ESTIMATES OF CAPITAL STOCK BY INDUSTRIES IN THE FEDERAL REPUBLIC OF GERMANY

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The main purpose of this paper is to discuss some of the measurement problems in connection with the perpetual inventory method applied for estimates of capital stock. In the Federal Republic of Germany, highly aggregated capital stock data by business sector are compiled by the Federal Statistical Office within its national accounts calculations, while more detailed capital stock estimates by industrial sectors are published by the German Institute of Economic Research (DIW) in Berlin. Because of various gaps in the statistical sources, the accuracy of the capital stock calculations is not yet entirely satisfactory. Aside from the problem of establishing long time series for gross fixed capital formation in constant prices for all sectors, it is difficult to obtain reliable data on the inter-sectoral transactions in secondhand capital goods. In addition, there are problems of determining price indices and service life distributions of the fixed assets in the various parts of the economy. This paper shows a way to arrive at a reasonably close approximation to the latter problem.

INTRODUCTION

The principles governing the computation and the presentation of the capital stock figures depend largely on the purpose of the analysis for which the figures are needed. This paper discusses the measurement of the capital stock in its function as a *factor of production*. This purpose necessarily means that certain problems connected with balance sheet presentation of tangible wealth or with the analysis of the personal wealth distribution are ignored.

Capital stock is defined here as the stock of fixed reproducible assets. In conformity with the definition of fixed capital in the system of national accounts, this includes buildings (residential and non-residential buildings and other construction) and machinery and equipment (transport equipment, machinery and other equipment). Consumer durables and non-reproducible tangible assets such as land are not included mainly because of evaluation problems. In the national accounts of the Federal Republic of Germany the capital stock is shown for the sectors enterprises (with three subsectors), general government and private non-profit institutions serving households. By definition private households do not own any fixed assets—residential buildings are fully allocated to the enterprise sector.

The *statistical unit* is the smallest legal entity that is the decision-making unit. This holds for the enterprise sector as well as for the sector general government (central government, state, local government and social security funds) and private non-profit institutions serving households. As far as the DIW capital stock estimates for industry are concerned, the local units are defined as the statistical unit. They are allocated to those sectors in which their main economic activity is concentrated.

Uses of Capital Stock Data

Capital stock estimates have gained great importance in the Federal Republic of Germany particularly in connection with the measurement of the *production potential* (potential GNP). Estimates of production potential are carried out by practically all institutions that are engaged in the forecasting of economic growth rates. The concept of the neutral budget with respect to business cycles (methodologically related to the full employment budget) which is used by the German Council of Economic Advisers is also based on estimates of production potential.[1] One of the most important determinants used by these institutions for the estimation of the potential GNP is the real growth of the gross stock of fixed assets of enterprises (excluding the housing sector). Capital stock data in a more detailed breakdown by business sectors would certainly improve the measurement of the potential GNP.

Another important area where capital stock data are applied in the Federal Republic of Germany are *productivity analyses* and production function estimates of total factor input. It may be worth mentioning that the DIW has quantified the rate of technical progress in the various industrial sectors for the period from 1958 to 1968 [5]. It is generally true that productivity analyses, owing to changes within the sectorial structure, have relatively little informational value if the analysis is made at a high level of aggregation. For that reason, productivity analyses should be carried out in as much sectorial detail as possible.

Finally, it should be mentioned that national accounts data on *capital consumption* can be derived on the basis of information on the stock of reproducible fixed assets. In accordance with the SNA guidelines[2] the Federal Statistical Office compiles the data on consumption of fixed capital on a straight-line basis with reference to the expected economic lifetime of the various types of assets. This is done in connection with the calculation of the gross and net stock of fixed assets by means of the perpetual inventory method for the economy as a whole and for those business sectors for which separate investment data are available (e.g. general government, agriculture and the housing sector). This standard procedure is supplemented, specifically in the case of the manufacturing sector, by data based on depreciation allowances derived from cost structure statistics and published balance sheets. Calculations of the capital stock in a more detailed breakdown by business sectors permit a noticeable improvement in the sectorial distribution of capital consumption; work along this line is in progress at the Federal Statistical Office.

From these important areas of application—only a few major ones have been mentioned—certain *requirements* regarding capital stock calculations can be established. In particular, data on capital stock should

—be computed in gross, as well as in net terms,
—be presented at replacement cost and at constant prices,
—comprise long time series,
—be in conformity with the concepts of national accounting,

[1]See e.g. *Jahresgutachten* (annual report) 1968–69 [10], paragraph 128, or the methodological explanations in the appendix of the annual report 1974–75 [10].

[2]See United Nations [12], paragraph 7.21.

—and, last but not least, should be broken down by sectors or industries to a sufficient degree.

The extent to which these requirements—their number could easily be enlarged—can actually be complied with depends mainly on the available statistical source material. The capital stock estimates of the Federal Statistical Office do generally satisfy the requirements mentioned above. The breakdown by business sectors, however, is still quite unsatisfactory for many potential uses.

Capital Stock Estimates in the German National Accounts

In 1971, the Federal Statistical Office began publishing capital stock data within its national accounts framework. At present, they cover the period from 1950 to the beginning of 1976 (see Table 1). The methodological aspects of these calculations, the statistical sources and the results have already been presented in detail in 1971 [7] and 1972 [8]. Therefore, the following discussion may be restricted to a few more general remarks on the method of measuring the capital stock within the system of national accounts.

As previously mentioned, the Federal Statistical Office calculates the capital stock according to the perpetual inventory method as described by R. W. Goldsmith in his "Perpetual Inventory of National Wealth" [3]. The major determinants are long time series of gross *capital formation* at constant prices. The estimates of capital formation series for the years prior to 1950 are less reliable than the national accounts figures beginning in 1950. Not only are the statistical sources for the early period rather incomplete, but it was also difficult to take into account the effects of the war. Moreover, the deflation of capital formation series over such long time spans is exceedingly problematical because of rapid technological changes. It is true that, as a result of the war and subsequent dismantling operations only a very small proportion of fixed assets in the present German capital stock is older than 25 years. In national accounts the gross fixed capital formation is measured by the commodity flow method. For purposes of capital stock estimates at current and at constant prices, the investment data are available broken down by 7 types of buildings and by over 200 types of machinery and equipment. For each of these groups, the average length of service life is estimated. The gross and the net stock of reproducible tangible assets and the capital consumption at constant prices are calculated by means of cumulating the capital formation over the service life of the fixed assets. To obtain the reproducible tangible wealth and/or the capital consumption data at current prices (at replacement costs) the data at constant prices are multiplied by the price indices of the corresponding groups of fixed assets.

For the deflation and the calculation at replacement costs different *price indices* are used. For building investments price indices for construction work performed at the building are available. In the case of machinery and equipment, Laspeyres' indices of producers' prices are used for domestic production, while similar base weighted indices of import prices were used for imported investment goods. The process of deflation in depth by types of goods permits the analysis of structural shifts and the adoption of "Paascheized Laspeyres' indices".

It is unrealistic to assume that all assets of a group of investment goods are simultaneously retired from the capital stock after they have reached their

TABLE 1

STOCK OF FIXED ASSETS

1,000 Million DM

Beginning of the Year	Fixed Assets, Total[1]	By Types of Assets: Machinery[2]	By Types of Assets: Buildings	By Business Sectors: Enterprises[3] Total	Enterprises[3]: Agriculture[4]	Enterprises[3]: Non-Agricultural Enterprises[5]	Enterprises[3]: Residential Buildings[6]	By Business Sectors: General Government[1]	By Business Sectors: Private Non-Profit Institutions
				Gross stock at 1962 prices					
1950[7]	542.2	163.0	379.2	489.0	53.8	236.4	198.8	45.3	7.9
1960	945.6	288.2	657.4	858.3	71.5	439.2	347.6	71.9	15.4
1970	1,683.3	581.6	1,101.7	1,524.6	105.0	865.2	554.4	126.8	31.9
1971	1,779.0	625.2	1,153.8	1,611.5	107.3	928.1	576.1	133.6	33.9
1972	1,879.6	670.2	1,209.4	1,703.4	108.8	994.2	600.4	140.2	36.0
1973	1,982.6	713.1	1,269.5	1,798.0	109.9	1,059.7	628.4	146.4	38.2
1974	2,084.5	755.4	1 329.1	1,891.5	111.5	1,123.5	656.5	152.7	40.3
1975[8]	2,171.1	789.5	1,381.6	1 968.2	112.5	1 175.9	679.8	160.4	42.5
1976[8]	2,249.2	821.3	1 427.8	2,036.4	113.2	1,223.2	700.0	168.5	44.2
				Net stock at 1962 prices					
1950[7]	282.3	74.6	207.7	252.0	25.6	114.8	111.6	26.5	3.8
1960	606.4	169.7	436.7	549.5	39.2	275.9	234.4	46.4	10.5
1970	1,124.4	335.8	788.6	1,011.7	59.4	552.5	399.8	88.6	24.1
1971	1,191.5	364.0	827.5	1,072.1	60.4	595.8	415.9	93.7	25.7
1972	1,261.2	392.2	869.0	1,135.3	60.7	640.3	434.3	98.5	27.4
1973	1,331.2	417.1	914.1	1,199.2	60.8	682.3	456.1	102.8	29.2
1974	1,398.0	440.2	957.8	1,260.1	61.4	721.0	477.7	107.1	30.8
1975[8]	1,448.0	454.5	993.5	1,302.8	61.5	747.2	494.1	112.7	32.5
1976[8]	1,489.0	466.7	1,022.3	1,336.8	61.4	768.3	507.1	118.6	33.6

				Net stock at replacement costs					
1950[7]	169.3	54.2	115.1	151.5	15.1	74.4	62.0	15.6	2.2
1960	521.0	156.7	364.3	472.3	34.2	244.0	194.1	39.8	8.9
1970	1,445.7	381.8	1,063.9	1,291.6	69.3	669.8	552.5	121.2	32.9
1971	1,681.3	438.2	1,243.1	1,498.6	76.5	779.5	642.6	143.1	39.6
1972	1,896.9	482.8	1,414.1	1,689.4	82.9	874.3	732.2	162.0	45.5
1973	2,089.7	519.4	1,570.3	1,860.3	87.1	959.1	814.1	178.1	51.3
1974	2,318.3	565.2	1,753.1	2,063.6	93.4	1,061.6	908.6	197.0	57.7
1975[8]	2,557.9	629.8	1,928.1	2,274.2	99.7	1,175.4	999.1	219.4	64.3
1976[8]	2,710.8	685.1	2,025.7	2,406.9	103.4	1,259.4	1,044.1	236.1	67.8
				Net stock at costs of acquisition[9]					
1950[7]	169.0	53.9	115.1	151.2	15.0	74.2	62.0	15.6	2.2
1960	430.7	147.7	283.0	391.6	27.6	214.5	149.5	31.7	7.4
1970	1,054.5	345.1	709.4	948.6	53.1	543.5	352.0	82.5	23.4
1971	1,159.9	384.3	775.6	1,042.9	55.1	607.3	380.5	91.0	26.0
1972	1,280.4	427.1	853.3	1,151.3	56.4	678.6	416.3	100.1	29.0
1973	1,408.9	466.4	942.5	1,267.3	57.7	748.7	460.9	109.2	32.4
1974	1,541.2	504.7	1,036.5	1,386.4	59.9	817.8	508.7	118.9	35.9
1975[8]	1,659.8	536.6	1,123.2	1,488.2	61.7	876.6	549.9	131.9	39.7
1976[8]	1,768.8	569.8	1,199.0	1,580.1	63.5	931.3	585.3	146.1	42.6

[1]Excl. public roads, dams, breakwaters and similar forms of public construction.
[2]Transport equipment, machinery and other equipment.
[3]Incl. public enterprises.
[4]Incl. forestry and fishing.
[5]Excl. residential buildings.
[6]Incl. owner-occupied and government owned dwellings.
[7]Excl. the Saar and Berlin.
[8]Preliminary figures.
[9]Capital goods invested before 1950 at 1950 prices.

Source: Federal Statistical Office [7], [8], and [11].

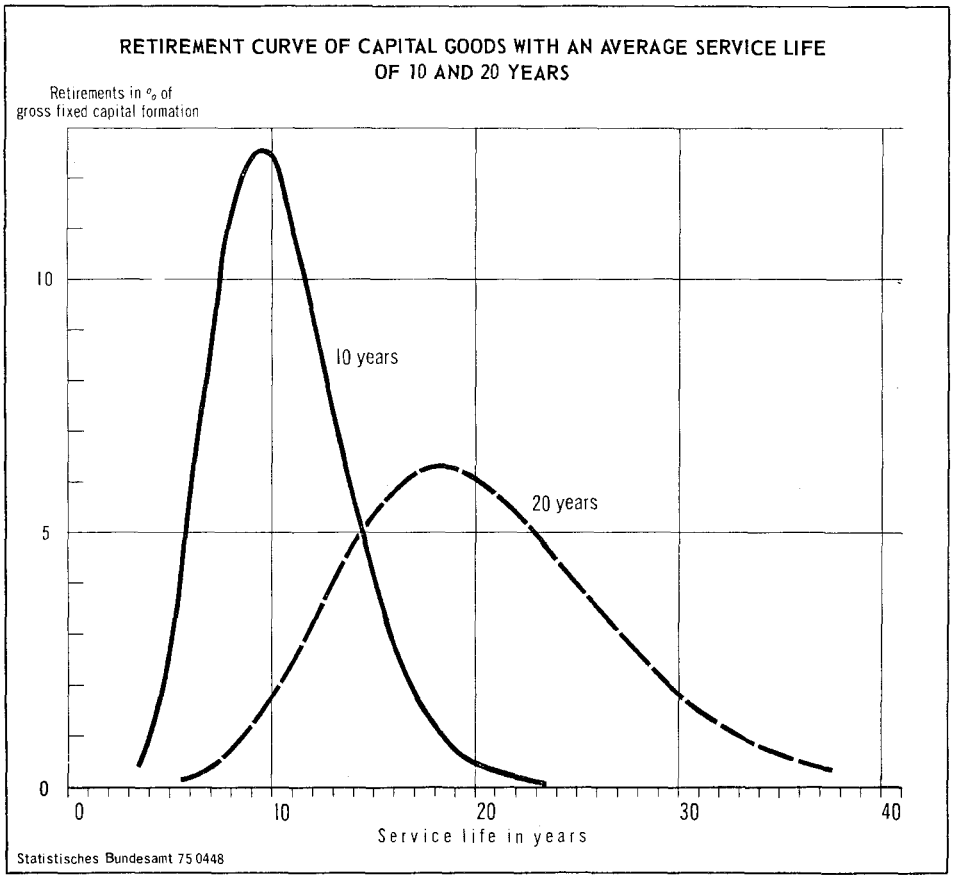

Figure 1

average length of life. So the average length of life concept is not applied directly in the perpetual inventory model. Instead, frequency functions for the retirement of capital goods are used which reflect the dispersion of scrappings and retirements over the average length of life per type of asset. Out of several types of functions tested, the gamma probability density function[3] was selected as the appropriate *retirement function* (time-to-failure distribution).

Using the maximum likelihood method,[4] this function was adjusted for the actual distribution of retirements per type of asset. Detailed statistical information on this is, inter alia, available with regard to retirements of motor vehicles.[5] As shown in Figure 1, we are dealing with a slightly left-modal, bell-shaped curve. It has a zero value at the point of investment, then reaches its maximum close to the average length of life point, and then asymptotically approaches the zero line

[3] $y(x) = a^p/[\Gamma(p)]\, x^{p-1}\, e^{-ax}$; $x \geq 0$.

[4] The maximum likelihood estimators for the parameters a and p are: $p = \bar{x}^2/s^2$ and $a = p/\bar{x}$; x is the year of retirement, $\bar{x}$ the average service life, and s^2 the variance of retirements.

[5] We also checked the series analysed by R. Winfrey [13].

again. The analyses of the scrappings and retirements series showed that the relation between the average length of life and the standard deviation was relatively constant. Therefore it seems reasonable to apply this relation also to those capital goods on which no statistical information on scrappings and retirements is available.[6] Sensitivity studies have revealed that the volume and the growth of the capital stock are rather insensitive with respect to slight variations in the structure of the frequency and/or the survival function.

Aside from the problems of estimating capital formation in the distant past, one of the greatest difficulties with the perpetual inventory method lies in the estimation of the average *length of life* per type of capital good. Here, relatively few statistical data are available. What is more, the expected service life of those capital assets which are still part of the capital stock can only be estimated with some degree of uncertainty, as is the case with all predictions of future developments. In addition to information supplied by enterprises and business associations, the most important basis for the estimation of the expected service life are the depreciation rates that are used for tax purposes in the Federal Republic of Germany.[7] It should be noted, however, that the tax lives of depreciable assets are considerably shorter than the actual service lives which should be used for national accounts purposes. In this context, the question arises about the extent to which the average length of life is constant in the long run. The Federal Statistical Office assumes that the service life is gradually growing shorter. The procedure is supported by various pieces of evidence. For one thing, the tax lives of depreciable assets were reduced several times during the last two decades. As far as motor vehicles are concerned, the available material shows that the "lifetime" in 1970 was essentially shorter than in 1955. The results of the 1969 enquiry conducted by the Ifo-Institute of Economic Research in Munich among close to 3,000 manufacturing enterprises also confirm the time trend towards a shorter lifetime. According to this enquiry, 60 percent of the respondents stated that the service life of their machines decreased over the past 10 to 15 years, and approximately 80 percent of the enterprises expect a further reduction over the next 10 to 15 years. Accelerating technical progress was usually given as the main reason.[8]

For the investment of three different years, Figure 2 shows the effect of the reduction in the average length of life on the service life distribution of the total of machinery and equipment. This distribution of scrappings and retirements is not to be confused with the above mentioned retirement function. Figure 2 shows the distribution of the sum of scrappings and retirements of all types of capital assets after the retirements per type of capital have been dispersed around their average length of life. For this, retirement functions were used.

The *results* of capital stock estimates in the national accounts are published annually [11]. The presentation includes the gross and net stock of fixed assets, the gross fixed capital formation and the retirements of machinery and buildings for five aggregated business sectors. All results are shown at replacement costs, at

[6]The retirement function is used as follows: $f\bar{x}(x) = 9^9(8!)^{-1}\bar{x}^{-9}x^8 e^{-9x/\bar{x}}$; $x = 1, 2, 3, \ldots$ is the year of retirement and $\bar{x}$ the average service life.

[7]Depreciation rates for tax purposes (AfA) were laid down by the Federal Ministry of Finance for nearly 100 branches of economic activity with more than 2,000 types of fixed assets [2].

[8]See J. Müller [9], pp. 36.

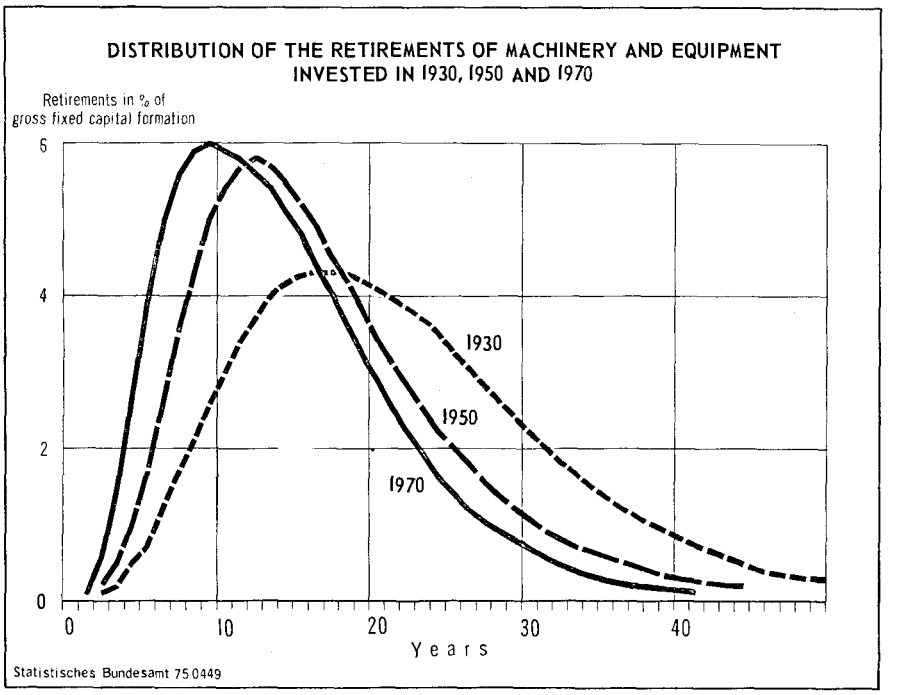

Figure 2

constant prices and at historical costs. In addition, stocks of inventories are computed annually. The value of non-reproducible tangible assets as well as the value of the consumer durables could not yet be determined. The definitions and classifications of the results presented here fully correspond to those in the national accounts. Thus, the results of capital stock estimates could be combined with the results of the national accounts without any need for transformation.

With regard to the results presented in Table 1, it should be mentioned that in some points the definitions of the German national accounts deviate from those of the present System of National Accounts (SNA) of the United Nations. For instance, residential buildings are included in the stock of fixed assets of the enterprise sector no matter whether the owner is a corporate enterprise, a private person or a public agency. In deviation from present SNA guidelines,[9] the stock of fixed assets in agriculture does not include the livestock (breeding stocks, dairy cattle and the like). In the German system of national accounts, livestock is part of the stock of inventories. It should also be mentioned that the stock of fixed assets of general government presented in Table 1 excludes the value of public roads, dams and similar forms of public construction. According to international guidelines, these fixed assets are not written off in the national accounts

[9]See United Nations [12], paragraph 6.108.

calculations.[10] Therefore it is not possible to differentiate between gross and net stock.

So far the relatively crude disaggregation of the capital stock by *business sectors*, as it is used for calculating the stock of fixed assets within the German system of national accounts, is still rather unsatisfactory. The main shortcoming is the lack of statistical data on capital formation in some business sectors. Thus, it was not possible to calculate the capital formation in detailed disaggregation by business sectors in a way that was compatible with the results of the national accounts calculation. Added to this is the fact that information on capital formation by business sectors is derived from different statistical sources. These are only partly comparable. As far as mining, manufacturing, construction and trade are concerned, detailed data on capital formation are available from the censuses which are conducted at intervals of several years. These figures are extrapolated with the help of annual investment survey data of those industrial enterprises that employ 50 or more persons (in building industry proper it is 20 and more persons). For trade, survey data of the Ifo-Institute are utilized which also include the capital expenditures of selected commercial enterprises. The capital formation of financial institutions and insurance companies is determined in the national accounts mainly on the basis of the annual reports published. With regard to general government, data from public expenditure statistics are available which are supplemented and adjusted from the cash basis to the accruals basis by commodity flow calculations. The commodity flow method is also used for determining investment in agriculture, forestry and fisheries and in the housing sector. In these instances, the type of capital good permits reasonable conclusions about the investor. The available data on the investment of different service sectors, and also on investment activities of private non-profit institutions, are rather poor. For these sectors, the capital expenditures have to be estimated, as far as this is possible at all, from incomplete information obtained from a limited and most likely not representative number of institutions and their annual reports. At the Federal Statistical Office work is presently in progress to calculate capital formation in a more detailed disaggregation by business sectors. As part of the next major revision of national accounts the results of these calculations will be published in full accordance with the results of the commodity flow calculations. It will then be possible to finish the sectorally more detailed calculation of capital stock within the system of national accounts.

A particularly difficult problem in connection with capital stock estimates by business sectors is the calculation of *price indices* and *service life distributions* of the capital goods by each investing sector. These problems are especially serious for machinery and equipment because of the large variations observed in the price indices and the lengths of life for the various types of assets. The variations are considerably smaller for investments in buildings and construction. Since the composition of the investment in machinery and equipment greatly varies from sector to sector, it would be hard to justify the use of the same price indices and service life distributions in all the business sectors. It is a serious drawback that statistical data on the structure of investments in machinery and equipment are

[10]See United Nations [12], paragraph 7.20.

only available for the economy as a whole and for a few business sectors (e.g. the general government), and also only for a few types of capital goods (e.g. motor vehicles). However, for some types of capital goods it is possible to determine the investing sector by information on the kind of commodity (e.g. farm tractors or machines used in the food industry).

Using all this information, the Federal Statistical Office in its capital stock calculation tries to solve the price index and lifetime distribution problems with the help of two-dimensional *investment–investor tables*, as far as this is feasible. In these tables, the capital formation in machinery and equipment by type of capital goods, as a first step, is broken down by investing sectors, using only rough estimates. Furthermore, the data on total expenditure on machinery and equipment, broken down into more than 200 types of capital goods, are written into the summation column, whereas the capital expenditures, broken down by business sectors, appear in the summation row at the bottom of the table. A computerized error-adjustment program is then used to make the roughly estimated breakdown of capital goods by investors compatible with the data in the contingency table margins. The smoothing-out occurs within intervals that are estimated for each single cell. These intervals are particularly wide for those commodities for which it is difficult to determine the investing sectors. Taking the smoothed-over table, the given price indice of each type of capital good, and the given average service life per type of capital good, the price indices and service life distributions per investing sector can now be calculated. Because of the lack of full information, it is assumed that—with few exceptions—the average service life for a given class of capital goods is the same for all investors. The calculation of the investment–investor tables is repeated annually. Thus, shifts in the structure of the investment in machinery and equipment per sector are not lost. In so doing, one obtains the Paasche indices which are needed for the deflation of the investment data by investing sectors. In view of the relatively large uncertainty of the estimations, it may be asked whether such detailed calculations are required. It should be kept in mind, however, that this procedure offers the advantage to make optimal use of all the available information in measuring capital stock by sector.

Capital Stock Estimates by Sector of Industry

For some time now, capital stock estimations have been part of the work program of the *German Institute of Economic Research*, Berlin (DIW). In this paper, the main emphasis is on the annually updated DIW measurement of the capital stock by industrial sectors. The results are published [6] for more than 40 sectors in manufacuring and mining (compare Table 2). The calculation of the capital stock is made according to the perpetual inventory method. Since the last revision in 1970 [1], survival functions have been used for this purpose. The function applied in this context is the "quasi-logistic" survival function developed by Kirner [4]. The frequency curve derived from this function gives a bell-shaped symmetrical retirement curve.

A parameter of this "quasi-logistic" survival function is the average *length of life* of the capital goods. The DIW estimates the average length of service life of two types of capital goods (construction and producer equipment) per industrial

TABLE 2

GROSS STOCK OF FIXED ASSETS OF INDUSTRY AT 1962 PRICES

Industrial Sector	1950	1960	1970	1971	1972	1973
			% of total			
Mining	16.3	13.5	6.3	5.9	5.5	5.2
Coal mining	13.8	11.1	4.5	4.1	3.8	3.5
Hard-coal mining	12.0	9.0	3.0	2.8	2.6	2.3
Brown-coal mining	1.7	2.1	1.4	1.4	1.3	1.2
Iron-ore mining	0.4	0.3	0.2	0.2	0.2	0.2
Potash and rock-salt mining	1.2	0.8	0.6	0.6	0.6	0.5
Production of petroleum and natural gas	0.9	1.1	0.9	0.9	0.9	0.9
Other mining	0.1	0.1	0.1	0.1	0.1	0.1
Manufacturing	83.7	86.5	93.7	94.1	94.5	94.8
Primary and producers' goods industries	39.0	35.5	36.7	36.8	36.9	36.9
Stone and earthen goods industries	2.9	3.5	4.5	4.5	4.6	4.7
Iron and steel industries	9.4	10.3	9.5	9.4	9.4	9.3
Iron and steel producing industries	6.5	7.5	7.3	7.2	7.3	7.2
Iron, steel and malleable iron foundries	1.9	1.6	1.3	1.2	1.2	1.2
Drawing plants and cold rolling mills	1.0	1.1	0.9	0.9	0.9	0.9
Non-ferrous metal industries	3.0	2.1	1.9	1.9	2.0	2.0
Chemical industry	17.7	13.3	14.0	14.1	14.0	14.0
Mineral oil industry	2.5	2.4	2.7	2.7	2.7	2.7
Manufacture of rubber and asbestos products	1.2	1.0	1.3	1.3	1.4	1.4
Sawmills and wood working	0.8	1.1	1.0	1.0	1.0	1.0
Manufacture of pulp and paper	1.5	1.9	1.9	1.9	1.9	1.8
Investment-goods industries	21.4	26.3	31.4	31.9	32.2	32.5
Structural engineering	0.9	1.1	1.1	1.1	1.1	1.1
Mechanical engineering	7.5	8.3	9.0	9.1	9.2	9.2
Manufacture of transport equipment	4.1	5.6	8.1	8.3	8.5	8.5
Shipbuilding	1.5	1.2	0.9	0.8	0.8	0.8
Manufacture of aircraft equipment	0.0	0.1	0.2	0.3	0.3	0.3
Electrical engineering	4.3	5.9	7.1	7.3	7.4	7.5
Precision and optical goods industries	0.7	0.8	0.9	0.9	0.9	0.9
Iron, steel, sheet and metal goods industries	2.4	3.3	4.0	4.1	4.1	4.2
Consumer-goods industries	12.0	13.7	14.6	14.6	14.6	14.7
Fine-ceramic industry	0.4	0.6	0.6	0.5	0.5	0.5
Glass and glass products industries	0.5	0.6	0.9	0.9	0.9	1.0
Wood working industry	1.1	1.3	1.5	1.5	1.5	1.6
Musical instruments and toys industries	0.2	0.2	0.3	0.3	0.3	0.3
Manufacture of paper and paperboard	0.4	0.7	1.1	1.1	1.1	1.2
Printing and related industries	1.4	1.9	2.1	2.1	2.1	2.1
Manufacture of plastics products	0.2	0.5	1.3	1.4	1.5	1.5
Leather industry	0.4	0.3	0.2	0.2	0.2	0.2
Leather products industry	0.2	0.2	0.1	0.1	0.1	0.1

TABLE 2—*continued*

GROSS STOCK OF FIXED ASSETS OF INDUSTRY AT 1962 PRICES

Industrial Sector	1950	1960	1970	1971	1972	1973
			% of total			
Footwear industry	0.5	0.5	0.4	0.4	0.4	0.4
Textile industry	6.1	5.8	5.1	5.0	4.9	4.9
Clothing industry	0.6	1.2	1.2	1.2	1.2	1.1
Food, beverages and tobacco industries	11.4	11.0	11.0	10.8	10.8	10.8
Grain mills and husking mills	1.3	0.7	0.4	0.4	0.4	0.3
Oil mills and manufacture of margarine	0.9	0.5	0.3	0.3	0.3	0.3
Sugar industry	0.8	0.7	0.6	0.6	0.6	0.6
Breweries and malting	2.5	2.5	3.1	3.1	3.1	3.1
Other food, beverages and tobacco	5.9	6.7	6.6	6.5	6.5	6.5
			million DM			
Total	92,710	190,290	344,770	365,400	383,870	399,860

Source: German Institute of Economic Research, Berlin [1] and [6]

sector. It is unsatisfactory that in the determination of the service distribution of machinery and equipment, the composition of capital formation with regard to type of capital goods is not taken into account at all. Although the use of the survival function leads to a certain dispersion of the scrappings and retirements around the average lifetime, it is hard to determine whether this dispersion accurately reflects the actual structure of producer equipment. The DIW estimated the shape of the survival function with the help of known retirements of some groups of capital assets (locomotives and passenger cars) rather than looking at retirements from the stock of machinery and equipment in the various industrial sectors. The DIW assumes that the length of service life of machinery or buildings does not change no matter at what point in the past these capital goods have been produced. This simplified assumption may not be warranted for long-run comparisons. For instance, the percentage of the shorter-lived producer equipment has significantly increased since 1950, which means that even if one assumes a constant service life per type of physical assets, the average length of life of total capital equipment would be reduced.

A condition for the application of the perpetual inventory method is the availability of adequate long time series for *capital formation.* For the post-war period, the DIW, in cooperation with the Munich Ifo-Institute of Economic Research, has calculated the investment data by sector of industry. Investment data obtained from surveys of investors result in lower figures than those calculated according to the commodity flow method. In its capital stock estimates by industrial sectors the DIW does not adjust the investment figures to the higher level of gross fixed capital formation as it is presented in the national accounts. Therefore, the DIW results cannot be combined with the results of the capital stock calculations by business sectors prepared at the Federal Statistical Office.

In the DIW's most detailed breakdown by *industrial sectors*, the reproducible tangible wealth has been calculated for 6 branches of the mining industry and 35 branches of the manufacturing industry. The definition of the term "industry" largely conforms to that of the German industry statistics. Not included are public power production, building industry proper, as well as local units with less than 10 persons employed. Handicraft enterprises,[11] without regard to their size, are also usually not included in the industry statistics. This procedure has the advantage that the capital stock data are compatible with other results of industrial statistics (e.g. turnover, net production, capital expenditure, persons engaged, time worked or wages and salaries). A serious drawback resulting from the missing information on the handicraft business and the incomplete coverage of small enterprises lies in the fact that a comparison between the results of industry statistics and the national accounts data is not really possible.

The *results* of the revised calculation of the industrial capital stock are now available for the period from 1950 to 1973. The gross stock of fixed assets at 1962 prices is continuously updated and published annually [6]. The net stock of fixed assets at 1962 prices and the retirement and the capital consumption from 1950 to 1968 have also been presented by the DIW [1]. The figures in Table 2 have been derived from these DIW publications. Table 2 shows the increase and distribution of the gross stock of fixed assets at constant prices in industry—in the above mentioned delimitation—from 1950 to 1973.

Problems of Measuring Capital Stock by Sectors

As has been mentioned before, it is highly desirable to prepare more detailed capital stock estimates by sectors within the system of national accounts of the Federal Republic of Germany. It must be emphasized, however, that the required statistical data base is still rather incomplete. The gaps in the source material cannot satisfactorily be filled even with advanced statistical techniques. Instead, it is necessary to make plausible assumptions and estimates in order to arrive at some reasonable figures. When interpreting the results of capital stock calculations, this shortcoming should always be kept in mind.

The most important requirement for the perpetual inventory estimates of capital stock by sectors are long time series for *capital formation*. In the Federal Republic of Germany, the available statistical material on gross fixed capital formation of the economy as a whole, on the larger parts of the enterprise sector, and on general government, is relatively complete. Unsatisfactory as yet—as mentioned above—is the statistical information on the capital expenditures of small enterprises, on a significant part of business services (including the professions), on private non-profit institutions, and for the years before 1950. Only rough estimates are possible in this area. In order to be able to check the plausibility of the results of the capital stock calculations by sectors against the results of the calculations for the whole economy, it is necessary to include, in all circumstances, capital stock estimations for these sectors, although one has to admit that those capital stock data are surrounded by considerable uncertainties.

[11] In Germany these are enterprises registered in the "Handwerksrolle". They are not necessarily different from the manufacturing industry, although they are generally not included in the German industry statistics. Instead, there are special censuses and surveys for handicraft.

The second most important requirement for the perpetual inventory approach is the average length of *service life* or the frequency distribution of life cycles of fixed assets, respectively. For this, reliable statistical data are available in the Federal Republic of Germany for passenger cars and—to a certain degree—for residential buildings. The various depreciation rates that are used for tax purposes allow comparisons of the length of service life for the different types of capital goods. Although generally the actual life exceeds the tax life of depreciable assets there is no really reliable information as to the degree of this deviation. When calculating the capital stock by business sectors, there is the additional problem to give estimates for the sector-specific retirement distributions.

For this purpose it might be desirable to have statistical data on the retirements from the capital stock of business and on the age of the retired goods. Moreover, for estimates of the potential GNP it would be important to know something about the relationship between the number of retirements and the phase of the business cycle. The present practice of using frequency functions implies a smoothed time sequence for the retirements. This means that possible short-term fluctuations in retirements from the capital stock cannot be considered.

This paper does not discuss the general problems of measuring the *price changes* of investment goods. For instance, the statistical difficulties of distinguishing between the price and the quality component or the problem of constructing long price series in the face of fast changes in the kind and in the quality of capital goods have not been dealt with. A particularly serious obstacle in capital stock calculations by industries is the need to develop investment good price indices for each single business sector. Lately, the price deflators of the various capital goods have shown rather large discrepancies. The goal of achieving a better understanding of this effect means that an improvement of the statistical basis for estimating investment–investor tables is urgently needed: an attempt should be made to obtain the expenditures for capital goods for each single business sector, broken down by type of capital good.

A problem of increasing importance are those investment goods that are *leased* rather than purchased. In capital stock calculations leased fixed assets ought to be allocated to those sectors that use them because the main interest lies in the relationship between capital stock and its use in production. On the other hand, if the interest is directed towards property aspects (e.g. in balance sheets or in studies on wealth distribution) it would be advisable to allocate the leased fixed assets to the actual owner. The German accounting regulations for tax purposes vary according to the kind of leasing contract. Although there is some justification for assuming that leased capital goods mostly appear on the books of the lessors, there is only little knowledge about the sectors in which these goods are finally used.

An important advantage of the perpetual inventory approach is obviously the comparability of the data between various years and between business sectors. There is, however, some doubt about the feasibility of correct estimates with respect to the level of capital stock figures. The assumed length of the economic life especially affects the level of the capital stock. In capital stock calculations by industries, problems arise from inter-sectoral transactions with existing fixed

assets. Transfers from one industrial sector to another are called for in capital stock calculation when used fixed assets are sold or when enterprises change their main field of economic activity. The more detailed the total capital stock is broken down by sectors, the more significant is this aspect. To achieve a correct evaluation of all these influences on the level of capital stock data it is essential to check the perpetual inventory estimates against *census-type* data at certain intervals, as already emphasized by R. W. Goldsmith.[12]

In the Federal Republic such comparisons can only be made on the basis of information on physical quantities of residential buildings and selected capital goods (e.g. tractors, automobiles, ships). The balance sheet data cannot be used for this purpose because it is uncertain to what extent the accounting values contain hidden reserves. It is also impossible to calculate figures at replacement costs on the basis of written-down original costs because the date of acquisition is not known. For the Federal Republic of Germany, the feasibility of conducting a comprehensive census of the stock of fixed assets must be treated with scepticism on account of the considerable costs involved. It is also doubtful whether the many difficulties to be expected in connection with such a census would permit a substantial improvement of the capital stock estimates. Therefore, collecting statistics of selected and relatively homogeneous capital goods such as buildings and certain types of machines would be the most appropriate procedure.

This enumeration of problems related to capital stock calculations by business sectors is by no means complete. It should suffice, however, to clarify the reasons for the unsatisfactory state of affairs in this area that can be observed in many countries. But it seems that the obstacles are not insurmountable as shown by capital stock calculations of other countries. It should be kept in mind that these calculations are still of a preliminary nature. Their results do not achieve the degree of accuracy that one is accustomed to in national accounts calculations which are derived from actually observed data.

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