) residential structures, (5) non-farm inventories, (6) farm inventories, (7) land.

Households and institutions utilize the services of consumers' and institutional durables, owner-occupied dwellings, institutional structures, and land without direct taxation. Part of property income is taxed indirectly through taxes based on the value of the property. To incorporate property taxation into the imputed price of capital services, we add the rate of property taxation to the rate of return, the rate of replacement, and the rate of capital loss in measuring the service price. We first consider the service price or implicit rental for owner-occupied dwellings, including both structures and land. The price of each component is the sum of terms representing the cost of capital, replacement, capital loss, and property taxes:

$$p^S_{34,t} = q^A_{4,t-1}r_{rp,t} + q^A_{4,t}\mu_4 - (q^A_{4,t} - q^A_{4,t-1}) + q^A_{4,t}t_{rp,t},$$

$$p^S_{37,t} = q^A_{7,t-1}r_{rp,t} - (q^A_{7,t} - q^A_{7,t-1}) + q^A_{7,t}t_{rp,t},$$

where r_{rp} is the rate of return on owner-occupied residential property, t_{rp} the effective tax rate on such property, μ_4 the rate of replacement of residential structures, and $q_4{}^A$ and $q_7{}^A$ are asset price indexes for residential structures and land, respectively.

Next, we consider the service price for institutional buildings, including structures and land:

$$p^S_{42,t} = q^A_{2,t-1} r_{rp,t} + q^A_{2,t}\mu_2 - (q^A_{2,t} - q^A_{2,t-1}),$$
$$p^S_{47,t} = q^A_{7,t-1} r_{rp,t} - (q^A_{7,t} - q^A_{7,t-1}),$$

where μ_2 is the rate of replacement of non-residential structures. We assume that rates of return on owner-occupied residential property and institutional real estate are the same. These classes of assets are treated identically from the point of view of the personal income tax. Owner-occupied dwellings are subject to property taxation, while institutional buildings are exempt. Flows of property income from owner-occupied dwellings and institutional buildings are imputed from market rental values of similar property in the U.S. national income and product accounts.[27]

The prices of consumers' durables held by private households and producers' durables utilized by non-profit institutions may be expressed as the sum of terms corresponding to the cost of capital, replacement, capital loss (or gain), and indirect taxes:

$$p^S_{31,t} = q^A_{1,t-1} r_{rp,t} + q^A_{1,t}\mu_1 - (q^A_{1,t} - q^A_{1,t-1}) + q^A_{1,t} t_{pp,t},$$
$$p^S_{43,t} = q^A_{3,t-1} r_{rp,t} + q^A_{3,t}\mu_3 - (q^A_{3,t} - q^A_{3,t-1}),$$

where μ_1 is the rate of replacement for consumers' durables, μ_3 the rate for producers' durables, t_{pp} the effective rate of property taxation for personal property, q^A_1 and q^A_3 the price indexes for consumers' and producers' durables, respectively. We assume the rates of return on consumers' and producers' durables are the same as those for household and institutional real estate. This results in a single rate of return for the sector comprising households and institutions.

We next consider the service prices or implicit rental values of the capital services of assets held by corporate business. The value of the flow of capital services for the corporate sector is the sum of the values of services from residential and non-residential structures, producers' durable equipment, non-farm inventories, and land held by that sector. We employ the capital service prices developed by Hall and Jorgenson [18, 19] for depreciable assets, modified to incorporate indirect business taxes.[28]

For producers' durable equipment held by the corporate sector, the price of capital services is:

$$p^S_{13,t} = \left[\frac{1 - u_t z_{13,t} - k_t + y_t}{1 - u_t}\right][q^A_{3,t-1} r_{cp,t} + q^A_{3,t}\mu_3 - (q^A_{3,t} - q^A_{3,t-1})] + q^A_{3,t} t_{cp,t},$$

where r_{cp} is the rate of return on corporate property, t_{cp} is the effective tax rate on such property, u is the effective corporate profits tax rate, z_{13} is the present value of depreciation deductions for tax purposes on a dollar's investment in producers' durables over the lifetime of the investment, k is the investment tax credit,

[27]See footnote 2, above.

[28]A detailed derivation of prices of capital services is given by Hall and Jorgenson [18, 19] for continuous time. We have converted their formulation to discrete time, added property taxes, and introduced alternative measurements for the tax parameters. Our measurements are described in the following section. Similar formulas have been developed by Coen [6].

$y = kuz_{13}$ for 1962 and 1963 and zero for all other years, and q_3^A is the price index for producers' durable equipment.

For non-residential and residential structures held by the corporate sector the prices of capital services are:

$$p_{12,t}^S = \left[\frac{1 - u_t z_{12,t}}{1 - u_t}\right][q_{2,t-1}^A r_{cp,t} + q_{2,t}^A \mu_2 - (q_{2,t}^A - q_{2,t-1}^A)] + q_{2,t}^A t_{cp,t},$$

$$p_{14,t}^S = \left[\frac{1 - u_t z_{14,t}}{1 - u_t}\right][q_{4,t-1}^A r_{cp,t} + q_{4,t}^A \mu_4 - (q_{4,t}^A - q_{4,t-1}^A)] + q_{4,t}^A t_{cp,t},$$

where q_2^A and q_4^A are price indexes for non-residential and residential structures, respectively.

For non-farm inventories held by the corporate sector the price of capital services is:

$$p_{15,t}^S = \frac{1}{1 - u_t}[q_{5,t-1}^A r_{cp,t} - (q_{5,t}^A - q_{5,t-1}^A)] + q_{5,t}^A t_{cp,t},$$

where q_5^A is the price index for inventories; the price of capital services from land held by the corporate sector is:

$$p_{17,t}^S = \frac{1}{1 - u_t}[q_{7,t-1}^A r_{cp,t} - (q_{7,t}^A - q_{7,t-1}^A)] + q_{7,t}^A t_{cp,t},$$

where q_7^A is the price index for land.

The value of the flow of capital services for the non-corporate sector is the sum of the values of services from residential and non-residential structures, producers' durable equipment, non-farm and farm inventories, and land held by that sector. Farm inventories are assigned to the non-corporate sector. For producers' durable equipment the price of capital services is:

$$p_{23,t}^S = q_{3,t-1}^A r_{np,t} + q_{3,t}^A \mu_3 - (q_{3,t} - q_{3,t-1}^A) + q_{3,t}^A t_{np,t},$$

where r_{np} is the rate of return on non-corporate property and t_{np} is the effective tax rate on such property; for non-residential and residential structures the prices of the capital services are:

$$p_{22,t}^S = q_{2,t-1}^A r_{np,t} + q_{2,t}^A \mu_2 - (q_{2,t}^A - q_{2,t-1}^A) + q_{2,t}^A t_{np,t},$$

$$p_{24,t}^S = q_{4,t-1}^A r_{np,t} + q_{4,t}^A \mu_4 - (q_{4,t}^A - q_{4,t-1}^A) + q_{4,t}^A t_{np,t},$$

for non-farm and farm inventories and land the prices of the capital services are:

$$p_{25,t}^S = q_{5,t-1}^A r_{np,t} - (q_{5,t}^A - q_{5,t-1}^A) + q_{5,t}^A t_{np,t},$$

$$p_{26,t}^S = q_{6,t-1}^A r_{np,t} - (q_{6,t}^A - q_{7,t-1}^A) + q_{6,t}^A t_{np,t},$$

$$p_{27,t}^S = q_{7,t-1}^A r_{np,t} - (q_{7,t}^A - q_{7,t-1}^A) + q_{7,t}^A t_{np,t}.$$

5. Rates of Return and the Tax Structure

To complete the imputation of capital service prices required for separation of the value of property compensation into price and quantity components, we must estimate rates of return for each sector of the economy. For tax purposes we have divided the private domestic economy into corporate business, non-

corporate business, and households and institutions.[29] Total property income for the private domestic economy may be divided into property income generated in each of these sectors. We measure the value of capital services for each sector before either corporate or personal income taxes, since property income includes direct taxes. However, we measure the rate of return after corporate income taxes but before personal income taxes. This convention facilitates the integration of the production account we have developed with income and expenditure accounts for private households, which are the ultimate recipients of income from property.

For each sector our basic accounting identity is that the value of all capital services is equal to property income. The value of corporate capital input in period t may be written:

$$\text{corporate property income} = p^S_{12,t}K^S_{12,t} + p^S_{13,t}K^S_{13,t} + p^S_{14,t}K^S_{14,t} + p^S_{15,t}K^S_{15,t} + p^S_{17,t}K^S_{17,t};$$

corporate capital input is the sum of services from residential and non-residential structures, producers' durable equipment, and inventories held by the corporate sector. Similarly, the value of non-corporate capital input in period t may be written:

$$\text{non-corporate property income} = p^S_{22,t}K^S_{22,t} + p^S_{23,t}K^S_{23,t} + p^S_{24,t}K^S_{24,t} + p^S_{25,t}K^S_{25,t} + p^S_{26,t}K^S_{26,t} + p^S_{27,t}K^S_{27,t},$$

the sum of the services from those classes of assets held by the non-corporate sector. Finally, the value of household and institutional capital input in period t may be written:

$$\text{household property income} = p^S_{31,t}K^S_{31,t} + p^S_{34,t}K^S_{34,t} + p^S_{37,t}K^S_{37,t} + p^S_{42,t}K^S_{42,t} + p^S_{43,t}K^S_{43,t} + p^S_{47,t}K^S_{47,t},$$

the sum of services from consumers' durables, residential structures, and land held by private households, and of services from producers' durables, non-residential structures, and land held by non-profit institutions.

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 rate of property taxation. Since property taxes are deducted from corporate income in determining corporate profits for tax purposes, the component of each capital service flow corresponding to property taxes is simply added to the other components. Similarly, the property tax component of each capital service flow for the non-corporate and household sectors is added to the rest. Accordingly, our first step in estimating rates of return for the three sectors is to deduct all property taxes from the value of capital input.

Our measurement of the flow of capital services for the household sector is independent of the measurement of flows of capital services for the corporate and non-corporate sectors. The value of services of owner-occupied buildings is the

[29]This division of the private domestic economy follows that for national income by legal form of organization, *NIP* [25], Table 1.13. The other sectors included in the U.S. national accounts are government enterprises, general government, and rest of the world.

sum of the space rental value of owner-occupied farm and non-farm dwellings,[30] less associated purchases of goods and services.[31] We assume that the proportion of purchases is the same for farm as for non-farm dwellings. The effective tax rate t_{rp} is the ratio of taxes as a component of total space rental value[32] to the asset value of owner-occupied dwellings, including both structures and land. The value of services of institutional structures is the space rental value of institutional buildings.[33] To estimate the rate of return r_{rp} we divide the space rental values of owner-occupied dwellings and institutional buildings, less associated purchases of goods and services for dwellings, less current replacement values, accrued capital losses, and taxes as a component of total space rental value for dwellings, by the current asset value of owner-occupied dwellings and institutional structures, including land.

Our treatment of consumers' and institutional durables differs from that of the U.S. national income and product accounts. We add the flow of capital services from consumers' and institutional durables to the value of capital input. The value of each service flow is the product of the service price given above and the corresponding service quantity. We assume that the rate of return on durables is the same as that on structures for the household sector. The effective tax rate on consumers' durables t_{pp} is the ratio of the following state and local personal taxes—motor vehicle licences, property taxes and other taxes[34]—plus federal automobile use taxes[35] to the current asset value of consumers' durables. The effective property tax rates on household property and the rate of return for the household sector are presented in Table 4.

In measuring the rate of return for the non-corporate business sector we first estimate the effective tax rate on non-corporate property t_{np}. We deduct property taxes on owner-occupied residential real estate from state and local business property taxes[36] to obtain state and local property taxes for corporate and non-corporate sectors. For the period 1948–1967 we have data on corporate and non-corporate property taxes;[37] for 1929–1947 we allocate state and local business property taxes, excluding taxes on owner-occupied residential real estate, between corporate and non-corporate sectors using the average proportion 0.33 for the period 1948–1950. We allocate business motor vehicle licenses[38] between corporate and non-corporate sectors in proportion to the value of producers' durables in each sector; similarly, we allocate other state and local business taxes[39] and federal capital stock taxes[40] in proportion to the value of all assets in each sector. The effective tax rate on non-corporate property is the ratio of the sum of property taxes, motor vehicle licenses, and other business taxes allocated to the non-corporate sector to the value of all assets held by the sector, including producers' durables, residential and non-residential structures, inventories, and land.

The value of capital services for the non-corporate sector is the sum of income originating in business, other than income originating in corporate

[30] *NIP* [25], Table 7.3. [31] *NIP* [25], Table 7.3. [32] *NIP* [25], Table 7.3.
[33] *NIP* [25], Table 7.3. [34] *NIP* [25], Table 3.3. [35] *NIP* [25], Table 3.1, note 1.
[36] *NIP* [25], Table 3.3.
[37] These data were provided to us by Charles Waite of the Office of Business Economics. We are indebted to him for permission to use these data.
[38] *NIP* [25], Table 3.3. [39] *NIP* [25], Table 3.3. [40] *NIP* [25], Table 3.1, note 2.

business, income originating in government enterprises, and net rent of owner-occupied dwellings and institutional structures, less labor compensation in the non-corporate sector, including imputed labor compensation of proprietors and unpaid family workers, plus non-corporate capital consumption allowances, less capital consumption allowances of owner-occupied dwellings and institutional structures, and plus indirect business taxes allocated to the non-corporate sector,

TABLE 4

EFFECTIVE TAX RATES AND RATES OF RETURN, HOUSEHOLD AND NON-CORPORATE SECTORS, 1929–1967 (annual rates)

Year	1. Effective Tax Rate on Owner-Occupied Residential Real Estate, t_{rp}	2. Effective Tax Rate on Owner-Utilized Consumers' Durables, t_{pp}	3. Effective Tax Rate on Non-Corporate Property, t_{np}	4. Rate of Return, Household Sector, r_{rp}	5. Rate of Return, Non-Corporate Sector, r_{np}
1929	0.010	0.009	0.021	0.009	0.100
1930	0.011	0.009	0.024	−0.052	−0.027
1931	0.012	0.010	0.026	−0.079	−0.071
1932	0.012	0.012	0.029	−0.097	−0.092
1933	0.011	0.012	0.027	0.048	0.064
1934	0.011	0.012	0.026	0.022	0.114
1935	0.010	0.014	0.026	0.043	0.110
1936	0.010	0.015	0.027	0.024	0.127
1937	0.010	0.014	0.027	0.072	0.132
1938	0.010	0.013	0.028	−0.012	0.042
1939	0.010	0.014	0.023	0.008	0.086
1940	0.010	0.014	0.029	0.028	0.121
1941	0.010	0.012	0.026	0.092	0.213
1942	0.009	0.012	0.023	0.138	0.258
1943	0.009	0.010	0.022	0.120	0.242
1944	0.009	0.010	0.021	0.082	0.230
1945	0.009	0.010	0.020	0.038	0.224
1946	0.009	0.009	0.017	0.131	0.310
1947	0.007	0.008	0.017	0.193	0.288
1948	0.008	0.008	0.017	0.057	0.185
1949	0.009	0.008	0.018	−0.006	0.062
1950	0.009	0.008	0.018	0.063	0.178
1951	0.009	0.007	0.017	0.103	0.214
1952	0.009	0.007	0.018	0.062	0.121
1953	0.009	0.007	0.019	0.030	0.089
1954	0.010	0.007	0.019	0.032	0.108
1955	0.011	0.007	0.020	0.040	0.114
1956	0.012	0.007	0.019	0.083	0.127
1957	0.012	0.007	0.020	0.069	0.127
1958	0.013	0.007	0.020	0.035	0.116
1959	0.013	0.007	0.020	0.047	0.103
1960	0.014	0.008	0.021	0.043	0.096
1961	0.015	0.008	0.022	0.047	0.099
1962	0.015	0.009	0.022	0.058	0.111
1963	0.015	0.009	0.023	0.058	0.104
1964	0.016	0.009	0.023	0.061	0.104
1965	0.016	0.009	0.024	0.067	0.115
1966	0.016	0.009	0.024	0.075	0.122
1967	0.016	0.009	0.024	0.080	0.108

as outlined above. We also allocate the statistical discrepancy to non-corporate property income.[41] To obtain our estimate of the non-corporate rate of return r_{np} we deduct property taxes and the current value of replacement, add accrued capital gains on non-corporate assets, and divide by the value of non-corporate assets. The effective tax rate on non-corporate property and the rate of return in the non-corporate sector are given in Table 4.

In measuring the rate of return for corporate business we begin by estimating the effective tax rate on corporate property t_{cp}. We add state and local business property taxes, business motor vehicle licenses, other business taxes, and federal capital stock taxes for the corporate sector to obtain total property taxes. The effective tax rate on corporate property is the ratio of these taxes to the value of all assets held by the corporate sector, including producers' durables, residential and non-residential structures, inventories, and land. We measure corporate property income less property taxes as income originating in corporate business, less compensation of employees,[42] plus corporate capital consumption allowances,[43] plus business transfer payments.[44] The value of corporate capital input, which is equal to corporate property income, depends on the effective corporate income tax rate u, the rate of return in the corporate sector r_{cp}, the investment tax credit k, and the present values of depreciation deductions for non-residential structures, producers' durables and residential structures—z_{12}, z_{13}, z_{14}.

We may write the value of corporate capital input less property taxes in the form:

$$\begin{aligned}
\text{corporate property income} &- t_{cp}(q^A_{2,t}K^S_{12,t} + q^A_{3,t}K^S_{13,t} + q^A_{4,t}K^S_{14,t} + q^A_{5,t}K^S_{15,t} \\
&+ q^A_{7,t}K^S_{17,t}) \\
&+ \left[\frac{1 - u_t z_{12,t}}{1 - u_t}\right][q^A_{2,t-1}r_{cp,t} + q^A_{2,t}\mu_2 - (q^A_{2,t} - q^A_{2,t-1})]K^S_{12,t}, \\
= &\left[\frac{1 - u_t z_{13,t} - k_t + y_t}{1 - u_t}\right][q^A_{3,t-1}r_{cp,t} + q^A_{3,t}\mu_3 - (q^A_{3,t} - q^A_{3,t-1})]K^S_{13,t}, \\
&+ \left[\frac{1 - u_t z_{14,t}}{1 - u_t}\right][q^A_{4,t-1}r_{cp,t} + q^A_{4,t}\mu_4 - (q^A_{4,t} - q^A_{4,t-1})]K^S_{14,t}, \\
&+ \frac{1}{1 - u_t}[q^A_{5,t-1}r_{cp,t} - (q^A_{5,t} - q^A_{5,t-1})]K^S_{15,t}, \\
&+ \frac{1}{1 - u_t}[q^A_{7,t-1}r_{cp,t} - (q^A_{7,t} - q^A_{7,t-1})]K^S_{17,t}.
\end{aligned}$$

Multiplying both sides by $1 - u_t$ we obtain the following expression for corporate income taxes:

$$\begin{aligned}
\text{corporate income taxes} = u_t\,(&\text{corporate property income} \\
&- \text{taxes on corporate property} \\
&- z_{12,t}[q^A_{2,t-1}r_{cp,t} + q^A_{2,t}\mu_2 - (q^A_{2,t} - q^A_{2,t-1})]K^S_{12,t} \\
&- z_{13,t}[q^A_{3,t-1}r_{cp,t} + q^A_{3,t}\mu_3 - (q^A_{3,t} - q^A_{3,t-1})]K^S_{13,t} \\
&- z_{14,t}[q^A_{4,t-1}r_{cp,t} + q^A_{4,t}\mu_4 - (q^A_{4,t} - q^A_{4,t-1})]K^S_{14,t}) \\
&- [k_t - y_t][q^A_{3,t-1}r_{cp,t} + q^A_{3,t}\mu_3 - (q^A_{3,t} - q^A_{3,t-1})]K^S_{13,t}.
\end{aligned}$$

[41]We assume that errors in reporting property income occur mainly in non-corporate business.

[42]*NIP* [25], Table 1.13. [43]*NIP* [25], Table 6.18.

[44]We assume that business transfer payments are taken mainly from corporate income.

Corporation income taxes less the investment tax credit are equal to the effective tax rate applied to corporate property income, less property taxes, and less deductions for capital consumption, expressed as proportions of current capital service flows after taxes.

Our estimate of the effective rate of the investment tax credit k is based on estimates of investment tax credit for corporations by the Office of Business Economics.[45] The effective rate is defined as the amount of the investment tax credit divided by gross private domestic investment in producers' durables by corporations. We assume that the effective rate of the investment tax credit is the same for corporations and for non-corporate business. Although the nominal rate of the investment tax credit is seven per cent, certain limitations on its applicability reduce the effective rate considerably below this level. Further, the tax credit was suspended from October 1966 to March 1967, reducing the effective rate in each year roughly in proportion to the period of suspension. The variable y describes the effects of reduction of the base for depreciation by the amount of the investment tax credit during 1962 and 1963; the value of this variable depends on the effective tax rate u.[46]

The present values of depreciation deductions on new investment—z_{12}, z_{13}, z_{14}—depend on depreciation formulas allowable for tax purposes, the lifetimes of assets used in calculating depreciation, and the rate of return.[47] A reasonable approximation to depreciation practice is provided by the assumption that the straight-line depreciation formula was the only one permitted for the period 1929–1953 and that an accelerated depreciation formula, sum of the years' digits, was employed with a single exception for the period 1954–1967. During the period of the suspension of the investment tax credit in 1966–67, accelerated depreciation on structures was suspended except for the 150 per cent declining balance formula. We have reduced the present value of depreciation deductions in 1966 and 1967, weighting the 150 per cent declining balance formula in proportion to the period of suspension of other accelerated formulas.[48]

[45] *NIP* [25], Table 7.5.

[46] Alternative provisions for the investment tax credit are discussed by Hall and Jorgenson [18].

[47] In these formulas we assume that no depreciation is taken during the year of acquisition.

[48] Formulas for the present values of depreciation deductions are:

straight-line:

$$\frac{1}{rt}\left[1-\left(\frac{1}{1+r}\right)^{t}\right]$$

sum of the years' digits:

$$\frac{2}{rt}\left[1-\frac{1+r}{r(t+1)}\left(1-\frac{1}{1+r}\right)^{t+1}\right]$$

150 per cent declining balance:

$$\frac{1.5/t}{r+(1.5/t)}\left\{1-\left[\left(\frac{1}{1+r}\right)\left(1-\frac{1.5}{t}\right)\right]^{t^{+}}\right\}+\frac{(1-1.5/t)^{t^{+}}}{r(t-t^{+})}\left[\left(\frac{1}{1+r}\right)^{t^{+}}-\left(\frac{1}{1+r}\right)^{t}\right]$$

where r = discount rate, t = lifetime allowable for tax purposes, t^{+} = optimal switchover point from 150 per cent declining balance to straight-line depreciation. At the rate of discount we have employed, ten per cent after taxes, the sum of the years' digits has the highest present value; see Hall and Jorgenson [19]. Depreciation practices have adapted to the use of accelerated methods only gradually, as Wales [28] has demonstrated.

To estimate average asset lifetimes for tax purposes we employ data from two Treasury surveys, one reporting lifetimes underlying depreciation claimed on corporation income tax returns for 1959[49] and the other reporting lifetimes used for depreciation of assets acquired in 1959.[50] For assets acquired up to 1959 the Treasury survey gives average lifetimes by class of asset for assets acquired through 1953 and for assets acquired from 1954–1959; these are:

	structures	equipment
through 1953	35.3	22.1
1954–1959	29.8	17.7

For assets acquired in 1959 the average lifetime for equipment is reported to be 15.2 years.

We assume that lifetimes for tax purposes remained constant through 1953 and that the average for the period 1954–1959 combines longer lives at the beginning of the period with shorter lives at the end. Second, we assume that the relative change for the average for the period 1954–1959 and for 1959 is the same for structures as for equipment. Average lifetimes for 1954–1956 are estimated by linear interpolation between the lifetimes for 1953 and the average for the period 1954–1959. Similarly, average lifetimes for 1957–1959 are estimated by linear interpolation between the average for the period 1954–1959 and the lifetimes for 1959. Finally, new guidelines for lifetimes of equipment were adopted in 1962, reducing the average to 12 years. We assume that lifetimes for structures were constant at the 1959 level for the period 1959–1967. We assume that lifetimes for equipment were constant for the period 1959–1961 at the level of 1959 and constant for the period 1962–1967 at the level of 1962. Lifetimes for residential structures are estimated as five per cent higher than the lifetime for non-residential structures; this is based on the ratio of lifetimes for structures in all industries and for the sub-industry finance, insurance, and real estate for 1954–1959.

Given depreciation formulas and lifetimes for tax purposes, calculation of present values of depreciation deductions requires an estimate of the rate of return for discounting these deductions. We assume that this rate of return was constant at ten per cent.[51] Substituting the present values of depreciation deductions into expressions for capital service prices we reduce the unknown variables to two, the effective corporate tax rate u and the rate of return in the corporate sector r_{cp}. Corresponding to these two unknowns, we have two equations. The first relates corporate property income and the sum of values of the individual capital services. The second relates corporation income taxes and the effective tax rate on corporate income, applied to the corporate income tax base, less the investment tax credit. We measure corporation income taxes as federal and state corporate profits tax liability.[52] Since the two equations are independent, we may solve for values of the effective corporate tax rate and the corporate rate of return in each time period. Variables describing the corporate tax structure and the corporate rate of return for 1929–1967 are presented in Table 5.

[49]See [21]. [50]See [20], page 3.

[51]The appropriate rate of return for this purpose is the long-term expected rate of return; ten per cent is close to the average of corporate after tax rates of return for the period 1929–1967.

[52]*NIP* [25], Table 6.14.

TABLE 5

TAX STRUCTURE AND RATE OF RETURN, CORPORATE SECTOR, 1929–1967 (proportions and annual rates)

Year	1. Effective Tax Rate on Corporate Property t_{cp}	2. Effective Rate of Investment Tax Credit k	3. Statutory Rate of Investment Tax Credit	4. Effective Tax Rate on Corporate Income u	5. Statutory Tax Rate on Corporate Income	6. Present Value of Depreciation Deductions, Non-Residential Structures z_{12}	7. Present Value of Depreciation Deductions, Producers' Durables z_{13}	8. Present Value of Depreciation Deductions, Residential Structures z_{14}	9. Rate of Return, Corporate Sector r_{cp}
1929	0.016	0.000	0.000	0.107	0.110	0.273	0.397	0.262	0.083
1930	0.018	0.000	0.000	0.083	0.120	0.273	0.397	0.262	−0.001
1931	0.019	0.000	0.000	0.074	0.120	0.273	0.397	0.262	−0.061
1932	0.020	0.000	0.000	0.111	0.138	0.273	0.397	0.262	−0.088
1933	0.020	0.000	0.000	0.198	0.138	0.273	0.397	0.262	−0.004
1934	0.019	0.000	0.000	0.135	0.138	0.273	0.397	0.262	0.083
1935	0.020	0.000	0.000	0.138	0.138	0.273	0.397	0.262	0.070
1936	0.021	0.000	0.000	0.170	0.150	0.273	0.397	0.262	0.082
1937	0.020	0.000	0.000	0.156	0.150	0.273	0.397	0.262	0.144
1938	0.020	0.000	0.000	0.132	0.190	0.273	0.397	0.262	0.034
1939	0.021	0.000	0.000	0.166	0.190	0.273	0.397	0.262	0.057
1940	0.021	0.000	0.000	0.241	0.240	0.273	0.397	0.262	0.105
1941	0.020	0.000	0.000	0.441	0.310	0.273	0.397	0.262	0.170
1942	0.017	0.000	0.000	0.496	0.400	0.273	0.397	0.262	0.209
1943	0.017	0.000	0.000	0.531	0.400	0.273	0.397	0.262	0.158
1944	0.017	0.000	0.000	0.495	0.400	0.273	0.397	0.262	0.145
1945	0.017	0.000	0.000	0.489	0.400	0.273	0.397	0.262	0.091
1946	0.016	0.000	0.000	0.466	0.380	0.273	0.397	0.262	0.170
1947	0.014	0.000	0.000	0.442	0.380	0.273	0.397	0.262	0.262
1948	0.014	0.000	0.000	0.390	0.380	0.273	0.397	0.262	0.154

TABLE 5—*continued*

Year	1. Effective Tax Rate on Corporate Property t_{cp}	2. Effective Rate of Investment Tax Credit k	3. Statutory Rate of Investment Tax Credit	4. Effective Tax Rate on Corporate Income u	5. Statutory Tax Rate on Corporate Income	6. Present Value of Depreciation Deductions, Non-Residential Structures z_{12}	7. Present Value of Depreciation Deductions, Producers' Durables z_{13}	8. Present Value of Depreciation Deductions, Residential Structures z_{14}	9. Rate of Return, Corporate Sector r_{cp}
1949	0.015	0.000	0.000	0.333	0.380	0.273	0.397	0.262	0.076
1950	0.015	0.000	0.000	0.481	0.420	0.273	0.397	0.262	0.107
1951	0.014	0.000	0.000	0.521	0.508	0.273	0.397	0.262	0.157
1952	0.014	0.000	0.000	0.462	0.520	0.273	0.397	0.262	0.079
1953	0.015	0.000	0.000	0.477	0.520	0.273	0.397	0.262	0.065
1954	0.015	0.000	0.000	0.476	0.520	0.413	0.543	0.400	0.061
1955	0.016	0.000	0.000	0.479	0.520	0.425	0.560	0.412	0.093
1956	0.016	0.000	0.000	0.477	0.520	0.438	0.579	0.426	0.124
1957	0.016	0.000	0.000	0.468	0.520	0.453	0.596	0.439	0.103
1958	0.016	0.000	0.000	0.465	0.520	0.469	0.614	0.456	0.059
1959	0.016	0.000	0.000	0.494	0.520	0.486	0.632	0.473	0.079
1960	0.016	0.000	0.000	0.487	0.520	0.486	0.632	0.473	0.063
1961	0.017	0.000	0.000	0.479	0.520	0.486	0.632	0.473	0.062
1962	0.017	0.037	0.070	0.480	0.520	0.486	0.706	0.473	0.085
1963	0.018	0.045	0.070	0.490	0.520	0.486	0.706	0.473	0.085
1964	0.018	0.047	0.070	0.483	0.500	0.486	0.706	0.473	0.096
1965	0.018	0.053	0.070	0.475	0.480	0.486	0.706	0.473	0.113
1966	0.017	0.052	0.054	0.467	0.480	0.466	0.706	0.453	0.126
1967	0.017	0.050	0.057	0.454	0.480	0.470	0.706	0.456	0.117

6. Capital Input in Constant Prices

In separating the value of capital input into price and quantity components our basic accounting identity is that for each sector the value of all capital services or property compensation is equal to the sum of the values of the individual capital services. Denoting the price of the ith capital service by p_{it}^S as, before,

$$p_t^S K_t^S = \Sigma p_{it}^S K_{it}^S,$$

where p_t^S and K_t^S are Divisia index numbers of capital service price and quantity.[53] In constructing these index numbers we combine service prices and quantities by class of asset for all sectors, obtaining the service price and quantity indexes for each class of asset as Divisia index numbers. Finally, we combine service price and quantity indexes by class of asset into an overall capital service price index p_t^S and potential service quantity index K_t^S, again as Divisia index numbers. We note that the overall service price and quantity indexes include capital services from assets held by households and institutions as well as by businesses. Price and quantity indexes of potential capital services for corporate, non-corporate and household sectors for 1929–1967 are given in Table 6.

The final step in the 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 the actual quantities of capital services are equal to the potential quantities. For non-residential structures and producers' durables, we adjust the potential quantities of capital services in the corporate and non-corporate sectors to reflect changes in relative utilization. Our adjustment for relative utilization is based on the consumption of electricity relative to the capacity to consume electricity, as measured by installed horsepower of electric motors.[54] A similar relative utilization adjustment has been made by Jorgenson and Griliches [23]. Horsepower of electric motors installed in U.S. manufacturing is employed as a measure of capacity and electric power consumed by motors as a measure of utilization. Installed capacity data are available only for 1929, 1939, 1954, and 1962; Jorgenson and Griliches calculate levels of utilization for those years and interpolate between them to measure utilization in other years.[55]

We assume that the ratio of installed horsepower to the potential flow of capital services changes only gradually. We compute the ratio of an index of potential capital services from non-residential structures and producers' durable equipment to installed horsepower for the benchmark years employed by Jorgenson and Griliches. We interpolate this ratio linearly between benchmarks and estimate installed horsepower for all years as the product of this ratio and our index of the potential flow of capital services. We then divide the electric power consumed by motors by our estimate of installed horsepower to obtain an index of relative

[53]Divisia price and quantity index numbers are discussed in greater detail by Christensen and Jorgenson [5].

[54]This measure of relative utilization was originated by Foss [9].

[55]Estimates of installed capacity for 1929, 1939, and 1954 are given by Foss [9]; the data for 1954 have been revised by Jorgenson and Griliches [23]. Consumption of electric energy is from the *Annual Survey of Manufactures* [2].

TABLE 6

POTENTIAL GROSS PRIVATE DOMESTIC CAPITAL INPUT, 1929–1967 (constant prices of 1958)

Year	1. Corporate Capital Input, Quantity Index	2. Corporate Capital Input, Price Index	3. Non-Corporate Capital Input, Quantity Index	4. Non-Corporate Capital Input, Price Index	5. Household Capital Input, Quantity Index	6. Household Capital Input, Price Index	7. Private Domestic Capital Input, Quantity Index	8. Private Domestic Capital Input, Price Index
1929	41.4	0.442	28.9	0.516	32.5	0.420	102.7	0.456
1930	42.4	0.357	29.6	0.349	32.9	0.392	105.0	0.365
1931	42.5	0.246	29.7	0.318	32.3	0.432	104.3	0.324
1932	41.1	0.165	30.0	0.203	31.2	0.373	102.1	0.240
1933	38.3	0.160	29.3	0.222	29.3	0.402	96.8	0.253
1934	36.0	0.251	28.6	0.267	27.7	0.295	92.1	0.270
1935	34.9	0.304	28.7	0.332	26.8	0.400	90.0	0.342
1936	34.2	0.373	28.9	0.379	26.6	0.368	89.5	0.374
1937	34.6	0.402	29.2	0.390	27.3	0.386	90.8	0.395
1938	35.5	0.335	30.0	0.352	28.0	0.341	93.2	0.343
1939	34.8	0.383	29.9	0.386	27.7	0.401	92.2	0.391
1940	34.9	0.479	30.2	0.418	28.2	0.397	93.0	0.435
1941	35.9	0.629	30.6	0.526	29.3	0.414	95.6	0.532
1942	38.1	0.747	31.4	0.644	30.8	0.423	100.0	0.617
1943	37.9	0.862	31.3	0.728	29.9	0.564	99.0	0.730
1944	37.1	0.879	30.8	0.865	28.5	0.520	96.7	0.767
1945	36.5	0.776	30.8	0.911	27.2	0.570	94.9	0.757
1946	36.9	0.700	30.9	0.892	26.4	0.830	94.8	0.795
1947	40.1	0.836	31.7	0.840	29.1	0.865	101.4	0.842
1948	43.3	0.970	32.5	0.880	32.5	0.711	108.7	0.862

TABLE 6 —*continued*

Year	1. Corporate Capital Input, Quantity Index	2. Corporate Capital Input, Price Index	3. Non-Corporate Capital Input, Quantity Index	4. Non-Corporate Capital Input, Price Index	5. Household Capital Input, Quantity Index	6. Household Capital Input, Price Index	7. Private Domestic Capital Input, Quantity Index	8. Private Domestic Capital Input, Price Index
1949	46.1	0.891	34.0	0.801	35.8	0.679	116.1	0.797
1950	47.3	1.027	34.9	0.894	39.0	0.846	121.2	0.930
1951	49.9	1.103	36.6	1.029	43.9	0.849	130.0	0.999
1952	53.3	1.011	37.6	0.968	46.6	0.938	137.3	0.977
1953	55.5	1.004	38.3	0.939	48.8	0.940	142.3	0.967
1954	57.6	0.970	38.9	0.930	51.8	0.969	148.0	0.961
1955	59.0	1.141	39.5	0.937	54.5	0.990	152.6	1.037
1956	61.9	1.101	40.3	0.864	58.9	1.011	160.8	1.010
1957	65.3	1.076	40.7	0.908	61.8	1.003	167.7	1.009
1958	67.8	1.000	41.2	1.000	64.3	1.000	173.3	1.000
1959	68.7	1.154	41.6	0.925	65.6	1.067	176.0	1.067
1960	70.9	1.119	42.2	0.890	68.5	1.121	181.8	1.066
1961	73.4	1.110	42.8	0.938	71.1	1.137	187.7	1.079
1962	75.2	1.211	43.2	1.024	73.1	1.171	191.9	1.151
1963	77.9	1.245	44.0	1.032	76.1	1.204	198.6	1.179
1964	80.7	1.320	45.0	1.032	79.9	1.216	206.2	1.213
1965	84.5	1.421	46.0	1.113	84.2	1.269	215.5	1.291
1966	89.5	1.477	47.3	1.162	89.4	1.302	227.2	1.336
1967	96.2	1.390	48.6	1.137	94.5	1.270	240.7	1.283

TABLE 7

ACTUAL GROSS PRIVATE DOMESTIC CAPITAL INPUT, 1929–1967 (constant prices of 1958)

Year	1. Corporate Capital Input, Quantity Index	2. Corporate Capital Input, Price Index	3. Non-Corporate Capital Input, Quantity Index	4. Non-Corporate Capital Input, Price Index	5. Private Domestic Capital Input, Quantity Index	6. Private Domestic Capital Input, Price Index	7. Index of Relative Utilization
1929	33.7	0.542	25.2	0.592	90.4	0.518	0.775
1930	32.1	0.471	25.1	0.411	89.1	0.431	0.697
1931	29.6	0.353	24.5	0.386	85.3	0.397	0.615
1932	25.4	0.267	23.7	0.257	79.6	0.308	0.523
1933	25.7	0.239	24.0	0.272	77.8	0.314	0.569
1934	26.3	0.343	24.4	0.314	77.0	0.323	0.626
1935	27.6	0.384	25.3	0.375	78.3	0.393	0.698
1936	28.7	0.444	26.2	0.417	80.2	0.418	0.756
1937	28.6	0.487	26.3	0.433	80.7	0.444	0.739
1938	26.3	0.452	25.9	0.408	78.3	0.408	0.627
1939	29.0	0.460	27.2	0.425	82.3	0.438	0.738
1940	32.2	0.518	28.8	0.438	87.8	0.461	0.853
1941	37.5	0.602	30.9	0.521	96.8	0.525	1.021
1942	42.4	0.671	32.7	0.619	105.3	0.586	1.132
1943	46.5	0.702	34.1	0.667	110.6	0.653	1.333
1944	45.9	0.710	33.8	0.790	108.6	0.683	1.349
1945	42.2	0.671	32.8	0.855	102.6	0.700	1.224
1946	38.9	0.664	31.8	0.867	97.7	0.771	1.083
1947	43.9	0.764	33.0	0.805	106.4	0.802	1.138
1948	46.8	0.900	33.7	0.848	113.3	0.827	1.116

TABLE 7—*continued*

Year	1. Corporate Capital Input, Quantity Index	2. Corporate Capital Input, Price Index	3. Non-Corporate Capital Input, Quantity Index	4. Non-Corporate Capital Input, Price Index	5. Private Domestic Capital Input, Quantity Index	6. Private Domestic Capital Input, Price Index	7. Index of Relative Utilization
1949	45.8	0.896	34.1	0.798	115.5	0.801	0.991
1950	49.8	0.974	36.0	0.867	124.7	0.905	1.075
1951	53.3	1.032	38.0	0.990	134.8	0.965	1.095
1952	55.2	0.976	38.5	0.946	139.9	0.959	1.048
1953	59.4	0.938	39.8	0.903	147.5	0.932	1.098
1954	58.4	0.958	39.3	0.920	149.0	0.955	1.019
1955	63.5	1.061	41.2	0.896	158.8	0.996	1.104
1956	66.8	1.020	42.2	0.825	167.6	0.970	1.109
1957	68.4	1.026	41.9	0.883	172.1	0.983	1.066
1958	67.8	1.000	41.2	1.000	173.3	1.000	1.000
1959	73.6	1.077	43.5	0.886	182.7	1.028	1.092
1960	76.5	1.038	44.2	0.849	189.4	1.023	1.101
1961	78.1	1.043	44.4	0.903	194.1	1.043	1.083
1962	83.0	1.096	46.0	0.962	202.5	1.091	1.138
1963	87.1	1.114	47.3	0.961	211.0	1.110	1.157
1964	94.0	1.133	49.7	0.935	224.1	1.116	1.224
1965	99.1	1.212	51.0	1.003	235.0	1.183	1.236
1966	105.9	1.248	52.8	1.042	249.1	1.219	1.252
1967	113.7	1.176	54.2	1.020	263.7	1.171	1.250

utilization. This utilization adjustment reflects both cyclical and secular changes in utilization; the adjustment employed by Jorgenson and Griliches reflects only secular changes.

As a final step we multiply the index of relative utilization by the index of potential capital services to obtain an index of actual capital services for non-residential structures and producers' durables in the corporate and non-corporate sectors. We then divide the price of potential capital services by the index of relative utilization. The value of the capital service flow as we have measured it is independent of the rate of utilization; we define a price and quantity index of actual capital services as price and quantity indexes of potential capital services, divided and multiplied, respectively, by our index of relative utilization. Price and quantity indexes of actual capital services for corporate and non-corporate sectors and price and quantity indexes of actual capital services for the private domestic economy for 1929–1967 are presented in Table 7. The index of relative utilization is also given in Table 7.

7. Summary and Conclusions

In this paper we have attempted to provide a conceptual basis for measuring real capital input. We have constructed estimates of real capital input for corporate business, non-corporate business, and households and non-profit institutions in the United States for the period 1929–1967. Fully satisfactory estimates of real capital input will require much further research. Additional research on land and inventory components of the capital stock, paralleling the OBE *Capital Stock Study* [16] for depreciable assets, would be valuable. Goldsmith's allocation of assets and investment by legal form of organization should be updated and extended.

Further improvement of investment goods price indexes, as in the "constant cost 2" price index for non-residential structures for the *Capital Stock Study*, is essential for the accurate measurement of investment goods output entering our perpetual inventory estimates of capital stock. The relative utilization adjustment for capital we have employed should be estimated separately for each of the components of capital stock from data similar to that compiled by Foss [9]. Finally, it would be useful to compile data on capital stock by detailed asset class, legal form of organization, and industry in order to incorporate additional aspects of capital quality into the measurement of capital input.

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