QUARTERLY AGGREGATE CAPITAL INPUT AND THE COST OF CAPITAL FOR THE U.S.: 1948 - 1993

Subhash C. Sharma[1]
Yijian He
Department of Economics
Southern Illinois University
Carbondale, IL 62901

Ph: 618-453-5070
Fax: 618-453-2717

E-mail: SHARMA@SIUCVMB.SIU.EDU

June 1995

[1]Authors would like to thank Ulrich Kohli and Daniel Levy for helpful discussions.

QUARTERLY AGGREGATE CAPITAL INPUT AND THE COST OF CAPITAL FOR THE U.S.: 1948 -1993

"The measurement of capital is one of the nastiest jobs that economists have set to statisticians."

Sir John Hicks (1981, p. 204)

"The measurement of the user cost of capital is the second nastiest job that economists have put to statisticians."

ABSTRACT

It is the flow of capital services, instead of the capital stock, along with the flows of other inputs which is related to the flows of outputs in economic theory of cost and production. In applied research, quite often to capture the dynamic phenomena which occurs within a year, there is a need to use quarterly data which may not be captured by annual data. However, quarterly data on capital input and the cost of capital are not readily available. Thus, in this paper the quarterly real and nominal aggregate net capital stock, flow of capital services (capital input), and the user cost of capital are constructed from 1948:I to 1993:IV. In the aggregation of net capital stock, we have combined four categories, i.e., nonresidential structures, nonresidential producers' durable equipment, residential structures and equipment, and business inventories. Following Jorgenson et. al. (1987), we then constructed aggregate capital input by using the Tornqvist aggregation index over these four categories. Finally, the composite cost of capital is obtained by dividing the revenue of capital by the aggregate capital input.

QUARTERLY AGGREGATE CAPITAL INPUT AND THE COST OF CAPITAL FOR THE U.S.: 1948-1993

1. INTRODUCTION

The measurement of capital stock and the cost of capital has drawn a great deal of attention during the last three decades. Given that the famous economist Sir John Hicks (1981, p. 204) has noted "the measurement of capital is one of the nastiest jobs that economists have set to statisticians", it is fair to extend Sir John Hicks quote to the cost of capital. Thus we state, "the measurement of the user cost of capital is the second nastiest job that economists have put to statisticians". Inspite of the complications, a number of researchers, e.g. Jorgenson and Griliches (1967), Christensen and Jorgenson (1969), Harper, Berndt and Wood (1989), and Jorgenson, Gollop and Fraumeni (1987) among others have dealt with the theoretical and empirical side of measuring the aggregate capital stock and the user cost of capital.

Jorgenson and Griliches (1967) distinguished between aggregation of capital stocks and aggregation of flows of capital services. It is the flow of capital services, instead of capital stock, that along with flows of other inputs is related to flows of outputs in economic theory of cost and production. Thus, it is the flow of capital services called capital input which is used along with the flow of labor services in the estimation of the production and cost function. The aggregate capital stock, the flow of capital services, and the cost of capital are among the many economic time series which due to their complexity are only measured annually yet commonly used in empirical work.

Christensen and Jorgenson (1969) developed methods for the measurement of capital input and constructed the annual estimates of capital input in constant and current prices for corporate business, non-corporate business and households, and nonprofit institutions in the U.S. from 1929 to 1967. Subsequently Christensen and Jorgenson (1970) incorporated these estimates along with social product and social factor outlay and constructed production accounts in constant and current prices for the U.S. from 1929 to 1967. Jorgenson, et. al. (1987) also constructed yearly data on aggregate capital input, the aggregate capital stock, and the cost of capital, along with many other series from 1948 to 1979, using 1972 as the base year. Recently, Kohli (1991) constructed yearly data on aggregate capital input and the cost of capital from 1948 to 1987 with the cost of capital normalized to one in 1982.

However, as is well known (also noted by Levy and Chen, 1994) that in applied research, e.g., in estimating the short run aggregate production function, in analyzing the dynamic relationship between aggregate factors of production and supplies, and in investigating business cycles, among others, there is a need to use high frequency data because some dynamic phenomena which occur within the year may not be captured by annual data. Moreover, since statistical inference from most econometric models is valid only asymptotically, quarterly data increases reliability of inference from these models.

By using four different methods, Levy and Chen (1994) recently computed quarterly estimates of three categories of gross and net capital stock from 1978 to 1991. They considered real and nominal consumer durable goods, business structures (also called nonresidential structures), and producers' durable equipment. In short, their methods can be described as (i) segmented linear interpolation; (ii) expressions of the quarterly depreciation rate as a nonlinear function of this year's and last year's annual capital stock and this year's quarterly investment; (iii) estimation of the quarterly depreciation by linearly interpolating the annual depreciation and (iv) estimation of the quarterly depreciation by assuming that the annual depreciation is spread equally across four quarters. Furthermore, they have also compared the characteristics (e.g. the short run and the long run behavior) of their quarterly series by analyzing the time and frequency domain properties of these series.

While using quarterly capital input in empirical analysis one also needs the user cost of capital. The cost of capital is rarely directly observed, unlike the labor cost (wage rate). However, in the process of investigating the effects of tax policy on investment, Hall and Jorgenson (1967) have provided a theoretical framework for the specification of the cost of capital by including four categories (the opportunity cost, the depreciation rate, the expected capital gains or losses, and the effects of various taxes). Jorgenson, Gallop and Fraumeni (1987) have compiled a data base for the yearly cost of capital from 1948 to 1979. Harper, et. al. (1989) provided five alternative specifications of the user cost of capital. However, there still remains a number of difficult and unsettled issues in empirical estimation of the user cost of capital. The expected capital gains or losses has been a debated issue. Jorgenson and Griliches (1967) employed an annual adjustment for asset appreciation in their measure of the user cost of capital. However, Denison (1969, p. 45) argued that use of annual capital gains calculations was dubious since capital gains are highly erratic from year to year. Moreover, the empirical researcher must deal with the issue of measuring unobserved expectations. In practice, Christensen and Jorgenson (1969) assumed perfect foresight and replaced expected with realized new investment goods prices. Other researchers have assumed static expectations or other alternative approaches. Yet, another issue, the tax effect, merits special attention. Although Hall and Jorgenson (1967) and Christensen and Jorgenson (1969) noted that a modification can be made to include the effects of various taxes in the specification of the user cost of capital, it is often very difficult to obtain reliable data on effective marginal tax rates since tax law interpretation is very complex.

Recently, Kohli (1991) constructed the annual cost of capital for the U.S. economy. Kohli excluded various taxes, but he adjusted the theoretical user costs of capital so that the income of capital input computed from the constructed costs of capital sums up to the income of capital computed from the "National Income and Product Accounts." Kohli (1991, p. 221) has clearly stated the distinction between his data sets and those of Jorgenson et. al. (1987). Furthermore, he estimated his translog model by using his data sets and by using only the input price data, and the input and output data sets of Jorgenson et. al. (1987) and compared the findings. The yearly data from 1948 to 1986 is used in this comparison. Kohli (1991, p. 223) notes that, "we find the outcome of this comparison cause for rejoicing. Unavoidably, there are some differences in magnitudes of some individual elasticity estimates. But, all in all, the qualitative nature of our earlier findings is vindicated by the use of Jorgenson's data base."

In this paper, first we construct the quarterly net residential capital stock series from 1948:I to 1993:IV and then we extend up to 1993:IV the quarterly estimates of the net non-residential structures and the net non-residential producers' durable equipment constructed by Levy and Chen (1994). In this study, we have used two of the four methods used by Levy and Chen (1994), i.e., (i) and (iv). Using their method (i), denoted here by MI, we obtain quarterly series by segmented linear interpolation of the annual capital stock, and using their method (iv), denoted here by MII, we use the annual capital stock depreciation and quarterly investment series. In this method we assume that the annual depreciation is equally spread across each quarter within a year. Second, the aggregate real and nominal net capital stock is constructed by summing over all the four categories. Third, following Jorgenson, et. al. (1987), by using the Tornqvist aggregation index, we construct the quarterly flow of capital services also called the capital input. Finally, we obtain the composite cost of capital by dividing the revenue of capital by the aggregate flow of capital input.

In order to use the Tornqvist aggregation index, we need to construct the relative cost shares of capital inputs (relative income shares of capital inputs). By following Kohli (1991, 1993) and Hall and Jorgenson (1967), we constructed the theoretical cost of capital for each category of capital input, i.e., nonresidential structures, nonresidential equipment, residential structures and equipment, and business inventories. First we obtained the theoretical income of capital for each category and then adjusted the theoretical incomes of capital inputs such that the incomes of capital inputs sum up to the revenue of capital computed from the National Income and Product Accounts.

In their study of the behavior of fixed investment in the U.S., Gordon and Veitch (1986) developed a data set including the quarterly user costs of capital for nonresidential structures and non-residential producers' durable equipment up to 1983. The cost of capital constructed here is not identical to their series. First, one of our main objectives is to construct a composite user cost of capital from 1948:I to 1993:IV; and we include four categories of capital inputs. Second, we have used two different techniques to construct the four types of quarterly net capital stock series. In particular, the equal depreciation method, MII, makes the use of the available quarterly data on investment, instead of simply using econometric interpolation procedure, to convert the annual capital series to quarterly observations. Third, following Levy and Chen (1994), we have adjusted estimates of nominal capital series for quarterly changes in capital goods prices, which during some years were very substantial. Fourth, we follow Kohli (1991) for the specification of the cost of capital, which differs from that in Gordon and Veitch in the treatment of the tax effects.

The paper is organized as follows. In Section 2, we give details of the different time series used in this paper and their sources. In section 3, the details of constructing the quarterly data on the residential structures and equipment, the aggregate capital stock and the flow of capital services are provided. Section 4 deals with the construction of the composite user cost of capital. Some concluding remarks are made in Section 5.

2. DATA AND NOTATIONS

2.1 Capital, Depreciation and Investment

Let K_i^y (i=1,2,3) be the real or nominal ith category of yearly net capital stock, and $K_i^{y:q}$ be the ith category of net capital stock in year y and quarter q. K_1^y is the yearly nonresidential structures, K_2^y is the yearly nonresidential producers' durable equipment, K_3^y is the yearly residential structures and equipment, and $K_4^{y:q}$ is the quarterly business inventories.

Yearly net capital stocks, K_1^y, K_2^y and K_3^y are taken from Tables 2 and 4 in Musgrave (1992) and $K_4^{y:q}$ is taken from Citicorp (1993) database, series GL and GLQ.

Let δ_i denote the yearly depreciation corresponding to K_i^y. The δ_i's are taken from Tables A6, A7, A9 and A10 in the Fixed Reproducible Tangible Wealth in the United States, 1929-1992 (FRTW, pp. 48-89).

Let $I_i^{y:q}$ (i=1,2,3) be the real or nominal investment for the ith category and $PI_i^{y:q}$ be the implicit price deflator for the ith investment in the yth year and the qth quarter. Quarterly data on $I_i^{y:q}$, $PI_i^{y:q}$ and interest rate, r, are taken from Citicorp (1993) database. The specific time series used for each category are as follows: $I_1^{y:q}$ is the nonresidential structures and are GIS and GISQ; $I_2^{y:q}$ is the nonresidential producer durable equipment and are GIPD and GIPDQ; $I_3^{y:q}$ is the residential structures and equipment and are GFRST, GFRPD, GFRSTQ and GFRPDQ; and $PI_1^{y:q}$,

$PI_2^{y:q}$ and $PI_3^{y:q}$ are the series GDIS, GDIPD and GDIR. The interest rate, r, is represented by the three-month U.S. T-bill rate and is the series FYGN.

All the series are updated to the fourth quarter of 1993 from August 1993 and March 1994 issues of *Survey of Current Business* (SCB).

2.2 Revenue of Capital:

Let VK be the revenue of capital which is calculated by using GNP identity

$$VK_t = VC_t + VI_t + VX_t - VM_t - VL_t$$

where VC is the current value of output of consumption goods including government purchases of nondurables; VI is the current value of output of investment goods including government purchases of durable goods and structures; VX and VM are the current values of exports and imports respectively; and VL represents the value of labor services including total compensation of employees for all private industries and government enterprises. The first four components on the right hand side of GNP identity are GNP excluding government purchases of services. Specifically, (i) the current value of consumption, VC, is the sum of personal consumption expenditures and government purchases of nondurable goods. The government purchases consists of federal government purchases of nondurable goods (national defense and nondefense) and state and local government purchases of nondurable goods. The data series are obtained from Citicorp (1993) and the specific series are as follows: personal consumption expenditures -series GC; and government purchases of nondurable goods: federal national defense - series GGNN, federal nondefense - series GGON, and state and local - series GGSN. (ii) The current value of investment, VI, is the sum of gross domestic private investment and government purchases of durable goods and structures. The government purchases of durable goods consist of federal government purchases of durable goods (defense and nondefense) and state and local government purchases of durable goods. These data series are also obtained from Citicorp (1993) and the specific series are: gross domestic private investment - series GPI; government purchases of durable goods: federal national defense - series GGND, federal nondefense - series GGOD, and state and local - series GGSD; and government purchases of structures: federal national defense - series GGNC, federal nondefense - series GGOC, and state and local - series GGSC. (iii) The current value of exports, VX, and the current value of imports, VM, are series GEX and GIM from Citicorp (1993). (iv) The value of labor services, VL, is the sum of total compensation of private industries and compensation of government enterprises (federal and state and local).

Note that the data on compensation of employees for total private industries and government are only available on an annual basis from the Citicorp database. In order to obtain the quarterly series on value of labor services, we subtract the compensation of employees for general government services (for federal, series GAPGFG, and for state and local, series GAPGSG) and for the rest of the world (series GAPRW) from total compensation of employees (table 6.2C line 1 or table 1.14 line 2 or Citicorp 1993 series GCOMP), since the quarterly data on total compensation of employees is readily available. We obtain the quarterly data on compensation of employees for general government services and for the rest of the world by equally interpolating the available yearly data. The equal interpolation method is appropriate since the magnitudes of these interpolated series are relatively small and stable.

Note that the quarterly data series GGNN, GGON, GGND, GGOD, GGNC and GGOC are only available from 1959. We therefore extend these series to 1948. For the series GGON, GGOD and GGNC values of observations are equal to zero from 1959 to 1972. It is natural to extend zero value to 1948. For the rest of the three series (GGNN, GGND and GGOC) the magnitudes are small and increasing slightly over time. Thus, we used linear regression to extend the series back to 1948.

3. QUARTERLY AGGREGATE CAPITAL INPUT

3.1 Aggregate Net Capital Stock:

Recently Levy and Chen (1994) estimated the quarterly data on two of the four categories of capital stock used in our aggregation; i.e., $K_1^{y:q}$, nonresidential structures (called business structures by Levy and Chen) and $K_2^{y:q}$: nonresidential producers' durable equipment (called producers durable goods by Levy and Chen, 1994). First, following Levy and Chen (1994) we have constructed the quarterly data for nominal and real residential structures and equipment, $K_3^{y:q}$. For this purpose we have used linear interpolation and equal depreciation across quarters within a year methods (i.e., methods (i) and (iv) in Levy and Chen, 1994).[2] Second, we extend the data upto 1993:IV on nonresidential structures and nonresidential producers' durable equipment.

Linear Interpolation Method: MI

The qth quarter observation in year y, $K_i^{y:q}$, is obtained by connecting two consecutive annual observations, i.e.,

$$K_i^{y:q} = K_i^{y-1} + \Delta_i^q \qquad (1)$$

where

$$\Delta_i^q = (K_i^y - K_i^{y-1})*q/4,\ q=1,2,3,4. \qquad (2)$$

---

[2]We have not used methods (ii) and (iii) of Levy and Chen (1994). In method (ii) the quarterly depreciation rate, δ_i, is a fourth degree polynomial (see Levy and Chen (1994), p. 319, eq. (8)). Thus, since their equation (8) has four roots, real or complex, we are not sure how they selected their one root. Their method (iii) is not used here since the fourth quarter capital stock estimates are not equal to the corresponding annual values.

By substituting (2) in (1), we get

$$K_i^{y:q} = \left(1 - \frac{q}{4}\right)K_i^{y-1} + \left(\frac{q}{4}\right)K_i^{y} \qquad (3)$$

where K_i^y is the yth year observation for category i. Note that for q=4, $K_i^{y:q} = K_i^y$.

Equal Depreciation across Quarters Method: MII

It is assumed that the annual depreciation δ_i^y is spread equally across four quarters, i.e.,

$$\delta_i^{y:q} = \delta_i^y/4.$$

Then $\delta_i^{y:q}$ is used along with yearly net capital stock and the quarterly investment to construct $K_i^{y:q}$, i.e.,

$$K_i^{y:q} = K_i^{y-1} + I_i^{y:q} - \delta_i^{y:q}. \qquad (4)$$

Following Levy and Chen (1994), the estimates of nominal series reported here are adjusted for quarterly variations in the prices of the capital goods. Thus, the quarterly nominal capital series are multiplied by the factor ($PI_{i,t}^{y:q}/PK_{i,t}^{y:q}$), where $PI_{i,t}^{y:q}$ denotes the quarterly implicit price deflator of new capital goods and $PK_{i,t}^{y:q}$ denotes the quarterly implicit price deflator of capital stock. To obtain the quarterly implicit price deflator of capital stock, we first obtain the annual implicit price deflator from $PI_{i,t}^{y:q}$ and then interpolate it to obtain the quarterly price deflator by assuming fixed quarterly rate of change within the year.

The real and nominal quarterly data for residential structures and equipment and the extended data on nonresidential structures and nonresidential producers' durable equipment are reported in the appendix in Tables A and A1.

3.2 The Aggregate Net Capital Stock:

The aggregate net capital stock is then obtained by taking the simple sum of these four individual categories, i.e.,

$$K_t^{y:q} = \sum_{i=1}^{4} K_{i,t}^{y:q} . \qquad (5)$$

Note that the quarterly data on $K_1^{y:q}$ and $K_2^{y:q}$ used here are from Levy and Chen (1994) and $K_4^{y:q}$ is described in section 2. The real and nominal values of the aggregate net capital stock are reported in Tables 1 through 4.

3.3 Quarterly aggregate flow of Capital Services (Capital Input):

As noted in the previous section, it is the flow of capital services instead of capital stock that along with flows of other inputs is related to the flows of outputs in economic theory of cost and production. The cost of capital is therefore the cost of using capital services. We follow the tradition here and make the assumption that the flow of capital services for each category, FK_i, is a constant proportion of capital stocks over time, i.e.

$$FK_{i,t}^{y:q} = Q_i \, K_{i,t-1}^{y:q} , \qquad (6)$$

where the constant of proportionality, Q_i, transforms capital stock into a flow of capital services. Q_i is known as the quality of capital stock (see Jorgenson, et. al. (1987, p. 267). Jorgenson, et. al. (1987, p. 266-267) and Harper, et. al. (1989, p. 342-343) used the Tornqvist aggregation index to aggregate the flow of capital services. Tornqvist (1936) introduced the Tornqvist quantity index which is a discrete approximation to continuous Divisia index. Diewert (1976) showed that the Tornqvist index can be viewed as an exact index corresponding to a second order approximation in logarithms to an arbitrary production or cost function. Harper, et. al. (1989, p. 342) also noted that the Tornqvist index has many attractive properties. Moreover, this index places no prior restrictions on the substitution elasticities among the goods being aggregated.

Jorgenson, et. al. (1987, p. 267) notes that the translog quantity index of capital input can be expressed either in terms of the categories of capital stock $K_{i,t}^{y:q}$ or in terms of the categories of flow of capital services, $FK_i^{y:q}$. By using the Tornqvist index the change in aggregate capital input is a weighted sum of the changes in the four categories of capital input where the weights are the relative cost (income) shares of capital inputs. Thus the Tornqvist index used here is given by

$$\ln FK_t^{y:q} - \ln FK_{t-1}^{y:q} = \sum_{i=1}^{4} \bar{w}_{i,t} \left[\ln FK_{i,t}^{y:q} - \ln FK_{i,t-1}^{y:q} \right]$$

$$= \sum_{i=1}^{4} \bar{w}_{i,t} \left[\ln K_{i,t-1}^{y:q} - \ln K_{i,t-2}^{y:q} \right], \qquad (7)$$

where

$$\bar{w}_{i,t} = (w_{i,t} + w_{i,t-1})/2,$$

and

$$w_{i,t} = CK_{i,t}\ FK_{i,t}^{y:q} \Big/ \sum_{i=1}^{4} CK_{i,t}\ FK_{i,t}^{y:q} = VK_{i,t} \Big/ \sum_{i=1}^{4} VK_{i,t}$$

where $CK_{i,t}$ is the user cost of capital services $FK_{i,t}$, $VK_{i,t}$ is the income of capital for the ith category, as derived in the next section and ln is the natural logarithm.

The real and nominal capital inputs obtained from (7) are reported in Tables 1 through 4. Note that the capital stocks reported are the beginning period values and the cost of capital is reported at an annual rate. Since we have used two methods in the construction of the quarterly capital stock, the capital inputs and the cost of capital are reported from both methods.

4. THE USER COST OF CAPITAL

Towards the goal of constructing a composite cost of capital, first we construct the income of capital for each of the four categories (nonresidential structures, nonresidential producers' durable equipment, residential structures and equipment, and business inventories). In computing the cost of capital we have followed the method given by Kohli (1991), which is a variation of that in Hall et. al. (1967). Our reasons for following Kohli are as follows. First, Kohli (1991) has shown that the use of Jorgenson's data on the user cost of capital led only to minor changes in his elasticity estimates. Second, Jorgenson's data set is very detailed and thus involves much more time to compile. Third, it is very difficult to obtain reliable data on effective marginal tax rates. Finally, for our purpose of obtaining the aggregate flow of capital input and the cost of capital, different specifications only result in different cost shares in the Tornqvist aggregation of capital inputs. Since the effective marginal tax rates are expected to have similar effect on cost of capital for each category of capital, relative cost shares are not expected to be very different with or without taking tax effects into account.

Thus, following Kohli (1991), the theoretical user cost of capital, denoted as CK_i for capital K_i, is specified as

$$CK_{i,t} = p_{i,t}(r_{i,t} + \delta_{i,t}),\ i=1,2,3,4, \qquad (8)$$

where $p_{i,t}$ and $r_{i,t}$ are the asset price for capital goods and a one period interest rate yield, $p_{i,t}r_{i,t}$ represents the opportunity cost of having funds tied up in plant and equipment, $\delta_{i,t}$ denotes depreciation rate for capital K_i, and $p_{i,t}\delta_{i,t}$ represents the compensation for depreciation to the owner. For the business inventories, the depreciation rate, $\delta_{4,t}$, is assumed to be zero.

From the theoretical user cost of capital, the theoretical income for each category of capital, V_i^*, is obtained by first multiplying the theoretical user cost of capital by the corresponding beginning period capital stock. That is,

$$V_{i,t}^* = CK_{i,t}\, K_{i,t-1}.$$

The resulting figures on $V_{i,t}^*$ are then scaled up or down by a common factor to ensure that the GNP identity is verified for each observation. The scale factor is calculated by

$$s_t = VK_t \,/\, \sum_i V_{i,t}^* ,$$

where VK_t is the revenue of capital. The revenue of capital, VK, is obtained as a residual using the GNP identity and is discussed in section 2 in detail. The adjusted income of capital, K_i, is denoted as VK_i, i = 1, 2, 3 and 4. After adjustment, the sum of the income for all four capital inputs is equal to the aggregate revenue of capital for the economy as a whole. The incomes of capital input, VK_i, i = 1,2,3, and 4, are then used in equation (7).

Finally, following Jorgenson (1987, p. 226), the composite user cost of capital for the economy as a whole is obtained by

$$C_t = VK_t/FK_t \qquad (9)$$

The real and nominal user cost of the capital are also reported in Tables 1 through 4. Note that the composite user cost of capital can be alternatively obtained by using the Tornqvist index,

$$\ln C_t - \ln C_{t-1} = \sum_i \bar{w}_{i,t} \; \{ \ln C_{i,t} - \ln C_{i,t-1} \} \qquad (10)$$

where

$$\bar{w}_{i,t} = C_{i,t}\, FK_{i,t} \,/\, \sum_{i=1}^{4} C_{i,t}\, FK_{i,t}.$$

The user cost obtained from equation (10) is almost the same as obtained from (9) and thus is not reported.

5. CONCLUSION

In this paper, the quarterly real and nominal capital input and the cost of capital for the U.S. are constructed from 1948:I to 1993:IV. The four categories of capital, i.e., non-residential structures, nonresidential producers' durable equipment, residential structures and equipment, and business inventories are used in the aggregation. The quarterly data on residential structures and equipment is constructed by two of the four methods used by Levy and Chen (1994). The quarterly data on nonresidential structures and nonresidential producers' durable equipment used here is taken from Levy and Chen (1994).

Thus, we have reported the aggregate capital stock, capital input and the cost of capital for both the methods. The series obtained by these methods are almost similar. However, we would recommend using the data obtained by method MII. In this method, the net capital stock is constructed by using the quarterly investment and depreciation as compared to obtaining capital stock by linear interpolation in method MI.

REFERENCES

Christensen, Laurits R. and Jorgenson, Dale W., The Measurement of U.S. Real Capital Input, 1929-1967, **Review of Income and Wealth**, Vol. 15, no. 4, 293-320, 1969.

Christensen, Laurits R. and Jorgenson, Dale W., U. S. Real Product and Real Factor Input, 1929-1967, **Review of Income and Wealth**, Vol. 16, no. 1, 19-50, 1970.

Citicorp Database Services, CITIBASE: **Macroeconomics Database,** 1993.

Denison, Edward F., Some Major Issues in Productivity Analysis: An Examination of Estimates by Jorgenson and Griliches, **Survey of Current Business**, Part II, May, 1-27, 1969.

Diewert, Erwin W., Exact and Superlative Index Numbers, **Journal of Econometrics**, Vol. 4, No. 4, 115-145, 1976.

Fixed Reproducible Tangible Wealth in the United States, 1925-1989, **Bureau of Economic Analysis, U.S. Department of Commerce,** 1993.

Gordon, Robert J. and Veitch, J. M., Fixed Investment in the American Business Cycle: 1919-83, in Gordon, R.J. (ed.), **The American Business Cycle: Continuity and Change ,**The University of Chicago Press, Chicago, 1986.

Hall, Robert E. and Jorgenson, Dale W., Tax Policy and Investment Behavior, **American Economic Review,** Vol. 57, No. 3, 391-414, June, 1967.

Harper, Michael J., Berndt, Ernst R., Wood, David O., Rates of Return and Capital Aggregation Using Alternative Rental Prices, In Jorgenson and Landau (eds) **Technology and Capital Formation**, The MIT Press, 1989.

Hicks, John, **Wealth and Welfare, Collective Essays on Economic Theory, Vol. 1**, Harvard University Press, Massachusetts, 1981.

Jorgenson, Dale W. and Griliches, Zvi, The Explanation of Productivity Change, **Review of Economic Studies,** Vol. 34 (3), No. 99, 249-282, 1967. Reprinted in "The Measurement of Productivity", **Survey of Current Business**, Vol. 52, No. 5, Part II, 3-36.

Jorgenson, Dale W., Gollop, Frank M. and Fraumeni, Barbara M., Productivity and US Economic Growth, Harvard University, Massachusetts, 1987.

Kohli, Ulrich, **Technology, Duality and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports**, The University of Michigan Press, 1991.

Levy, Daniel and Chen, Haiwei, Estimates of the Aggregate Quarterly Capital Stock for the Post-War U.S. Economy, **Review of Income and Wealth**, Vol. 40, No. 3, 317-349, September, 1994.

Musgrave, John C., Summary Fixed Reproducible Tangible Wealth Series, 1925-91, **Survey of Current Business**, October, 1992.

Tornqvist, Leo, The Bank of Finland’s Consumption Price Index, **Bank of Finland Monthly Bulletin**, Vol. 10, 1-8, 1936.