

PRODUCTIVE CAPITAL IN ITALY: A DISAGGREGATED ESTIMATE  
BY SECTORS OF ORIGIN AND DESTINATION: 1985-88

BY PAOLO COSTA

*University of Venice*

AND

GIANDEMETRIO MARANGONI

*University of Verona*

This study presents a series of matrices of the capital stock disaggregated both by branch of origin and by branch of destination for the years 1985 to 1988 for Italy. The tables, whose dimensions are  $23 \times 23$ , were constructed using the perpetual inventory method and are based on disaggregated time series of gross capital formation provided by Istat (Italian Statistical Institute). The tables refer to both gross and net capital (with straight-line depreciation) and have been tested on alternative hypotheses for the average expected service lives of capital goods and their survival functions.

1. INTRODUCTION

The purpose of this work is to estimate the disaggregated capital stock in Italy, not only by sectors of destination, but also by sectors of origin.

The necessity for disaggregated estimates of the productive capital stock of a country is dictated by accounting and analytical requirements. The principal accounting requirements (basically those linked to the calculation of depreciation) can be satisfied by an asymmetric disaggregation: not very detailed by sector of origin—i.e. for Italy, only three branches: Machinery and equipment, Means of transport, Building—but, on the contrary, very detailed by sector of utilization. The most important analytical requirements need, instead, a symmetric disaggregation, with an equal number of sectors of origin and destination of capital goods. Models of structural dynamics, disaggregated price formation and income distribution, or technological progress analysis, just to mention a few examples, require the availability of square capital stock matrices of large dimensions.

It is well known that the availability of detailed data on investments made by firms allows for more precise information on the capital stock disaggregated by sector of utilization. The amount of investments made by the various industries is calculated on the basis of the “method of purchase,” utilizing accounting information gathered directly from industries (quarterly in the Italian case). Conversely, the investment vectors, articulated by the production sector, may be calculated only through the “method of availability” and only for the years in which the input-output tables are available (i.e. in Italy, in 1980, 1982, 1985 and 1988). The method of availability evaluates indirectly the flux of capital goods which in a given period are available for final use, by subtracting from the total output of sectors producing capital goods the other intermediate and final uses.

The present work is based on the hypothesis that by supplementing the two data sources, it may be possible to obtain a series of annual investment matrices disaggregated by sector of origin and by sector of utilization, from which to build one or more matrices of productive capital stock. Implicitly these matrices are coherent with the aggregated estimates of investments and capital of Italian national accounts. In order to do this we first had to homogenize the series of investment matrices provided by Istat, described in section 3, and then to build the matrices of gross and net capital stock for Italy, 23 rows and 23 columns, calculated from 1985 to 1988, with alternative methodologies. The matrices follow the classification schemes of economic activities presently used by Istat with three possible levels of aggregation: 92, 44 and 23 productive sectors. As there is a limited number of sectors producing capital goods, it will be obvious that only a few of the rows in the matrices have values different from zero (11 precisely).

After having reviewed the previous estimates of the capital stock conducted in Italy (section 2), we discuss the methodological aspects of our disaggregated estimates of gross and net capital stock (section 3). In section 4 we present the disaggregated matrices of gross and net capital stock for Italy for the years 1985 to 1988. Matrices are reported in Tables 2–5. We then verify the sensitivity of the estimates to changes of the survival functions and average service lives of capital goods (sections 5–6 and Table 7). In the last section we compare our disaggregated estimates of capital stock with the aggregated estimates published by Istat for the years 1980 to 1991 (Tables 8–9).

## 2. PREVIOUS ESTIMATES OF CAPITAL STOCK IN ITALY

Italy has a long tradition in estimating the national wealth. Since the beginning of the century there have been about twenty estimates of the capital stock (we may mention those of Gini of the years 1908, 1914 and 1924–25). These estimates, however, furnish only some vectors of capital which record the total value of the capital for the different sectors.

In the last 25 years, there have been many surveys to evaluate the amount of the productive capital and to improve the knowledge of the accumulation process. The first capital matrices, published by Istat, cover the years from 1951 to 1972 (at 1963 prices) (Manfroni, 1975). These matrices have, however, a low level of disaggregation: three sectors supplying capital goods (Machinery and equipment, Means of transport, Building) and four sectors utilizing these capital goods (Mining, Manufacturing, Energy, Building). The method of estimating is the perpetual inventory method (PIM, see section 3), with two alternatives for the net capital: straight-line depreciation and variable depreciation. A second series of capital tables was published by Istat for the period 1960–75 (at 1970 prices) (Istat, 1978), by adopting the ESA (European System of Integrated Economic Accounts) classification system.

Thanks to the support of Confindustria (Italian Manufacturers' Federation) it has been possible to prepare tables with a higher degree of disaggregation. These still contain three productive sectors, but now there are 12 sectors utilizing the capital goods. A first study, done by Rosa (1979), covers the period from 1960 to 1976, while a second study by Rosa and Siesto (1985) looks at a longer period,

1950–83. Both works (at 1970 prices) refer to industrial production only. In both cases the method of estimating capital is that of the perpetual inventory; however, in the second study, it is assumed that retirements are normally distributed around the average expected service life, with either straight-line or progressive depreciation. There has been also a recent contribution by Annunziato, Esposito, Manfroni and Rosa (1992) in a report by Confindustria which offers  $3 \times 23$  capital tables for the years 1951 to 1988 (at 1985 prices).

In addition to these works which utilize, as stated, the indirect method of permanent inventory, there are direct surveys on manufacturing firms done by Mediocredito Centrale for the years 1968, 1973, 1978 and 1984 (Mediocredito Centrale, 1971–87) and a sample survey by the Centro Studi Confindustria for 1985 (Gros Pietro and Rosa, 1987).

The capital tables considered so far have an operative limit determined by the low level of disaggregation. The only capital matrix with a level of disaggregation comparable to the Italian input–output tables was built by Santeusanio (1988) for the year 1980. The matrix is made up of 44 rows and 23 columns: as there is a limited number of sectors producing capital goods, only 13 rows in the matrix have values different from zero.

### 3. SOME METHODOLOGICAL ASPECTS

In the present work we consider capital as a mean of production. The definition we adopt considers the (fixed) capital as a set of material goods which can be reproduced and which can be utilized for several productive periods in order to produce other goods or services (Marzano, 1975; Esposito, 1975). Therefore we do not take into account the following goods which are not capital goods: patents, licenses, copyright, permits, business goodwill, which are intangible assets; agricultural and urban land, waters, mines and natural resources, monuments and works of art, which are not reproducible; durable goods for consumption, which are not employed for production.

We consider two types of capital: gross and net capital. Gross capital includes all means of production available and usable at a particular time. If a capital good is disposed of because it is no longer operative or because it is obsolete, gross capital decreases by the same amount. Gross capital, therefore, reflects the productive capacity available at a given time. Net capital, instead, expresses the value of the capital itself in its future productive capacity. If a capital good has a service life of a certain number of years, year after year it loses a percentage of its total productive capacity even though it maintains the same level of efficiency up to retirement. A machine which has been used for a number of years has a lower value than a new one, not because it is less efficient, but because its future service life and productive capacity are lower. Taking depreciation into account leads to the concept of net capital.

In order to estimate the gross and net capital stock, in this work we adopt the procedure known as the “perpetual inventory method” (PIM). This method is based on the hypothesis that, at a certain moment, the capital stock is equal to the sum of the investments made in the past and still available as means of

production (Goldsmith, 1951). In general terms, and with reference to a homogeneous group of investment goods, the basic model of the PIM is the following:

$$K_t = \sum_{i=t-v}^t S_{it} I_i$$

where  $K_t$  is the gross capital at time  $t$ ,  $I_i$  the investments made at time  $i$ ,  $v$  the maximum period of capital goods utilization and  $S_{it}$  the percentage of investments made at time  $i$  and still in use at time  $t$ . The survival rate of investments  $S_{it}$  must satisfy the following conditions:

$$S_{it}=1 \quad \text{for } t-u < i; \quad S_{i+1,t} \geq S_{it} \quad \text{for every } i; \quad S_{it}=0 \quad \text{for } i \leq t-v$$

where  $u$  indicates the minimum period of capital goods utilization.  $S_{it}$  represents the survival function of investments made at time  $t$ .

If  $V_{it}$  indicates the percentage of the value that investments made at time  $i$  still have at time  $t$ , net capital  $K_t^*$  is equal to:

$$K_t^* = \sum_{i=t-v}^t V_{it} I_i$$

$V_{it}$  must satisfy the following conditions:

$$V_{it}=1 \quad \text{for } i=t; \quad V_{i+1,t} \geq V_{it} \quad \text{for every } i; \quad V_{it}=0 \quad \text{for } i \leq t-v$$

$V_{it}$  takes into account the retirement percentage as well. If, for example, at time  $t$  3/5 of the investments made at time  $i$  remain, and these investment goods still maintain 2/3 of their original value,  $V_{it}$  is equal to (2/3)(3/5), that is 2/5.

The application of the perpetual inventory method requires the following essential elements: (1) the availability of sufficiently long time series of investments, valued at constant prices, which must cover a period of time equal to the maximum utilization period of the capital goods, beginning with the date of the estimate, (2) the knowledge of the average expected service lives of capital goods, (3) the knowledge of the distribution of retirements, (4) the choice of the law of depreciation of capital.

### 3.1. Available Data

The starting data used in this work and provided by Istat are made up by three series of investments, of different length and level of aggregation (Monselesan, 1990). The first series covers the years from 1988 back to 1970 and reflects the above mentioned disaggregation of 23 sectors of origin and 23 sectors of destination. The second series, which covers the years back to 1951, is organized around three branches (Machinery and equipment, Means of transport, Building) still maintaining the 23 sector disaggregation as regards the destination. The third series, finally, refers to Building and to its 23 sectors of destination and goes as far back as 1870.

It was necessary to disaggregate the Machinery and equipment branch of the 1969-51 series into its nine sectors (see Table 1) in order to obtain a 23 sector classification. The disaggregation was done using a scheme which takes into

account the investment trend in each sector and their average values. More precisely, we constructed the disaggregated matrix of the average investments for the period 1979–70 and assumed that the 1969–51 investments result disaggregated in the same proportions. In any case the relevance of these data and of the scheme of disaggregation is very limited, since the average life of this branch is of about 18 years.

In estimating the value of real estate we took into account the damages caused by the Second World War. The value of residential and non-residential buildings and infrastructures built prior to 1946 was cut by 8 percent (Rosa and Siesto, 1985).

### 3.2. *Survival Functions*

On the basis of several simulations done both with real data and with different time investment distributions models we retained the hypothesis of simultaneous retirements. This law overlaps the minimum and maximum periods of capital goods utilization. All the investments (homogeneous group) made during a particular year are employed in the production process, and then retired at the same time. This is known as the simultaneous retirement hypothesis, or “one-hoss-shay” (Solow, 1962), associated with a rectangular survival function. This hypothesis, in addition to its simplicity, encompasses all other hypotheses as, from the analytical point of view, particular cases. The utilization of other survival functions is discussed in section 5.

### 3.3. *Average Service Life of Capital Goods*

A survey carried out in the OECD countries (OECD, 1983) showed that statistical bureaus use a wide range of average service lives in evaluating capital stocks. The choice of the average life of capital goods is a crucial point for the application of the PIM: if different duration of investment goods are considered, the estimate of capital stock can vary significantly. This is why it is difficult to compare international capital stocks and it would be necessary to adopt standard average lives for different countries (Maddison, 1993; O’Mahony, 1993).

As for the productive service lives of investment goods, we used the average expected lives officially provided by Istat and indicated in Table 1. This is a set of average service lives which is very articulate and which takes into account the types of capital goods (Machinery and equipment, Means of transport, Building) and their sectors of destination. The average service lives provided by Istat are obtained from a synthesis of preliminary works based on empirical evidences, international experiences and the opinions of experts in the field. The problem concerning the average service lives of capital goods and their influence on the estimate of the capital stock in Italy is discussed in detail in section 6.

### 3.4. *Retirements*

As regards the estimate of the net capital, we used the straight-line depreciation, in which capital depreciation is a linear function of the time. This method is recommended by international organizations (UNSO, 1968).

TABLE 1  
CLASSIFICATION OF SECTORS AND STANDARD AVERAGE SERVICE LIVES  
(years)

Sectors of destination	Types of Capital Goods			
	M.E.	M.T.	Build.	
	Average Service Lives			
1	Agriculture, forestry and fishery products	18	10	50
2	Fuel and power products	18	10	35
3	Ferrous and non-ferrous ores and metals	15	10	35
4	Non-metallic minerals and mineral-products	16	10	35
5	Chemical and pharmaceutical products	16	10	35
6	Metal products excl. machinery and means of transport	20	10	35
7	Agricultural and industrial machinery	18	10	35
7a	Tractors and agricultural machinery			
7b	Industrial machinery			
8	Office machines, precision, optical instruments, etc.	16	10	35
9	Electrical material and supplies	16	10	35
10	Means of transport	16	10	35
10a	Motor vehicles			
10b	Motor cycles			
10c	Other means of transport			
11	Food, drinks and tobacco	18	10	35
12	Textiles and clothing, leather, footwear	18	10	35
13	Paper, paper products, printing and publishing	16	10	35
14	Rubber and plastic products	15	10	35
15	Wood, wooden furniture and other manuf. products	18	10	35
15a	Wood and wooden furniture			
15b	Other manufactured products			
16	Building	18	10	35
17	Transport	18	10	50
18	Communications	18	10	50
19	Trade and goods for recovery and repairs	18	10	65
20	Lodging and catering	18	10	65
21	Banking and insurance	18	10	65
22	Other market services	18	10	80
23	Non-market services	18	10	80

M.E.: Machinery and equipment (sectors 1, 4, 6, 7, 8, 9, 12, 15, 19)

M.T.: Means of transport    Build.: Building

We did not take into account the other two laws of depreciation, progressive and declining depreciation, because they imply a very particular logic. With progressive depreciation it is assumed that the wear and tear of capital goods is greater in the years closer to retirement. This hypothesis fits those investment goods which are less subject to obsolescence (the loss of value caused by technological improvements) and which require a breaking-in period. The declining depreciation relates to those capital goods which are more productive during the first period of utilization and rapidly lose their value when the technological innovation is over.

#### 4. MATRICES OF GROSS CAPITAL AND NET CAPITAL IN ITALY: 1985-88

Tables 2-5 show the disaggregated matrices of the gross and net capital in Italy for the years 1985 and 1988.

TABLE 2  
ITALY—GROSS CAPITAL—YEAR 1985  
(1985 thousand million lire)

Sectors of Origin	Sectors of Destination							
	1	2	3	4	5	6	7	8
1	1,154	182	271	0	0	0	0	0
4	2,199	583	134	131	377	113	105	20
6	3,166	8,580	4,792	4,487	8,182	4,423	4,395	744
7a	81,625	0	0	0	0	0	0	0
7b	2,065	24,820	20,732	17,960	21,483	23,412	17,051	5,664
8	323	2,314	1,418	1,294	2,238	1,312	1,254	245
9	1,031	9,828	5,450	5,164	9,333	5,138	5,078	848
10a	1,841	236	411	2,938	792	2,379	1,481	242
10b	393	10	20	141	37	114	73	10
10c	1,605	666	0	0	0	0	0	0
12	0	73	12	13	44	13	15	0
15a	2,132	912	203	203	582	178	162	29
15b	0	62	13	10	45	9	9	2
16	226,025	148,203	23,827	16,634	31,901	21,120	13,969	2,254
19	0	0	0	0	0	0	0	0
Total	323,559	196,469	57,283	48,975	75,014	58,211	43,592	10,058

  

	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	1,296
4	51	135	1,966	952	137	65	60	2,036
6	1,978	3,437	2,660	7,334	2,518	2,886	2,786	9,243
7a	0	0	0	0	0	0	0	0
7b	16,235	23,767	16,462	32,099	11,699	8,325	15,326	26,679
8	658	1,076	961	2,113	744	821	833	2,107
9	2,256	3,973	3,771	8,302	2,867	3,346	3,235	8,656
10a	1,616	921	2,139	3,081	1,106	604	1,763	11,144
10b	80	44	102	147	49	29	88	525
10c	0	0	0	0	0	0	0	0
12	2	13	233	110	13	10	7	249
15a	78	207	3,676	1,479	210	101	93	3,192
15b	5	10	214	107	12	6	5	233
16	11,195	9,202	20,555	27,193	14,705	11,014	14,812	22,427
19	0	0	0	0	0	0	0	0
Total	34,154	42,785	53,739	82,917	34,060	27,207	39,008	87,787

  

	17	18	19	20	21	22	23	Total
1	0	0	0	0	0	0	0	2,903
4	0	0	4,612	939	159	1,639	258	16,671
6	1,329	1,184	8,168	2,179	4,429	4,853	9,630	104,383
7a	0	0	0	0	0	0	0	81,625
7b	0	0	18,570	523	0	1,231	0	304,103
8	1,719	2,331	5,885	1,275	9,794	21,727	10,837	73,279
9	3,241	39,101	10,639	6,850	0	26,473	0	164,580
10a	33,430	1,007	27,240	1,379	278	14,740	1,668	112,436
10b	1,676	49	1,303	65	12	1,126	21	6,114
10c	23,467	0	0	0	0	0	0	25,738
12	37	15	0	0	31	0	72	962
15a	476	655	19,845	8,470	4,197	8,890	6,508	62,478
15b	3	50	676	1,340	129	763	217	3,920
16	97,012	51,563	87,898	27,651	47,752	1,707,913	386,530	3,021,355
19	1,488	0	0	0	0	0	0	1,488
Total	163,878	95,955	184,836	50,671	66,781	1,789,355	415,741	3,982,035

TABLE 3  
ITALY—GROSS CAPITAL—YEAR 1988  
(1985 thousand million lire)

Sectors of Origin	Sectors of Destination							
	1	2	3	4	5	6	7	8
1	1,532	160	119	0	0	0	0	0
4	2,313	666	146	144	447	130	122	23
6	3,143	9,632	5,152	4,703	9,307	5,136	4,999	853
7a	88,613	0	0	0	0	0	0	0
7b	2,087	29,217	17,165	19,834	19,491	26,720	19,034	6,690
8	438	2,826	1,582	1,494	2,781	1,588	1,528	306
9	1,072	10,632	5,677	5,318	10,342	5,786	5,609	950
10a	2,220	305	452	3,277	1,038	2,378	1,626	273
10b	367	12	18	128	39	93	65	10
10c	1,482	660	0	0	0	0	0	0
12	0	60	9	10	35	13	12	0
15a	2,160	926	197	197	600	190	169	32
15b	0	115	25	20	86	19	18	5
16	239,774	165,015	24,078	17,095	31,716	22,029	14,926	2,600
19	0	0	0	0	0	0	0	0
Total	345,201	220,226	54,620	52,220	75,882	64,082	48,108	11,742

  

	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	1,167
4	59	147	2,258	1,089	170	75	68	2,228
6	2,226	3,579	4,213	8,263	3,033	3,261	3,074	10,265
7a	0	0	0	0	0	0	0	0
7b	19,579	27,431	19,611	35,191	14,423	9,252	16,593	26,941
8	810	1,238	1,164	2,526	989	1,007	973	2,406
9	2,479	4,065	4,137	9,076	3,345	3,653	3,491	9,029
10a	1,376	1,023	2,343	3,381	1,836	686	1,768	12,646
10b	58	40	92	132	66	27	71	485
10c	0	0	0	0	0	0	0	0
12	2	10	204	95	10	9	7	215
15a	79	201	3,864	1,527	224	100	96	3,162
15b	11	21	383	187	29	13	11	376
16	11,899	9,312	20,864	27,795	15,123	11,061	15,609	24,496
19	0	0	0	0	0	0	0	0
Total	38,578	47,067	59,133	89,262	39,248	29,144	41,761	93,416

  

	17	18	19	20	21	22	23	Total
1	0	0	0	0	0	0	0	2,978
4	0	0	5,807	1,094	182	1,981	322	19,471
6	2,187	1,497	11,714	2,939	5,639	6,948	14,020	125,783
7a	0	0	0	0	0	0	0	88,613
7b	0	0	22,047	602	0	1,400	0	333,308
8	2,083	3,007	8,049	1,774	12,358	31,091	15,147	97,165
9	5,004	50,085	13,752	8,685	0	33,623	0	195,810
10a	38,352	814	29,206	1,601	310	18,374	2,096	127,381
10b	1,568	34	1,148	61	11	1,156	21	5,702
10c	26,820	0	0	0	0	0	0	28,962
12	31	12	0	0	25	0	60	819
15a	469	603	20,948	9,423	3,645	8,872	6,577	64,261
15b	9	90	1,386	2,236	240	1,454	459	7,193
16	111,663	55,658	95,574	29,137	51,588	1,843,732	417,400	3,258,144
19	2,010	0	0	0	0	0	0	2,010
Total	190,196	111,800	209,631	57,552	73,998	1,948,631	456,102	4,357,600



TABLE 4  
ITALY—NET CAPITAL—YEAR 1985  
(1985 thousand million lire)

Sectors of Origin	Sectors of Destination							
	1	2	3	4	5	6	7	8
1	797	58	66	0	0	0	0	0
4	1,202	348	79	78	229	71	65	12
6	1,634	4,989	2,816	2,578	4,805	2,733	2,620	443
7a	47,931	0	0	0	0	0	0	0
7b	1,084	14,853	9,258	10,592	9,337	14,426	10,087	3,502
8	224	1,477	872	821	1,419	873	815	160
9	554	5,460	3,029	2,850	5,249	3,071	2,912	484
10a	1,092	141	231	1,645	480	1,315	838	146
10b	207	6	11	73	21	58	38	6
10c	828	349	0	0	0	0	0	0
12	0	36	5	6	20	7	7	0
15a	1,172	497	110	110	320	105	92	17
15b	0	50	12	9	37	8	8	2
16	138,250	95,557	13,894	9,439	17,089	12,727	8,897	1,482
19	0	0	0	0	0	0	0	0
Total	194,975	123,821	30,383	28,201	39,006	35,394	26,379	6,254

  

	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	427
4	31	79	1,208	590	83	38	37	1,224
6	1,167	1,938	2,247	4,440	1,481	1,671	1,658	5,674
7a	0	0	0	0	0	0	0	0
7b	10,078	14,232	10,493	18,751	6,974	4,673	8,860	14,887
8	427	669	629	1,383	481	516	536	1,337
9	1,275	2,158	2,164	4,806	1,614	1,842	1,860	4,850
10a	857	539	1,215	1,798	804	345	957	6,805
10b	40	24	54	79	33	16	44	294
10c	0	0	0	0	0	0	0	0
12	1	6	117	56	6	5	5	125
15a	43	110	2,114	840	116	53	52	1,758
15b	5	9	177	90	11	6	5	185
16	6,981	4,919	11,520	16,051	7,572	5,844	9,760	14,871
19	0	0	0	0	0	0	0	0
Total	20,905	24,683	31,938	48,884	19,175	15,009	23,774	52,437

  

	17	18	19	20	21	22	23	Total
1	0	0	0	0	0	0	0	1,348
4	0	0	2,937	552	97	987	158	10,105
6	962	810	5,981	1,550	3,033	3,472	6,924	65,626
7a	0	0	0	0	0	0	0	47,931
7b	0	0	10,864	292	0	675	0	173,918
8	918	1,612	4,076	887	6,461	15,232	7,405	49,230
9	2,160	25,531	6,696	4,236	0	16,144	0	98,945
10a	19,459	518	15,315	774	156	8,707	1,004	65,141
10b	908	24	680	34	6	630	12	3,298
10c	14,136	0	0	0	0	0	0	15,313
12	18	7	0	0	14	0	35	476
15a	235	325	10,746	4,724	1,879	4,616	3,445	33,479
15b	3	40	588	959	106	577	183	3,070
16	69,673	38,163	64,235	19,232	35,553	1,291,477	274,506	2,167,692
19	1,249	0	0	0	0	0	0	1,249
Total	109,721	67,030	122,118	33,240	47,305	1,342,517	293,672	2,736,821

TABLE 5  
ITALY—NET CAPITAL—YEAR 1988  
(1985 thousand million lire)

Sectors of Origin	Sectors of Destination							
	1	2	3	4	5	6	7	8
1	969	40	49	0	0	0	0	0
4	1,203	399	82	81	268	77	72	14
6	1,494	5,751	2,996	2,695	5,667	2,993	2,936	524
7a	49,151	0	0	0	0	0	0	0
7b	1,053	18,363	8,310	11,113	8,144	15,459	10,934	3,990
8	301	1,820	957	903	1,759	1,002	964	195
9	578	6,006	3,065	2,844	5,895	3,228	3,123	548
10a	1,321	171	256	1,844	659	1,307	919	160
10b	181	7	9	65	23	47	34	6
10c	771	468	0	0	0	0	0	0
12	0	24	3	3	13	5	4	0
15a	1,110	491	100	98	316	100	88	17
15b	0	93	20	17	69	17	15	4
16	144,110	103,685	12,712	8,959	15,640	12,053	8,793	1,646
19	0	0	0	0	0	0	0	0
Total	202,242	137,318	28,559	28,622	38,453	36,288	27,882	7,104

  

	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	293
4	35	82	1,330	644	105	44	39	1,286
6	1,348	2,020	2,529	4,872	1,904	1,951	1,723	6,149
7a	0	0	0	0	0	0	0	0
7b	11,639	16,196	12,153	19,566	8,686	5,307	8,668	14,287
8	509	738	735	1,584	648	637	582	1,473
9	1,406	2,141	2,294	5,051	1,970	2,036	1,855	4,897
10a	623	595	1,316	1,936	1,275	395	967	7,347
10b	24	21	48	69	43	14	35	255
10c	0	0	0	0	0	0	0	0
12	1	3	83	38	3	3	4	90
15a	41	98	2,046	798	121	51	48	1,614
15b	9	18	308	151	25	11	9	293
16	6,828	4,865	11,331	15,760	7,258	5,430	9,517	15,150
19	0	0	0	0	0	0	0	0
Total	22,463	26,777	34,173	50,469	22,038	15,879	23,447	53,134

  

	17	18	19	20	21	22	23	Total
1	0	0	0	0	0	0	0	1,351
4	0	0	3,711	618	109	1,220	205	11,624
6	1,649	998	8,512	2,014	3,838	5,016	10,212	79,791
7a	0	0	0	0	0	0	0	49,151
7b	0	0	13,144	332	0	803	0	188,147
8	1,215	2,008	5,613	1,216	8,116	22,031	10,585	65,591
9	3,527	32,006	8,945	5,339	0	21,365	0	118,119
10a	22,082	337	15,880	920	175	11,139	1,276	72,900
10b	823	13	566	32	6	647	11	2,979
10c	15,936	0	0	0	0	0	0	17,175
12	13	4	0	0	9	0	24	327
15a	244	285	10,761	4,670	1,562	4,592	3,568	32,819
15b	8	72	1,164	1,646	194	1,155	383	5,681
16	79,663	39,628	68,408	19,718	37,458	1,373,154	294,750	2,296,516
19	1,503	0	0	0	0	0	0	1,503
Total	126,663	75,351	136,704	36,505	51,467	1,441,122	321,014	2,943,674

The matrices are made up of 23 rows and 23 columns. The rows record sectors that produce capital goods (sectors of origin), whereas the columns record sectors which utilize the capital goods (sectors of destination). The classification by sectors is shown in Table 1 and follows the classification schemes of economic activities presently in use by Istat with three possible levels of aggregation: 92, 44 and 23 productive sectors.

As regards the 23 sectors of origin, only 11 produce investment goods. In three cases (Agricultural and industrial machinery, Means of transport, Wood, wooden furniture and other manufactured products) the level of disaggregation is higher: obviously it is enough to sum up the lines to obtain the 23 sector classification. In Tables 2-5, for the sake of space, we do not report those rows whose elements are all equal to zero.

All the matrices are evaluated at the 1985 prices. The total gross capital and the total net capital (in thousand million lire) amount to:

Year	Gross Capital		Net Capital	
	Value	Increment	Value	Increment
1985	3,982,035		2,736,821	
1986	4,100,224	85/86: 2.97%	2,799,647	85/86: 2.30%
1987	4,222,977	86/87: 2.99%	2,867,401	86/87: 2.42%
1988	4,357,600	87/88: 3.19%	2,943,674	87/88: 2.66%

On average depreciation reduces the value of the total stock by about 32 percent.

The most important piece of information derived from the table above is that the capital stock, both gross and net, increased between 1985 and 1988 at a yearly average rate of 2.5 percent-3 percent.

The disaggregated analysis, however, shows that the variations of the capital stock are quite different from sector to sector and according to capital goods: in some sectors new investments could not replace the used capital goods, thus causing a decrease in the capital itself.

It is also interesting to analyze the rows and the columns totals, which indicate the detailed composition of the capital stock by origin and destination sectors. It is clear that the most important capital items, after Building and before Means of transport, are those relating to Agricultural and industrial machinery and Electrical material and supplies (row totals). On the other hand the sectors which utilize the most capital are those relating to market and non-market services, followed, surprisingly enough, by Agriculture (column totals).

More than the absolute value of the capital utilized in various productive sectors, it is interesting to analyze the capital/output ratios, which make it possible to evaluate the capital intensity in the different sectors. Table 6 shows the (gross) capital/output ratios in various productive sectors for the years 1985 and 1988. During the period under study, the capital/output ratios have remained substantially stable, with small increases in some sectors and slight decreases in others. Particularly high capital/output ratios characterize Agriculture (5.22 in 1988),

TABLE 6  
ITALY—CAPITAL/OUTPUT RATIOS—1985  
AND 1988

Sectors	Capital/Output Ratios	
	1985	1988
1	4.94	5.22
2	2.79	3.09
3	1.36	1.22
4	1.53	1.34
5	1.25	1.03
6	1.30	1.20
7	0.85	0.89
8	0.39	0.88
9	1.44	0.83
10	1.11	0.97
11	0.68	0.70
12	0.92	0.91
13	1.17	1.11
14	1.27	1.12
15	1.09	1.08
16	0.86	0.87
17	2.09	2.06
18	5.82	5.43
19	0.99	1.02
20	1.00	1.01
21	1.35	1.43
22	10.65	9.32
23	2.94	2.84
Total	2.65	2.57

Fuel and power products (3.09), Communications (5.43) and Other market services (9.32).

The tables below show the division of capital (gross and net) in the three principal aggregates: Machinery and equipment, Means of transport, Building:

	Gross Capital (1985 thousand million lire)			
	1985	1986	1987	1988
Machinery and equipment	816,392 (20.50%)	851,506 (20.77%)	890,523 (21.09%)	937,411 (21.51%)
Means of transport	144,288 (3.62%)	149,018 (3.63%)	154,660 (3.66%)	162,045 (3.72%)
Building	3,021,355 (75.88%)	3,099,700 (75.60%)	3,177,796 (75.25%)	3,258,144 (74.77%)
	Net Capital (1985 thousand million lire)			
	1985	1986	1987	1988
Machinery and equipment	485,377 (17.74%)	502,225 (17.94%)	524,737 (18.30%)	554,104 (18.82%)
Means of transport	83,752 (3.06%)	85,838 (3.06%)	89,068 (3.11%)	93,054 (3.16%)
Building	2,167,692 (79.20%)	2,211,584 (79.00%)	2,253,596 (78.59%)	2,296,516 (78.02%)

## 5. ALTERNATIVE HYPOTHESES FOR CAPITAL GOODS SURVIVAL FUNCTIONS

The sensitivity of the estimates shown in the preceding Section to changes of the survival functions may be verified.

If we drop the hypothesis of simultaneous retirements, in order to formulate more realistic survival functions it is necessary to know the dispersion of the retirements of each homogeneous group of investment goods around its average service life and the minimum and maximum period of utilization of investments. Common sense and Winfrey's pioneer work (1935) suggest a bell-shaped distribution of retirements, to which corresponds a logistical survival function. One of the most common logistical survival functions, used in this work, is the one developed by the Deutsches Institut für Wirtschaftsforschung (DIW) (Hahn and Schmoranz, 1984):

$$S_{it} = \frac{1}{1 + e^s}$$

where

$$s = \frac{a}{v + 1 - i} + \frac{b}{1 - i} \quad \text{and} \quad a = cp, b = cq, c = 2v, p + q = 1.$$

The maximum life span of investment goods is still represented by  $v$ ;  $p$  and  $q$  are the parameters determining the function profile. When  $p=0.5$  and  $q=0.5$  the function is symmetric, whereas different values increase or decrease the shape of the function. If the value of  $q$  is near zero, the function is parabolical, with accelerated retirements in the early stages. When  $q$  tends toward one, the majority of retirements take place close to the maximum life span of the investments.

An alternative to the DIW survival function, which we took into account, relates to a linear survival function; this implies that every year a constant proportion of capital goods is retired.

The preceding logistical and linear survival functions presume that retirements take place during a time which spans the entire life of those goods. This hypothesis, especially for the linear case, is not realistic, because it assumes that retirements of investment goods begin immediately after their installation. We thought best to reduce the time span within which these retirements occur, limiting it to a period of a few years before and after the average life (limited survival functions).

The choice of a survival function obviously has consequences on the estimated value of the capital stock and on its growth rate. Most OECD countries accept the hypothesis of bell-shaped or simultaneous retirement distributions (OECD, 1989). The Central Statistical Office (CSO) of the U.K. adopted limited linearly decreasing survival functions, where retirements occur in a period of time of 20 percent more and 20 percent less of the average service life. The model is described in detail in Griffin (1975) and has had practical applications (Hibbert, Griffin and Walker, 1977). The statistical bureaus of Canada and Norway have published studies which show that the capital stock estimates, made on the hypothesis of bell-shaped or simultaneous retirements, do not differ much from each other

(Koumanakos, 1980; Biorn, Holmoy and Olsen, 1985). The hypothesis of bell-shaped retirements has the advantage of generating stable capital growth rates, softening the “echo” effect due to investment peaks in given years. It is worth noting that the bell-shaped distribution hypothesis, as opposed to that of simultaneous retirements, leads to underestimating the capital stock while the investments are expanding and to overestimating the capital stock when there is an investment reduction.

The simulations made with the Italian data highlight how the shape of the survival functions affects in a limited way the estimates of the capital stock. In Table 7, as an example, we compare the values of the gross capital stock for the year 1985, disaggregated by sectors of destination, with the values which were obtained, assuming equal average service lives, by adopting two different survival functions of investments: the linear and the DIW-logistical functions. For both survival functions we presumed that retirements occur in a period of time of 20 percent more and 20 percent less of the average service life.

The estimates performed under the hypotheses of limited linear retirements or limited bell-shaped retirements differ slightly from the estimates obtained with a simultaneous retirement scheme. These estimates differ less than 0.5 percent: precisely  $-0.41$  percent for the linear survival function and  $-0.17$  percent for DIW survival function.

## 6. ALTERNATIVE HYPOTHESES FOR THE AVERAGE SERVICE LIFE OF CAPITAL GOODS

While the choice of survival functions involves very low variations in the value of the capital stock, alternative hypotheses dealing with the average lives affect the estimated values rather significantly.

The problems concerning the variability of the average service lives of capital goods are numerous. A first question is to establish if the average service lives of capital goods increase or decrease over time. Some authors believe that due to high levels of technology and accelerated economic development, average service lives tend to decrease (Tengblad and Westerlund, 1976) or that average service lives adopted by some statistical bureaus are greater than the real ones (Smith, 1987). However, technological progress is only one among many factors which can affect the capital goods service life. Other factors are linked to the movement of relative prices, to the variations of the demand of commodities and to the maintenance of capital goods. It is worth emphasizing that these circumstances may either increase or decrease the average service life of the investment goods, so that it is difficult to assess if, in the long run, they tend to become longer or shorter.

The discussion on the variability of average service lives also addresses sectorial and territorial aspects. The same investment goods may have a different average service life depending on the productive sector in which they are employed (i.e. means of transport employed in the chemical products sector, or in the trade sector, or in the building sector). The same phenomenon was observed at a territorial level, depending on the regional location of the capital goods (Anderson and Rigby, 1989).

TABLE 7  
 ITALY—GROSS CAPITAL—YEAR 1985  
 (1985 thousand million lire)

ALTERNATIVE HYPOTHESES FOR THE SURVIVAL FUNCTIONS AND THE AVERAGE SERVICE LIVES

Sectors of Destination	SE	LSF	% var.	DIW	% var.	-20%	% var.	-10%	% var.	+10%	% var.	+20%	% var.
1	323,559	324,232	0.21	324,035	0.15	301,891	-6.70	313,487	-3.11	341,033	5.40	354,709	9.63
2	196,469	195,024	-0.74	195,935	-0.27	179,136	-8.82	192,129	-2.21	205,914	4.81	211,541	7.67
3	57,283	55,768	-2.64	56,614	-1.17	46,819	-18.27	55,399	-3.29	60,904	6.32	61,532	7.42
4	48,975	48,024	-1.94	48,550	-0.87	43,055	-12.09	47,723	-2.56	51,426	5.00	52,902	8.02
5	75,014	72,839	-2.90	73,955	-1.41	63,329	-15.58	72,806	-2.94	79,128	5.48	81,608	8.79
6	58,211	57,803	-0.70	58,067	-0.25	53,832	-7.52	56,563	-2.83	59,459	2.14	60,667	4.22
7	43,592	43,017	-1.32	43,408	-0.42	40,492	-7.11	43,150	-1.01	45,085	3.42	46,072	5.69
8	10,058	9,861	-1.96	9,972	-0.86	9,135	-9.18	9,934	-1.23	10,381	3.21	10,604	5.43
9	34,154	33,698	-1.34	33,979	-0.51	31,374	-8.14	33,660	-1.45	35,339	3.47	36,133	5.79
10	42,785	41,722	-2.48	42,349	-1.02	36,626	-14.40	41,769	-2.37	45,174	5.58	46,521	8.73
11	53,739	53,002	-1.37	53,480	-0.48	47,987	-10.70	52,316	-2.65	56,564	5.26	58,082	8.08
12	82,917	81,969	-1.14	82,645	-0.33	75,086	-9.44	81,105	-2.19	87,505	5.53	89,709	8.19
13	34,060	33,788	-0.80	33,999	-0.18	30,061	-11.74	33,259	-2.35	36,500	7.16	37,707	10.71
14	27,207	26,945	-0.96	27,158	-0.18	23,011	-15.42	26,303	-3.32	29,588	8.75	29,945	10.06
15	39,008	38,532	-1.22	38,856	-0.39	36,583	-6.22	38,500	-1.30	40,064	2.71	40,736	4.43
16	87,787	86,335	-1.65	87,160	-0.71	79,712	-9.20	86,287	-1.71	91,422	4.14	93,956	7.03
17	163,878	163,849	-0.02	163,867	-0.01	150,221	-8.33	156,686	-4.39	171,197	4.47	178,067	8.66
18	95,955	95,861	-0.10	95,899	-0.06	92,092	-4.03	94,834	-1.17	98,895	3.06	101,229	5.50
19	184,836	183,623	-0.66	184,277	-0.30	170,639	-7.68	180,773	-2.20	191,738	3.73	199,148	7.74
20	50,671	50,291	-0.75	50,527	-0.28	47,692	-5.88	49,893	-1.54	51,933	2.49	53,223	5.04
21	66,781	66,353	-0.64	66,588	-0.29	63,121	-5.48	65,979	-1.20	68,474	2.54	70,001	4.82
22	1,789,355	1,788,072	-0.07	1,788,486	-0.05	1,729,432	-3.35	1,756,551	-1.83	1,821,867	1.82	1,852,886	3.55
23	415,741	415,171	-0.14	415,391	-0.08	394,262	-5.17	404,056	-2.81	427,342	2.79	438,341	5.44
Total	3,982,035	3,965,779	-0.41	3,975,197	-0.17	3,745,588	-5.94	3,893,162	-2.23	4,106,932	3.14	4,205,319	5.61

SE: Standard estimate. LSF: Linear survival function. DIW: DIW survival function.  
 -20%, -10%, +10%, +20%: Variations of average service lives.

The differences in the average service lives used by the statistical bureaus of various countries do not allow international comparisons for capital stocks. Works such as Maddison's (1993) are therefore of particular interest because the estimates of capital stock (of France, Germany, Japan, Holland, Great Britain, United States) are obtained using identical average service lives and survival functions.

The average service lives or, more generally, the minimum and maximum periods of utilization of capital goods may be determined by direct surveys or may be estimated indirectly. Some methods of indirect estimate utilize balance sheet data of manufacturing firms (Atkinson and Mairesse, 1978; Tarasofsky, Roseman and Waslander, 1981; Cette and Szpiro, 1988; Jaffey, 1990). Other indirect estimate methods assume production technologies of "putty-clay" variety, which means that once a capital good is installed its technical characteristics, including the amount of labour employed per unit of capital, remain constant throughout its service lifetime. This assumption considers changes in employment levels through time linked to new investments and to the retirement of capital goods no longer employed (Varaiya and Wiseman, 1981; Anderson and Rigby, 1989).

We verified the consequences of the variation of the average service lives on the estimated values of capital stock. On the basis of several simulations taking into account average service lives longer or shorter than the official ones provided by Istat, we noticed that different lengths of investment goods lead to significantly different estimates of capital stock. The results are very different from sector to sector.

As an example, Table 7 records the values of the gross capital stock for the year 1985, disaggregated by sector of destination, obtained by varying the average service lives for an interval of time of  $\pm 20$  percent of the standard values. These intervals of variation of the average service lives ( $\pm 20$  percent of Istat values) include the average lives that a number of European and non-European countries usually adopt in estimating capital. These average lives are shown in the table below taken from Rosa and Siesto (1985) and, for Austria, from Hahn and Schmoranz (1984):

	Machinery and Equipment			M.T. Centr.	Building		
	Min.	Centr.	Max.		Min.	Centr.	Max.
Italy	15	18	20	10	35		80
France	12	16	20		30	35	40
Germany	19	24	34			50	
U.K.	16	25	50	10		80	
Denmark	10		20		80		90
Sweden	10	20	40	6	60		80
U.S.A.	12	17	22			50	
Canada	15	22	29		35	40	50
Austria	8	20	25		40		60

#### 7. GROSS AND NET CAPITAL STOCK IN ITALY FROM 1980 TO 1991: A COMPARISON

We were able to verify the reliability of our estimates of the capital stock by comparing them with those prepared by Istat. This has been made possible



TABLE 8  
ITALY—AGGREGATED GROSS CAPITAL—YEARS 1980-91  
(1985 thousand million lire)

Sectors of Destination	1980	1981	1982	1983	1984	1985	<b>1985</b>	1986
1	304,594	314,063	322,430	330,896	339,237	347,019	<b>323,559</b>	354,840
2	167,963	175,093	181,938	188,841	195,768	203,364	<b>196,469</b>	212,439
3	52,806	53,833	54,786	55,576	56,090	56,596	<b>57,283</b>	56,919
4	39,539	42,117	44,121	45,848	47,610	48,680	<b>48,975</b>	49,371
5	68,446	69,854	71,001	71,924	72,885	73,851	<b>75,014</b>	74,232
6	46,936	49,649	52,061	54,209	56,363	58,011	<b>58,211</b>	59,685
7	35,094	37,237	38,917	40,410	41,962	43,405	<b>43,592</b>	44,947
8	7,120	7,857	8,356	8,795	9,377	9,984	<b>10,058</b>	10,576
9	26,173	27,918	29,531	30,942	32,613	34,038	<b>34,154</b>	35,400
10	32,528	34,300	36,969	39,311	41,291	42,369	<b>42,785</b>	43,428
11	43,189	45,536	47,710	49,649	51,845	53,529	<b>53,739</b>	55,216
12	68,616	72,068	74,800	77,209	80,250	82,823	<b>82,917</b>	85,052
13/14/15	84,592	88,863	92,207	95,048	98,026	100,217	<b>100,275</b>	103,215
16	71,809	75,980	79,248	82,117	85,168	88,518	<b>87,787</b>	90,924
17	137,568	143,794	149,359	155,198	162,612	168,973	<b>163,878</b>	176,024
18	75,020	78,540	82,605	87,164	91,746	96,513	<b>95,955</b>	101,031
19	152,650	159,719	166,305	172,058	178,869	186,324	<b>184,836</b>	194,684
20	41,518	43,585	45,534	47,288	49,117	50,819	<b>50,671</b>	52,716
21	54,952	57,553	60,171	62,672	64,956	66,983	<b>66,781</b>	69,171
22	1,548,404	1,601,366	1,652,008	1,704,506	1,756,377	1,808,958	<b>1,789,355</b>	1,860,927
23	395,181	407,547	418,897	429,282	440,632	454,306	<b>415,741</b>	467,730
Total	3,454,698	3,586,472	3,708,954	3,828,943	3,952,794	4,075,280	<b>3,982,035</b>	4,198,527

  

	1986	1987	1987	1988	1988	1989	1990	1991
1	<b>330,219</b>	362,310	<b>337,279</b>	371,006	<b>345,201</b>	378,822	385,280	390,704
2	<b>205,208</b>	221,136	<b>213,402</b>	228,637	<b>220,226</b>	236,432	244,272	253,459
3	<b>56,910</b>	56,702	<b>55,950</b>	56,123	<b>54,620</b>	55,948	56,860	58,026
4	<b>49,272</b>	50,645	<b>50,408</b>	52,231	<b>52,220</b>	54,417	56,265	57,845
5	<b>74,944</b>	74,945	<b>74,937</b>	75,959	<b>75,882</b>	77,323	78,415	79,342
6	<b>60,073</b>	61,399	<b>61,693</b>	63,689	<b>64,082</b>	66,136	68,254	70,067
7	<b>45,067</b>	46,441	<b>46,552</b>	48,242	<b>48,108</b>	50,437	52,303	53,656
8	<b>10,637</b>	11,161	<b>11,120</b>	11,803	<b>11,742</b>	12,374	12,838	13,170
9	<b>35,498</b>	36,911	<b>36,988</b>	38,625	<b>38,578</b>	40,689	42,662	44,694
10	<b>43,797</b>	45,347	<b>45,119</b>	47,369	<b>47,067</b>	49,052	50,817	52,862
11	<b>55,305</b>	57,120	<b>57,107</b>	59,346	<b>59,133</b>	61,579	63,571	65,532
12	<b>84,922</b>	87,274	<b>87,043</b>	89,788	<b>89,262</b>	92,060	94,495	96,367
13/14/15	<b>103,073</b>	106,460	<b>106,404</b>	110,162	<b>110,153</b>	113,891	117,277	120,415
16	<b>89,768</b>	93,143	<b>91,362</b>	95,277	<b>93,416</b>	97,830	99,921	101,984
17	<b>170,762</b>	185,620	<b>180,125</b>	195,785	<b>190,196</b>	206,298	217,579	227,742
18	<b>100,345</b>	106,302	<b>105,497</b>	112,247	<b>111,800</b>	119,364	128,771	138,768
19	<b>193,308</b>	202,095	<b>200,610</b>	211,006	<b>209,631</b>	220,113	229,556	238,431
20	<b>52,701</b>	54,659	<b>54,790</b>	57,248	<b>57,552</b>	60,497	63,403	65,912
21	<b>68,953</b>	71,587	<b>71,322</b>	74,337	<b>73,998</b>	76,764	80,108	83,074
22	<b>1,841,301</b>	1,912,771	<b>1,892,923</b>	1,967,814	<b>1,948,631</b>	2,023,143	2,080,384	2,138,356
23	<b>428,161</b>	483,002	<b>442,346</b>	497,826	<b>456,102</b>	513,508	529,662	546,004
Total	<b>4,100,224</b>	4,327,030	<b>4,222,977</b>	4,464,520	<b>4,357,600</b>	4,606,677	4,752,693	4,896,410

Source: ISTAT and authors' estimates (in boldface).

by the recent publication of the time series of gross and net capital stock for the years 1980-91 made available by the Italian Statistical Institute (Istat, 1994; Lupi and Mantegazza, 1994). The Istat estimates are disaggregated at the level of three productive sectors (Machinery and equipment, Means of transport, Building) and of 23 sectors utilizing capital goods. The evaluations are at 1985 prices. The method for estimating capital is perpetual inventory, with normal limited retirement functions. In the retirement functions used by

TABLE 9  
ITALY—AGGREGATED NET CAPITAL—YEARS 1980-1991  
(1985 thousand million lire)

Sectors of Destination	1980	1981	1982	1983	1984	1985	<b>1985</b>	1986
1	215,731	221,482	226,042	230,619	234,977	238,684	<b>194,975</b>	242,344
2	115,989	121,184	125,959	130,642	135,187	140,219	<b>123,821</b>	146,499
3	30,908	30,864	30,666	30,300	29,758	29,398	<b>30,383</b>	29,105
4	24,240	25,588	26,316	26,754	27,238	27,107	<b>28,201</b>	26,709
5	40,614	40,174	39,498	38,695	38,094	37,712	<b>39,006</b>	37,023
6	30,980	32,162	32,992	33,522	34,022	34,022	<b>35,394</b>	34,077
7	22,751	23,814	24,371	24,710	25,088	25,365	<b>26,379</b>	25,767
8	4,708	5,152	5,340	5,460	5,710	5,982	<b>6,254</b>	6,243
9	17,206	18,028	18,664	19,053	19,663	20,025	<b>20,905</b>	20,349
10	19,559	20,302	21,830	22,964	23,732	23,685	<b>24,683</b>	23,731
11	26,113	27,460	28,551	29,345	30,333	30,794	<b>31,938</b>	31,273
12	42,089	43,853	44,803	45,360	46,474	47,120	<b>48,884</b>	47,487
13/14/15	52,531	54,319	55,125	55,460	55,976	55,816	<b>57,958</b>	56,560
16	44,784	46,974	48,165	48,873	49,693	50,791	<b>52,437</b>	51,045
17	92,828	97,217	100,785	104,470	109,476	113,185	<b>109,721</b>	117,347
18	53,671	55,428	57,601	60,121	62,517	64,963	<b>67,030</b>	67,032
19	100,178	104,408	108,049	110,775	114,409	118,534	<b>122,118</b>	123,437
20	28,002	29,167	30,162	30,918	31,703	32,333	<b>33,240</b>	33,144
21	39,063	40,791	42,481	44,003	45,271	46,257	<b>47,305</b>	47,377
22	1,155,313	1,191,617	1,224,888	1,259,291	1,292,370	1,325,362	<b>1,342,517</b>	1,356,957
23	353,739	364,685	374,490	383,224	392,800	404,543	<b>293,672</b>	415,880
Total	2,510,997	2,594,669	2,666,778	2,734,559	2,804,491	2,871,897	<b>2,736,821</b>	2,939,386

  

	<b>1986</b>	1987	<b>1987</b>	1988	<b>1988</b>	1989	1990	1991
1	<b>197,276</b>	245,602	<b>199,158</b>	250,043	<b>202,242</b>	253,641	256,026	257,625
2	<b>129,223</b>	152,181	<b>133,990</b>	156,498	<b>137,318</b>	160,881	165,105	170,419
3	<b>29,976</b>	28,544	<b>29,327</b>	27,827	<b>28,559</b>	27,598	28,389	29,306
4	<b>27,722</b>	26,972	<b>27,972</b>	27,605	<b>28,622</b>	28,851	29,789	30,497
5	<b>38,180</b>	36,943	<b>38,016</b>	37,393	<b>38,453</b>	38,373	39,218	39,991
6	<b>35,422</b>	34,218	<b>35,532</b>	34,965	<b>36,288</b>	35,911	36,601	37,091
7	<b>26,767</b>	26,162	<b>27,149</b>	26,889	<b>27,882</b>	28,026	28,870	29,257
8	<b>6,516</b>	6,501	<b>6,774</b>	6,819	<b>7,104</b>	7,070	7,216	7,250
9	<b>21,213</b>	20,856	<b>21,715</b>	21,596	<b>22,463</b>	22,699	23,737	24,870
10	<b>24,663</b>	24,701	<b>25,624</b>	25,823	<b>26,777</b>	26,639	27,543	28,708
11	<b>32,402</b>	31,985	<b>33,118</b>	33,019	<b>34,173</b>	34,070	34,898	35,719
12	<b>49,206</b>	47,945	<b>49,634</b>	48,789	<b>50,469</b>	49,510	50,498	51,050
13/14/15	<b>58,688</b>	57,622	<b>59,771</b>	59,186	<b>61,364</b>	60,808	62,144	63,319
16	<b>52,666</b>	51,242	<b>52,857</b>	51,495	<b>53,134</b>	52,292	52,794	53,453
17	<b>113,706</b>	123,739	<b>120,030</b>	130,496	<b>126,663</b>	137,474	145,111	151,548
18	<b>69,195</b>	69,712	<b>71,996</b>	72,910	<b>75,351</b>	77,108	83,357	89,937
19	<b>127,156</b>	127,342	<b>131,170</b>	132,682	<b>136,704</b>	138,190	144,015	149,253
20	<b>34,077</b>	34,002	<b>34,962</b>	35,503	<b>36,505</b>	37,652	39,459	40,867
21	<b>48,464</b>	48,685	<b>49,821</b>	50,277	<b>51,467</b>	51,499	53,561	55,170
22	<b>1,375,177</b>	1,387,620	<b>1,406,938</b>	1,420,524	<b>1,441,122</b>	1,452,838	1,486,197	1,519,488
23	<b>301,952</b>	428,869	<b>311,847</b>	441,222	<b>321,014</b>	454,202	467,408	480,525
Total	<b>2,799,647</b>	3,011,443	<b>2,867,401</b>	3,091,561	<b>2,943,674</b>	3,175,332	3,261,936	3,345,343

Source: ISTAT and authors' estimates (in boldface).

Istat the means of the distributions coincide with the average service lives of the investment goods and the variances are proportional to the means.

Tables 8-9 show the Istat estimates of gross and net capital stock for the years 1980-91 disaggregated by sectors of destination. The comparison with our estimates (in boldface) for the years 1985-88 is very satisfactory and discrepancies are rarely greater than a few percentage points.

Between 1980 and 1991 gross capital has increased, on the average, slightly

over 3 percent a year and net capital slightly over 2.5 percent. It is possible to note the particularly high values of the growth rate of sectors "Office machines", "Electrical material", "Means of transport", "Transport and Communications".

The availability of the Istat data allows us to place our disaggregated estimates of capital stock into a wider, even though more aggregated, temporal context and it makes possible to follow the evolution of the capital stock in Italy during the last 12 years.

#### REFERENCES

- Annunziato, P., Esposito, G., Manfroni, P. and Rosa, G., *La stima del capitale per settore e area geografica e alcuni indici di produttività*, Centro Studi Confindustria, Roma, 1992.
- Anderson, W. P. and Rigby, D. L., Estimating Capital Stocks and Capital Ages in Canada's Regions: 1961-81, *Regional Studies*, 23, pp. 117-126, 1989.
- Atkinson, M. and Mairesse, J., Length of Life of Equipment in French Manufacturing Industries, *Annales de l'INSEE*, Paris, 30-31, 1978.
- Biorn, E., Holmoy, E. and Olsen, O., Gross and Net Capital and the Form of the Survival Function: Theory and Some Norwegian Evidence, *Review of Income and Wealth*, 35, pp. 133-149, 1989.
- Cette, G. and Szpiro, D., The Means of Production, Their Average Age and Life Span, *Economie et Statistique, Annales de l'INSEE*, 208, Paris, 1988.
- Esposito, G., Concetti e metodi di misura della ricchezza e del capitale, *Annali di Statistica*, Serie VIII, Vol. 28, Istat, Roma, 1975.
- Goldsmith, R. W., A Perpetual Inventory Method of National Wealth, *Studies in Income and Wealth*, 14, National Bureau of Economic Research, pp. 5-61, New York, 1951.
- Griffin, T. J., Revised Estimates of the Consumption and Stock of Fixed Capital, *Economics Trends*, 264, 1975.
- Gros Pietro, G. M. and Rosa, G., Investimenti, processi innovativi e riflessi sulle strategie d'impresa, *Rivista di Politica Economica*, LXXVII, pp. 229-245, 1987.
- Hahn, F. and Schmoranz, I., Estimates of Capital Stock by Industries for Austria, *Review of Income and Wealth*, 30, pp. 289-307, 1984.
- 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, pp. 117-135, 1977.
- ISTAT, Principali aggregati economici a livello territoriale. Anni 1970-76, *Bollettino mensile di statistica*, No. 1, 1978.
- , *Serie storiche degli investimenti fissi lordi, degli ammortamenti e dello stock di capitale*, Dipartimento di Contabilità Nazionale ed Analisi Economica (on floppy disk), 1994.
- Jaffey, M., The Measurement of Capital Through a Fixed Asset Accounting Simulation Model (FAASM), *Review of Income and Wealth*, 36, pp. 95-110, 1990.
- Koumanakos, P., *Alternative Estimates of Non-residential Capital in Canada 1929-80*, Statistics Canada, Ottawa, 1980.
- Lupi, C. and Mantegazza, S., Ricostruzione delle serie degli investimenti per branca utilizzatrice, per branca proprietaria e calcolo dello stock di capitale, *Quaderni di Ricerca*, Serie Economia e Ambiente, Istat, Roma, 1994.
- Maddison, A., Stime standardizzate dello stock di capitale: un confronto fra sei paesi, *Innovazione e Materie Prime*, pp. 20-47, 1993.
- Manfroni, P., Il capitale fisso riproducibile delle attività industriali, anni 1951-72, *Note e Relazioni*, 52, Istat, Roma, 1975.
- Marzano, F., Il concetto di capitale nella teoria economica, *Annali di Statistica*, Serie VIII, Vol. 28, Istat, Roma, 1975.
- Mediocredito Centrale, *Indagine sulle imprese manifatturiere*, Roma, 1971-87.
- Monselesan, A., *Le nuove stime degli investimenti fissi lordi*, Dipartimento di Contabilità Nazionale ed Analisi Economica, Istat, Roma, 1990.
- O'Mahony, M., Capital Stocks and Productivity in Industrial Nations, *National Institute Economic Review*, 145, pp. 108-127, 1993.
- OECD, *Service Lives of Fixed Assets*, Department of Economics and Statistics, Paris, 1983.
- , *Reliability of Service Life Assumptions Used in Measuring Gross Capital Stocks*, Department of Economics and Statistics, Paris, 1989.
- Rosa, G., *Lo stock di capitale nell'industria italiana. Nuove stime settoriali e territoriali*, Centro Studi Confindustria, Roma, 1979.

- Rosa, G. and Siesto, V., *Il capitale fisso industriale*, Il Mulino, Bologna, 1985.
- Santeusano, A., La matrice del capitale: un tentativo di stima per l'Italia al 1980, *Ricerche Economiche*, XLII, pp. 114-142, 1988.
- Smith, A. D., A Current Cost Accounting Measure of Britain's Stock of Equipment, *National Institute Economic Review*, pp. 42-57, 1987.
- Solow, R. M., Substitution and Fixed Proportions in the Theory of Capital, *Review of Economic Studies*, 24, pp. 207-218, 1962.
- Tarasofsky, A., Roseman, I. G. and Waslander, H. E., *Ex Post Aggregate Real Rates of Return in Canada: 1947-76*, Economic Council of Canada, 1981.
- Tengblad, Å. and Westerlund, N., Capital Stock and Capital Consumption Estimates by Industries in the Swedish National Accounts, *Review of Income and Wealth*, 22, pp. 331-344, 1976.
- UNSO, *A System of National Accounts*, United Nations, New York, 1968.
- Varaiya, P. and Wiseman, M., Investment and Employment in Manufacturing in U.S. Metropolitan Areas, 1960-76, *Regional Science and Urban Economics*, 11, pp. 431-469, 1981.
- Winfrey, R., Statistical Analyses of Industrial Property Retirements, *Bulletin 125*, Iowa Engineering Experiment Station, Iowa State College, 1935.