ESTIMATES OF CAPITAL STOCK BY INDUSTRIES FOR AUSTRIA*

BY FRANZ HAHN

Austrian Institute of Economic Research, Vienna

AND

INGO SCHMORANZ

Institute for Advanced Studies, Vienna

The present investigation is the first attempt to calculate gross capital stocks for 19 industries which together cover the whole Austrian economy. A production-oriented concept of capital formed the basis of the investigation; the estimation procedure follows that of C. Almon *et al.* In contrast to the traditional perpetual-inventory methods, Almon's modified estimation technique combines the advantages of differentiated cumulation containing a logistical retention function with relatively moderate requirements with respect to investment data. A thorough description of this estimation technique is given in the third section of the paper, combined with a number of comparative model calculations. These demonstrate very clearly that capital stock figures calculated according to the Almon method rarely deviate from those found with the help of the traditional inventory method, which requires considerably more information and uses more complicated calculation procedures. Finally, the sectorally disaggregated capital stock estimates calculated according to the Almon method are presented with some interpretative remarks.

1. INTRODUCTION

In recent years, repeated attempts have been made in Austria to calculate the value of fixed assets of individual industries or of the total economy.[1] The rising need for such figures is apparent, since without data on capital stock a wide spectrum of empirical economic research cannot be carried out satisfactorily. Interest in capital stock data, especially sectorally disaggregated time series, has arisen in many different quarters. To begin with, there are the statistical requirements for establishing overall national accounts, for consistent and sectorally disaggregated capital stock estimates are needed in order to arrive at sectoral depreciation rates. Furthermore, such figures are indispensable to a multitude of analytical studies, e.g. analyses of sectoral profitability or productivity, calculations of the degree of utilisation of individual sectors, or estimates of sectoral production and investment functions.

Capital stock estimates by industries are particularly relevant to the current discussion about structural problems, since indicators such as the intensity or productivity of capital on a sectorally disaggregated level are of crucial analytical importance to research into economic structure.

---

* We are indebted to K. Bayer, G. Fink and J. Skolka for helpful discussions and to N. Nemeth for his assistance with some data problems. All responsibility remains, of course, solely with the authors.

[1] See e.g. Bruckmann–Riese–Seidel (1968), Handler–Merth–Morwind (1969), Kausel (1971, 1975), Schenk–Fink (1976) and Prucha (1976).

The present study is a first attempt to calculate gross capital stocks for 19 industries which together cover the entire Austrian economy.[2]

The study proceeds as follows. The first section attempts to define the concept of capital underlying the present calculations, although the fundamental problems surrounding it can not be examined in great detail. The second section summarises the existing quantitative methods of capital stock measurement, especially the so-called cumulation or perpetual-inventory method. The third section introduces the so-called Almon method, which is based on the cumulation method. This method was applied in constructing the estimates of this study. Finally, the results of the estimation are presented. Due to the wealth of resulting data it was decided to present real capital stock at 1976 prices, as well as nominal capital stock at replacement costs, both for the total economy and for the 19 industries.

2. The Concept of Capital

The present capital stock calculations are based on a production-oriented concept of capital.[3] Capital is defined as the sum total of all durable means of production that have been produced. This definition of capital largely coincides with the concept of fixed assets used in business economics which, however, also includes land in addition to buildings, machines and vehicles. In contrast, land and natural resources are considered as "gifts of nature" (Robinson, 1958) in the concept of capital underlying the present study. Therefore, the term "capital" encompasses all means of production which are themselves results of production processes and which are transformed into other goods during a time-span transcending one production period. This temporal aspect, which points to the allocation of resources to present or future consumption, is a constituent part of our definition of capital.

Such a definition will, of course, also give rise to a number of problems in empirical capital stock estimates, which may be circumscribed by the opposing terms homogeneity/heterogeneity, economic profit concept/cost concept, or gross/net concept.

In empirical capital stock calculations the heterogeneity of capital goods can only be taken into account insofar as to include institutionalised conceptual differentiations (e.g. subdivision into sectors and/or differentiation between equipment and plant). Apart from this, the fiction that capital goods are homogeneous must be used, homogeneity being particularly assumed with respect to technical progress (since empirical capital stock estimates are based on the assumption of disembodied technical progress).

The problem of evaluating the cost or profit of fixed assets can be reasonably discussed only in conjunction with one's particular analytical aims, and must therefore be considered together with the question of adopting a gross or net concept. According to the cost concept, the basis of evaluation and consequently of comparison is derived from production costs, while according to the profit concept, possible future profits are used as units of evaluation and comparison.[4]

---

[2] This study is a product of participation in C. Almon's ERI Project.

[3] Good surveys of the controversies surrounding capital theory are contained in Lutz (1963), Harcourt (1972), Burmeister (1974), Männer (1978) and Orosel–Weizsäcker (1979).

[4] Cf. Schenk–Fink (1976).

The distinction between gross and net capital stock is one of the most important differentiations in empirical analyses. Gross capital stock encompasses all produced physical fixed assets that are available and used for productive purposes. If a particular asset is eliminated because of sudden destruction, technical outdatedness or economic inefficiency, the gross capital stock is reduced by this particular asset. Thus, the gross capital stock reflects the maximum available production capacity of fixed assets at one particular point in time, which is why the term "capacity concept" has also been applied. While the gross capital stock concept is more oriented towards the past, the net capital stock concept rather aims at the future, i.e. at the remaining future capacity to produce. This concept is based on the assumption that new capital goods contain a capacity to produce that will diminish successively through usage, with the reduction appearing as economic depreciation. The net capital stock can therefore be considered as gross capital stock corrected for the losses resulting from past usage. There is a loose relationship between the concept of net capital stock and the book value of investment goods as used in business economics, since both concepts aim at potential reserves which are still present. The fundamental difference between them lies in the fact that the net capital stock concept is based on production reserves that are available for the future, while the book value stated in a balance sheet is oriented towards recovering past costs, and must therefore aim at estimating the diminution through usage of original investments.

Because of the primarily analytical aims of the present capital stock estimation mentioned in the introduction, and as a first step towards a comprehensive calculation of national wealth, the gross concept based on the cost principle seemed to be the best link between evaluation and calculation methods.

3. THE METHODS OF CAPITAL STOCK ESTIMATION

3.1. *General Considerations*

Capital stock may be estimated by two different methods: First, by so-called status calculations, which arrive at the status at a given point of time; and second, by so-called cumulation methods. Status calculations can be subdivided into estimates based on tax payments, on insurance contracts, on published annual balance sheets, or on questionnaires. Status calculations play only a minor role in modern empirical capital stock studies and are therefore not discussed in greater detail. The most commonly used methods of capital stock estimation are collectively called "cumulation methods" in the relevant literature.

3.2. *The Cumulation Method*

The cumulation or perpetual-inventory method has already been described in detail elsewhere, which allows us to limit ourselves to the essentials in the present discussion.[5] In principle, it is based on the assumption that at any given point in time fixed assets are the weighted sum of the investments made in

---

[5] Cf. Goldsmith (1951), Kirner (1968).

previous periods that are available as means of production during the period of investigation. Decisive for this method is the economic service life of the respective annual investment groups, i.e. the availability of information about the economic service life, and access to the respective investment time series. For empirical calculations, such time series must reach back to the beginning of the estimation (the initial capital stock being known) for as long a time as is assumed to be the total period of utilisation.

In general terms and using continuous notation, the basic model of the perpetual-inventory method is as follows:

$$K(t)=\int_{t-m(x)}^{t}\int_{x_0(i)}^{x_1(i)} g(t-i, x)I(i)\,di\,dx \tag{1}$$

$K(t)$ = gross fixed assets at time t, $I(i)$ = gross investment at time i, m = maximum service life of investments, $g(t-i, x)$ = retention rate of an annual investment group at time $(t-i)$, where x is a so-called portmanteau variable[6] used for determining the retention function, including the maximum service life m over time.

From (1) it follows that—assuming necessary length of investment time series—the quality of capital stock estimates depends solely on the level of information about the economic service life of the individual annual investment groups, i.e. on their distribution over time and the changes in this distribution during the period in question.

With the cumulation method, the minimum necessary information is knowledge of the average economic service life of a representative annual investment group. Assuming that this average economic service life is constant over time, the basic model (1) is simplified to

$$K(t)=\int_{t-m}^{t} I(t)\,di. \tag{2}$$

The retention rate $g(t-i, x=\text{constant})$ has the extreme value of 1 under certain restrictive assumptions about total economic utilisation, namely that all annual investment groups are available in their entirety as means of production during the whole period of economic utilisation and that they all suddenly and at once disappear from the fixed assets. Therefore, the weighting and retention function $g(t-i)$ within the cumulation method is, in its simplest form, a rectangle.[7] To assume such a process is highly unrealistic, and the sudden elimination of an entire annual investment group can only be justified as a first attempt at approximating reality in the face of very meagre information on economic service life.

In order to formulate retention functions that are closer to reality, we not only need to know the average economic service life, but also require additional

---

[6] Portmanteau variables are proxies for all those lagged and exogenous model variables which have not explicitly been included.

[7] This is known as the one-hoss-shay assumption in Anglo-Saxon literature; cf. especially Kirner (1968), footnote 19.

information about the (statistical) dispersion of eliminations from each annual investment group over their mean value, i.e. the average service life. Since each annual investment group is composed of a multitude of different fixed assets of varying durability, and since very little precise information is usually available, it is empirically very difficult to establish a representative distribution of varying service lives, from which a retention function could be derived. However, through long-term and very comprehensive analyses of elimination dispersions of typical compositions of fixed assets (mainly in the United States, Iowa State College, and in the F.R.G., Deutsches Institut für Wirtschaftsforschung) it was possible to derive more or less characteristic dispersions of mean service lives for various kinds of fixed assets, whose weighted average resulted in a dispersion over the mean value resembling a normal distribution of a scatter diagram. The resulting retention function is a symmetrical logistical one which, in contrast to the version resulting from the one-hoss-shay or rectangle approach, shows a smoother and therefore much more realistic development of fixed assets, scrapping, and age structure, since eliminations from each annual investment group are spread over its entire period of utilisation.

One of the most commonly used retention functions is that developed by the Deutsches Institut für Wirtschaftsforschung (DIW, German Institute of Economic Research). The so-called DIW survival function has the form

$$g(i)=\frac{1}{1+e^{s(i)}}, \tag{3}$$

where $g(i)$ must be chosen such that

$$g(1)=1, \qquad g(m+i)=0 \quad \text{and} \quad \frac{dg(i)}{di}<0 \quad \text{for } 0<i<m.$$

The conditions are fulfilled if $s(i)$ is defined as follows:

$$\begin{aligned} s(i)&=\left[\frac{a}{m+1-i}+\frac{b}{1-i}\right] \\ a&=c\cdot p \\ b&=c\cdot q \\ c&=2m \\ p+q&=1. \end{aligned} \tag{4}$$

In (4) a and b are parameters. They are usually chosen in such a way that one can implicitly assume a symmetrical scrapping function (i.e. $p=0.5$ and $q=0.5$ respectively). However, the latest DIW calculations are based on parameters resulting in retention functions with asymmetrical scrapping dispersions. By assuming $q<0.5$, the scrapping function becomes "skewed towards the right," which corresponds to the idea that the scrapping of short-lived investment goods has a greater impact during the first few years, while the aggregated scrapping function will most strongly be influenced by fixed assets with the longest service life (Görzig, 1982). (By varying q, and consequently p, within the interval $0\leq q\leq 1$, it is of course possible to simulate both exponential and paraboloid retention functions, and in the extreme case with $q=1$ a rectangular one.)

The retention functions outlined so far assume constancy over time of the distribution of scrapping. This assumption, besides the choice of the basic type of the retention function, is among the most controversial issues in empirical capital stock estimates. Most researchers believe that the respective average and maximum service lives change over a period of two or more decades. However, there is controversy over the question whether the average service life has a tendency to become longer or shorter. Tengblad and Westerlund (1976) believe concerning Sweden that in the presence of high-level technical progress and dynamic economic development (at least) the average service life decreases. The DIW, on the other hand, used nearly identical arguments to defend the assumption of constancy over time of the distribution function, and consequently assumes a constant average service life (in particular, the Institute considers technical progress as a factor that will tend to stabilise the average economic service life; cf. Baumgart–Krengel, 1970).

If factors are taken into account that influence the average and maximum service lives of fixed assets over time, the retention function is turned into a bivariate or joint distribution through the inclusion of a so-called portmanteau variable (see equation (1)).

However, up to the present time there are hardly any empirically confirmed convincing findings about the influence and behaviour of this portmanteau variable, which is why nearly all capital stock estimates—including the one under discussion—continue to work with the assumption of constant distribution over time of the retention function. The extensive data requirement associated with the traditional perpetual-inventory method is not limited to the retention function; as mentioned above, it also requires investment time series of considerable length. Assuming an average economic service life of 40 years in the simplest possible case (one-hoss-shay approach), investment time series of 40 years are needed beginning with the initial time of calculation, and with the initial stock being known. Time series of such length are hardly ever available. In Austria, in the most fortunate cases, they are only available from 1955 onwards, and therefore the development of the so-called old stocks must be estimated, which introduces considerable possibilities of error and imprecision regarding the initial period.

3.3. *A Modified Perpetual-Inventory Method: The Almon Model*

The extremely high information needs of the traditional perpetual-inventory method requiring a certain quantitative scope of investment data was the direct reason for the development of a modified cumulation method which combines the advantages of differentiated cumulation containing a logistical retention function, i.e. including a differentiated age structure, with relatively moderate requirements concerning investment data and the availability of information about economic service life of assets.

This modified estimation technique, which has been developed by C. Almon *et al.* (1974), starts from the hypothesis that gross fixed assets are composed of two components. The first one may be considered as being identical with the book value, the kind of net capital stock shown in a balance sheet. However, depreciation of the book value does not decrease production capacity, but gradually replenishes the second component representing the hidden reserves contained in the physical fixed assets. Only eliminations from these reserves reduce production capacity and consequently gross capital stock. The Almon model has the following form:

$$K(t)=K_1(t)+K_2(t) \tag{5}$$

$$\frac{dK_1(t)}{dt}=I(t)-s\,K_1(t) \tag{6}$$

$$\frac{dK_2(t)}{dt}=s[K_1(t)-K_2(t)] \tag{7}$$

$K_1(t)=$ net capital stock

$K_2(t)=$ hidden reserves

$s=$ depreciation rate.

As can be shown very easily, the system of differential equations (5), (6) and (7) has an implicit retention function of the following form:

$$g(i)=(1+si)\,e^{-si}. \tag{8}$$

This function essentially fulfills the conditions (3) that must be satisfied by a logistical retention function. The retention function (8) and Figure 1 show clearly how gross capital stock (expressed by $(1+si)\,e^{-si}$) may be approximated by a net conception with a double-declining-balance rate of depreciation (expressed by the term e^{-si}) and by including hidden reserves (which are replenished in the form of the distribution ($si\,e^{-si}$) which is skewed to the right, corresponding to the depreciation rate). This rate of depreciation s can be calculated by the following improper integral, the average economic life m^d being known:

$$m^d=\int_0^\infty (1+si)\,e^{-si}\,di=\frac{2}{s} \tag{9}$$

$$s=\frac{2}{m^d}. \tag{9a}$$

In the present formulation of the Almon model and in the following estimation procedure, the depreciation rate s is taken to be constant over time.

From a more sophisticated point of view, however, often it seems to be more realistic, as discussed above, to start from the assumption that the depreciation rate and with it the average economic service life is variable over time. Basically, variable average economic service lives can be considered approximately very easily in the Almon model by taking the coefficient s as a function of time in equations (6) and (7).

However, as mentioned above, there are hardly any empirically confirmed findings in Austria which give convincing information about how this rate is changing over time and what are the factors responsible for the change.

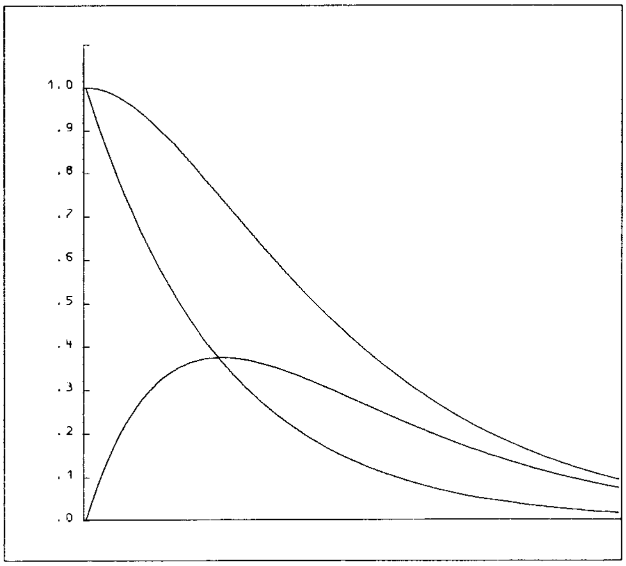

Figure 1. Retention Function of Almon-Type

It follows from the above that, in order to carry out calculations according to the Almon method, one needs the initial capital stock sub-divided into book value and hidden reserves, the average economic service life which is constant over time, and an investment time series which, in contrast to the traditional perpetual-inventory method need only begin at the time of the actual capital stock estimation.

The following is a comparison of the Almon method with the traditional perpetual-inventory method, carried out by contrasting the form of Almon retention functions with several logistical retention functions of the DIW type, and also by looking at a number of comparative model calculations. Equation (3) was used for calculating the logistical DIW retention function.

As is shown in Figure 2, the difference between the Almon retention function and a logistical one with symmetrical scrapping order (i.e. $p = 0.5$), assuming the same average economic service life, is relatively big despite the similarity of the two curves. However, this difference becomes markedly smaller if the logistical DIW retention function is calculated using scrapping orders that are skewed to the right, since the Almon method in principle results in a retention function skewed in this way and is, according to many experts, based on more realistic scrapping orders.

Test calculations based on hypothetical investment time series also show very clearly that under the assumption of right-skewed scrapping orders (and with the same average economic service life) capital stock figures calculated according to the Almon method rarely deviate from those found using the DIW's perpetual inventory method, which requires considerably more information and uses complicated calculation procedures.

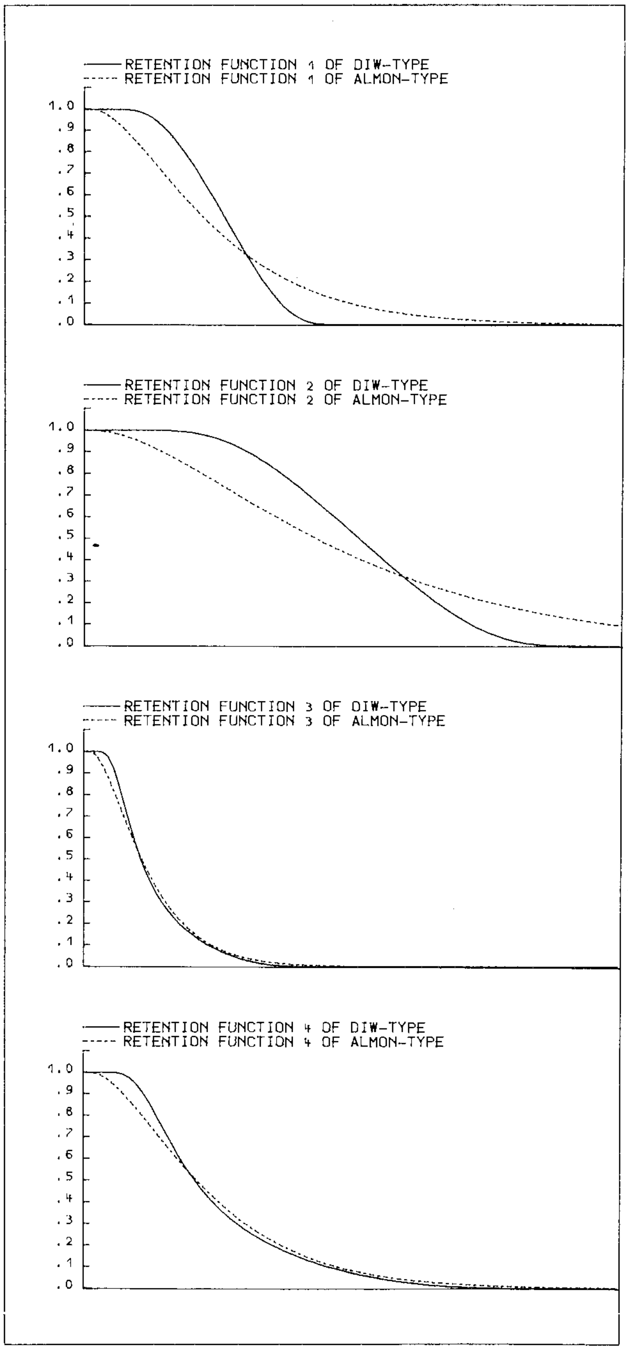

Figure 2. Retention Functions according to Almon and DIW
Retention Function 1: maximum service life 50 years, $p = 0.5$
Retention Function 2: maximum service life 100 years, $p = 0.5$
Retention Function 3: maximum service life 50 years, $p = 0.8$
Retention Function 4: maximum service life 100 years, $p = 0.8$

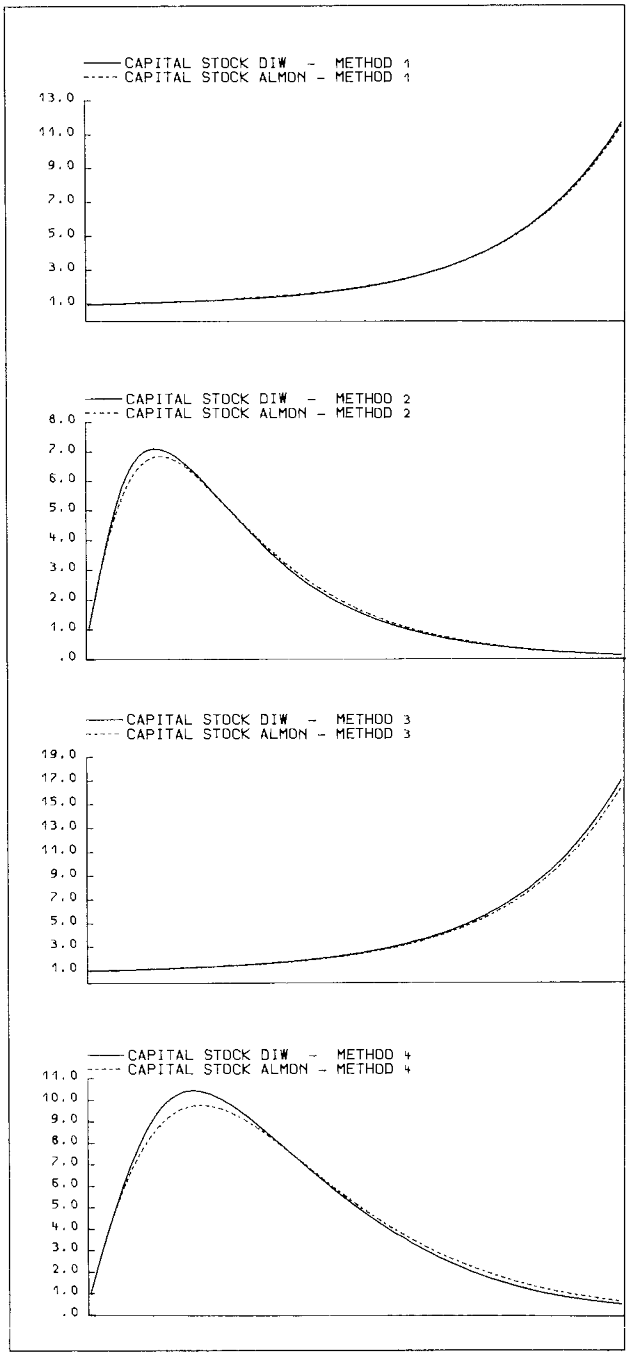

Figure 3. Comparative Model Calculations

Method 1: maximum service life 50 years, $p = 0.8$, hypothetical investment series with growth rate: +5 percent.

Method 2: maximum service life 50 years, $p = 0.8$, hypothetical investment series with growth rate: −5 per cent.

Method 3: maximum service life 100 years, $p = 0.8$, hypothetical investment series with growth rate: +5 percent.

Method 4: maximum service life 100 years, $p = 0.8$, hypothetical investment series with growth rate: −5 percent.

4. THE ESTIMATION PROCEDURE

The capital stock estimates were carried out in real and nominal terms, the latter according to the principle of replacement values. The capital stock at constant prices was calculated on the basis of investment series at 1976 prices. The capital stock at market prices $K(t)^N$ then is calculated as

$$K(t)^N = K(t)^R \cdot PI(t) \tag{10}$$

where $PI(t)$ stands for the price index of the respective investment type (either equipment or plant, identical for all industries), drawn from the official National Income Accounts; $K(t)^R$ then represents the capital stock at constant prices.

The initial capital stocks for the base year 1964 were adapted by the authors from Kausel's estimates, which were calculated by the different methods of status calculations mentioned above, mainly, however, on the basis of published annual balance sheets and questionnaires (see Kausel, 1971). The ISIC groups were aggregated into the 19 industries of the Austrian input-output classification (see Appendix Table 1). Table 1 shows the base data for 1964 and the assumed average

TABLE 1

NOMINAL INITIAL CAPITAL STOCKS (1964) AND AVERAGE ECONOMIC SERVICE LIVES

	Equipment		Plant	
	Average Service Life (Years)	Capital Stock 1964 (Millions of Schillings)	Average Service Life (Years)	Capital Stock 1964 (Millions of Schillings)
Agriculture and Forestry	18	44,767	60	99,267
Mining and Quarrying	20	8,980	40	3,510
Manufacture of Food, Beverages and Tobacco	22	15,230	40	8,480
Textile, Wearing Apparel and Leather Industries	17	13,110	40	6,560
Manufacture of Wood and Wood Products	15	3,570	40	2,800
Manufacture of Paper and Paper Products, Printing and Publishing	18	9,590	40	4,400
Manufacture of Chemicals	18	6,579	40	5,239
Crude Petroleum, Natural Gas and Petroleum Refineries	18	8,061	40	1,481
Manufacture of non-Metallic Mineral Products	17	7,600	40	3,240
Basic Metal Industries	20	11,530	40	5,680
Manufacture of Fabricated Metal Products, Machinery and Equipment	20	19,290	40	13,160
Electricity, Gas and Water	18	41,500	40	34,760
Construction	8	9,060	40	5,760
Trade	20	22,720	40	31,440
Restaurants and Hotels	20	10,960	40	14,820
Transport, Storage and Communication	25	60,110	40	98,220
Financing, Insurance, Real Estate and Business Services	20	2,940	40	354,150
Social and Personal Services	20	7,340	40	28,880
Public Administration and Defence	15	8,530	40	115,370

service life for plant and equipment. The average service life is also based on Kausel's estimates, but was revised on the basis of more recent information (experts' opinions, OECD investigations). The investment series were calculated by Nemeth (1982).

In addition to these statistical inputs the Almon method requires the initial capital stock to be split into the components net capital stock $K_1(t)$ and hidden reserves $K_2(t)$.

If a constant growth rate r is assumed for investment, the relation of net capital stock to hidden reserves can be represented, as will be shown in Appendix II, by

$$\lim_{t\to\infty}\frac{K_1(t)}{K_2(t)}=\frac{r+s}{s}. \tag{11}$$

By means of this formula, applying actual sectoral investment growth rates, the initial capital stock was split into its components $K_1(t)$ and $K_2(t)$. The share of hidden reserves in gross capital assets was estimated at 40 percent for plant and equipment.[8]

The estimates were carried out as shown in formulas (5), (6) and (7), but in their discrete form (12), (13) and (14).

$$K_t=K_{1,t}+K_{2,t} \tag{12}$$

$$K_{1,t}=K_{1,t-1}+I_t-sK_{1,t-1} \tag{13}$$

$$K_{2,t}=K_{2,t-1}+sK_{1,t-1}-sK_{2,t-1}. \tag{14}$$

The depreciation rate s was calculated for individual industries with the aid of formula (9) and the average service lives shown in Table 1.

Table 2 presents the estimates of capital stock for 19 industries, for the period 1964–80, in 1976 prices and at current replacement cost.

5. CONCLUDING REMARKS: FIRST INTERPRETATION OF THE FINDINGS

According to the above estimates real total assets expanded by an average rate of 3.5 percent p.a. between 1964 and 1980. Real GDP grew slightly faster at an average rate of 4 percent. Among the industries capacity expansion (as measured by the growth of real assets) was fastest in the manufacture of wood and wood products where it grew by an average rate of around 8 percent per year. Other industries with above-average capacity expansion were the manufacture of food, beverages and tobacco, chemicals, crude petroleum, non-metallic mineral products, basic metals, fabricated metal products (including machinery and equipment), construction and several service industries (hotels and restaurants, trade and transport, storage and communication). The capital stock of the mining industry shrank by around 20 percent during the period under investi-

---

[8] The more or less arbitary division of the intial capital stock into net assets and hidden reserves influences the time path development of the gross capital stock only during the first years. The ratio $K_1(t)$ to $K_2(t)$ converges rather quickly to an equilibrium value.

TABLE 2

CAPITAL STOCK (MILLIONS OF SCHILLINGS)

	01	02	03	04	05	06	07	08	09	10
					Real, at 1976 prices					
1964	261,360.0	21,011.0	40,474.0	33,424.0	11,043.0	23,688.0	20,502.0	15,663.0	18,298.0	29,224.0
1965	267,182.8	20,586.9	43,054.5	34,360.1	12,243.6	24,114.6	22,620.3	15,827.7	19,700.8	29,900.7
1966	272,702.8	20,209.5	44,685.0	34,887.0	14,011.0	24,562.4	24,314.7	16,052.1	22,139.8	31,156.4
1967	278,101.3	19,630.0	46,865.8	35,178.4	15,046.2	25,546.2	25,833.0	16,239.4	24,417.0	32,253.5
1968	282,532.3	19,208.0	48,932.9	35,878.7	16,319.4	26,100.0	27,518.8	16,718.9	26,223.1	33,002.5
1969	287,464.0	18,854.6	51,096.0	36,968.1	17,668.4	26,803.3	29,924.9	17,584.7	27,455.5	33,733.6
1970	292,173.4	18,574.7	53,116.5	38,063.4	19,710.3	28,142.9	32,218.5	18,317.5	28,850.1	34,957.4
1971	296,836.8	18,268.3	55,830.6	39,251.9	22,240.4	30,085.6	34,652.2	19,879.8	30,874.1	36,398.1
1972	301,798.9	17,995.2	59,519.3	40,425.7	25,224.9	31,497.6	37,355.8	21,430.1	33,906.1	38,936.6
1973	303,326.2	17,575.3	61,926.8	41,549.4	28,039.6	32,645.5	39,879.5	22,186.2	35,929.9	43,671.5
1974	305,459.8	17,281.4	64,406.6	42,035.5	30,295.3	33,923.3	42,516.4	22,525.1	37,684.8	47,573.7
1975	307,226.2	17,192.1	66,575.0	42,102.8	31,365.7	34,994.7	44,346.9	23,426.9	38,497.7	50,020.2
1976	309,128.8	17,137.1	69,059.6	42,408.5	33,065.9	26,117.8	46,637.2	24,356.6	38,997.9	50,894.7
1977	311,442.9	16,862.8	71,821.0	42,583.8	34,683.7	37,702.1	48,507.3	26,268.6	39,986.6	53,025.5
1978	313,706.9	16,669.0	74,355.0	42,504.3	35,708.6	39,886.8	50,294.7	28,204.1	40,872.6	53,632.8
1979	315,394.0	16,968.5	76,545.4	42,539.8	36,854.7	40,624.7	51,487.9	29,748.3	41,814.6	55,166.7
1980	317,690.6	16,880.7	78,842.5	42,795.5	38,287.4	41,537.2	53,065.4	31,448.7	43,149.2	57,743.5

See end of table for interpretation of column headings.

TABLE 2 (*continued*)

Nominal, at replacement values

1964	144,034.8	12,490.1	23,709.8	19,670.1	6,369.9	13,991.1	11,817.9	9,542.3	10,840.0	17,209.8
1965	160,005.9	12,720.4	26,456.4	21,136.2	7,476.8	14,869.7	13,810.0	9,888.8	12,165.0	18,409.8
1966	166.223.8	12,767.1	28,054.8	21.924.7	8,744.6	15,486.5	15,163.7	10,279.9	13,988.0	19,612.5
1967	172,113.8	12,657.6	30,017.7	22,550.8	9,574.6	16,445.2	16,429.4	10,649.5	15,755.8	20,729.7
1968	176,552.9	12,560.0	31,777.3	23,311.8	10,528.2	17,047.5	17,744.3	11,152.4	17,166.0	21,512.5
1969	181,704.3	12,620.9	33,916.1	24,535.9	11,632.9	17,925.4	19,733.8	12,085.4	18,419.1	22,507.6
1970	194,796.2	13,136.8	37,244.4	26,663.2	13,697.1	19,900.4	22,442.0	13,318.4	20,454.6	24,665.9
1971	209,086.9	13,698.8	41,504.6	29,133.1	16,370.3	22,548.4	25,575.0	15,370.7	23,220.5	27,250.9
1972	236,537.1	14,581.2	48,004.9	32,574.8	20,232.1	25,539.1	30,024.5	17,676.3	27,549.7	31,541.1
1973	254,729.1	15,062.6	52,934.1	35,481.7	23,882.1	28,009.1	34,034.7	19,221.9	30,852.6	37,461.5
1974	280,225.8	16,021.0	59,633.4	38,896.5	27,997.1	31,476.4	39,334.0	21,005.0	34,975.7	44,144.9
1975	295,441.1	16,630.1	64,362.3	40,684.1	30,289.3	33,784.2	42,844.5	22,740.9	37,267.6	48,422.7
1976	309,128.8	17,137.1	69,059.6	42,408.5	33,065.9	36,117.8	46,637.2	24,356.6	38,997.9	50,894.7
1977	334,319.4	18,008.7	76,721.1	45,516.4	37,089.8	40,243.6	51,868.7	27,951.6	42,665.0	56,569.6
1978	354,589.6	18,610.9	83,030.4	47,547.0	39,986.3	44,426.3	56,316.6	31,177.4	45,511.3	59,685.3
1979	370,637.8	19,564.3	88,215.1	49,178.4	42,668.2	46,622.3	59,604.1	33,721.0	47,982.5	63,231.8
1980	400,635.7	20,691.8	96,512.1	52,662.5	47,196.1	50,523.2	65,417.0	37,516.0	52,489.7	70,074.6

	11	12	13	14	15	16	17	18	19	Total
					Real, at 1976 prices					
1964	55,898.0	132,607.0	25,447.0	96,367.0	45,823.0	283,765.0	682,996.0	66,994.0	234,545.0	2,099,129.0
1965	59,106.3	136,266.9	27,438.7	101,215.9	48,196.0	296,663.2	697,083.2	67,804.1	239,616.3	2,162,984.7
1966	62,915.1	141,118.5	29,237.5	106,388.0	50,840.4	311,235.3	714,110.7	68,999.5	245,428.8	2,234,995.3
1967	66,106.3	146,627.8	30,166.0	111,692.3	53,666.9	325,659.1	731,472.2	70,532.9	252,829.0	2,307,863.3
1968	68,654.4	151,558.9	30,756.9	117,327.2	56,778.6	339,367.3	749,403.1	72,498.7	260,502.8	2,379,182.5
1969	71,669.7	154,500.2	31,963.8	123,239.1	60,224.2	354,883.0	766,886.1	74,849.6	267,931.3	2,453,701.7
1970	76,120.4	157,894.7	33,797.0	129,626.0	63,873.7	372,312.4	785,271.0	77,462.8	276,083.0	2,536,565.7
1971	82,028.7	161.726.5	36,517.0	136,386.9	68,098.5	392,973.6	807,650.1	80,529.3	286,451.2	2,636,681.8
1972	88,569.9	167,994.8	40,708.0	143,064.5	73,076.8	414,786.4	833,955.4	83,276.3	299,038.5	2,752,560.8
1973	94,583.2	174,286.7	43,924.4	150,166.0	76,613.2	437,649.5	864,652.0	85,808.1	311,864.8	2,868,277.8
1974	100,794.6	183,524.5	46,204.0	157,634.4	83,912.5	462,171.0	896,287.9	88,486.6	325,202.5	2,987,919.7
1975	104,525.5	191,920.4	47,254.7	164,405.2	89,187.7	486,840.7	927,017.3	91,496.6	340,083.3	3,098,479.7
1976	109,112.4	200,123.9	48,515.4	171,360.9	94,901.6	510,691.8	959,781.3	94,337.6	353,408.8	3,210,037.7
1977	114,455.7	207,747.5	50,015.4	179,298.9	101,310.4	534,448.6	992,249.5	97,390.5	366,833.6	3,326,634.6
1978	118,973.7	215,461.1	50,398.1	187,038.0	108,760.6	560,230.0	1,023,039.1	100,557.4	380,264.4	3,440,557.2
1979	123,975.1	220,452.2	50,767.4	195,712.5	117,218.2	586,409.2	1,052,438.0	103,856.3	392,746.8	3,550,720.1
1980	129,946.9	224,862.3	51,399.0	205,368.5	126,160.9	611,384.2	1,079,081.2	107,013.2	403,141.9	3,659,796.8

Nominal, at replacement values

1964	32,450.0	76,259.7	14,819.6	54,159.5	25,779.6	158,329.8	357,089.9	36,220.2	123,900.0	1,148,684.0
1965	36,171.4	82,984.5	16,826.7	61,113.7	29,066.5	178,390.4	407,978.4	40,255.4	140,862.9	1,290,610.6
1966	39,318.7	87,567.1	18,329.3	65,480.7	31,243.2	190,466.1	423,029.5	41,606.3	146,198.6	1,355,485.3
1967	42,116.2	92,518.8	19,288.5	69,935.1	33,497.5	202,246.3	437,008.5	43,075.2	152,108.5	1,418,716.7
1968	44,306.4	96,703.3	19,924.3	74,324.4	35,785.7	212,590.4	449,566.9	44,635.2	157,560.3	1,474,749.6
1969	47,204.9	100,201.4	21,154.1	79,326.0	38,430.4	224,766.0	459,057.9	46,403.5	162,150.7	1,533,778.2
1970	52,943.8	107,962.6	23,645.1	88,113.4	42,924.1	248,246.8	493,636.7	50,575.0	175,598.0	1,669,964.2
1971	60,448.8	116,906.5	27,136.9	96,182.5	46,292.5	276,497.4	533,189.4	55,422.5	191,561.0	1,831,396.5
1972	71,132.2	133,450.0	32,893.5	113,512.7	57,436.5	324,785.6	631,228.5	64,468.1	227,913.4	2,141,060.5
1973	80,630.1	147,575.7	37,616.2	127,126.7	66,114.6	367,322.0	710,796.7	71,533.7	257,449.0	2,397,833.7
1974	93,191.1	169,113.4	42,824.2	145,255.4	77,027.3	423,808.7	813,115.4	80,871.7	295,677.5	2,734,594.3
1975	100,966.1	185,034.2	45,705.0	158,519.4	85,790.4	468,037.7	885,766.8	87,800.4	325,369.8	2,975,546.5
1976	109,112.4	200,123.9	48,515.4	171,360.9	94,901.6	510,691.8	959,781.3	94,337.6	353,408.8	3,210,037.7
1977	122,365.5	222,467.6	53,416.1	191,963.2	108,738.1	573,868.7	1,071,451.1	104,750.1	395,635.5	3,575,609.8
1978	133,118.7	242,016.0	56,263.8	209,958.0	122,905.3	633,683.3	1,173,551.7	114,218.7	434,865.0	3,901,461.6
1979	143,309.9	256,533.4	58,521.9	227,331.1	137,708.1	689,926.2	1,266,321.8	122,998.5	470,246.8	4,194,322.9
1980	159,895.0	279,347.5	63,003.1	254,219.0	159,054.4	772,514.1	1,410,450.6	136,552.4	523,103.8	4,651,858.3

01 Agriculture and Forestry
02 Mining and Quarrying
03 Manufacture of Food, Beverages and Tobacco
04 Textile, Wearing Apparel and Leather Industries
05 Manufacture of Wood and Wood Products
06 Manufacture of Paper and Paper Products, Printing and Publishing
07 Manufacture of Chemicals
08 Crude Petroleum, Natural Gas and Petroleum Refineries
09 Manufacture of Non-Metallic Mineral Products
10 Basic Metal Industries
11 Manufacture of Fabricated Metal Products, Machinery and Equipment
12 Electricity, Gas and Water
13 Construction
14 Trade
15 Restaurants and Hotels
16 Transport, Storage and Communication
17 Financing, Insurance, Real Estate and Business Services
18 Social and Personal Services
19 Public Administration and Defence

gation. Several traditionally capital-intensive industries, such as agriculture, public utilities (electricity, gas and water) and financial services (including financing, insurance, real estate and business services) achieved only average or even below-average growth rates.

These branches (with the exception of agriculture and mining) also exhibited below-average expansion of their capital intensity (gross assets per employee). For the total economy real assets per employee expanded by 3.4 percent p.a. The industry with the highest growth rate of capital intensity was again the manufacture of wood and wood products (8 percent p.a.). The highest assets per employee were recorded for public utilities, financial services and transport, storage and communication.

According to these estimates the long-run real capital-output ratio for the total economy amounts to 4.5, exhibiting a slightly falling trend. A cyclical component is superimposed on this trend. The real capital-output ratio reached its lowest value of 4.3 in the boom years at the beginning of the seventies. During the recession years 1967/68, 1975 and 1977/78 it was above the longer-term average. Among the industries, agriculture and forestry has the highest capital-output ratio of around 9. The primary sector (agriculture and mining) shows a significantly falling trend, however. The capital-output ratio of the secondary sector (manufacturing, construction and public utilities) is relatively constant in the long run and amounts to around 2.8. The industries belonging to the tertiary sector have an increasing capital-output ratio with an average value of around 6.8.

These estimates are based on retention rates of around 4 percent p.a. for equipment and 1.5 percent p.a. for plant, i.e. an average of 2.3 percent p.a.

REFERENCES

Albers, W. *et al.* (eds.), *Handwörterbuch der Wirtschaftswissenschaften*, Gustav Fischer, Stuttgart, 1978.

Almon, C., Buckler, L. M., Horwitz, L. M. and Reimbold, T., *1985 Interindustry Forecasts of the American Economy*, Lexington Books, Lexington, Mass., 1974.

Barna, T., On Measuring Capital, in Lutz, pp. 75–94, 1963.

Baumgart, E., Kapital: Messung des Kapitalstocks, in Albers *et al.*, pp. 369–378, 1978.

Baumgart, E. and Krengel, R., *Die industrielle Vermögensrechnung des Deutschen Institutes für Wirtschaftsforschung*, Ergebnisse einer Neuberechnung, Duncker Humblot, Berlin, 1970.

von Böhm-Bawerk, E., *Kapital und Kapitalzins*, Innsbruck, 1984.

Breuss, F., Potential Output und gesamtwirtschaftliche Kapazitätsauslastung, *Monatsberichte des Österreichischen Instituts für Wirtschafsforschung* 2, Vienna, 1982.

Brown, M., Sato, K., and Zarembka, P. (eds.), *Essays in Modern Capital Theory*, North-Holland Publishing Company, Amsterdam, 1976.

Bruckmann, G., Riese, H., and Seidel, H., *Gutachten zur Erstellung mittelfristiger Prognosen in Österreich*, Wien-Linz, 1968.

Bruse, H., and Fuhrmann, G. H., Capital Stocks of Firms—Calculation on a Microeconomic Basis, *Zeitschrift für Nationalökonomie*, 41 (3–4), 361–383, 1981.

Bureau of Economic Analysis, *Fixed Non-Residential Business and Residential Capital in the United States 1925–1975*, Washington, D.C. 1976: NTIS Reference PB-253,725.

Burmeister, E., Synthesizing the Neo-Austrian Alternative Approaches to Capital Theory: A Survey, *Journal of Economic Literature*, 413–456, 1974.

Coen, R., Alternative Measures of Capital and its Rate of Return in United States Manufacturing, in Usher, pp. 121–152, 1980a.

Feldstein, M. S., and Foot, D. K., The Other Half of Gross Investment: Replacement and Modernization Expenditures, *Review of Economics and Statistics*, 53, 49–58, 1971.

Fink, G., *Preisverzerrungen und Unterschiede in der Produktionsstruktur zwischen Österreich und Ungarn*, Springer, Vienna, 1981.

Goldsmith, R. W., A Perpetual Inventory of National Wealth, *Studies in Income and Wealth*, 14, National Bureau of Economic Research, New York, 1951.

Görzi, B., Das Sachvermögen in den Wirtschaftsbereichen der Bundesrepublik Deutschland, DIW, *Beiträge zur Strukturforschung*, Heft 71, 1982.

Griffin, T., The Stock of Fixed Assets in the United Kingdom: How to Make Best Use of the Statistics, in Patterson-Schott, pp. 99–132, 1979.

Griliches, Z., Capital Theory Discussion, *American Economic Review*, Papers and Proceedings, 51, 127–130, 1961.

Groes, N., Measurement of Capital in Denmark, *Review of Income and Wealth*, 22, 271–286, 1976.

Handler, H., Merth, E., and Morwind, K., Kapitalstockschätzungen für Österreich, *Forschungsbericht des Instituts für Höhere Studien*, Vienna, 1968.

Harcourt, G. C., *Some Cambridge Controversies in the Theory of Capital*, University Press, Cambridge, 1972.

von Hayek, F. A., *The Pure Theory of Capital*, London, 1941.

Hibbert, J., Griffin, T. J., and Walker, R. L., Development of Estimates of the Stock of Fixed Capital in the United Kingdom, *Review of Income and Wealth*, 23, 117–135, 1977.

Hicks, J. R. *Value and Capital*, Oxford University Press, New York, 1939.

Kausel, A., Revision der Gesamtrechnung 1954–1964. Kapitalstock-Abschreibungen, Österreichisches Statistisches Zentralamt, mimeo, Vienna, 1971.

———, Gutachten zur Neuberechnung des Kapitalstocks der Industrie 1955–1973, Österreichisches Statistisches Zentralamt, mimeo, Vienna, 1975.

Kendrick, J. W., Some Theoretical Aspects of Capital Measurement, *American Economic Review*, Papers and Proceedings, 51, 102–111, 1961.

Kirner, W., Zeitreihen für das Anlagevermögen in der Bundesrepublik Deutschland, *DIW-Beiträge zur Strukturforschung*, Berlin, 1968.

Lutz, F. A., and Hauge, D. C., (eds.) *The Theory of Capital*, MacMillan, London, 1963.

Lützel, H., Estimates of Capital Stock by Industry in the Federal Republic of Germany, *Review of Income and Wealth*, 23, 63–78, 1977.

Marston, A., Winfrey, R., and Hempstead, J. C., *Engineering, Valuation and Depreciation*, Iowa State University Press, 1953.

Männer, L., Kapital, in Albers *et al.*, pp. 347–359, (1978).

Mitter, P., and Skolka, J., Entwicklung der Arbeitsproduktivität in Österreich 1964 bis 1977, *Monatsberichte des Österreichischen Instituts für Wirtschaftsforschung* 1, Vienna, 1981.

Müller, J., Bedarf der Unternehmen an technologischen Vorausschätzungen, *Schriftenreihe des Ifo-Instituts dür Wirtschaftsforschung*, Berlin, 1973.

Nemeth, N., Brutto-Analageinvestitionen nach Wirtschaftsbereichen, *Monatsberichte des Österreichischen Instituts für Wirtschaftsforschung* 10, Vienna, 1982.

OECD, Service Lives of Fixed Assets, Doc. DES/NI/82.3, Paris, 1982.

Orosel, G. O., and v. Weizsäcker, C. C., Kapitaltheorie, in Selten, pp. 119–131, 1979.

Patterson, K. D., and Schott, K. (eds.), *The Measurement of Capital*, Macmillan, London, 1979.

Prucha, I., Ein ökonometrisches Modell der österreichischen Wirtschaft. Unter besonderer Berücksichtigung mittelfristiger Aspekte und der Kapitalstockmessung, Forschungsmemorandum des Instituts für Höhere Studien, Vienna, 1976.

Robinson, J., The Production Function and the Theory of Capital, *Review of Economic Studies*, 21, 81–106, 1958.

———, *Contribution to Modern Economics*, Basil Blackwell, Oxford, 1979.

Schenk, W., and Fink, G., Das Brutto-Sachanlagevermögen der österreichischen Industrie 1955 bis 1973, *Monatsberichte des Österreichischen Instituts für Wirtschaftsforschung* 10, Vienna, 1976.

Selten, R., (ed.) *Handwörterbuch der Mathematischen Wirtschaftswissenschaften, Bd.* 1, *Wirtschaftstheorien*, Wiesbaden, 1979.

Skolka, J., Außenhandelsverflechtung der österreichischen Wirtschaft: Ein Input-Output-Vergleich zwischen 1964 und 1976, *Monatsberichte des Österreichischen Instituts für Wirtschaftsforschung* 10, Vienna, 1981.

Solow, R. M., The Production Function and the Theory of Capital, *Review of Economic Studies*, 23, 101–108, 1956.

Streissler, E., Structural Economic Thought—On the Significance of the Austrian School Today, *Zeitschrift für Nationalökonomie* XXIX/1969.

Tengblad, Å., and Westerlund, G., Capital Stock and Capital Consumption Estimates by Industries in the Swedish National Accounts, *Review of Income and Wealth*, 22 (4), 331–344, 1976.

United Nations, *A System of National Accounts*, New York, 1968.

Usher, D., (ed.) *The Measurement of Capital*, The University of Chicago Press, Chicago, 1980a.

———, Introduction, in Usher, pp. 1–22, 1980a.

Ward, M., *The Measurement of Capital*, OECD, Paris, 1976.

APPENDIX I

TABLE 1

CLASSIFICATION OF INDUSTRIES

	ISIC groups[1]
1. Agriculture and Forestry	1
2. Mining and Quarrying	2 minus 22, 2901
3. Manufacture of Food, Beverages and Tobacco	31
4. Textile, Wearing Apparel and Leather Industries	32
5. Manufacture of Wood and Wood Products	33, 3902, 3903
6. Manufacture of Paper and Paper Products, Printing and Publishing	34, 9592
7. Manufacture of Chemicals	35 minus 353
8. Crude Petroleum, Natural Gas and Petroleum Refineries	22, 353
9. Manufacture of Non-Metallic Mineral Products	36, 2901
10. Basic Metal Industries	37
11. Manufacture of Fabricated Metal Products, Machinery and Equipment	38
12. Electricity, Gas and Water	4
13. Construction	5
14. Trade	61, 62
15. Restaurants and Hotels	63
16. Transport, Storage and Communication	7
17. Financing, Insurance, Real Estate and Business Services	8 minus 833
18. Social and Personal Services	9 minus 91, 9592, 96
19. Public Administration and Defence	91

[1] International Standard Industrial Classification of All Economic Activities, Rev. 2, United Nations, New York, 1968.

APPENDIX II

This appendix derives formula (11), which determines the relation of net capital stock to hidden reserves under the assumption of a constant growth rate for investment. The latter obviously implies an exponential time path of investment $I(t)$.

$$I(t) = I(0)\, e^{rt}. \tag{1'}$$

Now, we substitute (1′) into the net capital condition (6) of the Almon model. The result is the following first-order linear differential equation with constant coefficient and variable term.

$$\frac{dK_1(t)}{dt} + sK_1(t) = I(0)\, e^{rt}. \tag{2'}$$

The general solution of this equation consists of the sum of the so-called complementary function and the so-called particular integral.

$$K_1(t) = A_1\, e^{-st} + \frac{1}{r+s} \cdot I(0)\, e^{rt} \tag{3'}$$

$$A_1 = K_1(0) - \frac{1}{r+s} \cdot I(0) \tag{3'a}$$

$$K_1(0) = I(0). \tag{3'b}$$

The definite solution of (2′) then has the following form:

$$(4')\qquad K_1(t)=\left[1-\frac{1}{r+s}\right]\cdot I(0)\,e^{-st}+\frac{1}{r+s}\cdot I(0)\,e^{rt}.$$

The next step that follows is to substitute (4′) into the hidden reserves condition (7) of the model. In that case, we obtain:

$$(5')\qquad \frac{dK_2(t)}{dt}+sK_2(t)=\left[1-\frac{1}{r+s}\right]\cdot sI(0)\,e^{-st}+\frac{s}{r+s}\cdot I(0)\,e^{rt}.$$

The general solution of (5′) then can be expressed as follows:

$$(6')\qquad K_2(t)=A_2\,e^{-st}+\left(1-\frac{1}{r+s}\right)\cdot sI(0)t\,e^{-st}+\frac{s}{(r+s)^2}\cdot I(0)\,e^{rt}.$$

Furthermore, since $K_2(t)=K_2(0)=0$ when $t=0$, the constant A_2 can be written as

$$(6'a)\qquad A_2=-\frac{s}{(r+s)^2}\cdot I(0)$$

so that the definite solution of (5′) will be

$$(7')\qquad K_2(t)=\left[-\frac{s}{(r+s)^2}\,I(0)\right]\cdot e^{-st}+\left(1-\frac{1}{r+s}\right)\cdot sI(0)t\,e^{-st}+\frac{s}{(r+s)^2}\cdot I(0)\,e^{rt}.$$

Now, we can evaluate the limit of the net capital–hidden reserves ratio as t becomes infinite. To facilitate the evaluation of this limit we transform the ratio function into the following:

$$(8')\qquad \frac{K_1(t)}{K_2(t)}=\frac{\left[1-\dfrac{1}{r+s}\right]}{\left[-\dfrac{s}{(r+s)^2}\right]+\left[\left(1-\dfrac{1}{r+s}\right)st\right]+\left[\dfrac{s}{(r+s)^2}\cdot e^{(r+s)t}\right]}$$
$$+\frac{\dfrac{1}{r+s}}{\left[-\dfrac{s}{(r+s)^2}\cdot e^{-(r+s)t}\right]+\left[\left(1-\dfrac{1}{r+s}\right)\cdot st\,e^{-(r+s)t}\right]+\left[\dfrac{s}{(r+s)^2}\right]}.$$

The first term on the right now tends to zero as t becomes infinite. The first and second term of the denominator of the second ratio on the right also approaches 0 as $t\to\infty$.

We may therefore conclude that

$$(9')\qquad \lim_{t\to\infty}\frac{K_1(t)}{K_2(t)}=\frac{1/(r+s)}{s/(r+s)^2}=\frac{r+s}{s}. \qquad \text{Q.E.D.}$$